Abstract: The Hungarian-born French painter Vera Molnar is among the few pioneering artists who used the computer as a creative medium starting in the late 1960s. This article explores how Molnar's computer-generated works used programming as a means to reflect upon the autographicity of the hand-made trace in drawing, and in painting in particular.

Vera Molnar's Computer Paintings

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In 1948, Claude Shannon and Norbert Wiener independently published two works which would durably shape the concept of information for the digital age.[1] Both mathematicians defined information in terms of entropy – a term borrowed from physics, which describes the disorganization or unpredictability of a system. While they differed in their interpretation of the term, both agreed to define information as a probability function wholly independent from material conditions.[2] As Wiener famously stated in his book *Cybernetics*: "Information is information, not matter or energy."[3] The distinction Shannon and Wiener inaugurated between information and its context would have lasting consequences far beyond the narrow realm of communication engineering. Writing fifty years later, the literary critic N. Katherine Hayles summarized: "The time was ripe for theories that reified information into a free-floating, decontextualized, quantifiable entity that could serve as the master key unlocking secrets of life and death."[4]

The definition of information as disembodied pattern, in turn, led to a series of misconceptions that still inform contemporary conceptions of digital media. By contrast, Hayles argues that "for information to exist, it must *always* be instantiated in a medium […C]onceiving of information as a thing separate from the medium instantiating it is a prior imaginary act that constructs a holistic phenomenon as an information/matter duality."[5] In this

article, I aim to extend Hayles's analysis to the history of art by focusing on a series of computer-generated works produced by the Hungarian-born French artist Vera Molnar. A classically-trained painter who started working in French computer laboratories in 1968, Molnar opened a space of mediation between the computational realm of information processing and the material practice of painting; in so doing, she directly challenged the duality between information and materiality that Hayles condemned.

Information needs to undergo a certain amount of analogizing before humans can experience it, a task which today is routinely, and more or less invisibly, performed by interfaces. Information, therefore, not only needs to be "instantiated" in a medium in the general sense, as Hayles contends, but also relies on specific material conditions in order to be perceptually experienced and cognitively processed. This holds important consequences for the visual arts. Well before the user-friendly interfaces that we know today, early technologies of data visualization and inscription enabled such an experience. Originally developed for the military during World War II, the electronic visualization and plotting of data (on a cathode ray tube screen, and on paper respectively) was refined throughout the 1960s for the benefits of the booming post-war industry. It is in this context that a few computer scientists, working in research institutions that encouraged collaboration between engineers and artists, exploited the creative possibilities of the machines at their disposal.

As early as 1962, the engineer A. Michael Noll produced a series of "Computer-Produced Patterns" at Bell Telephone Laboratories, using the newly acquired Stromberg-Carlson 4020 microfilm printer (also known as the "microfilm plotter").[6] From the outset, Noll situated his "patterns" – black and white plotted line-drawings, generated by connecting a series of points with straight lines – at the periphery of artistic creation, in order to avoid "an unintentional debate at this time on whether the computer-produced designs are truly art or not."[7] However, the relation between these computer-produced works and modern visual

culture was far from being unambiguous. While Noll did not set out to create "art," several of his productions appropriated an aesthetic derived from the canon of modern painting, whether intentionally or not: for instance, one of his first patterns, *Gaussian-Quadratic* (1962), "reminded [him]" of Picasso's cubist painting *Ma Jolie* of 1911–12.[8] Two years later, Noll also produced a series of computer-generated simulations of Mondrian's *Composition in Line* (second state) (1916–17) – a work to which I shall come back in reference to Molnar's practice.

In Europe, computer graphics also originated in a scientific context. At the University of Stuttgart, the first works of computer art were produced between 1963–64 by the mathematics students Frieder Nake and Georg Nees, using the Zuse Graphomat Z64 plotter.[9] Yet these early works were already embedded in a broader intellectual environment that sought to rethink the production and reception of art in the age of the computer. As early as 1964, the inventor of the Graphomat Z64 Konrad Zuse had foreseen that his device – while primarily designed for technical purposes – could be put to artistic use.[10] Moreover, Nake and Nees were closely associated with the philosopher Max Bense, whose information aesthetics aimed at developing a mathematical framework for the perception and creation of art. For these pioneers of computer graphics, modern art and visual culture functioned as a point of reference rather than as an example to emulate. However, as the context briefly sketched above indicates, their endeavors existed in tension with, rather than outside of, the artistic sphere.

By the late 1960s, a small number of artists had started experimenting with computers.[11] For them, computer-graphics did not exist in contradiction with modern art; rather, they envisioned using the machine to further develop features usually associated with human-made creation, such as inventiveness and organicity. Foregrounding the importance of materiality at the point when the algorithm is not only traced, but also drawn and painted,

became a key strategy to legitimize the computer as artistic tool. At the time, however, such works were largely dismissed by critics of traditional art, who failed to recognize any aesthetic specificity to the artistic appropriation of the computer as medium. Today, computer art is no longer an object of condemnation; yet it has remained on the periphery of the artistic canon, and is generally classified by museum institutions under the category of print media. While media history and media archeology have done much to clarify the technological context of emerging computer art, such approaches fail to account for the way computer art has related to fine art. Among those artists who saw in the computer a new means to expand the possibilities of painting, Vera Molnar best brought into productive discussion the so-called immateriality of the algorithm and the materiality of the computer-generated trace.

Molnar studied painting at the Budapest College of Fine Arts between 1942 and 1947, and moved to Paris in 1947. Between 1947 and 1960, she collaborated with her husband François Molnar – an academic researcher in experimental psychology at the CNRS (*Centre national de la recherche scientifique*), the French national center for scientific research – on artistic productions which they saw as "scientific experiments."[12] Having gained access to a computer in 1968, Molnar relied on the new discipline of information aesthetics, developed independently by the French physicist and philosopher Abraham A. Moles and the German philosopher Max Bense during the 1960s, as a theoretical framework for her creative practice. As a result, the balance between randomness and redundancy – crucial to information theory and its application to the visual arts – became central to the dialogue between classical painting and computer programming that she inaugurated. The manipulation of random parameters, in particular, enabled the production of "autographic" effects, such as trembling and hesitation, suggesting that the plotted line could imitate key characteristics of the hand-made trace.

In this article I argue that Molnar's computer-generated works reflect upon painting as a practice, a historical tradition, and an aesthetic experience. This claim, in turn, invites a reassessment of computer art in relation to the materiality of painting. The elements that constitute computer art as a medium – the coding process, the computer, the screen, the plotting table – all engage with materiality in fundamentally different ways to drawing and painting. Molnar's production, however, shows that as soon as code becomes materialized, it is perceived in relation precisely to these existing instances of materially-instantiated visual culture. My argument is structured around three series of works, realized between 1973 and 1988. The first section deals with Molnar's appropriation of information aesthetics in two series of plotter-drawn variations, *Hommage à Barbaud* (Tribute to Barbaud) (1974) and *Computer-rosace* (Computer-rose) (1975), in which Molnar experiments with Bense's concept of an "aesthetic state." In the second section, I investigate the different ways in which the materiality of computer-generated paintings comes to the fore firstly in *(Dés)ordres* ((Dis)orders), a plotter drawing in color ink on white paper (1974), and secondly in a group of acrylic paintings begun in 1973, entitled *Computer icône* (Computer icon). In the last section, I focus on a single series of works produced during the 1980s, entitled *Lettres de ma mère* (My mother's letters), to suggest that coding, in simulating autographic qualities, may evoke the materiality of painting.

