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Dissertation Chapter

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The Dialectics of Women's Work and Impairment in Lillian F. Schwartz's Hybrid-Computer
Film *Pixillation*, 1970

I will always see a sixteen-year-old with fiery red hair, a new blue canvas coat, orange pants, and a hand spattered with Prussian blue blissfully contemplating the nude women in gold frames; without the slightest doubt, he—in his clothes of a modern work, blazing with color—killed the whole exhibition. Nothing more remained on the walls than vaporous shadows in old frames. The dazzling kid who looked as though he had been fathered by a piece of machinery was the symbol...of the life of tomorrow. — Fernand Léger, "The Machine Aesthetic: The Manufactured Object, the Artisan, and the Artist"¹

For four minutes on the screen, we see a montage of hand painted bi-color film cells, computer-generated animations, and stop-motion micro-photography: flashes of swirling red and blue liquid erupt; jagged outcroppings of crystals rise up like geological formations accelerated to the time scale of human beings; and chevrons of pixels proliferate across our total field of vision. The soundtrack, at once melodic and oscillating, ebbs and flows like the soundscape of a mid-20th-century science fiction film (fig.1).²

This hybrid-computer film is *Pixillation*, 1970, the first of artist Lillian F. Schwartz's moving image works that she would make while a resident artist and consultant at AT&T Bell Telephone Laboratories Acoustical and Behavioral Research Center (Bell Labs: ARBC) in Murray Hill, New Jersey between 1969 and 2002. Included as part of the recent retrospective *Lillian Schwartz: Whirlwind of Creativity* at the Henry Ford Museum of American Innovation, visitors could be seen moving quickly past

¹ Fernand Léger, "The Machine Aesthetic: The Manufactured Object, the Artisan, and the Artist," in *Functions of Painting*, ed. Edward F. Fry, The Documents of 20th-Century Art (New York, New York: The Viking Press, Inc., 1973), 61.

² A digitized version of Schwartz's film is presently available in The Henry Ford's Digital Collection online. See Lillian F. Schwartz, *Pixillation*, <https://www.thehenryford.org/collections-and-research/digital-collections/artifact/519817#slide=gs-66565>, 1970, *Lillian F. Schwartz & Laurens R. Schwartz Collection: The Henry Ford*.

the screening area, unsurprising given that this film and other of her early works such as *U.F.O. 's*, 1971 have, by Schwartz's description, "caused headaches and hallucinations and, in one instance, uncrossed a case of chronically crossed eyes."³ Scholars have been more attentive; although, much of this research such as Zabet Patterson's chapter "Pixillation" in her book *Peripheral Vision: Bell Labs, the S-C 4020, and the Origins of Computer Art*, has focused on historicizing the machines, engineers, and computer-programming that made these films possible.⁴ It is a literature to which Schwartz herself has greatly contributed through the 1992 publication of her book *The Computer Artist's Handbook: Concepts, Techniques, and Applications*; more than an instruction manual, her handbook is a comprehensive, nearly 300-page volume that explains the conceptual and technical underpinnings of computer art practice, using her own artworks as examples. With a "Foreword" by Nobel Prize holder Arno Penzias, then vice-president of research at Bell Labs, the book explains an approach to controllable pixels that she calls Pixellence™. It is a term that, at once, recalls pixel bitmapping, a fundamental process in computer graphics whereby an image is broken into a two-dimensional array of discrete "bits" of information, with color and intensity mapped out in rows and columns; and, pixilating, a stop-motion technique whereby still-images of human figures are animated through film editing.⁵ And yet, although this technical description of Schwartz's computer-film works is helpful to understanding their formal qualities, I contend that it is only by looking deeper into the optical effects that resulted from these forms, sometimes sickening her viewers, that the profound significance of computer-films such as *Pixillation* becomes visible. After all, Pixellence™ is neither the only, nor I contend, the best description of an artistic practice that had also been termed *morphodynamism*; it is Schwartz's morphodynamic practice that I historicize and theorize in my chapter.

³ Lillian F. Schwartz and Laurens R. Schwartz, *The Computer Artist's Handbook: Concepts, Techniques, and Applications* (New York, New York: W. W. Norton & Company, Inc., 1992), 115.

⁴ Schwartz has also been honored by the Computer History Museum and it is notable that her archive is now held as the *Lillian F. Schwartz & Laurens R. Schwartz Collection* at The Henry Ford in Dearborn, Michigan.

⁵ Schwartz and Schwartz, *The Computer Artist's Handbook: Concepts, Techniques, and Applications*, 136. There is a further comparison to be drawn between computer graphics and divisionism that I have not yet developed.

The coinage of then Director of the ARBC Max Matthews, Lillian Schwartz had been given the title of “Morphodynamicist” in the early 1970s; it is a term that combines “morphology,” the study of the biological form and structure of plants and animals, with “dynamics,” the study of the fundamental, physical mechanics of motion.⁶ And, far more than a professional or honorific title, morphodynamism epitomizes the way in which Schwartz’s practice would take up and extend the *dynamism* of the historical avant-garde; just as dynamism images the intrinsic and extrinsic motion of objects in the static image, morphodynamism shows this motion as change, moreover, extending the 2D image into a 3D vision. Tracing this aesthetic practice to Schwartz’s artistic training, her studies in 1959 with American painter Ugo Giannini, a student of avant-gardist Fernand Léger, I demonstrate how Schwartz transforms Léger’s “Dynamic Divisionism” into a feminist practice for the purpose of negating the alienating conditions of women’s work in late 20th century America. Drawing on feminist, historical materialist, and disability studies methods, and working through formal analysis, I show how in her computer artworks such as *Pixillation*, Schwartz re-figures the female nude, a longstanding trope in the history of art, as a laboring body; moreover, as I demonstrate, hers is a body that has been physically impaired by the dangerous working conditions of women’s labor. And while the artwork offers no corrective for these dangers, I contend that it is nevertheless wielded by Schwartz as a tool constructed through her own impairment and by which she negates the alienating effects that activists fighting in the women’s and disability rights movements and scholars such as Barbara Ehrenreich, Dorothy Sue Cobble, and James Charlton have attributed to 20th century America’s gendered and abled division of labor.⁷

⁶ Lillian F. Schwartz, interview by Christopher Garcia, 2013.

⁷ The Women’s and Disability Rights Movements have a common history of fighting paternalism in society writ large and the Labor Movement more specifically; some overlap should be presumed between these two social justice movements, especially where I reference feminist texts from the Occupational Safety Movement. Industrial accidents were moreover critical to the actions of the early Disability Right’s Movement. For historical overviews of disability history, see Kim E. Nielson, *A Disability History of the United States*, Revisioning History (New York, New York: Beacon Press, 2013); Doris Z. Fleischer, *The Disability Rights Movement: From Charity to Confrontation* (Philadelphia, Pennsylvania: Temple University Press, 2012); James I. Charlton, *Nothing About Us without Us: Disability Oppression and Empowerment* (Berkeley, California: University of California Press, 1998). For a legal discussion of disability and labor, see Samuel R. Bagentos, "Disability Rights and Labor: Is This Conflict Really Necessary?," *Indiana Law Journal* (2017).

Abstract of a Woman Artist

A member of the storied collaboration Experiments in Art and Technology (EAT) and with artworks in major exhibitions such as the canonical 1968 show *The Machine as Seen at the End of the Mechanical Age* at the Museum of Modern Art (MoMA), Schwartz is definitively not an outsider artist. And yet, in an era of increasingly institutionalized arts education in the United States, her training was notably piecemeal; it is impossible to extricate this fact from the material realities that had most likely prevented her from undertaking a more formal course of study. After all, born in Cincinnati, Ohio on July 13, 1927, Schwartz's path to art education was very different from than her older brother Barney who attended art school and first taught her to use Conte crayons. One of 13 children of Russian and English Jewish immigrants, Schwartz's father was a barber active in local politics and her mother a housewife. And Schwartz has recalled a household filled with art and music; with her mother's permission she and her siblings would use household supplies and broken bits of crayon to draw on the wallpaper of the family home. Her older sister Belle would give her a violin, and when Schwartz would join Belle working as a secretary in bankruptcy court for her first job the two would visit art museums on their lunch breaks. Yet, as much as her early art training was due to a familial zeal, her relationship to educational institutions was also marked by anti-Semitic violence that pervaded Schwartz's childhood. The artist has recalled being regularly beaten up on her way to school, a circumstance that led her mother to assign the children an extra day for the weekend, posting false notices on the door of the home that the children had fallen ill with measles, mumps, and chicken pox; her father would for the same reason use his local connections to shift the school day to an earlier schedule. Schwartz has also recalled being regularly beaten up by school classmates, a circumstance so dire that her sister was thrown down the steps of her high school; paralyzed, she would die of complications a year later. Even the protective barrier of the home would end when her father became too ill to work. Moving to Clifton a suburb where they had been allowed to own,

but not live due to anti-Semitic covenants, Schwartz has vividly recalled waking up to find that her family dog had been killed; the words “Jew Dog” were incised into the dog’s corpse.⁸

It is yet another domesticated ordeal that would affect the next significant dimension of Schwartz’s artistic training; the US atomic bombing of Hiroshima and Nagasaki, Japan in 1945 which had destroyed the region’s infrastructure and killed hundreds of thousands of civilians from the blasts together with long-term side effects; incidents of leukemia, thyroid, lung and other cancers due to the exposure to radiation would rise significantly in the next decade with birth-defects, including impairments and an increased risk of cancer, appearing in the next generation. An accompanying but less commented on effect of the destruction was the rise in the spread of contagious diseases including cholera and poliomyelitis, more commonly known as polio. It is polio that Schwartz would contract shortly after her arrival in 1949 with her young son in Fukuoka, Japan—midway between the two bombed out cities—to join her husband, an Army doctor as a military spouse while he finished his military contract. Partially paralyzed and isolated from her family for months, she would be hospitalized for more than a year. It is while hospitalized and, more significantly, paralyzed that Schwartz would begin her studies of Chinese brushwork under a Zen Buddhist man named Tshiro beginning with the previsualization of her brush strokes: the pressure of the brush, its connection to the paper, and its sweeping gesture.⁹ Schwartz’s incapacity necessitated this previsualization; yet, it is also characteristic of brushwork techniques where each stroke is undertaken as a definitive and defining gesture. We see a direct connection to this training in Schwartz’s artworks, including her 1949 ink-work *On the Yangtze* (fig. 2), made on a torn fragment of a Japanese newspaper and later computer-graphics such as her *Birthday Card*, 1988 (fig. 3); this digital work bears an unmistakable likeness to a Japanese woodblock print of a woman’s profile and upper torso cuddling a cat, Tsukioka Yoshitoshi’s *The Courtesan Usugumo Holding a Cat* from the series *A Mirror of*

⁸ Schwartz, "Schwartz, Lillian F. Oral History," 2-3.

⁹ *Ibid.*, 5.

Beauties of the Past and Present, 1876 (fig. 4) in particular.¹⁰ Shown as an example of digital brushwork in her chapter “Drawing” in her *Handbook*, Schwartz describes the creation of custom brushes as a mode of self-expression in relation to a new kind of previsualization, the act of programming through the computer language C; as in Zen calligraphy, here the brushstroke is framed as to tell us something not only about the character or scenery depicted but also the maker at the moment that the stroke was made.¹¹

Unsurprisingly, Schwartz’s works made during her recovery from polio show the traces of her physical impairment. The brushstrokes in *On the Yangtze*, for example, show changes in thickness that are telltale signs of shifts in pressure and hesitancy across her gesture. Her oil painting *After Polio*, 1950 (fig. 5) is even more labored in its presentation; the heaviness of each stroke of sticky paint reveals a lethargy of movement. Painted in pastel tones, *After Polio* depicts a hospital scene, physical therapy, that becomes eerier as one looks longer at the soft-hued details; moving inward from the right edges of the painting, two female figures in nursing uniforms complete with skirts and telltale caps stand; two other female figures, their patients, have sunken eyes and bushy brown hair; they wear short dresses that give the impression of hospital gowns and each holds onto parallel bars, whilst concentric rings of cream, burnt orange, and navy blue radiating from their right feet; the right leg of one patient jutting to the side at an odd angle; whilst the stock straight legs in blue give the impression that the other, a white bow in her hair, wears bracing; in the background, a ghostly figure painted in periwinkle looks to the nurse in profile yet turns its back to the scene; all the while, the nurse looks back with a thickly painted yet subtly upturned smile.

With its pastel tones reminiscent of Claude Monet’s impressionism, this painting like others made by Schwartz during the same period is a temporal matrix of different events viewed from a variety of perspectives and early suggestions of her interest in the avant-garde’s experiments with color and light, and with dynamism as a depiction of the movement and energy; the bull’s-eyes radiating from the right

¹⁰ For another example, see figure *Japanese Baby*, 1989 Schwartz and Schwartz, *The Computer Artist's Handbook: Concepts, Techniques, and Applications*, 39.

