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Mathematics as Motive, Means and Method in Art: An Example

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> A long time ago when I was reading about the philosophy of science, I found the theory of models in the sciences interesting because, according to that, there were models which were tests and models which were illustrations. For me, an artwork must involve a test. Art that doesn't work in this context consists of illustrations of what art might be. (Joseph Kosuth)[1]

Ⅰ. Preliminary Remarks

1. A Note on "Author = Artist"

It could be argued that it is sort of infamous to be the promoter of one's own work. This potential objection shall be replied with a quote from Brian Eno:

> There is a terrible prejudice in the arts against articulacy actually. There is a sort of suspicion of, if people can talk well or think about their work they couldn't be proper artists; because artists are supposed to be sort of passionate inarticulate people who dredge things from this sort of primitive centre of their being.[2]

Regarding potential suspicion of bias it should be noted that firstly, this article gives insight into the artist's reflection process and secondly, the author – in her capacity as mathematician – can ensure adequate objectivity.

2. Art as Way of Knowing

1 Stuart Morgan, "Art as Idea as Idea. Interview with Joseph Kosuth," *Frieze* 16 (May 1994), from http://www.frieze.com/issue/article/art_as_idea_as_idea/(accessed November 15, 2014).

2 In an interview broadcasted on TV: "Brian Eno in Conversation" *Artscape, ABC HD, Australia*, 2009-07-21, 10 pm AEST, available at https://www.youtube.com/watch?v=Ywxo4dOHUPE, minute 3:50 ff (accessed November 18, 2014).

In 2011 a conference on the subject of "art as a way of knowing"[3] took place in San Francisco. Amongst others, artist and theorist Simon Penny pointed out that "some of our most important insights and understandings are not transmissible through text or symbol" and that "art is humankind's evolved cultural tool for grappling with ideas and understandings"[4] ; and Alva Noë, philosopher from Berkeley, California, argued for art as a means "to help frame problems and to provoke thought."[5] Art offers diverse and unusual forms of inquiry and an artistic approach may provide new insights regarding unanswered questions. The art project introduced here is an example.

II. The Intertwinement of Mathematics and Art

1. A Description of the Artworks

The art project comprises of a series of sculptural paintings or reliefs, that is, the canvas' plane extends into space in a certain way. Photographs can merely capture this three-dimensional quality. Nevertheless two images and four pictures of details (see Figs. 1 to 6) are provided for a better understanding. Additionally a short explanation is given in what follows.

The series of works can be considered a variation on a theme. There are two versions: some paintings appear to present a pattern of cavity-like cuts in the surface (e.g. Fig. 1) – like holes in a solid material; some appear to manifest a pattern of bumps (e.g. Fig. 2). With a closer look these "cuts"(Fig. 6) could be identified as a funnel-like local reverse buckling of the canvas' fabric or what the artist calls "intrusions." The "bumps" (Figs. 3-5) resemble bud-like bulges

3 Marina McDougall, Bevan Brown and Robert Semper, "Art as a Way of Knowing. San Francisco March 3+4, 2011, Conference Report," http://www.exploratorium.edu/knowing/pdfs/ConferenceReport.pdf (accessed November 15, 2014).

4 Ibid., p. 12.

5 Ibid., p. 13.

or what the artist calls “protrusions.” A closer examination also reveals “parallel” thin lines at each intrusion/protrusion that extend the entire length (or width respectively) of the canvas. The paintings are colored in a way that gives most of them a “natural” (wooden, metallic, stone- or even skin-like) appearance. Some have a soft powdery surface, some look heavy and solid. The pattern of intrusions/protrusions appears to be randomly distributed though there seems to be a cluster, a denser occurrence somewhere in the middle.

Fig. 1 C. Gröbner, 33-v: 16 Intrusions, acrylic on constructed cotton, 110 x 80 cm, 2014, collection of the artist

Fig. 2 C. Gröbner, 22: 77 Protrusions, acrylic and pastel chalk powder on constructed cotton, 200 x 140 cm, 2011, collection of the artist

Fig. 3 22: 77 Protrusions (detail: 6 protrusions, lateral view)

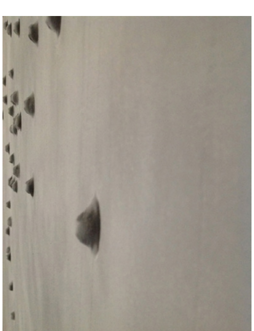

Fig. 4 22: 77 Protrusions (detail: lateral view)

Fig. 5 22: 77 Protrusions (detail: one protrusion)

Fig. 6 33-v: 16 Intrusions (detail: 2 intrusions)

2. An Account of the Manufacturing Process

Before starting with the analytical part we want to provide an account of the manufacturing process not just in order to shed further light on what a potential beholder might be facing but mainly because this process will be discussed in detail in the subsequent part.