Generating an Aesthetic State

In 1974, Molnar produced a series of China ink on white paper computer-plotted drawings entitled *(Dis)orders*, later renamed *Tribute to Barbaud* after the French algorithmic music composer Pierre Barbaud.[13] A long-term friend of Molnar's, Barbaud had facilitated the production of her very first computer-generated works at the Bull Machine Company (*Compagnie des Machines Bull*) in early 1968, shortly before she succeeded in gaining more

sustained access to a computer at the Paris 1 University research laboratory in Orsay.[14] The starting point of the series is nine sets of concentric squares arranged in a three-by-three grid structure; the size, shape, and distribution of the squares on the page vary according to chance-determined parameters. The level of disorder differs widely throughout the series: in some cases (fig. 1), the disruption only affects the outer edge of the concentric figures, resulting in a line-pattern that connects the nine sets to one another, as if the line had been hand-drawn without lifting the hand. In other cases (fig. 2), the concentric squares appear to have been pulled apart, entirely deconstructing the original grid structure, and leaving a tangled mess of approximate quadrilaterals amid choppy lines. In an article describing the production process of the *Tribute to Barbaud* series, Molnar sheds light on the theoretical principle that led her to experiment with the deconstruction of the original structure: "For something to happen on a surface and for an 'aesthetic state' (*état esthétique*) to be created, one must break with the original monotony, which amounts to lowering the redundancy rate."[15]

By the 1960s, artists using computers had become familiar with the basic tenets of information theory, manipulating redundancy and randomness rates to achieve aesthetic effects. The idea that the quantity of information in a given message can be equated with unpredictability (or disorder), derived from Shannon's theory of communication, became an important principle for electronic musical composition in the 1950s. Lejaren A. Hiller, who pioneered computer-generated music on an ILLIAC digital computer at the University of Illinois, defined musical composition as a balance between the total randomness of white noise, and the total organization (redundancy) of the telephone dial tone: "To obtain sufficient variation in texture the composer must move away at least a little from total randomness or total redundancy."[16] Molnar would have been aware of this intellectual context through her collaboration with Barbaud; but her reference, in the quote above, to an "aesthetic state,"

more specifically uncovers the importance of Bense's information aesthetics for her artistic practice.

The concept of information immediately became central to the Macy Conferences on Cybernetics, superseding discussions on feedback as early as the 1949 meeting.[17] The conferences famously sought to create a unified theory of knowledge by bringing together scientists and humanists: the speakers were chosen to represent "the principles of the current computer generation, the latest developments of neurophysiology, and finally a vague 'humanistic' combination of psychiatry, anthropology, and sociology."[18] Strikingly, however, there was no representative from the arts, and it was not until the mid-1950s that information theory came to influence the aesthetic and artistic fields. The works of Moles and Bense, mentioned in the introduction, were crucial in this respect. Bense had been aware of cybernetics since reading Wiener's *Cybernetics* in 1949.[19] Throughout the 1950s, he developed an aesthetic theory grounded in the statistical principles of information theory, a work which would culminate in his book *Aesthetika. Einführung in die neue Aesthetiks* (Aesthetika, introduction to the new aesthetics, untranslated) (1965). From the early 1960s onwards, Bense also collaborated with pioneers of computer art, including Nake and Nees, at the University of Stuttgart. His short text, "projekte generativer ästhetik" ("The Projects of Generative Aesthetics"), was published in 1965 on the occasion of the first exhibition of computer art worldwide featuring Nees' work at the University of Stuttgart.[20] It is widely considered as "the first manifesto of computer art."[21]

In this text, Bense makes a distinction between the "material carrier" of an artwork, and its "aesthetic state" (*ästhetischer Zustand*).[22] Elsewhere he defines an "aesthetic state" as the statistically-expressed structure of an artwork, calculated as a ratio between order and complexity: "In general, the 'aesthetic state' will be considered as a state of order (O) applying to a repertory of material elements of a certain complexity (C)."[23] While aesthetic

states, for Bense, may be materially instantiated, he is primarily interested in quantifying the work's formal organization.[24] In *Art et ordinateur* (Art and computer, untranslated) (1971), Moles posits a set of similar (if not identical) distinctions, differentiating between the "content" (*contenu*) of an artwork (its meaning or emotional content), and its "form" (*contenant*) (the actual structure or code of the work).[25] While both distinctions privilege the syntactic structure (Moles' "form," Bense's "aesthetic state") of the artwork, Moles acknowledges that the structure is "a mental form, [which] only exists insofar as it is perceived."[26] Moles' interest in the role that embodied perception plays in judging the aesthetic quality of a given structure goes back to his *Théorie de l'information et perception esthétique*, published in 1958 and translated into English as *Information Theory and Esthetic Perception* in 1966.[27] Transposed into the context of computer-generated works, his focus on perception opens up new possibilities for thinking of computer art in terms of information *and* materiality.

Molnar was familiar with the work of Moles and Bense, both of whom she knew personally.[28] While she appropriates Bense's terminology of the "aesthetic state," she does not indiscriminately embrace its dematerializing implications for art production and appreciation. In this, she differs from other computer artists, such as Nees, whose generative computer art was directly spurred by Bense's *Aesthetika III* (1958), and Manfred Mohr, who was so inspired by Bense's concept of "rational" art that he turned from *Informel* abstract painting to programming.[29] Rather, as a painter whose interest in programming was minimal, Molnar pursues a more empirical approach in line with Moles' position. Indeed, her practice is rooted in an experimental framework originally developed in the context of the GRAV (*Groupe de recherches d'art visuel* / Visual art research group), which Vera and François Molnar co-founded in 1960, and further developed by François Molnar in an article co-written with the French painter François Morellet.[30] A truly "experimental art," according to them

involves the practice of "trial and error," "the repetitions of the same problem while changing a single variable," and "the systematic use of chance," all of which are central to the realization of *Tribute to Barbaud*.[31] Molnar describes how, in pictorial terms, the creation of an "aesthetic state," in this specific series, is gradually achieved through a series of step-by-step measures: the random suppression of some of the squares; the modification of the probability of suppression according to each square's size; the deletion of one, two or three of each square's side; and finally, the use of color, reinstating a relation "with the richness of traditional painting."[32]

Moreover, Molnar's interpretation of how to assess an "aesthetic state" was facilitated by her collaboration with her husband, whose research in experimental psychology sought to conciliate information aesthetics with scientific measures of perception. The *Computer-rose* series demonstrates this point.[33] Made in 1975, these four plotted-drawings were generated using a program called RESEAU-TO, which enabled the production of a number of variations on a given geometric structure – here a single instance of concentric squares – through the successive modifications of specific variables (fig. 3). In an article discussing the variations, Molnar writes that by introducing one modification at a time within the original image, she is able to assess at which exact point an "aesthetic satisfaction" is reached:

> Fig. 4(a) is a picture that I find aesthetically "indifferent." Its aesthetic quality seems improved to me when some straight lines are replaced by segments of parabolas (Fig. 4 (b)) and even more so when sine curve segments replace parts of the straight lines (Fig. 4 (c)) but when the number and amplitude of the sine curve segments are increased, a result is obtained that I find aesthetically disappointing (Fig. 4(d)). I believe that the majority of those who view these examples will agree with my opinion as to their aesthetic quality.[34]

The fact that the level of disorder in fig. 4(d) exceeds our tolerance for complexity points to the difficulty of establishing an ideal order/complexity ratio; by contrast, the most aesthetically pleasing drawing – fig. 4(c), according to Molnar – presents some level of complexity, yet also retains a certain degree of structural organization. In grounding her preference of fig. 4(c) in her *a posteriori* reaction ("my opinion"), Vera Molnar puts Bense's *a priori*, statistical, definition of an "aesthetic state" at a distance.