¹¹ *Ibid.*, 56.

feet of her stiffened figures are energetic, suggesting a kind of radiating pain. Yet, interspersed with more realist paintings of children's toys and Disney scenery such as *6 Dwarfs*, 1949, (fig. 6) her experiments across media take on the character of a coherent practice after her studies with the painters Michal Lenson and Ugo Giannini in New Jersey in the 1950s.¹² Best known for his Works Progress Administration (WPA) murals and mannered figures of workers integrating social realism with surrealism and cubism, Lenson had trained at the National Academy of Design in New York City and later studied at the Slade School in London and the Academie des Beaux Arts in Paris; he would become a major art critic from the 1950s to the 1970s and is especially known for his knowledge of the techniques of the Renaissance masters.¹³ Giannini too had been trained at the National Academy before serving in WW II, continuing his studies at the Art Students League postwar before a year spent in 1949 in the Paris studio of the avant-gardist Fernand Léger.¹⁴ The style of his works would change radically after his studies in Paris, transitioning from the gritty realist style of his academic training that would be published posthumously in the 2013 portfolio *Drawing D-Day* of Giannini's letters and sketches of the Normandy invasion by US forces, to an ever evolving abstract-realist style that reveals the clear influence of the avant-garde, including Miro, Picasso, and Braque.¹⁵ "Subject matter is mere appearance," Giannini would insist in a handwritten note describing his stylistic transition as a new realism. "Painting...is the art of discerning and manipulating the structures and processes of seeing. ...Reality for me is what I experience by working with forms and colors."¹⁶

Giannini's language mirror's Léger's published writings, and even the American's stylistic promiscuity bears the mark of the avant-gardist's experimental approach; it is this same characteristic

¹² Lillian F. Schwartz, "Painting," <http://lillian.com/drawing-and-painting>. Her 1950 painting *Homage to Léger*, alternatively titled *Still Life with Ugo Giannini* can also be found here on her website. Her website is currently unstable but is well documented on the Internet Archive's Wayback Machine at <http://web.archive.org/>.

¹³ Lenson would be Director of the Newark School of Fine and Industrial Arts between 1944 and 46.

¹⁴ Petra ten-Doesschate Chu, "Biography - Ugo Giannini," Rehs Contemporary Galleries, Inc., <https://rehs.com/eng/contemporary-bio/ugo-giannini/>.

¹⁵ For an overview of Giannini's stylistic transition, see Ugo Giannini and Maxine Giannini, *Drawing D-Day: An Artist's Journey through War* (Mineola, New York: Dover Publications, Inc., 2013). He would return to the subject matter of war however in an abstract-realist style at the end of his life.

¹⁶ Chu, "Biography - Ugo Giannini". Art historian Petra ten-Doesschate Chu is an expert on Cezanne and Courbet.

promiscuity that is noted by Schwartz of Léger in her *Computer Handbook*, a fact that she attributes to her studies with Giannini. Yet, this experimental attitude is neither the only nor perhaps the most significant marker of Léger's influence in the work of the Italian-American artist; for example, Giannini's major series of *Contrasting Forms* (fig. 6) paintings is an Anglicization of Léger's own *Contraste de formes* created in 1913 (fig. 7).¹⁷ Exemplary of an approach that Léger calls "dynamic divisionism," in his 1913 polemic "The Origins of Painting and its Representational Value"—published in English-translation in 1965 in MoMA's *The Documents of 20th Century Art: Functions of Painting Fernand Léger*—these paintings were made in a technique that Léger had described as the "further development and expansion" of what he describes as impressionism's "divisionism in color."¹⁸ Although Léger makes no direct mention of George Seurat, it is helpful to note that the neo-impressionist's had worked in a technique known as "divisionism" that drew on scientific research into color vision by psychologists such as Hermann von Helmholtz; often used interchangeably with "pointillism," Seurat's technique relies on the juxtaposition of points of colored pigments that are chosen according to chromatic rules either to contrast or mix in the retina of the viewer (fig. 9). Because every object in his work is made of these dots and only really given form through these color relations, Seurat's divisionism is a likely reference for what Léger calls "divisionism in color." Further developing this technique in his own dynamic divisionism, the avant-gardist would add to color clashes between line and form; works such as Léger's *Contraste de formes* seem to vibrate with these juxtapositions. And it is this vibration, what we might otherwise recognize as a characteristic principle of modernity, that is, dynamism that had led the avant-gardist to extend neo-impressionism's theories forward.¹⁹

Describing Léger's dynamic divisionism as a destructive act taken against figuration, art historian Christopher Green has noted that the artist would however return to the human figure in his drawings and

¹⁷ For Schwartz's own *Homage to Léger* see Figure 8.

¹⁸ Léger, "The Origins of Painting and Its Representational Value."7. He calls Cezanne and Manet impressionists although art historians would tend to distinguish them as post-impressionists or neo-impressionists.

¹⁹ Dynamism, speed, motion is a common theme in the characterization of modernity, one especially present in avant-gardist writings.

paintings made during and after his time as a soldier in World War I.²⁰ It is during this period that abstract forms would give way to representations of the figure as a catastrophe of corporeal and machine-parts, or what Green calls Léger's machine-man.²¹ Just as in Léger's earlier experiments, an underlying dynamism unifies the artworks of this period. And it is importantly Léger's machine-man that I argue we see taken up and extended by Schwartz as woman in works such as *Pixillation*.²² Although, two further points must be noted about Léger's purpose before proceeding. First, although Léger would only join the French Communist Party in his later years, and be particularly active while Giannini was his student, he had like many in the avant-garde already a Marxist, in the sense of his work having been heavily influenced by Karl Marx's philosophical writings. What becomes clear when reading Léger's polemical writings on art through this lens is that what Green describes as machine-man is for Léger a dialectical subject who is brought forth by his own labor in relation to a world that is objectively machinic.²³ Second, and relatedly, what we might term Léger's *dialectical realism* was attempt to create a plastic art for the common working man. It is by organizing the plastic elements of line, color, and form in relation to the speed and fragmentation characteristic of modern life that he sought to create a kind of realism that was legible to the working-class whose labor produced these industrial realities. It is a similar point that Schwartz makes in discussing her own homage to Léger, *Women on Red Background*, 1988, for a retrospective of the

²⁰ For an overview of Léger's dynamic divisionism, its relationship to Futurism, and its destruction of the figure, see Christopher Green, "Léger's Contrastes and the Parisian Avant-Garde, 1913-14," in *Léger and the Avant-Garde* (New Haven, Connecticut: Yale University Press, 1976). Green introduces the concept of machine-man on page 84 of this section. My summary of Léger elides many of the stylistic periods that Green discusses. I am more concerned with the striking consistency of the theme of machine-man, which Green notes across Léger's work.

²¹ For a discussion of the influence of the war on his painting, see "Léger's War, the War-Time Avant-Garde and La Partie De Cartes."

²² I am not the first to claim that Schwartz's *Pixillation* must be understood as an interrelation between the human subject and the machine. Helena Schaskevich in her 2021 article "Encoded Perception: Remapping Vision in Lillian Schwartz" discusses *Pixillation* as a binary of human versus machine vision. However, my claim differs in being dialectical, meaning that machine and human systems influence. It is my contention that the dialectic is more appropriate to the intellectual milieu at Bell Labs where researchers were studying the more fundamental dynamics described by physics and biology. Our disparate readings of this theme in Schwartz's work can to some degree be traced to a more general disagreement in the history of science and technology, and especially arguments over humanism and cybernetics.

²³ See Fernand Léger, *Functions of Painting*, ed. Robert Motherwell and Bernard Karpel, trans. Alexandra Anderson, *The Documents of 20th-Century Art* (New York, New York: The Viking Press, Inc., 1973).

avant-gardist's work in West Germany in her *Computer Handbook*.²⁴ Here she recalls that it was Giannini who had impressed upon her the significance of understanding Léger's forms in relation to his "identification with working-class attitudes."²⁵ As I shall discuss in my next section, it is an identification with the working-class that is just as evident in Schwartz's morphodynamism, unsurprising given Schwartz own biography.

At War with the Body: Gender and the Laboring Figure

It was not simply the war, but the work of the common soldier that had revived Léger's interest in the figure. As Green describes in his canonical 1976 book *Léger and the Avant-Garde*, Léger would become fascinated by the common infantryman commonly with agricultural backgrounds, known in French as the *poilu*. It is the *poilu* whom he would depict as machine-man. As Green argues, Léger's depictions of the *poilu* show us the theme of the force of modern industry that had undergirded dynamic divisionism, for example, the card players in his 1917 painting *La partie de cartes (The Card Players)* (fig. 10) have tubular limbs and fingers are suggestive of the cylindrical bombs, gas-cans, and bullets of wartime. As Léger had written in a letter of his wartime experience: "Without any period of transition I found myself on the level with the whole of the French people; thrown into the Engineers, I found that my new mates were miners, navies, woodworkers, and ironworkers...When I'd bitten into this reality a concern with real objects never left me."²⁶ He would bring together the two themes of these men and the brutality of the machine in his paintings, as Green notes, extracting his subject matter from his experiences of the contemporary moment. Thus, as the war ended, his direct engagement with war would give way to other, more quotidian expressions of figuration under the machine-man that nevertheless maintained the connection to the object. And yet, critically, although Léger's style would shift from the Simultanism of 1918-1919, what Green calls his "call to order" and a period of classical figuration from 1921-24 and produced his famed nude of three female figures with still life *Le Grand Dejeuneur*, 1921,

²⁴ Schwartz and Schwartz, *The Computer Artist's Handbook: Concepts, Techniques, and Applications*, 144.

²⁵ *Ibid.*

²⁶ Fernand Léger, "Fernand Léger 1881 - 1955," ed. Musée des Arts Décoratifs (Paris 1956), 30.

the theme of war would remain visceral in his artworks.²⁷ For example, in a 1924 essay Léger describes the modern condition as that of an “economic war [that] leaves him [the common man] no room to breathe. It is another state of war as lamentable as the first.”²⁸

Studying with Léger as a U.S. veteran in post-war Paris of 1949, Giannini’s stylistic transition is likewise tied to his experiences as a soldier during World War II; and while less straightforward, it is the work of war that we also see in Schwartz’s own development of dynamic divisionism into morphodynamism in artworks such as *Pixillation*. It is Schwartz herself who has connected her films to the horrors of WWII. In particular, she has linked these works to her indelible memory of seeing the afterimages of human beings who had been turned to shadows by the bombs dropped on Japan, their flesh eviscerated in the blast. And yet, Schwartz’s role in the war-effort precedes this experience as she had enlisted in the Navy Nurse Cadet Corp to attend college at the University of Ohio in Cincinnati College of Nursing and Health.²⁹ As she notes in her *Handbook*, her “courses in anatomy and biology, the technique in fashioning plaster-casts, and the ability to entertain sick children through on-the-spot sketches became invaluable lessons in art.”³⁰ Established with the June 1943 passage of the Bolton Act, the Nurse Cadet’s program had been created to fill a gap in trained nurses both in American hospitals and in the Army, Navy, and Air Force Nurse Corps that had served in combat zones since 1901. Like many U.S. service members working in domestic support roles, Schwartz would not see combat. However, distinct from the male doctors enlisted in the Medical Corps, Nurse Cadet Corp members would have their contracts duly terminated on the conditions of marriage, pregnancy, and at the end of combat. By Schwartz’s arrival in Japan in 1949 the war had ended, she had married and given birth to one son; her contract might have been terminated on any of these conditions. And yet, Schwartz had arrived in Japan still under the

²⁷ Christopher Green, *Léger and the Avant-Garde* (New Haven, Connecticut: Yale University Press, 1976).

²⁸ Léger, "Notes on the Mechanical Element," 37.

²⁹ Schwartz was too young to enlist and required special permission to attend the program. For a history of women’s enlistment during World War Two, see D’Ann Campbell, *Women at War with America: Private Lives in a Patriotic Era* (Cambridge, Massachusetts: Harvard University Press, 1984).

³⁰ Schwartz and Schwartz, *The Computer Artist’s Handbook: Concepts, Techniques, and Applications*, 5.

military's rubric of sexual difference now as the military spouse of her pediatrician husband whose service contract extended into the 1950s.³¹

Despite the military's sexual division of labor, there was however no disconnection of women's military service work from danger; indeed, as the late 20th century feminist literature on labor reveals, the constant vigilance of the enlisted serviceman was more broadly characteristic of women's professional work which carried with it a pervasive threat of sexual harassment. "Sexual harassment of women workers is not incidental," a 1978 special issue of the leftist journal *Radical America* avers, "but virtually universal."³² It is a circumstance that would be highlighted by increasingly available social sciences research through the 1980s. "Statistics on jobs, raises, and training that were lost because women refused to be sexually available at work suggests that sexual harassment has served as a major, though hidden, barrier to women's economic security and advancement," notes psychologist and research director of the Working Women's Institute in 1984 Peggy Crull.³³ Crull goes on, "The phenomenon of sexual harassment is not new, it was simply unnamed until the mid-1970s."³⁴ And these dangers had been heightened for Nurse Corp members stationed in combat zones during WWII, for whom American servicemen had become a danger as persistent as their work under sniper fire, exposure to chemical agents and diseases, and the possibility of their being taken as prisoners of war. Indeed, as Judith A. Bellafaire, Chief Historian at the Women in Military Service for America Memorial, has documented, women service members, for example, in the Pacific theater were subject to a widespread and persistent threat of sexual harassment and violence. Women nurses were in some instances fenced-in, confined to

³¹ It was only as late as February 26, 1944, that even the Nurse Corps would become established on a permanent basis, then the only women's unit to be granted official military rank. The first female commissioned officers appointed as late as April 16, 1947. The Nurse Cadet Corps now remains the only U.S. Medical Service Corps personnel without veteran status.