In the beginning a decision is made regarding the scale of the painting and, dependent on that, the number N of local deformations that shall be displayed as well as their planned spatial extent S. A random number generator is then used to generate N pairs of numbers.[6] These are 2d scatter-plotted(for verification reasons at a later date) and translated into x/y-coordinates, i.e., recalculated according to the scale of the painting and printed as a list output.

A rectangular piece of cotton fabric is cut to a size that exceeds the scale of the planned painting in width and length allowing for a margin (that will later be turned around the wooden stretcher frame) plus an additional length of N times twice the chosen spatial extent S in length. According to the list of x/y-coordinates the fabric is marked with a pencil. Each y-coordinate is translated into a "column" (two parallel lines with width W) extending the full length of the fabric, the corresponding x-coordinate marks a position in the respective column where a crossed square with length W is drawn. The final marked fabric now displays a pattern of parallel lines with crossed squares.

Afterwards, a sewing machine comes into play: at each column the fabric is folded so that the two parallel lines are on top of each other. Then the fold is sewn along this folded line while at the marked cross the seam runs along a jagged line in the case of future intrusions or a wave-shaped line in case of future protrusions, respectively. In so doing each fold will feature an "opening"

6 To be more precise, MATLAB's "multivariate normal random numbers" function with standard input parameters is used. The function will return N random number-pairs that are chosen from the standard bivariate normal distribution - but more on that later.

at the corresponding x-mark. This "constructed" fabric is eventually mounted on a wooden stretcher frame.

Depending on the direction of canvas "extension" the procedure continues as follows. *Backward*: Each fold is pulled back at the bottom of its "opening" by means of a thin wire, or to be more precise, the wire is pushed through the jagged line's apex and then strained and fixed to the stretcher frame. *Forward*: Each fold is turned inside out (i.e. pushed from the back to the front) at its "opening" and wadded with cotton. Both versions spawn local deformations of the canvas' surface. This constructed canvas is finally primed and colored with several layers of acrylic paint in different dilutions and different tones of grey. The painting process itself is executed rather mechanic, meaning "without thinking." There are no considerations like "this shade, this tone evokes certain associations to XYZ" with XYZ being some particular observed thing. If anything it is a covering, a coating of the canvas surface, fueled by intuition.

3. A Fictitous Conversation

In the following dialogue a fictitious questioner "Q" converses with the artist "A" about her motives and the different levels on which mathematics affects her art project.

Q: *You claim that your art project is a meditation on the principle of mathematical modeling. A mathematical model is "a mathematical construct which, with the addition of certain verbal interpretations, describes observed phenomena,"*[7] *as John von Neumann puts it, or in more technical terms: a mathematical model is a conglomerate of functions that is fed with some certain parameters and returns any numbers. What do you mean when you say "principle"?*

7 Cited in Derek Abbott, "The Reasonable Ineffectiveness of Mathematics," *Proceedings of the IEEE* 101:10 (October 2013), p. 2151.

A: What I call the "principle of mathematical modeling" is simply the fact that mathematical models are used as a means to describe and simulate observed phenomena and moreover to predict a future behavior. However, the parameters you talked about depend on the properties of the observed phenomenon that is supposed to be simulated and the resulting numbers need an interpretation, as you quoted von Neumann. While the mathematics inside these models may be ideal and true, the interpretation part and above all the parameters derived from observations may lack accuracy and adequacy.

Q: *Can you give an example?*

A: Take the financial market. There is a model called "Black-Scholes" that simulates option prices. This model and its input parameters are based on certain assumptions, for instance regarding the market behavior, people's risk aversions, price patterns; and these assumptions are of course an idealization of real observations. It may be self-evident that the prices this model calculates are artificial and biased. But there are decisions made that base on these prices. What do we conclude from this?