This does not mean, however, that Molnar reinstates a traditional conception of the aesthetic judgment, exclusively located in the individual's subjective appreciation. Rather, the empirical method that she uses to assess what counts as an "aesthetic state" must be situated in relation to the utopian aim stated in Moles' aesthetic theory: "to try and elucidate, instead of the 'mystery' of art, the yet unformulated underlying rules, which decide that such product of the algorithm is to be preferred, if not unanimously, at least generally, to another."[35] The hope that such rules could be identified, in turn, had received some encouragement at the time thanks to developments in the field of neuropsychology, which had revealed common patterns of aesthetic judgements relative to the perception of complexity. François Molnar spells this out in an article published in 1977: "Many experiments have shown a strong correlation, between, on the one hand, the level of complexity of the stimulation and the level of arousal [of a specific cortical region], and, on the other hand, the level of arousal and aesthetic pleasure."[36]

The importance, for a discussion of Molnar's work, of the mutual influence between her artistic practice and her husband's research, further comes to light in François Molnar's discussion, in the same article, of Noll's 1964 "Human or Machine" Mondrian experiment. Noll presented one hundred test subjects working at Bell Labs with both a xerographic reproduction of Mondrian's *Composition in Line* (second state) of 1916–17, and a computer-generated version of the original painting. Noll found that the majority of the subjects not

only mistook the computer-generated version – also known as a "Mondrian stimulus" – for the original, but also preferred it.[37] Given that the computer image was "more random" than the original painting, Noll concluded that randomness played a key role in the aesthetic appreciation of the images.[38] The fact that, according to Noll, some of the subjects "strongly associated randomness with human creativity" further indicates that randomness more specifically evokes hand-made, autographic qualities habitually associated with painting, – a point I shall develop in the last part of this article, when considering Molnar's series *My Mother's Letters*.[39]

The connection between Noll's Mondrian experiment and Vera Molnar's artistic production has not only remained unexplored, but also been deemed irrelevant, with Molnar specialist Vincent Baby claiming that Noll's experiment is "inane for the history of art."[40] And yet, François Molnar reveals that he had conducted a similar experiment to Noll's in his own laboratory using computer-generated versions of the Mondrian painting, "independently and perhaps even prior to the Noll's [own experiment]."[41] In contrast to Noll's Mondrian stimulus, François Molnar's experiment "did not merely simulate the painting":[42] rather, it generated a series of original *variations* on the original painting (fig. 4). Crucially, these computer-generated variations are part of Vera Molnar's own artistic investigations into Mondrian's painting: as the artist's catalogue raisonné demonstrates, Molnar had produced a large amount of these variations during 1974, on screen and on paper, some of which were plotted as the *Molndrian* series.[43] Borrowing the linear aesthetic of Mondrian's *Composition in Line*, Molnar's *Molndrian* plotter drawings crop the painting's original spherical shape into a square, while spacing out its elements to produce sparer, deconstructed versions (fig. 5).

In uncovering this specific connection between Molnar's *Molndrian* series and her husband's research, I aim to situate her artistic production of that time-period within a unifying theoretical framework. This connection demonstrates that the *Tribute to Barbaud*

and *Computer-rose* series, made in 1974 and 1975 respectively, were generated at a time when Molnar sought to negotiate the combined impact of information aesthetics and experimental psychology on her artistic production. Molnar would likely have agreed with François Molnar's assessment that while "the problems of order and disorder […] are extremely relevant to art, […] using the precise terminology of information theory amounts to implying that we have in aesthetics the knowledge that we possess in thermodynamics or in telecommunications."[44] Thus, if her discussion of *Computer-rose* implies that some aesthetic judgments – hers, in this case – are likely to be shared by a "majority," this cannot be accounted for by Bense's notion of an *a priori*, aesthetic value, inherent to the structure of the work. Rather, Molnar's interpretation of an "aesthetic state" relies on the moment when structural modifications are materialized, on the screen or on paper, in order to be put to the test of the viewer's aesthetic response.[45] As I now go on to show, this process often introduces elements of material contingency that exceed the mere visualization of information patterns, and inaugurates a dialogue with the medium of painting.

Materializing Information

Molnar's early black and white plotter drawings, considered above, may be judged to be "aesthetic states"; but can they be said to be artistic, and more specifically, painterly, as I have been suggesting? Discussions regarding the manner in which the *aesthetic* and the *artistic* spheres relate to one another are central to the literature on information aesthetics of the 1950s–70s. Theoreticians such as Moles were cautiously optimistic that one day the gap between the two fields could be bridged: namely, that research in information aesthetics would eventually lead to the quantification of aesthetic perception *and* artistic production alike. Moles' hypothesis relied on those artistic practices that mediated between the quantitative and the qualitative, such as what he termed "permutational art," a practice that

systematically explores the variables of a finite set. According to Moles, Molnar was one of the few painters (with Mondrian and the German *Informel* painter K. O. Götz) to exemplify this new approach by conducting experiments in the "*quantification of reality*."[46] Moles believed that such experiments, when paired with perceptual psychology, would lead to the extraction of general principles of aesthetic perception, also known as "aesthetic super rules."[47] In turn, these empirically-deduced rules, once systematized, would ideally make it possible for the "emotion engineers" of the future to "program aesthetic pleasure."[48]

By contrast, artists often expressed stronger reservations. Götz used statistical calculations derived from information theory to produce a series of *Rasterbilder* (Raster pictures) between 1959–63, black and white geometric abstractions composed of small squares arranged in a gridded canvas. However, he explicitly differentiated his interest in the quantification and statistical determination of the image field from his practice as an *Informel* painter.[49] As for Molnar, she relied on various modalities of materialization of the computer-generated image to adapt and subvert the tenets of information theory for her painterly purposes. The technological shift to the cathode ray tube (CRT) screen, shortly after she started working in the computer laboratory at Orsay, proved crucial in this respect. Prior to this, the computer had been a punch-card operated machine without a display screen: the only option for visualizing data would have been pen plotters or line printers, which did not allow for real-time interaction.[50] By contrast, the IBM 2250 CRT screen that the laboratory acquired made it possible for the user to visualize each modification of the code as it took place, as well as to edit the image directly on-screen using a light pen. The arrival of the screen therefore enabled a form of immediate interaction which had not been possible with the plotter, and which Molnar refers to as the "conversational method."[51] This locution positions Molnar's practice within the framework of Moles' information aesthetics that defines the image as a quantifiable, analyzable "message," and contends that "any artistic expression is a

communication phenomenon."[52] But crucially, the "conversational method" is also what allows Molnar to think of the CRT screen in analogy with painting:

> I make the parameter changes quickly while viewing the images on the CRT screen. […] This approach is not new; it had been applied long before computers were constructed. Erasing, scraping, retouching or covering part of a picture are familiar techniques used by painters.[53]

Thanks to the screen, the computer acquired a painterly function. In the mid-1970s, Molnar produced a group of acrylic paintings entitled *Computer icon*, based on a series of plotted variations realized in 1973. A comparison between one of the paintings, *Computer icon - 2* (1975) (fig. 6a) and one of the plotted drawings (fig. 6b) reveals that the artist used the computer as a sketching tool: the line-drawing, which clearly inspired the final painting, is part of a series of experiments on the geometric shape of the square, some of which were published, in 1975, in the article "Towards Aesthetic Guidelines for Paintings with the Aid of a Computer." The article is illustrated with six different examples of these "computer drawings" produced between 1972–73, all entitled *Carrés* (Squares) and numbered. Here, the computer appears as a tool capable of producing more variations on a theme than a human mind ever could, generating a wealth of possibilities from which the artist will choose which configuration to paint.