³² Margery Davies Frank Brodhead, Marla Erlie, Phyllis Ewen, Linda Gordon, Jim Green, Allen Hunter, Jim O'Brien, Nick Thorkelson, Ann Withorn, "Introduction," *Radical America: Sexual Harassment in the Workplace*, 1978, 3.

³³ The Working Women's Institute was a national center for information on sexual harassment on the job, and often gave expert testimony in sexual harassment cases. As the subject of sexual harassment became less taboo

³⁴ Peggy Crull, "Sexual Harassment and Women's Health," in *Double Exposure: Women's Health Hazards on the Job and at Home*, ed. Wendy Chavkin (New York: Monthly Review Press, 1984), 101, 16-17.

their quarters during free-time, and accompanied by armed escorts after 6 pm and while travelling off post. Officially, as Bellafaire notes, these restrictions on women service member's liberty were rationalized by the existence of Japanese guerilla patrols; and yet, as has been made clear in the decades since, the U.S military has a rape problem.³⁵

Stressed by American feminists of the 1970s, the problems of on-the-job assault and harassment were of a kind with the conditions of marriage and pregnancy that were typical limiting factors to women's employment; that is, women's work was oftentimes contingent on sexual and reproductive availability. A period when American work was undergoing massive changes including computerization, the establishment of the Occupational Safety and Health Administration (OSHA) in 1971, and a rising service sector, there exists a substantial literature on the working conditions of this period.³⁶ And this characteristic of women's work is evident even in other, more nonspecialist accounts of workers such as Studs Turkel's 1974 oral history *Working: People Talk About What They Do All Day and How They Feel About What They Do*. For example, in his chapter "Terry Mason" in a section entitled "A Pecking Order," he records the oral history of Mason, a 26-year-old airline stewardess recently married. At the time a high-status union job for women, Mason's recounting of her professional duties is primarily a list of rules governing her conduct and appearance towards a proprietary image that differed for each airline. "I think our average age is twenty-six," Mason notes, "But our supervisors tell us what kind of make-up to wear, what kind of lipstick to wear, if our hair is not the right style for us, if we're not smiling enough.... They call us professional people but they talk to us as very young, childishly. They check us all the time on appearance. They check our weight every month. Even though you've been flying twenty years, they check you and say that's a no-no."³⁷ Even for women workers in less public-facing occupations such as

³⁵ Judith A. Bellafaire, "The Army Nurse Corps," United States Government, <https://history.army.mil/books/wwii/72-14/72-14.htm>.

³⁶ For period resources on the hazards of work, see Jeanne M. Stellman and Susan M. Daum, *Work Is Dangerous to Your Health: A Handbook of Health Hazards in the Workplace and What You Can Do About Them* (New York, New York: Random House, Inc., 1973); Michael McCann, *Artist Beware: The Hazards and Precautions in Working with Art and Craft Materials* (New York, New York: Watson-Guption Publications, 1979).

³⁷ Studs Terkel and Terry Mason, "A Pecking Order: Terry Mason, Airline Stewardess," in *Working: People Talk About What They Do All Day and How They Feel About What They Do* (1974), 42, 47.

secretaries and telephone operators, written and unwritten rules restricting women's dress and marital status were nevertheless common. Schwartz has recalled how the women employed at Bell Labs during her early years as a resident artists wore skirts as an unofficial but nevertheless standardized uniform; as the artist describes it, it was only after her regular appearances at the Lab working in trousers that this standard would begin to change amongst the female staff.³⁸

Writing in 1971 in the feminist journal *Liberation* and later republished in 1975 in the anthology *Women: A Feminist Perspective*, then research assistant at the Institute for Community Studies Linda Phelps argues that the impact of this sexual divide was what she describes as a “special case of alienation” in which women begin to experience themselves as symbols and subsequently to relate to the world in alienated relations that she calls *symbol-objects*.³⁹ Although her focus in this essay is women's sexuality, the inherent sexualization of women's work makes her analysis appropriate more broadly to the sexual division of labor. Drawing on the anthropologist Ernest Becker's social psychology of alienation, Phelps describes women's alienation as a kind of sex-based deskilling whereby women are disengaged from their own capacities through processes of socialization. After Becker she identifies this self-alienation as a tripartite progression which takes place (1) first, “along the dimension of time” through childhood behavioral patterns of approval that she notes, may become entrenched despite changing circumstances; (2) then, “within the dimension of the roles we play” such as mother, wife, and even what it means to be educated. She emphasizes that for women these roles are characterized by an inherent role conflict. “Not only are females confined to a small number of socially acceptable roles, but they are given conflicting messages about these roles. Motherhood, for example, is viewed as a sacred task, but mothers are not taken seriously when they act outside their kitchens and homes.”; (3) and, finally a breakdown of the

³⁸ Schwartz, "Schwartz, Lillian F. Oral History," 22. She discusses the gendered division of labor at the lab and instigating a petition to have a women's bathroom on every floor.

³⁹ Linda Phelps, "Female Sexual Alienation," in *Women: A Feminist Perspective*, ed. Jo Freeman (Palo Alto, California: Mayfield Publishing Company, 1975). Although Phelps is focused largely on the failure of the sexual revolution, her point, that female sexuality is alienated by socialization in a male dominated society where women internalize a self-image as symbol-objects is appropriate for the way that women's sexualization was integrated into their working.

sense of self which she describes as being experienced as fractured, that is, the subject becomes what Becker calls schizophrenic.⁴⁰ It is this gradual breakdown of the self that Phelps insists leads women to “relate neither to ourselves as self-directed *persons* nor to our partners as the *objects* of our desire, but to a false world of symbol and fantasy.” That is, our relations are no longer that of the person [self] and its object, but rather women experience themselves as passive symbols of male desire while men, also degraded by this alienated-relation becomes narcissistic mirrors reflecting back acculturated images of the desirable female body.⁴¹

Although she gives no date, Schwartz has recalled in oral histories how she would formally join the Women’s Movement sometime during or after the 1970s after having been stopped from projecting her own films at MoMA because she was not a member of the projectionist’s union; it was a union to which she was preemptively denied entry as a woman.⁴² It is hence unsurprising that a feminist lens has been applied to her artworks in the still limited art historical literature on her work, most notably, in Helena Shaskevich’s 2021 article *Encoded Perception: Remapping Vision in Lillian Schwartz’s Computer Art* which views Schwartz’s early films through a binary of rational versus organic that can be traced to a feminist critique of continental philosophy, that of Emmanuel Kant especially.⁴³ And yet, because it was Schwartz’s exclusion from a highly technical trade—NYC projectionists were then licensed through a test administered by the Bureau of Gas and Electricity—that had led the nurse, technologist, and later programmer with a working-class Jewish background to the Women’s Movement. Rather, I contend that her labor-orientation within the Women’s Movement makes the Marxist lens of feminists such as Phelps more appropriate to the study of her artworks; it is a leftist lens that is suggested more so by recognizing

⁴⁰ Ibid., 17-18.

⁴¹ Ibid., 19.

⁴² Projectionists were also licensed by the Bureau of Gas and Electricity because of the risk of fire from electrical shorts and high-heat light bulbs.

⁴³ Shaskevich’s understanding of vision is based in Orit Halpern’s Deleusian reading of scientific research into visual perception in her 2014 book *Beautiful Data: A History of Vision and Reason since 1945*. Patterson’s account of vision and perception studies at Bell Labs stays much closer to the intellectual milieu of her subject matter. For a related of the development of digital images in relation to perception psychology, see Charissa N. Terranova, *Art as Organism: Biology and the Evolution of the Digital Image, 1920-1970* (London, England: Tauris, 2016).

the extent to which Schwartz's artistic training and professional affiliations were likewise oriented towards the left. After all, Schwartz was a part of EAT alongside many neo-avant-garde figures; moreover, she had trained with Lenson, a well-documented socialist, and Giannini, whose studies with Léger coincide with the avant-gardist's official involvement with the French communist party. In Schwartz's own recollection, it was "Ugo Giannini who impressed upon me the artist's [Léger's] strong design elements (influenced by Cézanne, Picasso, and Braque) and identification with working-class attitudes."⁴⁴ Without question, we see the same "rejection of stylistic unity" that Green attributes to Léger's promiscuous avant-gardism across Schwartz's own oeuvre. It is reasonable to presume that she had just as readily identified her art, and her feminism, with her own working-class beginnings.

And yet, however much Schwartz's historical connection to Léger might suggest this left-feminist lens, it is perhaps more significant that by means of this lens that we can begin to see how and why her artworks seem to develop Léger's dynamic divisionism into "morphodynamism." It is a development that we can begin to trace by recalling that Léger's post-war machine-man takes up the dialectical interpenetration of the subject and object as an element of formal contrast. Yet, when Léger's machine-man is considered through the lens of Phelps' Beckerian theorization of women's alienation as the reification of the symbol as the self, a kind of pseudo-dialectic of the symbol-object, figurative works such as Léger's *Nude on a Red Background (Nu sur fond rouge)*, 1927 that take the female nude as their subject matter, represent women as symbol; meaning that no dialectical interpenetration of the subject-object is achieved.⁴⁵ It is a dialectic that is instead realized in Schwartz's development of dynamic divisionism by her subversion of the reified women as the nude. It is by inverting the female nude from a spectacle of the sexual division of labor to a figure internal change and movement, shifting the avant-garde's longstanding engagement with vision to that of interoception, that Schwartz is able to represent woman as subject and therefore to reestablish the dialectic that Léger had intended. It is a strategy that we

⁴⁴ Schwartz and Schwartz, *The Computer Artist's Handbook: Concepts, Techniques, and Applications*, 144.

⁴⁵ For Schwartz's discussion of *Nude on a Red Background*, see *ibid.*, 144-45.

see hinted at even in her ostensibly exterior representations of the female nude, notably in her own 1988 homage *Variation on Léger's Nude on a Red Background*. In a technical account of her preparations for a talk that she would give that year at the opening of an exhibition of Léger's work in West Germany, she describes the process by which she discovered that the avant-gardist "had not, in fact, neatly 'closed up' the boundary" of his nude figures. Lacking formal closure, his figures in *Three Women on a Red Background*, 1927 and *Nude on a Red Background* remain open to their own environs; it is this lack of closure that Schwartz would take up in her reworking of these two artworks—the dialectic as a kind of corporeal permeability.⁴⁶

From *Computer Nude*, 1967 to Cellular Cubism

Schwartz's arrival at Bell Laboratories is inextricable from a clear-cut example of the quotidian sexism faced by working women: the creation of *Studies in Perception I (Alpha Serendipity)* by programmer Ken Knowlton and computer vision researcher Leon Harmon in 1967 (fig. 11). Also known as *Computer Nude*, this now canonical work of early computer art had begun as an office prank on Knowlton and Harmon's boss, then executive director of communications systems research Edward E. David. "When the boss is away, the mice do play," jokes Knowlton in an interview on how the two had come to make and hang the 5-foot x 12-foot black and white print of a female nude as a mosaic of computer symbols reconstructing the tones of a photograph of dancer Deborah Hay.⁴⁷ Draped in a recumbent posture, Hays face is unrecognizable as her neck tilts back from the camera. Her full, left breast, stomach, dark pubis, left hip and thigh are however on full display. Knowlton and Harmon would hang the exceedingly large print in David's cramped office where it was visible to the naked eye only as a vast field of computer symbols. Yet, a custom-made optical lens made by a coworker miniaturized the field to a scale at which it was possible to view Hay's nude figure. Effectively transforming David's office into a peepshow, then a still common sight in nearby Times Square, Knowlton and Harmon's prank

⁴⁶ Ibid.

⁴⁷ Debora Wood, "Studies in Perception I (Alpha Serendipity)," in *Coded: Art Enters the Computer Age, 1952-1982*, ed. Sara Cody (New York, New York: Los Angeles Museum of Art and DelMonico Books, 2023).

would be deemed inappropriate by office management; it would be removed and rehung by David in a more private venue for pinups, his basement.⁴⁸ In fact, it was only after *Computer Nude* was anointed as an artwork by Robert Rauschenberg in a 1967 issue of *The New York Times* and later exhibited in the 1968 show *The Machine at the End of the Mechanical Age* at MoMA that Bell Labs would permit it to be publicly associated.⁴⁹ And yet, while, *Computer Nude* would become palatable to Bell Labs' management, as a condition of women's work, the female nude as artworks would later be identified by feminist artists and art historians as no less sexist. "Do women have to be naked to get into the Met. Museum?" reads a Guerrilla Girls screen-print from 1989.