Q: *There is an observed phenomenon, a mathematical model that predicts a future "version" of that phenomenon and some entity that acts depending on this prediction – the future observable phenomenon may be different due to that action?*

A: Correct. And, for instance, Donald MacKenzie has shown this for Black-Scholes.[8] One can argue that mathematical models affect the world; they are performative, in terms of "they have effects; they make differences; they enact realities; and they can help to bring into being what they also" simulate.[9] This performativity aspect interests me, and that's why I investigate the performativity of the normal distribution.

8 Donald MacKenzie, "Is Economics Performative? Option Theory and the Construction of Derivatives Markets," *Journal of the History of Economic Thought* 28:1(2006), pp. 29-55.
9 John Law and John Urry, "Enacting the Social," *Economy and Society* 33:3 (2004), p.393.

Q: *Let me give some explanations for the gentle reader. The normal distribution is an important function in probability theory and statistics that describes a certain distribution of random variables (the mathematical expression for uncertain events, if you will). The graph of its density function is the so-called bell curve– you may recall that one from school. Normal distributed random variables cluster around a mean and spread out with increasing distance; the "variance" is a measure for the latter, it defines the "fatness" of the bell. "The normal distribution was originally called error law,"*[10] *and for example "imported into social science by Adolphe Quetelet,"*[11] *who thought of it as "ubiquitous,"*[12] *found in "measurements of the human body, crime, marriage, suicide."*[13]

A: And in finance, for example, changes in the logarithm of price rates are often modeled as normal distributed, which means the so called "assumption of normal distribution" – which is one of the assumptions of Black-Scholes we talked about earlier – is applied.

Q: *There are so many different observed phenomena that appear to be normal distributed that – let me quote the French physicist Gabriel Lippmann here, "everyone believes in [it]: experimentalists believing that it is a mathematical theorem, mathematicians believing that it is an empirical fact."*[14]

A: But it is neither nor and its application has been and still is controversially discussed.[15] For me the basic difficulty here is the

10 Ian Stewart, *Does God Play Dice? The New Mathematics of Chaos* (London: Penguin Books, 1997), p. 40.
11 Ibid.
12 Alex Bellos, *Here's looking at Euclid* (New York: Free Press, 2010), p. 252.
13 Stewart, p. 41.
14 In a letter to Henry Poincaré, as told and recited in Bellos, p. 265.
15 To name but a few: Karl Pearson, "'Das Fehlergesetz und Seine Verallgemeinerungen durch Fechner und Pearson.'A Rejoinder,"*Biometrika* 4:1-2 (June 1905), pp. 169-212; Aidan Lyon, "Why Are Normal Distributions Normal?," *The British Journal for the Philosophy of Science* (forthcoming) http://aidanlyon.com/papers/Lyon-normal_distributions.pdf (accessed November 15, 2014); Nassim N. Taleb, *The Black Swan: The Impact of the Highly Improbable* (New York: Random House, 2007).

dichotomy between apparently ideal, independent eternal true, immaculate mathematics and our experienced "reality."

Q: *So this is what motivated you to, in your words, "meditate on the principle of mathematical modeling by means of exploring the performativity of the normal distribution." Now what exactly do you do?*

A: Let's take a look again at mathematical modeling from a mechanistic or machinistic perspective. The observed phenomenon is in a broader sense the input for sort of a machine that outputs an imitation of this phenomenon. What happens, when we let the machine run without input? This is to say, what, if we let the ideal, independent eternal true and immaculate mathematics in this machine speak for itself? What type of machine would that be? This is where art comes in. I displace this function out of its usual mathematics setting to an art setting. Think Duchamp: when he displaced this urinal from some store for sanitary installations to an art context, he created all sorts of questions. With such a displacement, you sort of cut the old connections and it can be surprising what new connections establish. So for my machine I use the standard bivariate normal distribution, which you can imagine visually as the bell curve rotated around its line of symmetry, thus, a bell. My machine, however, has no observed phenomenon as input; there is only the abstract mathematical function…

Q: *... but there is an output – the sculptural paintings; and the machine's processing equals the procedure of their creation. Let us talk about this manufacturing process. This step-by-step procedure – from the sampling of numbers to their recalculation into coordinates to markings on cotton fabric to local deformations of the canvas to the final painting – is an algorithm.*