And yet, calling the computer a "tool" – despite the many occasions on which Molnar has herself insisted that this is all that the computer was to her practice – does not quite capture the symbiotic relation between artist and computer.[54] Discussing the difficulty, for the painter, of "materializing" a "mental image," Molnar quotes the phenomenologist Mikel Dufrenne: "At the beginning of the creative process are […] mental images which […] are not inscribed in reality […]." This is where the computer steps in:

> The painter's aim has always been, and remains, to make visible, to materialize […] this fuzzy dream, and to ensure that the materialized image be as close to the imagined model as possible. For the stage of composition which consists of the meticulous matching of the mental reference, the painter now has highly efficient prostheses at his disposal: computers. As soon as the painter uses a computer, the emerging image ceases to be a chaos of unknown or undefined shapes and colors, to become instead a matrix composed of thousands of discrete, discontinuous and quantified points. Without the help of the computer, he would never have been able to so faithfully materialize an image which previously only existed in his imagination.[55]

In the *Computer Icon* series, the computer does not merely produce a series of possible configurations; crucially, it also facilitates compositions which might never have been fully conceived mentally by the artist. This, in turn, stimulates the painter's creativity, in a logic that Molnar defines as one of "visual feedback": the computer not only gives tangible form to the mental images of the painter, but also suggests new ones.[56] The model of the feedback loop, which Molnar borrows from cybernetics, suggests that there is no real opposition between the information handled by the computer, the painter's imagination, and the material realization of the work, but rather a productive and sustainable exchange.

In the process of materializing information, factors such as the screen resolution, the plotting speed, the paper format and quality, and the type of pen and ink all impart material qualities to what was originally a mere signal. This becomes apparent in those plotted drawings that use color felt-tip pens and Benson paper, such as *(Dis)orders* of 1973 (fig. 7). This drawing demonstrates how the plotter, far from being a mere technical means of visualization, becomes a transformative medium. From afar, the composition made of different combinations of concentric squares suggests the cool precision of computer-generated geometric abstraction. However, a closer inspection of the computer-generated

trace reveals small imperfections. In some places, the pen has gone too far by a millimeter or so, giving the impression that the ink has bled slightly; in other parts, the changing intensity of the ink color exposes the pen's trajectory, where it might have rested a while, leaving a small blot of darker color in the corner of a square. This is neither technological determinism, nor pure artistic intention; rather, Molnar uses these modifying factors, when they arise, for her own purpose. What we might consider as unintended autographic effects are integral to the way we perceive a plotted pattern as a rich pictorial surface. In the 1980s, with the series of works entitled *My Mother's Letters*, Molnar further explored the computer's autographic potential by intentionally manipulating randomness to evoke painterly qualities.

My Mother's Letters

Plotted in blue or black ink on white paper, the variations in the series *My Mother's Letters* resemble short hand-written paragraphs, whose closely-arranged lines exhibit varying levels of disorder (fig. 8 and 9).[57] The project originates in the letters Molnar received from her mother, who had remained behind the Iron Curtain, throughout her adult life. As her mother aged, the letters became more difficult to read and, eventually, undecipherable; yet Molnar continued to value them as fascinating aesthetic objects. The mother's handwriting was particularly unusual in that it "began each line regularly and strictly with Gothic letters, which toward the end of the line became more and more restless […].[58] After her mother's death, Molnar played with random parameters at the programming level to resurrect the aesthetic imbalance so characteristic of the original, with strikingly poignant effect: the increased disorder rate, located either towards the end of the line or the end of the paragraph, depending on the versions, gives the impression of an entropic loss that cannot be recuperated. The progressive and irrevocable disorganization of the line achieved through automated stochastic procedures, therefore, not only mimics the degradation of the handwriting, but also evokes the loss of meaning that results from increasing psychological

and physical frailty.

Before computers were available, painters achieved unpredictability by using a variety of techniques. Morellet, a close collaborator of the Molnar couple, used the phone directory as a makeshift random number generator, where the random occurrence of odd and even numbers determines the color and organization of simple geometric shapes on the canvas. Molnar used a similar method for a time, before developing a strategy which, following the composer Michel Philippot, she called the "imaginary machine" (*machine imaginaire*): a step-by-step approach based on the logic of computer programming, which rendered her work "more systematic."[59] These experiments took place within a context that favored the depersonalization of the artistic gesture and its production: the Charter of Foundation of the GRAV, for instance, called for their members to "overcome the traditional image of the artist as a unique genius, creator of immortal works," echoing Vasarely's own "Yellow Manifesto," published in the 1950s.[60] Isabelle Ewig traces Molnar's refusal of personal expression to an earlier occurrence: Theo van Doesburg's 1930 "Manifesto of Concrete Art," which recommends a "mechanical" technique, and states that the artwork "must show no trace of human weakness: no trembling, imprecisions, hesitations, unfinished parts, etc."[61] Indeed, for most of her career, Molnar systematically refrained from using painting as a means of self-expression, to the extent that she has often employed studio assistants to generate the regular blocks of solid colors characteristic of her geometric style.[62] Ewig concludes that Molnar's turn to the computer in 1968, "pushes this logic to the end […]: by entrusting the execution of the work to the plotting table, she fundamentally calls into question the values of personal handwriting and originality."[63] However, as the works considered in this section show, the computer is precisely the means through which those qualities associated with "human weakness," such as "trembling," "imprecisions," and "hesitations" find their way back into

Molnar's corpus. We therefore need to consider how what might appear as a mere return to, or reinstatement of, autographicity takes on a new meaning in the context of computer art.

My argument rests on the complex role that computer-generated randomness plays in simulating autographic qualities in *My Mother's Letters* and related works of the same time-period. In *Languages of Art*, Nelson Goodman defines an autographic artwork – and by extension autographic arts – as one which cannot be copied without losing its authenticity, such as a painting.[64] By contrast, allographic arts, such as music – an art form that relies on notation (the score) – can be duplicated without any consequence to their authenticity status: "there are," Goodman asserts, "no performances that are forgeries of the London Symphony."[65] Because, according to Goodman, "assurance of genuineness can come only from identification of the actual object produced by the artist," the term "autographic" is often used loosely to denote productions of the human hand, although Goodman's definition includes partly mechanized reproduction techniques, such as printmaking.[66] In this article, I take "autographic" to refer more generally to qualities that are either produced, or perceived to be produced, by the human hand, as opposed to the computer. While Molnar's account of randomness in *My Mother's Letters* highlights a formal agenda that focuses on disrupting the laws of compositional balance, I argue that this series foregrounds an aesthetic of the handwritten trace that challenges the filiation with artistic depersonalization sketched above.[67]

One of the questions that underpins Goodman's argument is whether the "institution of a notational system [could] transform painting or etching from an autographic into an allographic art."[68] Meredith Hoy has explored this question with regard to Paul Klee's use of graphical notation, in particular his attempts to translate musical notation into a pictorial form in the 1920s.[69] While these works, according to Hoy, performed a balancing act between "graphically articulating measurable quantities, which can be represented notationally and digitally, and qualities that would seem to escape quantification," Klee's 1930s paintings go

further, unilaterally emphasizing a "divisionist approach" comparable to digital quantification.[70] In other words, Hoy argues that Klee's paintings – like those of other systematic painters, such as Georges Seurat and Victor Vasarely – can be understood in analogy with the digital medium.[71] By contrast, Molnar's use of randomness prompts us to ask whether we may consider some computer-generated works in analogy with analogue productions of the human hand – such as writing and drawing –, and in particular with painting. In *My Mother's Letters*, the use of randomness foregrounds, rather than negates, the imperfection of the hand-made trace, the personal signature, and the evocation of an absent author – qualities that, according to the definition set out above, we may broadly describe as "autographic." However, rather than enacting a mere return to a humanistic conception of artistic production, I argue that *My Mother's Letter* belongs to a context of computer art practices that turned to randomness with the explicit aim to *simulate* human qualities, or, as it was commonly referred to as the time, human "intuition."