It was while showing her own kinetic sculpture *Proxima Centauri*, 1968 also in *The Machine at the End of the Mechanical Age*, that Schwartz had first seen *Computer Nude*. Without needing to denounce this work, or the two men who made it, she would nevertheless already in her 1969 *Untitled (Homage to Computer Nude)* (fig. 12), likewise a nude of Deborah Hay, begin to refigure the female nude such that it negates its spectacularization of the sexual division of labor. Schwartz's negation begins with two principal interventions into the nude that are characteristic of its symbolic basis: (1) its finitude, that is, its quality of having limits or boundaries; and (2) its stillness, both its typically recumbent posture and relatively interchangeable figuration. Exemplary of what Schwartz had called "technological pointillism," this lack of finitude was already characteristic of *Computer Nude* when viewed without the specialized lens that might compress its grid of icons into more solid edges.⁵⁰ Sharing this infinitude and likewise monochrome, in Schwartz's *Untitled Hays* nude figure is no less exposed, yet smaller at only 20 ¾-inches by 10 ¼-inches framed Hays posture is more dynamic and repeated five times across the page. And Schwartz would continue to develop her figuration of bodies without boundaries. We see this approach

⁴⁸ See *ibid.*

⁴⁹ Repeating this story with only minor variations, scholars of art history have readily excused the indiscretion of the work's origins as it shifted into an art milieu. See *ibid.* Shaskevich is less conciliatory in her interpretation of this origin.

⁵⁰ Pointillism is generally understood to have been developed by Seurat after divisionism, although the two terms are also used interchangeably. Schwartz's intervention into technological pointillism begins from the nude's lack of finitude. As she notes in her *Handbook*, Léger's own nudes would also lack edge closure.

not only in her female nudes but in her figures more generally, for example, in her film *Olympiad*, 1971 (fig. 13) in which the body, here the male figure taken from Eadweard Muybridge's study in animal locomotion, formed through pulsing, multicolored, nested key patterns.⁵¹ This unboundedness is also characteristic of a series of etchings that she would make with Robert J. Tatem using the same process as that used to make integrated circuits for computers. For example, Schwartz's *Homage to Duchamp (Nude Ascending Staircase)*, 1975 (fig. 14) delineates its nude moving through space and time using a series of discrete, interwoven chevrons of metallic wires.⁵²

More than simply a lack of closure, in these artworks we see Schwartz's figures turn towards a *physiognomic* expression of the nude as a body laid bare, not in its flesh but rather in its function; physiognomy is the depiction of the inner workings of the body displayed outwardly.⁵³ While not immediately clear to the untrained eye, we see this outward expression of bodily function in *Olympiad* as the action of the runner's joints which are, by Schwartz's account, more physiognomically correct than had been possible through the animation technique of rotoscoping that describes natural motion by tracing over film-footage of live actors frame by frame.⁵⁴ Without explanation as to how the joint actions of Schwartz's figures are more correct, what presents itself as most likely is that her patterning of pixels, circulating and pulsing as the figure moves, are depictions of the electrical impulses that control the movement of joints through the peripheral nervous system. We see this bioelectrical function likewise suggested by her circuitry series of etchings in works such as *Homage to Duchamp*. Because this etching might carry an electrical current, it is at once a representation of spatialized motion across time, and the suspension of the literal motion of an electrical current that makes this bodily motion possible by triggering muscular contractions and sensory feedback.

⁵¹ It is notable that Muybridge's original would have been animated by having displayed through his Zoopraxiscope projector.

⁵² She would also make a *Nude Descending* but there is something to be said about Schwartz's inversion of Duchamp's nude who is no longer descending, but now ascends the staircase.

⁵³ Though often used to refer to the pseudoscientific reading of temperament, or character from facial expression. The term *physiognomic* is used on Schwarz's website to suggest this more anatomical, scientific drawing.

⁵⁴ Lillian F. Schwartz, "2d-3d Animation," <http://lillian.com/digital-animations>.

Having worked across the fields of electronics, biology, and chemistry before her arrival at Murray Hill, Schwartz would have been well prepared to integrate thermodynamics research, that is, the study of the fundamental interactions between forms of energy (e.g. kinetic, chemical, or electromagnetic) into her art making; critically, this research was then characteristic of the communications research at Bell Labs.⁵⁵ Computers, like film projectors, were defined by the underlying phenomenon that controlled their function: the electromotive force more commonly known as voltage. Indeed, rather than mathematical computation, binary describes a pulse of electricity (1), and a not pulse of electricity (0); it is this fundamental operation that Schwartz would have studied in her programming and Boolean logic courses at the New School.⁵⁶ This thermodynamic understanding of computer operations has significant implications for the understanding of early computer graphics such as *Computer Nude* which is not solely the representation of Hay's nude figure but moreover the material translation of the light that had once reflected off her body; electromagnetic radiation (light) is translated into voltage and then to a printed graphic which is again perceptible because of electromagnetic radiation. Other research, such as Max Mathews and Gershon Kingsley's speech studies, similarly translated the sound waves of human speech into voltage and then back to now disembodied sound waves through magnetic energy.⁵⁷ Although cutting edge, the study of the link between biological and technical systems was however far from a nascent area; connections between the human nervous system and electronic systems had been widespread enough to be appear in the popular imagination since at least the 19th century invention of the electric telegraph.⁵⁸

⁵⁵ We see this training given form in Figure 8, *Olympiad*. Under the section, "First and Discoveries" of her website, Schwartz notes that this film has physiognomically correct joints unlike traditional rotoscoped animations.

⁵⁶ Noted in interviews. Schwartz had of course trained in the biological sciences at the college level and had also shown an interest in chemistry first in her work at the hospital pharmacy as a nurse. Nurse anesthetics were especially needed upon the creation of the Cadet Corps. She would create a series of sculptures experimenting with plastic catalysts before her arrival at Bell Labs. Her kinetic work *Proxima Centauri*, made in association with EAT, uses pressure sensors and an electric motor.

⁵⁷ This research would be translated into resource guides distributed by Bell Labs to high-school students. See Peter B. Denes and Elliot N. Pinson, *The Speech Chain: The Physics and Biology of Spoken Language* (New York, New York: Bell Telephone Laboratories, Incorporated, 1963; repr., Fourth Printing).

⁵⁸ Becoming a major area of research by the early 20th century, bioelectric phenomena have been studied since at least Luigi Galvani's 18th century experiments whereby he electro-stimulated the leg muscles of dead frogs; bioelectricity is also the animating principal of Mary Shelley's monster in her 1818 novel *Frankenstein*.

And the translation of biological input to technological output was by the mid-20th century far from obscure in American culture; it then formed the basis of the free teaching aids published under the Bell System Aid to High School Science Program and distributed through a series of booklets including *The Speech Chain: The Physics and Biology of Spoken Language* to sciences classes throughout the country.⁵⁹ Thus when, in his 1964 book *Understanding Media*, the Canadian media theorist Marshall McLuhan proposes that “electricity [in media] may be said to have outered the central nervous system itself, including the brain,” he is to a great extent merely reiterating this long-existent field of study.⁶⁰

Of course, Schwartz’s title of morphodynamicist had not been coined by Max Matthews from nothing, and morphology, as the study of the form and structure of organisms and other organic entities, connects her physiognomic nudes just as significantly to the research then ongoing at Bell Labs. Two principal areas of morphological study at the Lab are most relevant to Schwartz’s work there: (1) cell morphology, or the size, shape and structure of the cells that make up biological organisms including human beings; and (2) crystal growth morphology, or the transformations of shape and scale that crystalline structures undergo as they grow. These areas of study were imperative to both the physical and digital operations of the Labs’ computer systems. Silicon computer chips for example, are comprised of lab-grown silicon crystals that have been stimulated into perfectly ordered growth patterns. An electroconductive material, silicon was not the only crystal to be grown and studied in pursuit of ever more sophisticated computer systems. For example, the 1974 Bell Lab’s microphotographic film *Crystal Growth Morphologies* records the formation of temperature sensitive crystals.⁶¹ This research coincided with studies of biological cell growth that would be simulated on the computer through cellular automaton such as Knowlton’s EXPLOR (Explicit Patterns, Local Operations and Randomness). Cellular

⁵⁹ We see these ideas reappear in popular culture, for example, in Disney’s 1969 feature film *The Computer Wore Tennis Shoes*.

⁶⁰ Marshall McLuhan, *Understanding Media: The Extensions of Man* (Cambridge, Massachusetts: The MIT Press, 1994), 247. There are artists who have accused McLuhan of pilfering from Moholy-Nagy. Although I’m unwilling to go this far without further archival research, there is some suggestion of Moholy-Nagy’s influence, unfortunately uncited.

⁶¹ This research footage was shot under the direction of Charles Miller at Schwartz’s behest. It would be edited together by Bell Labs in 1974.

automata are probabilistic machines that are used, for example, to model the biological phenomena of carcinoma and tumor proliferation as well as the effects of radiation on cell death. Most famously realized in John Conway's 1970 "no-player game" *The Game of Life*, automata may also be used to model the formation and decay of societies and, in physics, to simulate fluid flows including blood as it travels from the heart to the arteries.⁶²

Visible throughout Schwartz's other works, it is in *Pixillation* that these thermodynamic and morphological visions of human biology are montaged together into the formal whole of her hybrid-computer film. At only 18 seconds in we see the first EXPLOR-generated patterns emerge from a sanguine cascade of hand-painted red and blue inky swells; the cellular forms appear as a flash of interlocking squares, a labyrinth of alternating light and dark that proliferates across the screen (fig. 18). Intercut with viscous swells, these cell growths flash on the screen and grow (fig. 15). In the background, the melodic flourish and mechanical thump of the soundtrack heightens the bodily connection of these images, its downbeat recalling the whomping, whooshing sound of a heartbeat as it throbs through the tissue of the eardrums. This is the refrain of the circulatory system, a sound known to medical science as pulsatile tinnitus, a symptom of stress as well as more malignant ailments such as an overactive thyroid or tumors of the head and neck. As an eruption of sound, it is this rhythm that had anticipated the sanguine rushes at the beginning of the film, its pulsing downbeat beginning in the cut to black that marks the end of the opening credits. A hard cut punctures this darkness, bringing forth a swirling pool of indigo and translucent pink on which droplets of crimson begin to fall in succession, blooming and coalescing to fill the frame, marching to the downbeat of the electronic soundtrack. Yet not all of the images are viscous and corporeal, we begin to see microphotographic footage of a crystal begin growing from the left to right of the screen (fig. 15). Commissioned by Schwartz under the research direction of Charles Miller this footage—later used in *Crystal Growth Morphologies*—is Phenol Salicylate, more commonly known as

⁶² For a revived *The Game of Life*, see John Conway, "Conway's Game of Life," <https://playgameoflife.com/>.

Salol, an internal antiseptic and mild analgesic sometimes used in pharmacological compounds for the treatment of inflammation, pain, and infection.⁶³

A Dynamism of the Domestic Front

It is the glimpse of pain and disease suggested by the Salol crystals growing across the arc of Schwartz's montage is a reminder that *Pixillation's* swells of crimson and cells are connected to the horrors that the artist had witnessed in post-war Japan; these allusions are reflected in the anxiety triggered by the accelerations within the film, a kind of panic that is translated to the viewer.⁶⁴ It is as if in her film the human form has been turned inside out by the sheer force and terror of the bomb, as if Schwartz has montaged together the fragmented cubist figure once described by Léger in one of his letters yet without nullifying its rupture; "There is nothing more cubist than a war like this one [World War I]," Leger had once written, "which can more or less cleanly section a man into several pieces and blast him into the four cardinal corners."⁶⁵ And yet, the growth and rhythmic flow of Schwartz's film belie this spectacle of death; bodies blown apart have no pain, nor do their hearts beat, their cells grow, their blood flow. It is a vitality reinforced by her titles' implicit connection to pixilation, the stop-motion technique in which live actors are animated frame-by-frame. What we see in *Pixillation* is thus a live body pulled apart, decomposed by war, and yet still living and changing. And there is another precedent to this figure in Leger's work, the already discussed *La partie de cartes*, 1917. Completed during the artist's convalescence after surviving a mustard gas attack by German troops on the Aisne front in Verdun, France, this painting depicts common poilu engaged in a game of cards, a quotidian scene within the trenches that are suggested by the uneven geometry of the background. Drawing the eye to the height of what might otherwise have been a table, a mustard-yellow cacophony of irregularly edged, interlocking volumes settles around their torsos; and, still dressed in their tinman uniforms they seem to be shed of

⁶³ Walter Forsberg, "Lillian Schwartz Sees in Four Dimensions," *INCITE Journal of Experimental Media*, no. 3 (2011).

⁶⁴ Although I presently lack certainty, there is a striking visual similarity in side by side comparison of some of Schwartz's EXPLOR automata and poliovirus cells. See Figure 17.

⁶⁵ Fernand Léger, "Fernand Léger À Louis Poughon," in *Les Cahiers Du Musée D'art Moderne* (1990).

flesh from their mouths to their bellies, a spinal column of vibrant red triangles suggesting their insides turned-outward.

Far from isolated to warzones and other traditionally male professions, the chemical agents to which soldiers such as Léger were exposed were perhaps even more present in women's work; it is a fact that is exceedingly relevant to how we read the figure in *Pixillation*. Indeed, although chemical, biological, and radiological agents would be banned in international treaties after major conflicts such as WWI, women workers were often more likely to risk exposure to these invisible and slower acting toxins rather than sudden and violent injury. This exposure was especially true in professions such as nursing whereby nurses such as Schwartz come into more persistent and direct contact with patients and their bodily fluids, often more so than physicians; this was especially dangerous in hospitals which in the midcentury period were commonly understaffed, subjecting nurses overloaded with responsibilities on overlong shifts that were highly rationalized. Yet, chemical, and radiological exposures were even typical of the white-collar office work and "clean" manufacturing trades that were more likely to characterize women's employment; women who were often employed in these roles for their presumed greater patience and finer handiwork than male employees.⁶⁶ This circumstance is noted by Robin Baker and Sharon Woodrow in their article "The Clean, Light Image of the Electronics Industry: Miracle or Mirage." They document that by 1984 stereotypes including those of women's patience and dexterity meant that "more than 75 percent of the production workers" in their study of the production of electronic components were women. And while work including the production of silicon computer chips had been represented as clean to the popular imaginary, when viewed rather from an operational standpoint the work was highly toxic. As they write: "Contrary to the popular image of wires and vacuum tubes, the real tools of the electronics trade are the wide variety of chemicals. Organic solvents, such as xylene, chloroform, trichloroethylene (TCE), freons, methyl ethyl ketone (MEK), and numerous others...known

⁶⁶ Robin Baker and Sharon Woodrow, "The Clean, Light Image of the Electronics Industry: Miracle or Mirage?," in *Double Exposure: Women's Health Hazards on the Job and at Home*, ed. M.D. Wendy Chavkin (New York, New York: Monthly Review Press, 1984), 22.

to cause a range of health problems, including dermatitis; central nervous system effects such as nausea, dizziness, and headaches; liver and kidney damage and even cancer.”⁶⁷

Published in the 1984 anthology *Double Exposure: Women's Health Hazards on the Job and at Home*, Baker and Woodrow's article contributes to a small but significant body of literature written in left feminism at the intersection of the Labor and the Occupational Safety Movements. Signed into law by then President Richard Nixon, on December 29, 1970, the Occupational Safety and Health Administration (OSHA) under the US Department of Labor was meant to increase worker safety by setting guidelines for exposure limits and procedures as well as mandating personal protective equipment (PPE) where needed. However, widely recognized to have exceedingly limited powers, OSHA was seen to be especially ineffective in regards to the safety of women workers. Not only were exposure standards set to men's greater body mass, but women's health problems were often ignored or misattributed. For example, when in the early 1970s a number of women workers at assembly plants in California began to complain of symptoms including “headaches, dizziness, and nausea,” their complaints were initially written off by OSHA investigators as “mass psychogenic illness,” a diagnosis that Baker and Woodrow note was merely the updating of female hysteria. Moreover, where problems such as excessive toxins were discovered, corrective procedures differed along the sexed division of labor. Where jobs were performed by men, plants would be shut down until the problem could be mitigated with ensuing changes in PPE. Women were instead often banned, whether explicitly or in practice once toxins were documented; although, the reason for this exclusion was often displaced onto their “unborn children.”⁶⁸ The problem for industry was thus not that women might get cancer, but rather that they might face stillbirths, miscarriages, and birth defects. As Baker and Woodrow document, this circumstance had not infrequently led to the coercive sterilization of blue-collar women who were forced to choose between the possibility of

⁶⁷ Ibid., 23-24.

⁶⁸ For an historical account of how biological myths were used against women see, Ruth Hubbard, Mary Sue Henifen, and Barbara Fried, eds., *Biological Woman - the Convenient Myth: A Collection of Essays and a Comprehensive Bibliography* (Cambridge, Massachusetts: Schenkman Publishing Company, Inc., 1982).

reproduction and survival. Other women were demoted in pay and status, shifted away from manufacturing into janitorial.⁶⁹

It is a simple irony of historically women's work that this relegation to janitorial work did nothing to limit these women's exposure, and moreover often exposed them to other innumerable other dangerous chemicals used as cleaning agents. It is a reality that was also characteristic of the women who were unemployed, relegated to the domestic work of a wife and mother and that led the authors of *Double Exposure* to their title describing women's work as a condition of dangerous exposure twice-over, at once professional and domestic. As Harriet G. Rosenberg writes in the anthology: "The walls of a house do not act as a magical detoxifying barrier." Rather, in many cases women were exposed to dangerous toxins in their domestic life that were otherwise highly controlled or altogether banned in industry and warfare. This exposure included household cleaning agents such as bleach and ammonia, that can and certainly still are sometimes unknowingly mixed to produce the nerve agent chlorine gas.⁷⁰ Other chemicals then commonly found in household goods were in industrial settings considered to be hazardous at every point of use, production, and disposal. For example, by 1984 limits on exposure to Vinyl Chloride (VC) had been set in industry, yet, as Rosenberg notes these chemicals were still common in the form of Polyvinyl Chloride (PVC) which was—and still is—a common household material. Although generally considered safe as PVC, it was known that products made from this material could and would under certain conditions leech toxins such as phalates and dioxins now known as "forever chemicals." Other chemicals used in insecticides and pesticides were then banned from industrial production in the United States, yet when produced overseas, these products were still legally sold for use in the home and garden provided that they were already sealed into ant and roach traps. And other exposures, for example, to nuclear fallout were entering the home environment. "Fallout," Margo Bennett writes in her 1964 *The Intelligent*

⁶⁹ Baker and Woodrow, "The Clean, Light Image of the Electronics Industry: Miracle or Mirage?." As they also note, this the idea that only female reproduction was affected by chemical exposure was a myth. In fact, sperm are often more sensitive to harm.

⁷⁰ The humorist David Sedaris has written of his own experience nearly killing himself with cleaning supplies.

Woman's Guide to Atomic Radiation, “has caused a certain pollution, a very thin scattering of contamination, in some of the food we eat. This is one of the reasons why the book is addressed more to women than to men. Men and women are equal in most respects, but the mother is far more intimately concerned with the health of the family than the father.”⁷¹ As industrial catastrophes such as Love Canal had made clear, the home was moreover subject to the chemicals leeching from factories and illegal dumping; and these same toxins were carried home by male workers whose exposure was more permissible than their female counterparts.⁷²

We can thus read the health effects from these domestic exposures as a kind of mangling more akin to Marx’s account of factory workers—and Léger’s description of bodies being blown apart—than might be initially presumed. Yet, rather than the isolated event of an individual worker whose arm is ripped off by a machine, or a soldier whose body is torn apart by a bullet or bomb, chemical and radiological exposures often lead to traumas that are at once microscopic and internal to the body and at the macroscopic scale of population. It is a duality that we see given form in *Pixillation* most clearly in three elements of the film: the cellular automata, the electronic soundtrack, and a blocky human face that, although hitherto unremarked in scholarship, flashes on the screen 5 times throughout the film (fig. 20). By means of these elements Schwartz’s film suggests both a growing fetus in the womb and a wartime catastrophe. For example, the same cellular automata that model the growth of a living organism also simulates the social transmission of diseases such as polio, pickets of cancer, and the leech pattern of radiation and chemicals. Whilst the film’s soundtrack, in which we hear the oscillating Doppler effect of a GROOVE (Generated Real-Time Output Operations on Voltage-controlled Equipment) digital-analog hybrid synthesizer and Moog analogue synthesizer recalls the circulatory system because its technology is similar to that used to simulate a fetal heartbeat during sonogram; it is a sound that is also characteristic of

⁷¹ Margot Bennett, *The Intelligent Woman's Guide to Atomic Radiation* (Baltimore, Maryland: Penguin Books Ltd., 1964), 11. For an account of widespread fallout in the United States see, National Cancer Institute, Get the Facts About Exposure to I-131 Radiation, (Online: U.S. Department of Health and Human Services, February 28, 2023), <https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/i-131>.

⁷² This permissibility is made exceedingly clear by Baker and Woodrow’s study.

this era of radar technology. The blocky, flattened visage that flashes across the screen beginning at 00:47 intercut with the viscous swells of blue and red oil and plastic paints, and the more geometric cells of the EXPLOR patterns, takes on the character of a fetus growing in the womb (fig. 19).⁷³ Yet, also juxtaposed with the jagged growth of Salol, which is stimulated by increases in temperature, and together with the accelerating pace of the montage, this becomes the shadow of the horrors that Schwartz encountered on her visits to Hiroshima and Nagasaki.

And just as Léger's *La partie de cartes* exceeds the vantage of witness to image his own perspective as survivor, *Pixillation* represents the horrors wrought by Little Boy and Fat Man as an embodied experience; it is an autobiographical vantage that is made unsurprising by recognizing that Schwartz had been exposed to nuclear fallout during her time in postwar Japan. Just as the surviving Japanese citizens in the surrounding areas would be slowly poisoned by radiation, Schwartz and her husband and children would suffer the aftereffects of the bombing. Less acute than polio, the extent of the radiation poisoning would only begin to become clear in the ensuing years; her children, notably her youngest who was born in Japan would suffer the worst consequences including debilitating chronic pain. Her eldest son, Laurens with whom she would partner on her book and website would be wheelchair bound. Schwartz had been diagnosed with thyroid cancer years before her arrival at Bell Labs. It is a diagnosis that she attributes to sculptural work with plasticizers and solvents; however, a common effect of radiation poisoning, it is likely that her plastics work was neither the sole, nor even the most significant catalyst. At once, she would begin to lose vision in her left eye, a kind of macular degeneration known as chorioretinitis that can more clearly be attributed to exposure to high levels of radiation. Describing her radiated vision as "seeing like Picasso," Schwartz would lose the capacity to perceive three-dimensional form. As she has described it in an email correspondence with Walter Forsberg noted in his "Lillian Schwartz Sees in Four Dimensions": "I [Schwartz] had the first symptoms in 1954/black spots in my right

⁷³ Although not visible in the still, in the context of the film this face is intercut with viscous images that leave after-impressions.

eye/I was diagnosed within a few weeks when dots became larger...at critical point I had no vision in right eye/slowly vision returned but with a scar down the macula like that of a split in the ground, post-earthquake/macula shifted, one side higher than other/irregular gash through it/some small areas around major scarring also scarred/has not changed."⁷⁴ It is a condition that we see given form in the film which can in fact be viewed doubly, in either 2D or 3D through the use of anaglyphic glasses.⁷⁵

The Female Nude, Exposed Doubly

Schwartz's description of her own vision suggests the naturalization of these catastrophes of modernity to human sight; and it is this vision that adds yet another dimension to her figuration of the female nude, that body stripped bare as a physiognomic form, is now seen through the double vision that has resulted from its exposure. Beginning from this formal quality, it is my contention that just as Léger in his dynamic divisionism had once extended divisionism's use of color to include a clash of [line and form], Schwartz's morphodynamism extends its hail to the viewer's own perception to become yet another layer of contrast; it is a contrast most immediately evident in the 2D viewing of *Pixillation* which can be headache inducing for those with undamaged binocular vision. This discomfort appears to result from two formal qualities: the total visual field within the film's framing, and the contrast between its red and blue coloration. Whilst impressionism had used contrasting colors to create intensity and divisionism had relied on the viewer's perception to mix primary colors placed side by side—the same principal that underlies the Bayer array used in digital sensors—Schwartz's juxtaposition of red and blue creates an antagonism that seems to pull the eyes apart; it is as if she has produced diplopia, that is, double vision. This effect is heightened by the fact that the film rarely has a single point of focus, each eye often seeming to focus on a different area; the forms on the screen are ever growing and changing and what we

⁷⁴ Forsberg, "Lillian Schwartz Sees in Four Dimensions."

⁷⁵ Curator of Audio-Visual Media for Smithsonian Libraries and Archives, Forsberg gives what I believe is the best account to date of Schwartz's work, especially on the subject of how she related to technology through vision. In direct conversation with the artist, Forsberg explains that Schwartz was able to improve her dimensional vision through her use of saturated color and the looping of computer images. He argues that as an effect of Schwartz's visual impairment she was able to anticipate the ChromaDepth technologies of the 1990s. For Schwartz's own account of how color affected her vision see Schwartz, "Schwartz, Lillian F. Oral History," 5.

see is often extended by perceptual aftereffects, illusions that appear after viewing a moving stimulus. Using public screenings as tests, the artist was aware of the physical discomfort that her films (plural) caused. Recalling a screening of the film *U.F.O.'s*, 1971 which uses many of the same techniques as *Pixillation*, she describes her method of adding in black frames to imperceptibly give the eyes a moment of respite; however, it is only enough to extend our capacity to tolerate the film's physical discomfort.⁷⁶ It is only through the intervention of anaglyphic glasses that we are able to restore a sense of normal binocular vision.