Bense first put forward a version of this idea in "The Projects of Generative Aesthetics":

> It is obvious that even the machine is unable to produce an identical repetition of a product if chance is introduced by means of a random number generator. The uniqueness of aesthetic objects – even those made with the aid of a machine – is maintained in a pseudo-individual or pseudointuitive way.[72]

Frieder Nake further developed this claim, first in a short article from 1968, and later in his 1974 book on computer aesthetics, *Ästhetik als Informationsverarbeitung* (Aesthetics as information processing, untranslated) (1974).[73] Molnar was aware of this discussion as early as 1976, as her article describing the "Molnart" program demonstrates. In this text, Molnar imagined a viewer's reaction to, on the one hand, computer-plotted drawings and, on the other hand, drawings by Klee. "It is possible," she writes, "that one may prefer Klee's drawings";[74]

as a result, she experimented further with the program to simulate the effect of the human hand:

> I introduce a certain percentage of clumsiness and irregularities by artificially generating "human qualities" (*de "l'humain"*). […] More concretely, I move each vertex of each square according to chance. This adjustment varies between 0 and a value determined arbitrarily. In this way, one gets more or less regular quadrilaterals, and is able to see which degree of irregularity, of clumsiness, of humanity (*de l'humain*), is the most satisfying. By fixing the upper limit very close to 0, one gets very small, almost imperceptible, irregularities, like a slight trembling […] When simulating human clumsiness, one injects more disorder into big squares than into small squares: the bigger the square, the more clumsily the hand draws it.[75]

While Molnar's "Klee" thought experiment, with the resulting introduction of randomness to increase the viewer's aesthetic satisfaction, is reminiscent of Noll's Mondrian experiment, it also differs from it in a significant way. In this case, Molnar does not merely use randomness for general aesthetic purposes; rather, as her description makes clear, she brings her experience as a draughtswoman to bear upon the programming process, strengthening the ties with manual practices, and drawing in particular ("the bigger the square, the more clumsily the hand draws it").

Between 1981 and 1984, precisely at the moment that she is producing the first hand-sketched and plotter-drawn variations of *My Mother's Letters*, Molnar directly references Nake on this point. In 1981, she writes: "Thanks to the possibilities that randomness generators offer, one can imitate, simulate (to use computer terminology) artistic intuition," with a footnote referring to Nake's book;[76] three years later she writes in her artistic diary: "*HASARD à utiliser pour simuler 'l'intuition' (NAKE)*" (Use CHANCE to simulate 'intuition' (NAKE)) (fig. 10).[77] This diary entry, dated 1 July 1984, immediately precedes a series of

entries composed of hand-made and computer-generated simulations of handwriting (9 July 1984; 26 July 1984; and so on), with the heading "Lettres de ma mère" (*My mother's letters*) (fig. 11). While Molnar does not explicitly link the use of computer programming to simulate human intuition to *My Mother's Letters*, her own discussion of the method, and the chronology established by her dairies, justify the connection.

If, as I suggest, Molnar uses randomness to generate autographic effects in *My Mother's Letters*, then this work plays an important role in redefining the relation between information (at the programming level) and painting (at the perceptual level). Despite the emphasis on handwriting throughout the series, the paradigm through which the viewer receives *My Mother's Letters* is a pictorial one: because the simulated handwriting is syntactically and semantically void, the viewer perceives the work less as writing than as image. Moreover, *My Mother's Letters* foregrounds the fact that computer-generated writing relates to the materiality of painting in complex ways: not, of course, in the literal sense of texture, impasto, or brushwork, but rather through their shared connection with the authorial weight of the autographic inscription. This comes to light in the mathematician and historian of computer art Erwin Steller's description the work:

> *My Mother's Letters* were a good argument against the reproaches levelled at computer-generated drawings, namely that they seemed impersonal, flat, and that they did not preserve the so-called artist's handwriting (*Handschrift des Künstlers*). In a way, Vera Molnar had proven the contrary, which greatly pleased me.[78]

Importantly, what Steller here terms *Handschrift des Künstlers* does not merely denote "the artist's handwriting" in a narrow sense, but also more broadly the artist's (psychic) signature, in an explicit reference to Abstract Expressionism.[79] In bringing this loaded locution to bear upon his interpretation of *My Mother's Letters,* Steller arguably plays on the double signification of the term *Handschrift* to suggest that the series engages with the linear

aesthetic of writing (however disrupted), as well as with an artistic tradition that emphasizes the material inscription of the painter in the canvas.

The importance of such inscription for painting, however, is not limited to postwar tropes of self-expression. Rather, the artist's signature has, from the eighteenth century onwards, crystallized the ambivalent status of writing in relation to painting. Charlotte Guichard has shown, in a discussion of autographicity that historicizes Goodman's definition of the concept, that from this moment the painter's signature in the canvas came to signify "in its very materiality, the presence of its creator."[80] In the twentieth century, Abstract Expressionism further radicalized the pictoriality of the artistic "signature": Barnett Newman's "zip," for instance, is not only integrated in the canvas's pictorial space, but actively constitutes it. As Isabelle Graw reminds us, painting is an indexical medium: "[r]egardless of its depiction or reference, a painting will be perceived as a physical manifestation of its absent author."[81] Crucially, this "indexical effect," according to Graw, is not limited to traditional forms of painting, but also occurs in technologically-mediated practices:

> [T]he artist does not need to set his or her hand on the picture, to have brandished a brush, or to have thrown paint on canvas. A mechanically-produced silkscreen by Andy Warhol […], the digitally-printed paintings by Wade Guyton, are no less capable of conveying the sense of a latent presence of the artist […].[82]

It is inescapable, Graw concludes, that painting be perceived as a form of "handwriting," even in the case of those artists who promote an anti-subjective approach (Frank Stella; Gerhard Richter).[83]

The increasing technologization of painting since the 1960s demands that we historicize further the concept of autographicity in relation to this medium. In *My Mother's Letters*, the writing simulation inaugurates a dynamic of presence through absence similar to that which