Without a description of how Schwartz herself experiences this film, it is unclear the extent to which it differs in her own vision; yet, what is clear from the artist's accounts of viewers with impaired vision is that the film itself could function as a technology of remediation. Schwartz has repeatedly told a story of a woman with strabismus, what is more colloquially known as crossed eyes, who would regularly attend screenings of *Pixillation*, most likely shown in 2D at the Museum of Modern Art, before her dates; it is with delight that the artist recalls the woman's story of having her eyes temporarily uncrossed by the film, altering her vision and appearance for the evening. Although this corrective is unavailable to those without strabismus, there are techniques of viewing that can offer some sense of how this experience differs. For example, the closure of one eye immediately removes the conflict of focus that challenges our brain's ability to produce a single image; this simple act creates a more comfortable viewing. Perhaps more akin to experience of strabismus, by pointedly blurring one's eyes either by crossing them or relaxing ocular muscles, also removes the focal conflict that makes the viewing of this film painful. The other obvious technique to remove discomfort is close both eyes or, look away altogether, leaving one in darkness only with the electronic soundtrack.⁷⁷

Schwartz had developed the film's visual experience by integrating the neuroscientific studies of Bell laboratories researcher, the psychologist Bela Julesz, whose groundbreaking *Foundations of Cyclopean*

⁷⁶ Schwartz and Schwartz, *The Computer Artist's Handbook: Concepts, Techniques, and Applications*, 114.

⁷⁷ Students in my classes often find this work more difficult to watch than Tony Conrad's 1966 stroboscopic film *The Flicker*.

Perception would be published in 1971, a year after *Pixillation*. Describing the process whereby the two images seen in binocular vision, i.e., having two eyes, are merged through neurological processes to produce a singular image with perceptible depth, Julesz's research would be instrumental in the development of computer graphics; he uses the term "cyclopean eye" to refer to these internal areas of visual processing. As Julesz notes in his Preface to a 2006 facsimile edition, his "aim was to trace the visual information flow in the human brain without a knife, a sort of 'psychoanatomical' study. To this end I developed novel tools: the random-dot stereograms and random-dot cinematograms."⁷⁸ It is notable that Julesz's "psychoanatomical" study is essentially similar to Schwartz's physiognomic images, that is, it is a translation of the inner workings of the body into graphic form. *Pixillation* is a cinematogram, a moving picture that presents slightly different images to each eye; here, the randomness that Julesz had achieved by computer algorithms is manufactured by the unpredictable flow that Schwartz achieves through the liquidity of her paints.⁷⁹ Julesz was of course only able to reproduce his stereograms in book form although his discussion of how cyclopean perception, that is dimensional perception, can be stimulated through proximal motion suggests the likely significance of the cinematogram to Schwartz's filmmaking. As Julesz notes, although still images require both eyes to see three-dimensional form, it is possible with the addition of movement to see in 3D with monocular vision, i.e., having only one eye.⁸⁰

Julesz's note is critical to understanding how Schwartz's use of motion in *Pixillation* as a change of state and scale is most likely an attempt to translate her own impaired vision into a technique of 3D vision; it is a technique that she would continue to pursue in her computer film-works until her last works made at Bell Labs in 2002. And we see an accompanying fascination with 3D perspective also in her still artworks and research, for example, in her own 1988 article "The Staging of Leonardo's *Last Supper*: A Computer-Based Exploration of its Perspective" presented to the International Symposium of Electronic Art (ISEA).

⁷⁸ Bela Julesz, Thomas V. Pappathomas, and Flip Phillips, *Foundations of Cyclopean Perception* (Cambridge, Massachusetts: The MIT Press, 2006), Preface. His research is also discussed in Orit Halpern's *Beautiful Data*.

⁷⁹ You can see this flow in the film, but she has also described the mess that she made in the labs, not to be repeated.

⁸⁰ Julesz, Pappathomas, and Phillips, *Foundations of Cyclopean Perception*, 74-75. Here he discusses how Emmert's law can be exploited for cyclopean perception through proximal motion. A footnote where he discusses monocular vision more particularly evades me for the moment.

Using computer analysis Schwartz argues that “Leonardo’s [Davinci] use of an accelerated perspective in his construction [of the mural]...locate[s] the vantage points at the door and in the viewing plane of the monks, who sat along the side walls of the Refectory.”⁸¹ Locating Leonardo’s perspective in the posture and vantage of a specific viewer, in Schwartz’s analysis the *Last Supper* is understood to be a skillful rendering not only of the tableau itself but furthermore of its audience’s particular vision. It is a relationship between perspective and subjective vision that we see in her own earlier experiments with 3D rendering. For example, Schwartz’s 1983 rendering *MOMA Gallery I*, a test for a poster celebrating the Museum of Modern Art’s new building renders the gallery halls and their artworks to a scaled model of herself. Describing her procedure for building the 3D rendering of the galleries in 2D software she explains how she and Dick Voss at the IBM Center in Yorktown reprogrammed the software to incorporate “principles of true perspective,” only for Schwartz to override them. “[T]he eye you develop may well reject a strict application of perspective,” she forewarns in a precedent instruction.⁸²

Schwartz’s efforts to develop her visual impairment into a technique of 3d vision, necessarily affects the way that we read *Pixillation*’s rendering of the female figure. Although, to understand this effect it is helpful to first make a more careful distinction between impairment as a condition of the body’s own relation to its function and disability as, in essence, a kind of alienation; it is a distinction that has been made by some more leftist scholars writing in disability studies.⁸³ And this distinction is critical to Schwartz’s work; although there is no avoiding the fact that her visual impairment was an invidious effect of fallout, she however treats her new vision not as an impoverishment but rather as a formal problem, that of the construction of cyclopean perception. In so doing the artist translates three-dimensional form

⁸¹ Lillian F. Schwartz, "Lillian Schwartz – the Staging of Leonardo’s Last Supper," *International Symposium on Electronic Art* (1988). For the published version and related material see, "The Staging of Leonardo’s *Last Supper*: A Computer-Based Exploration of Its Perspective," *Leonardo: Journal of the International Society for the Arts, Sciences and Technology*, no. Published in conjunction with the First International Symposium on Electronic Art (1988); "Computer-Aided Illusions: Ambiguity, Perspective and Motion," *The Visual Computer* 14 (1998).

⁸² Schwartz and Schwartz, *The Computer Artist's Handbook: Concepts, Techniques, and Applications*, 97-98.

⁸³ See Colin Cameron, "Not Our Problem: Impairment as Difference, Disability as Role," *The Journal of Inclusive Practice in further and higher education*, no. 3.2 (2015); Nielson, *A Disability History of the United States*; Fleischer, *The Disability Rights Movement: From Charity to Confrontation*; Charlton, *Nothing About Us without Us: Disability Oppression and Empowerment*.

into an interrelation between the interior, neurological function of the viewer's brain and the outside world. Here, the eyes are treated as specialized, mediating lenses, much like the optical lens that had been constructed for Knowlton and Harmon's peep show. Schwartz translates the binocular procedure of cyclopean perception into its monocular form, using aftereffects to overlay two slightly different images across the film's time sequence; she constructs 3D experience rather than the illusion of binocularity. It is a gesture with evident similarities to her training in Chinese brush painting, not only because she often achieves this dimensional experience through her own definitive gestures on the film cells, but moreover because these gestures function as a kind of autobiographical register of her impairment. Notably, Schwartz's use of the time sequence to construct dimensionality is also characteristic of Ken Jacobs' 1975 to the 2000s series of *Nervous System Performances* using magic lantern; Jacobs overlays the time sequence of films more directly using two identical film prints and two projectors.⁸⁴ For example his 2013 *The Guests* applies this technique to the Lumiere brother's *A Wedding Party Enters the Church* (*Entrée d'une noce a l'église*); the film is spatialized without the use of 3D glasses.

It is therefore without needing to correct her visual impairment that Schwartz is able to negate her estrangement from the 3D world by constructing the formal language of her film through this monocular form of cyclopean perception. *Pixillation* insists that the abstract forms of avant-gardism are in fact the form of a natural, human vision wrought under the damaging conditions of industrial modernity, and especially characteristic of women's work. And just as Schwartz's inverts the exposure of the female nude by figuring the body not as a passive spectacle of recumbent flesh, but rather as a morphodynamic figure constructed through the forms of an active corporeality pumping blood whilst undergoing cellular growth and change, she inverts the alienating conditions of a world that has otherwise been constructed for binocular vision. As a total visual field, the film is a milieu in which the formal conditions have been naturalized to an impaired vision. And although here this naturalization produces an alienating experience

⁸⁴ Jacobs cites the Swiss painter Alfons Schilling as inventing the shutter technique that he uses. There is reason to suspect that the use of time sequencing to create a new dimensional optics might be a fruitful area for further study.

for those with undamaged binocular vision, causing pain, dizziness, and by some descriptions even vomiting. It is, however, critical to remember that this estrangement is an impermanent condition; the binocular viewer can be reconciled to the film through their active participation; this viewer can either by relaxing both eyes, closing one eye, or through the use of anaglyphic glasses as a kind of binocular corrective, disalienate their own experience.

Conclusion

At the end of two World Wars, two artists, male and female, sought to reconcile their vision of a world irrevocably altered by new chemical and mechanical agents with their humanity by means of their artistic media. In the work of Léger and Schwartz, we see the rejection of a staging of a contradiction between technological and organic ways of seeing: a dialectical vision that shows instead how these two aspects of 20th-century human life interpenetrate. Utopian, it is nevertheless a vision that is inextricable from the harm that they both suffered.

In the ensuing years, Schwartz's would continue to advance her morphodynamic vision, for example, in 2013 producing the 3:34 minute computer-animation *Exquisite Motions*. Like *Pixillation* before it this film seems to suggest the interior of a body, here the twisting forms of the gut; and it moreover seems designed for monocular vision. The film appears to be 3D without any further intervention, a dimensionality that seems to be constructed through its patterning of colors which grow and change like a charcoal snake. However, most strikingly the dimensionality of the film is heightened by closing one eye. And this difference, between *Pixillation* and *Exquisite Motions* by lacking any of the subsequent estrangement of the earlier film tells us something about Schwartz's earlier work that while tacit was yet to be fully resolved. That is, through the singularity of her vision she creates an experience that reaches a kind of equilibrium that negates the alienations that have been naturalized to the American scene as differences of gender, impairment, etcetera.

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Figure 1. Lillian F. Schwartz, music by Gershon Kingsley, *Pixillation* (Still), 1970, Digitized montage of optically printed film of hand-painted, computer-generated, and microphotographic film cells, 00:04:00, Dearborn, Michigan, Lillian F. Schwartz & Laurens R. Schwartz Collection: The Henry Ford.

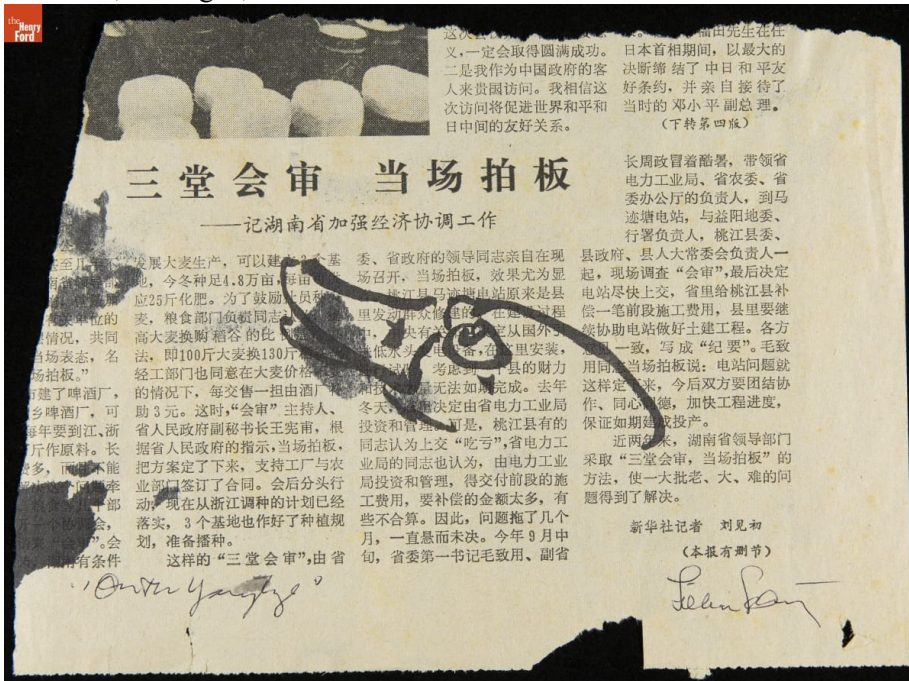


Figure 2. Lillian F. Schwartz, *On the Yangtze*, 1949, India ink on fragment of Japanese newspaper, 6 1/4" x 8 1/2", object ID: 2021.14.355, Dearborn, Michigan, Lillian F. Schwartz & Laurens R. Schwartz Collection: The Henry Ford.