Graw describes, albeit of a slightly different kind: in the perceptual encounter with *My Mother's Letters*, the randomly-generated autographic effects of the computer-plotted trace are perceived in relation to what is absent – namely, painting. If there is a materiality of computer painting beyond that of the plotted trace, it is therefore one that implies previous experiences of painting, and an encounter with something, in the work, that reactivates these encounters precisely at the very moment when painting is not present. What this "something" is, however, depends on the nature of these previous "encounters." As Moles argued, there is no univocal equivalence between "semantic information" (code) and "aesthetic information" (experience), because the latter "refers to the repertoire of knowledge common to the particular transmitter and particular receptor."[84] Thus, in his interpretation of Noll's Mondrian experiment, the art historian Meyer Schapiro argued that the test subjects who had expressed a preference for the computer-generated image had connected randomness to a recent moment in the history of painting: namely, one defined by "the vogue of Abstract Expressionist painting," whose apparent spontaneous generation had legitimized "randomness as a new mode of composition."[85] As a result, Noll's use of random procedures in making his own computer-generated "Mondrian" was, in Whitney Davis' words, "perceived to be 'arty' Pollock-style procedures."[86]

In contrast to the above, *My Mother's Letters* belongs to a cultural context in which the visualization of imperfection, or error, was no longer exclusively associated with the human hand; rather, it had also begun to be understood as a form of creativity specific to the machine. Colette S. Bangert, another pioneer of computer art active at the same time as Molnar, wrote in 1974 that "a 'bug' [in the program] may produce something particularly interesting […] It is this experience of serendipity that makes work with a computer intriguing and that presents a real challenge to both the artist and the programmer."[87] In other words, an appearance of randomness may equally evoke the spontaneity and autographicity of the

human hand, *and* the machine's glitch. Thus, the raised randomness rate in *My Mother's Letters* does not, on its own, account for the perception we may have of it as autographic; rather, the autographic effect is successful because it takes place in a context in which the definition of the medium is shifting. Indeed, the anxiety relating to the contemporary relevance of painting pervades Molnar's discourse on *My Mother's Letters*: "While creating and reflecting, a visual artist might ponder whether these traditions and 'recipes' are still valid for today's visual world. And what if they have become obsolete?"[88] *My Mother's Letters*, therefore, engages with the tradition of painting at the very moment when the defining characteristics of the medium have already been appropriated by the computer.

The Ghostly Materiality of Painting

Before Molnar, Klee had reflected upon the obsolescence of another hand-led medium – drawing – with the oil transfer drawings.[89] Klee used carbon paper to duplicate some of his drawings in what Tamara Trodd called a "semi-mechanized" production process.[90] According to Trodd, the black ink marks that figure on the surface of the drawings – an apparent by-product of the accidental rubbing of the hand on the makeshift carbon paper during the transfer process – were obtained "in a number of carefully thought-out and interesting ways. [...] [T]hey are the material traces holding the "memory" of what was at stake – namely, the reproduction of drawing – in Klee's oil-transfer practice."[91] In the oil-transfer drawings, a mechanized procedure (transfer) has superseded a hand-determined medium (drawing); yet it is in the very procedure of transfer that Klee reintroduces autographic marks, displacing the hand-made quality of drawing as if to better preserve it. The relation between simulated handwriting and painting in *My Mother's Letters* is one of a similar kind: Molnar uses randomness at the programming level to generate autographic effects, but those are only perceived as such within a broader cultural context that remembers the materiality of painting.

To borrow W. J. T. Mitchell's conceptual duo, *My Mother's Letters* is both a materially instantiated *picture* – a computer-plotted trace on paper – and an *image* of painting, as it endures "in memory, in narrative, and in copies and traces in other media."[92]

My Mother's Letters, which entirely foregoes painting as a medium, foregrounds a form of autographic inscription that does not need to rely on the hand-made mark. If, as I suggested above, we want to think about our reaction to the irregular tracings as a form of experience that evokes painting as a "memory" of the medium, it is necessarily one of a disembodied, ghostly, kind.[93] In Klee's oil-transfers, the marks which, according to Trodd, hold the memory of drawing, are indexical. By contrast, *My Mother's Letters*'s engagement with a rhetoric of memory is one that does not conform to the intellectual tradition that, in the wake of Freud, has prioritized the physical imprint. My *Mother's Letters* therefore shifts the terms of the debate, to redefine materiality in analogy with what we remember materiality to be, or to have been, in relation to painting.

One last point enables me to conclude on the broader question of the relation between information and materiality. The works that I considered in the first and second sections of this article emphasized the material instantiation of information, in a way that developed Hayles's original claim for the context of the visual arts. In the third section, I argued that *My Mother's Letters*'s evocation of the painterly as a ghostly reminiscence of painting is irreducible to traditional conceptions of materiality. However, this evocation is not wholly independent of the materiality of the plotted trace on paper. The perceptual mechanism that enables us to anthropomorphize the plotter-generated drawing, which we automatically associate with handwriting, relies on associations that the media of ink and paper trigger. Such a mechanism would most likely not function, were the same patterns displayed on an LCD screen. In *My Mother's Letters*, the two levels of materiality that I discussed throughout this article – the material output of computer-generated work, and the experience of

materiality that code may produce in analogy with painting – therefore work together, enabling each other. If information determines the formal conditions for *My Mother's Letters*'s painterliness, it is the material and historical specificity of its realization that enables us to experience the work as a form of painting.

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[1] Claude Shannon, "A Mathematical Theory of Communication," *The Bell System Technical Journal* 27: 379–423, 623–656 (July, October 1948); Norbert Wiener, *Cybernetics: Or Control and Communication in the Animal and the Machine* (Cambridge MA, 1948). Shannon's text was republished, accompanied by an essay by Warren Weaver, as *The Mathematical Theory of Communication* (Urbana, 1949).

[2] Shannon equated unpredictability with the amount of information transmitted in a message (positive entropy), whereas Wiener believed that the more random a set of messages, the less information is transmitted (negative entropy).

[3] Wiener, *Cybernetics*, 132.

[4] N. Katherine Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics* (Chicago, 1999), 19.

[5] Hayles, *How We Became Posthuman*, 13.

[6] A. Michael Noll, "Patterns by 7090," *Bell Telephone Laboratories Technical Memorandum*, 28 August 1962. On the history of the Bell Laboratories, see Jon Gertner, *The Idea Factory: Bell Labs and the Great Age of American Innovation* (London, 2013). On the Stromberg-Carlson microfilm printer see Zabet Patterson, *Peripheral Vision: Bell Labs, the S-C 4020, and the Origins of Computer Art* (Cambridge, MA, 2015).

[7] Noll, "Patterns by 7090," 1.

[8] A. Michael Noll, "The Beginnings of Computer Art in the United States: A Memoir," *Leonardo* 27, no. 1 (1994): 39–44 (39).

[9] Erwin Steller, *Computer und Kunst* (Mannheim, 1992), 57. Unless otherwise stated, all translations from the German and the French are my own.

[10] Andrés Burbano & Esteban García Bravo, "Konrad Zuse: enabler of computational art?" in Everardo Reyes-García, Pierre Châtel-Innocenti, Khaldoun Zreik (eds), *Archiving and Questioning Immateriality: Proceedings of the 5th Computer Art Congress* (Paris, 2016), 190–203. The authors emphasize that "there is no evidence that Zuse was aware of Nees and Nakes' artistic endeavors with his Graphomat Z64" at that time (194).

[11] On the history of computer art, see Grant D. Taylor, *When the Machine Made Art: The Troubled History of Computer Art* (New York, 2014).

[12] Jean-Pierre Arnaud, "Une Hongroise à Paris, Entretien avec Véra Molnar" (20 February 2002), in Vincent Baby, *Le Système Molnar* (1946–1976), unpublished PhD, Paris IV University, 2003, 266–276 (266). Interview originally published in *Artistes hongrois en France, 1920–2000* (Angers, 2002), 52–66. In this, the couple's practice was arguably indebted to the Bauhaus, and in particular to Josef Albers's definition of art as "scientific experiments" ("Creative Education," from "VI. Internationaler Kongress für Zeichnen, Kunstunterricht und Angewandte Kunst in Prag, 1928" (Sixth International Congress for Drawing, Art Education, and Applied Art In Prague, 1928), reprinted in Hans Maria Wingler, ed., *The Bauhaus: Weimar, Dessau, Berlin, Chicago* (Cambridge MA, 1969), 142.)