Figure 3. Lillian F. Schwartz, Birthday Card, 1988, Fig. 29 in her *Computer Artist's Handbook*, page 56.



Figure 4. Tsukioka Yoshitoshi's *The Courtesan Usugumo Holding a Cat* from the series *A Mirror of Beauties of the past and present* (*Kokon Hime Kagami*), 1876, 15 1/2" x 10 1/2", color woodcut, accession number: 1989-47-2, Philadelphia, Pennsylvania, Philadelphia Museum of Art.



Figure 5. Lillian F. Schwartz, *After Polio*, 1950, oil paint on board, 24'' x 36'', object ID: 2021.14.139, Dearborn, Michigan, Lillian F. Schwartz & Laurens R. Schwartz Collection: The Henry Ford.



Figure 6. Lillian F. Schwartz, *6 Dwarfs*, 1949, oil on board, 24'' x 10'', from the artist's website, <http://lillian.com/1940paintings>.

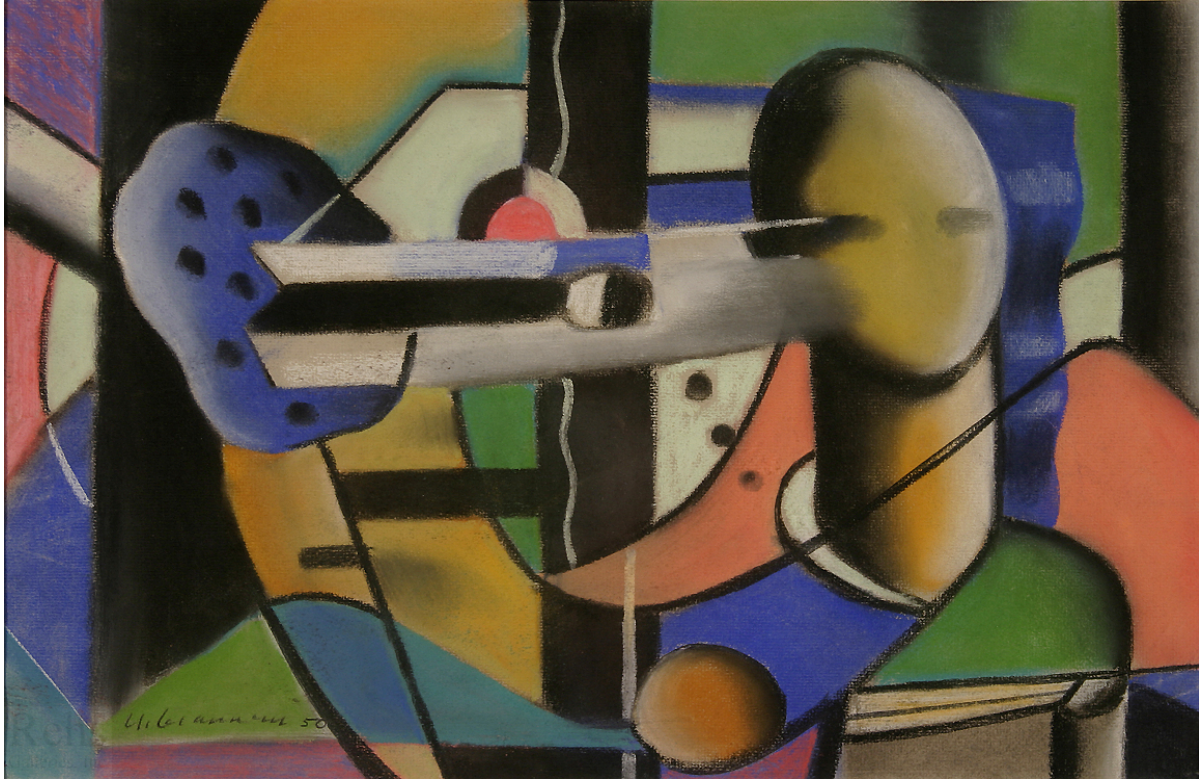


Figure 6. Ugo Giannini, *Composition with Bust* from his *Contrasting Forms*, 1950, 12 1/5" x 20", pastel on paper, Rehs Contemporary Galleries, Inc.

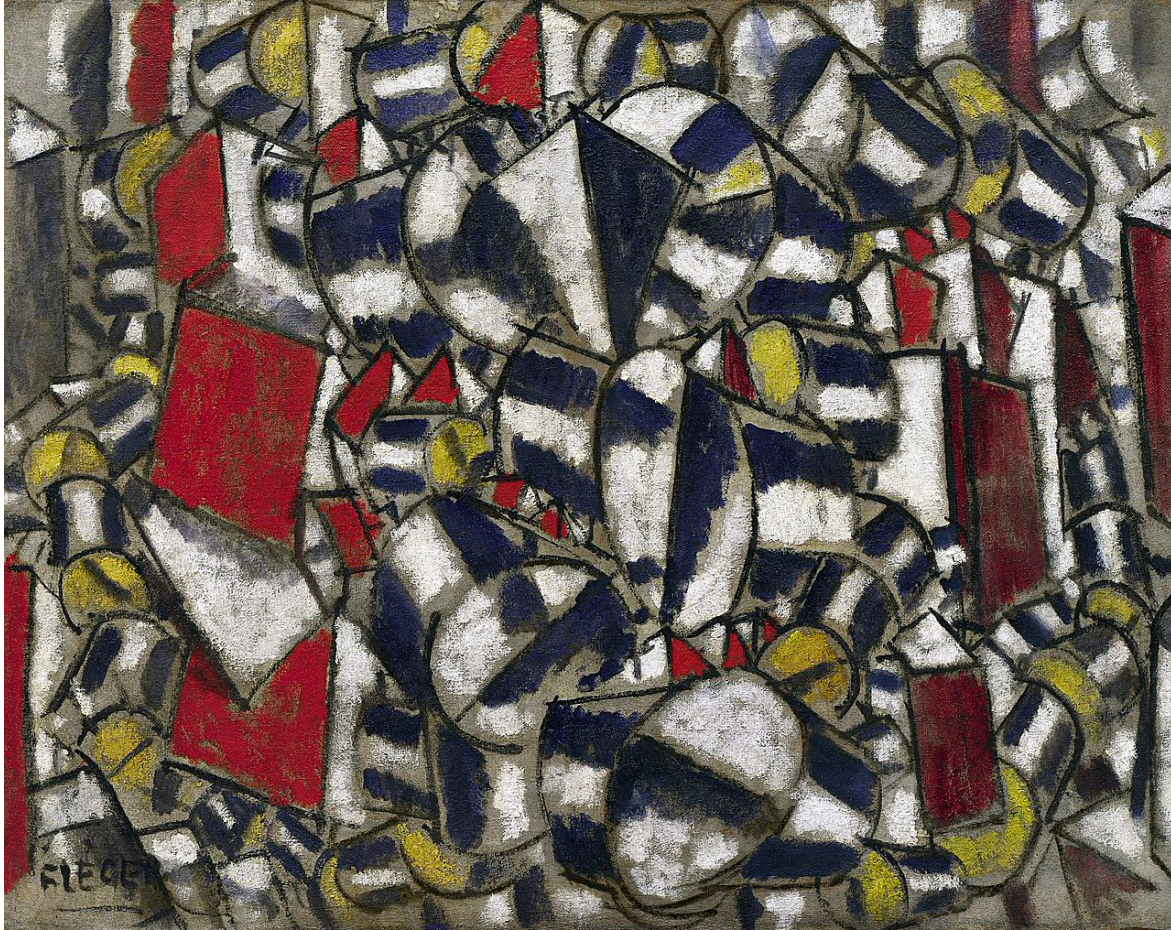


Figure 7. Fernand Léger, *Contraste de forms*, 1913, oil on burlap, 38 7/8" x 49 1/4", accession: 38.345, New York, Solomon R. Guggenheim Founding Collection: Solomon R. Guggenheim Museum.



Figure 8. Lillian F. Schwartz, *Homage to Léger (Still Life with Ugo Giannini)*, 1953,



Figure 9. Georges Seurat, *Parade de cirque (Circus Sideshow)*, 1888, oil on canvas, 39 ¼" x 59", accession number: 61.101.17, New York, New York, The Met Museum.



Figure 10. Fernand Léger, *La partie de cartes (The Card Players)*, 1917, oil on canvas, 129,5 cm x 194,5 cm, KM: 101.351, AW Otterlo, Nederlands, Kröller-Müller Museum.

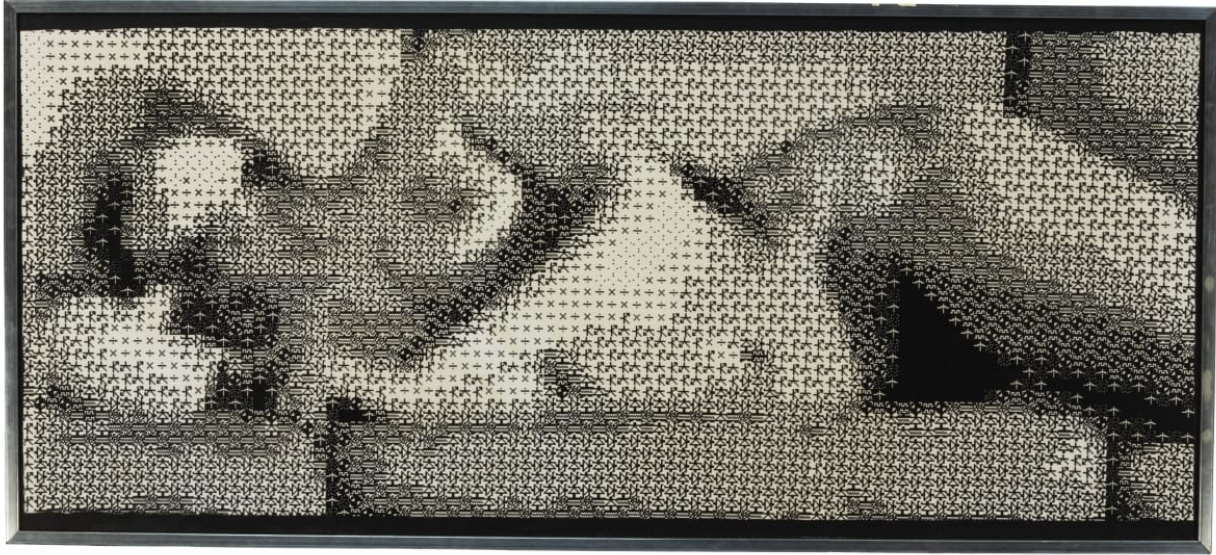


Figure 11. Ken Knowlton and Leon Harmon, *Studies in Perception I (Alpha Serendipity), (Computer Nude)*, 1967, screen print, 71 1/2" x 32 1/4", object ID: 2021.14.188, Dearborn, Michigan, Lillian F. Schwartz & Laurens R. Schwartz Collection: The Henry Ford.