[13] On Barbaud and computer-generated music, see Jean-Claude Risset, "Une Expérimentation plastique en actes," in *Véra Molnar. Une rétrospective 1942–2012*, exh. cat., curated by Sylvain Amic and Vincent Baby (Paris, 2012), 28–35.

[14] Vera Molnar in conversation with the author, Paris, September 2017. Thereafter: Molnar to the author, 2017.

[15] Molnar, "Description du programme 'Molnart' (1974–1976)," unpublished, unpaginated. A PDF is available on the artist's website: http://www.veramolnar.com/?cat=8. Accessed 28 July, 2019. Molnar also writes, in the same article, "And as everyone knows – thanks to the work of information theorists and aestheticians – an entirely redundant image can be neither aesthetic nor artistic."

[16] Lejaren A. Hiller, Jr., "Computer Music," *Scientific American* 201, no. 6 (December 1959): 109–121 (112).

[17] Ronald R. Kline, *The Cybernetics Moment: Or Why We Call Our Age The Information Age* (Baltimore, 2015), 56.

[18] Claus Pias, "The Age of Cybernetics," in Claus Pias, ed., *Cybernetics: The Macy Conferences 1946–1953. The Complete Transactions* (Zurich, 2016), 11.

[19] Elisabeth Walther, "Max Bense und die Kybernetik," in *Computer Art Faszination* (Frankfurt am Main, 1999), 360.

[20] Max Bense, "projekte generativer ästhetik," in Georg Nees und Max Bense, *Computer-grafik*, *rot* 19 (Stuttgart, 1965), republished as "The Projects of Generative Aesthetics," in Jasia Reichardt, ed., *Cybernetics, Art and Ideas* (London, 1971).

[21] Frieder Nake, "The Semiotic Engine: Notes on the History of Algorithmic Images in Europe," *Art Journal* 68, no. 1 (Spring 2009): 76–89 (80).

[22] Bense, "The Projects of Generative Aesthetics," 57.

[23] Max Bense, "Aesthetics and Programming," in Margit Rosen, ed., in coll. with Peter Weibel et al., *A Little-Known Story about a Movement, a Magazine, and the Computer's Arrival in Art: New Tendencies and Bit International, 1961–1973* (Cambridge, MA, 2011), 296–299 (296). First published as "Ästhetik und Programmierung – Aesthetics and Programming," in *IBM Nachrichten* 180 (1966): 294–296.

[24] For Bense, "[t]he system of generative aesthetics aims at a numerical and operational description of characteristics of aesthetic structures (which can be realized in a number of material elements) […]" (Bense, "The Projects of Generative Aesthetics," 57).

[25] Abraham A. Moles, *Art et ordinateur*, (Paris, 1971), 15.

[26] Ibid., 124.

[27] Abraham A. Moles, *Information Theory and Esthetic Perception*, trans. Joel E. Cohen (Urbana, 1966).

[28] Molnar to the author, 2017. In 1956, Molnar had attended the defense of Moles' doctoral dissertation, *La création scientifique* (The scientific creation, untranslated), and subsequently read his books. The fact that Moles' 1971 book reproduces an early untitled work by Molnar, made in 1969, confirms that they were in contact at that time (*Art et ordinateur*, 126).

[29] See Elisabeth Walther, "Max Bense und die Kybernetik," in *Computer Art Faszination* (Frankfurt am Main: Dr. Dotzler, Medien-Institut, 1999), 360; Hansjörg Fröhlich, "Vom Rhythmus Zum Algorithmus: Der Digitalkunst-Pionier Manfred Mohr im Interview," *Sonnendeck Magazin* (April 2017): 4–12 (5).

[30] The Molnars co-founded the group, which was originally called the CRAV (Centre de recherches d'art visuel / Visual art research center) in July 1960 with several artists, including Yvaral, François Morellet and Julio Le Parc; they left the group in November of the same year.

[31] François Molnar and François Morellet, "For a Progressive Abstract Art," in Rosen, *A Little-Known Story*, 136–143 (140). Originally published as "Pour un art abstrait progressif," offprint within the framework of the exhibition *nove tendencije* 2, Galerija suvremene umjetnosti, Zagreb, 1963. The *Tribute to Barbaud* series was produced using the "Molnart" program (*Programme "Molnart*)", a computer program co-written by Vera and

François Molnar with the explicit aim to perform "systematic pictorial *experiments*," (Molnar, "Description du programme 'Molnart,'" emphasis mine).

[32] Molnar, "Description du programme 'Molnart.'"

[33] While she took FORTRAN classes in the early days, Molnar never became a programmer. Over the years, she relied on a variety of people for programming, from her husband to technical collaborators and assistants, most notably Pierre Braun and Erwin Steller. According to Braun, "Mohr [who had taught himself FORTRAN] followed the logic of the program; Vera didn't," Pierre Braun to the author, telephone interview, July 2017 (thereafter: Braun to the author, 2017).

[34] Molnar, "Toward Aesthetic Guidelines for Paintings with the Aid of a Computer," *Leonardo* 8, no. 3 (Summer 1975): 185–189 (189).

[35] Moles, *Art et ordinateur,* 128.

[36] François Molnar, "L'ordinateur dans l'art et dans la science de l'art," in *Dossiers art plastique: L'ordinateur et les arts plastiques* (Paris, 1977), 56–74 (58).

[37] A. Michael Noll, "Human or Machine: A Subjective Comparison of Piet Mondrian's 'Composition with Lines' (1917) and a Computer-Generated Picture," *The Psychological Record* 16, no.1 (January 1966): 1–10. Whitney Davis offers a thorough discussion of the Mondrian stimulus – an image designed to resemble a Mondrian painting in order to test the viewer's response to abstract patterns – in the context of perceptual neuropsychology in "Binding and Unbinding the Mondrian Stimulus," *British Journal of Aesthetics* 58, no. 4 (October 2018): 449–467.

[38] Noll, "Human or Machine": 10.

[39] Ibid.: 9.

[40] Baby, *Le Système Molnar*, 182.

[41] F. Molnar, "L'ordinateur dans l'art et dans la science de l'art," 70.

[42] Ibid.

[43] Examples of these works figure in the catalogue raisonné published on the artist's website. See in particular 197444, 197445, 197446 (year 1974). http://www.veramolnar.com/diapo.php?y=1974 Accessed July 24, 2019. The connection between the illustrations published in François Molnar's article and the *Molndrian* series was confirmed by Galerie Oniris, Rennes (email to the author, July 26, 2019).

[44] F. Molnar, "L'ordinateur dans l'art et dans la science de l'art," 59.

[45] There is not enough space here to fully investigate the hypothesis that aesthetic invariants, to which Molnar alludes, could be traced to research in the physiological (neurological) aspects of perception. However, François Molnar had postulated, together with Morellet, the existence of an "organizing force," at the heart of human visual perception, to account for our ability to perceive abstract art as a certain arrangement of shapes, when these were "things not previously seen and known"; this force, whose existence we "must admit," would be informed by the physiology of our retina and its links to the cortex, as well as by broader factors, such as memory and emotions (F. Molnar and Morellet, "For a Progressive Abstract Art," 141).

[46] Moles, *Art et ordinateur*, 122 (emphasis in original).

[47] Ibid., 129.

[48] Ibid., 130.

[49] Karl Otto Götz, "Möglichkeiten und Grenzen der Informationstheorie bei der exakten Bildbeschreibung," (1967), in Hans Ronge, ed., *Kunst und Kybernetic* (Cologne, 1968), 183–192. This distinction, which so univocally situates the Raster Pictures outside the artistic sphere, needs to be nuanced. See Aline Guillermet, "K. O. Götz's Electronic Kinetic Painting and the Imagined Affordance of Television," *Media Theory* 3, no.1 (2019). URL: http://mediatheoryjournal.org/aline-guillermet-k-o-gotzs-kinetic-electronic-painting/ Accessed July 28, 2019.

[50] If the use of cathode ray tube (CRT) screen was first developed by the U.S. military in the late 1940s, and most notably in the 1950s with the development of the SAGE (Semi-Automatic Ground Environment), interactive technologies of visualization did not filter into U.S. research institutions until the 1960s, and, in the case of Orsay, the end of the decade. See Arthur L. Norberg and Judy E. O'Neill, with contributions by Kerry J. Freedman, *Transforming Computer Technology: Information Processing for the Pentagon, 1962–1986* (Baltimore, 1996), 119–152.

[51] Molnar, "Toward Aesthetic Guidelines": 187.

[52] Moles, *Art et Ordinateur*, 15.

[53] Molnar, "Toward Aesthetic Guidelines": 187–188.

[54] Vera Molnar, "Un Moment éphémère de certitude," (1980), unpublished, unpaginated. A PDF is available on the artist's website: http://www.veramolnar.com/?cat=8. Accessed July 28, 2018.

[55] Vera Molnar, "Léonard de Vinci, s'il eut eu un ordinateur…" (1981), unpublished, unpaginated. A PDF is available on the artist's website at: http://www.veramolnar.com/?cat=8. Accessed July 28, 2018. (My translation follows the French convention of using the masculine as default gender).

[56] Molnar, "Léonard de Vinci, s'il eut eu un ordinateur…"

[57] Depending on the type of plotting table, some versions of the work are presented on separate pieces of paper and framed individually, while others are plotted continuously on a paper roll.

[58] Vera Molnar, "'My Mother's Letters': Simulation by Computer," *Leonardo* 28, no. 3 (1995): 167–170 (167).

[59] Molnar, "Un Moment éphémère de certitude."

[60] Quoted in Douglas Davis, *Art and the Future: A History-Prophecy of the Collaboration Between Science, Technology and Art* (London, 1973), 135.

[61] Isabelle Ewig, "Paul Klee Hat Mich," in *Véra Molnar. Une rétrospective*, 36–47 (40).

[62] Braun to the author, 2017.

[63] Ewig, "Paul Klee Hat Mich," 40.

[64] Nelson Goodman, *Languages of Art: An Approach to a Theory of Symbols*, 2nd edition, (Indianapolis, 1976), 113–15.

[65] Ibid., 118.

[66] Ibid.

[67] According to Molnar, the introduction of disorder in this series was a willful attempt at "composing badly" ("My Mother's Letters": 169.)

[68] Goodman, *Languages of Art*, 195.

[69] Meredith Hoy, *From Point to Pixel: A Genealogy of Digital Aesthetics* (Hanover, New Hampshire, 2017), 77.

[70] Ibid., 78, 80.

[71] The argument, which drives Hoy's book, that painting anticipates a digital logic was first developed by Whitney Davis in his "How to Make Analogies in a Digital Age," *October* 177 (Summer 2006): 71–98.

[72] Bense, "The Projects of Generative Aesthetics," 60. The German is even more explicit in linking aleatory procedures with human intuition: Bense speaks of the computer's possibilities to produce "stochastic, intuitive […] aesthetic structures" (*(stochastischer, intuitiver) […] ästhetischer strukturen*), but this does not appear in the English translation. See Bense, "projekte generativer ästhetik."

[73] Frieder Nake, "Notes on the Programming of Computer Graphics," in Jasia Reichardt, ed., *Cybernetic Serendipity: The Computer and the Arts* (London, 1968), 77–78 (77); Frieder Nake, *Ästhetik als Informationsverarbeitung* (Vienna, 1974).

[74] Molnar, "Description du programme 'Molnart.'"

[75] Ibid.

[76] Molnar, "Léonard de Vinci, s'il eut eu un ordinateur…".

[77] Vera Molnar, *Journal Intime*, vol. 2, 1 July 1984.

[78] Erwin Steller, "Les Lignes continues de Véra Molnar," in *Véra Molnar. Une rétrospective*, 67–78 (67).

[79] Steller, *Computer und Kunst*, 59.

[80] Charlotte Guichard, "Signatures, Authorship and Autographie in Eighteenth Century French Painting," *Art History* 41, no. 2 (April 2018): 266–91 (269). I thank Sophie Cras for bringing Guichard's work to my attention.

[81] Isabelle Graw, "The Economy of Painting: Notes on the Vitality of a Success Medium and the Value of Liveliness," in Manuela Ammer, Achim Hochdörfer, and David Joselit, eds., *Painting 2.0: Expression in the Information Age* (Munich, 2016), 260–61 (260).

[82] Isabelle Graw, "The Value of Liveliness: Painting as an Index of Agency in the New Economy," in Isabelle Graw and Ewa Lajer-Burcharth, eds., *Painting Beyond Itself: The Medium in the Post-Medium Condition* (Berlin, 2016), 79–101 (93). This is an expanded version of the text quoted in note 81.

[83] Ibid., 96.

[84] Moles, *Information Theory and Esthetic Perception*, 129.

[85] Meyer Schapiro, "Mondrian: Order and Randomness in Abstract Painting," in Meyer Schapiro, *Modern Art, 19th and 20th Centuries: Selected Papers* (New York, 1979), 253.

[86] Davis, "Binding and Unbinding the Mondrian Stimulus": 464.

[87] Colette S. Bangert and Charles J. Bangert, "Experiences in Making Drawings by Computer and by Hand," *Leonardo* 7, no. 4 (Autumn 1974): 289–296 (290).

[88] Molnar, "My Mother's Letters," 167.

[89] The reference to Klee is meaningful in several ways. First, it was a comparison between Molnar's computer-generated production and his drawings that prompted Molnar's first experiments with mechanized autographicity. Moreover, Molnar produced a series of hand-made and computer-plotted works directly inspired by Klee's *Variationen* (*Progressives Motiv*) (*Variations (Progressive Motif*) (1927) entitled *A la recherche de Paul Klee* (*Searching for Paul Klee*) (1970–71). See Ewig, "Paul Klee Hat Mich," and Vera Molnar, "Auf der Suche nach Paul Klee," in Ulrike Lehmann, ed., *Vera Molnar: Als das Quadrat noch ein Quadrat war…* exh. cat., (Bielefeld, 2004), 114–115.

[90] Tamara Trodd, *The Art of Mechanical Reproduction: Technology and Aesthetics from Duchamp to the Digital* (Chicago, 2015), 36.

[91] Trodd, *The Art of Mechanical Reproduction*, 37.

[92] W. J. T. Mitchell, "Four fundamental concepts of image science," in James Elkins, ed., *Visual Literacy* (New York, 2007), 14–21 (16).

[93] Both Graw and Mitchell also use the term "ghostly" in their argument.