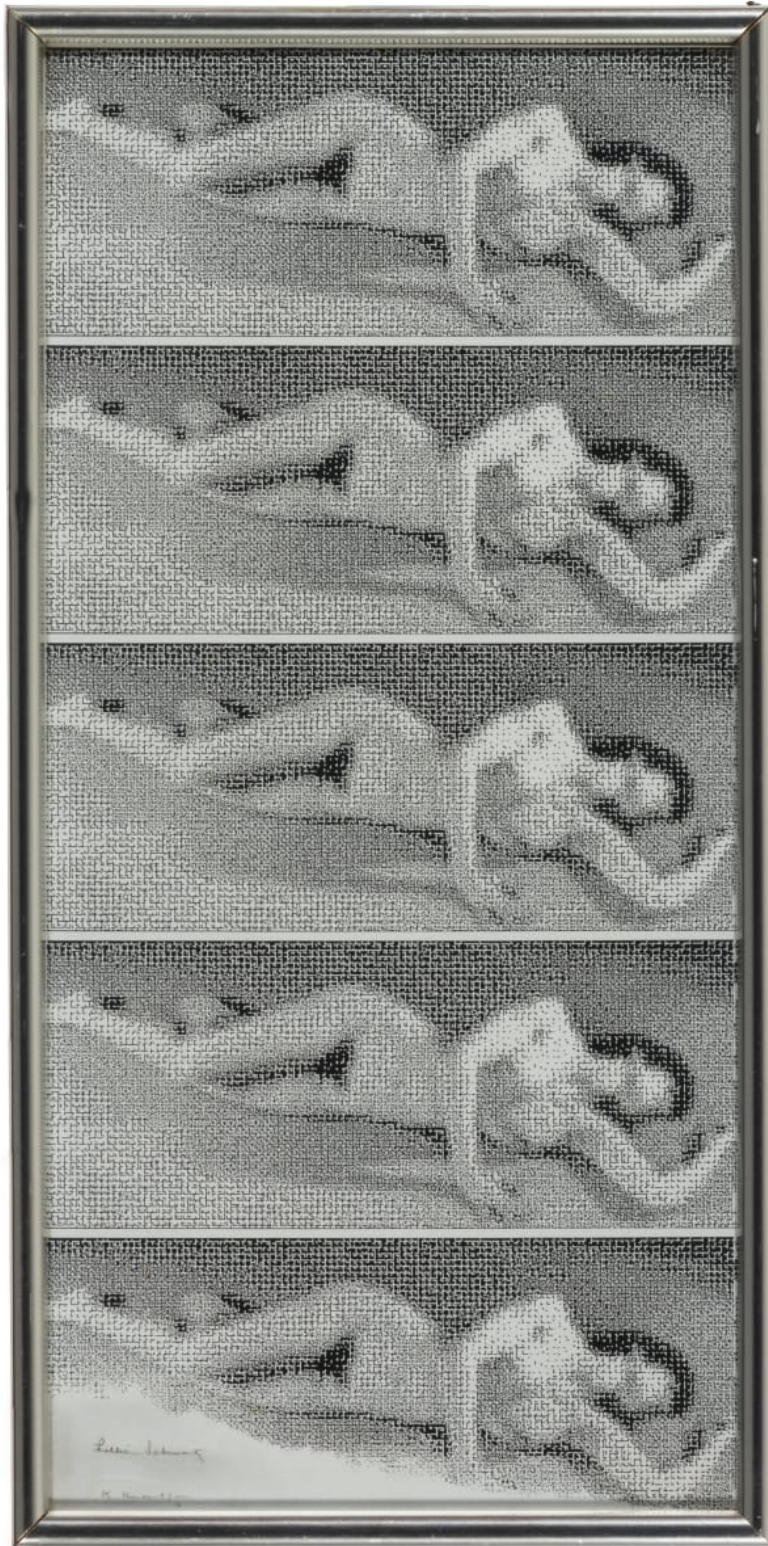


Figure 12. Lillian F. Schwartz with Kenneth Knowlton, *Untitled Homage to Computer Nude*, 1969, silver-gelatin print, 20 3/4" x 10 1/4", object id: 2021.14.117, Dearborn, Michigan, Lillian F. Schwartz & Laurens R. Schwartz Collection: The Henry Ford.



Figure 13. Lillian F. Schwartz, music by Max Mathews, *Olympiad* (Still), 1971, digitized 16 mm computer film animation (not restored), 00:03:20, object ID: 2021.14.209, Dearborn, Michigan, Lillian F. Schwartz & Laurens R. Schwartz Collection: The Henry Ford.



Figure 14. Lillian F. Schwartz with Robert J. Tatem, *Homage to Duchamp (Nude Ascending Staircase)*, 1975, etching (circuit), 20" x 18 ¼", object ID: 2021.14.400, Dearborn, Michigan, Lillian F. Schwartz & Laurens R. Schwartz Collection: The Henry Ford.

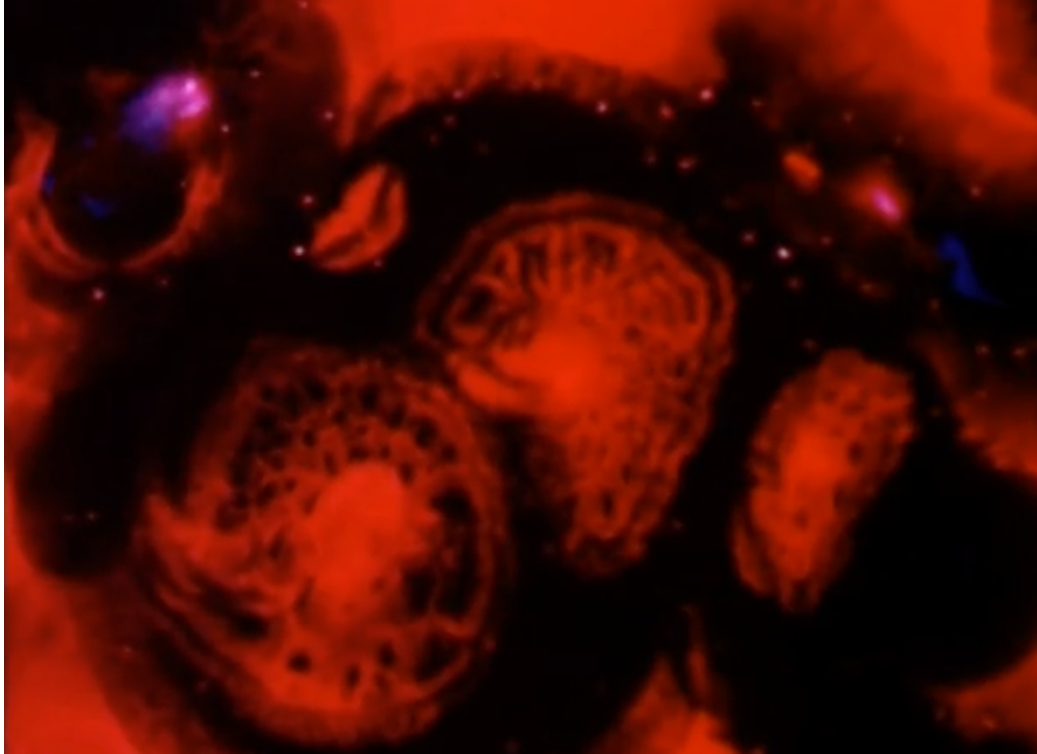


Figure 15. Lillian F. Schwartz, *Pixillation* (Still), 1970, Excerpted still of digitized montage of optically printed film of hand-painted film cells, 00:04:00, Dearborn, Michigan, Lillian F. Schwartz & Laurens R. Schwartz Collection: The Henry Ford.

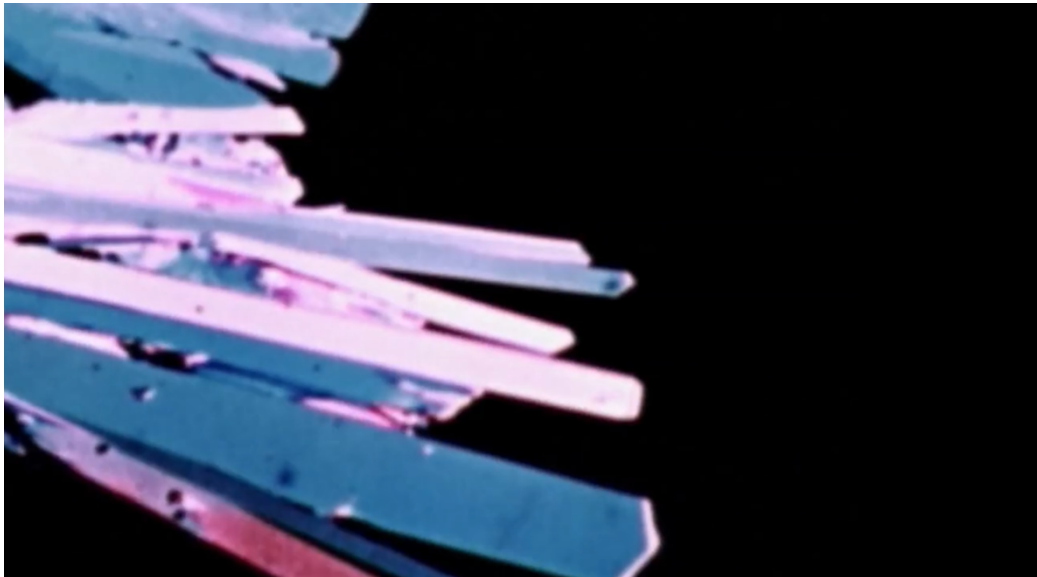


Figure 16. Lillian F. Schwartz, *Pixillation* (Still), 1970, Excerpted still of digitized montage of optically printed film of micro-photographic film footage of Salol crystal formation, 00:04:00, Dearborn, Michigan, Lillian F. Schwartz & Laurens R. Schwartz Collection: The Henry Ford.

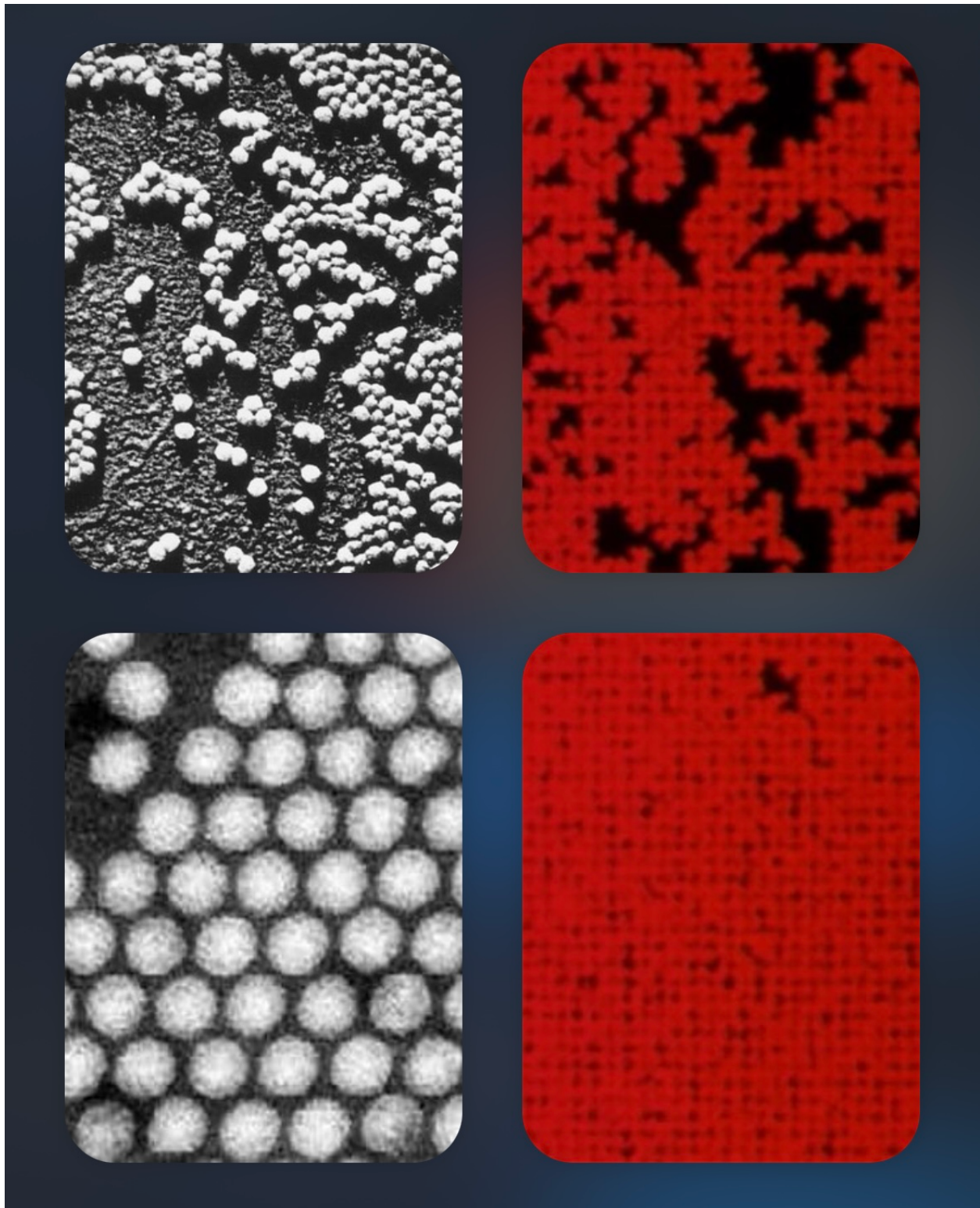


Figure 17. Side by side image of microphotographic photographs of poliovirus cell-growth (black and white) with cellular automata images from Lillian F. Schwartz, *Pixillation*, 1970 (red and black).



Figure 18. Lillian F. Schwartz, *Pixillation* (Still), 1970, Excerpted still of digitized montage of optically printed film of computer-generated cellular automata, 00:04:00, Dearborn, Michigan, Lillian F. Schwartz & Laurens R. Schwartz Collection: The Henry Ford.



Figure 19. Lillian F. Schwartz, *Pixillation* (Still), 1970, Excerpted still of digitized computer-generated (face1), 00:04:00, Dearborn, Michigan, Lillian F. Schwartz & Laurens R. Schwartz Collection: The Henry Ford.



Figure 20. Lillian F. Schwartz, *Pixillation* (Stills), 1970, Side by side comparison of 5 faces excerpted from digitized computer-generated film, 00:04:00, Dearborn, Michigan, Lillian F. Schwartz & Laurens R. Schwartz Collection: The Henry Ford.