A: I argue that it is more than just that. It is the successive displacement of the normal distribution; it is a chain of translations. Michel Callon emphasizes that translations – concomitant to being displacements –

have another quality, that "to translate is also to express in one's own language what others say."[16] To put it differently, the output of translation is a representative, a "spokesman"[17] for the input of translation. – In my manufacturing there is a continuity of displacements: an incorporeal formula is translated into abstract number pairs (as bits and bytes in a computer, then as unit-less dots on paper), these are translated into actual coordinates (numerals with a unit of length, and numbers on paper), these are translated into marks (lines and crosses drawn with a pencil on fabric), these are translated into local deformations of a canvas (sewn folds with "openings"). At the same time, "formula language" is translated into "numeral language" is translated into "construction language" is translated into "canvas language" (yes, these canvasses speak; they are not just supports for some paint). What is interesting is that the creation process remains within the realm of technique and construction (of formulae, numbers, lines, marks) up to the point where the local deformation is fixed (by wire or cotton, respectively). Then it sort of passes a threshold and resides in the realm of nature; as if the deformed canvas' voice had an organic timbre.

Q: *Does this mean, at this point, the translation is interrupted? That the representativity, the baton – to speak in terms of a relay race – is not passed to the next runner, the coloring?*

A: Referring to Callon once more, one could argue that at this point a "controversy"[18] emerges and with the next step of coloring, the "translation becomes treason."[19] The emerging organic quality is emphasized with the painting technique from which a naturally looking surface results that conceals the mathematical and technical construction.

16 Michel Callon, "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay," in *Power, Action and Belief: A New Sociology of Knowledge*, ed. John Law (London: Routledge & Kegan Paul Books, 1987), p. 222.

17 Ibid.

18 Callon, p. 219.

19 Ibid.

Q: *Sounds like you were a mere marionette, the puppeteer holding the strings being this mathematical object "normal distribution" that tries to actualize itself. Could mathematics be one of those higher beings to which Sigmar Polke ironically refers to?*[20] *Could it even be that your work addresses this age-old question "Why does nature appear to follow mathematical laws?"*

A: It is up to you what you want to read from it. I'd rather think in Deleuzian terms of "the virtual" unfolding via "progressive differentiation" to "the actual"; there is no creator, there is only "becoming."[21] And I prefer to take the view of actor-network-theory[22] that does not discriminate between human and nonhuman "actors."[23] Well, I am all for digging deeper into these social and ontological aspects, but aren't we supposed to discuss mathematical issues?

Q: *Then let us stop here and return to the question of performativity. You said, in your "machine there is no observed phenomenon as input, only the abstract mathematical function."*

A: Yes. This means, the "machine" does not reference any antetype. It does not try to imitate any observed phenomenon. One could say the manufacturing process begins in an abstract ideal space that is free of representations of reality or concrete things, the space of pure mathematics. One inhabitant of this space is the normal distribution, an "idea" of some ideal distribution with certain characteristics. This "idea" inscribes itself as a formula and an algorithm with which one can generate representatives of it – random number-pairs that underlie a normal distribution that

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20 Sigmar Polke's famous painting *Höhere Wesen befahlen: rechte obere Ecke schwarz malen!* (1969) roughly translated to "Higher Beings commanded: paint top right corner black!"

21 Manuel De Landa, *Intensive Science & Virtual Philosophy* (London and New York: Continuum, 2002).

22 A good introduction provides Bruno Latour, *Reassembling the Social – An introduction to Actor-Network-Theory* (Oxford: Oxford University Press, 2005).

23 Jim Johnson (alias Bruno Latour), "Mixing Humans and Nonhumans Together: The Sociology of a Door-Closer," *Social Problems* 35:3 Special Issue: The Sociology of Science and Technology (1988), p. 303.

are still abstract in the sense of without unit, they don't reference a "real measured thing." But they visualize the formula, there is a plot, you can see representative points on a paper. Then comes the coordinates with a unit of length, inscribed as a list on paper; then the markings inscribed to the fabric by pencil; the pocket-like "openings" in cotton fabric inscribed by sewing folds in a certain way; eventually the local deformations inscribed to the canvas by fixation. One could say that this "idea" of a normal distribution has successively enacted reality (which is the formation of local deformations); it brought "structures [...] into existence."[24] But this "idea" not only has become manifest in the canvas – a transition occurs…

Q: *…you called this a "controversy" before…*

A: …and again using Callon's metaphors, these local deformations "refuse" to be just that, representatives of normal distributed spots. They become "dissidents." This organic quality emerges, the local deformations start to represent something organic; they do not stick to their designated "role," do not abide by the agreement *just visualize me*. And they form an "alliance" with the color. The color is the "traitor" that sees to it that the whole sculptural painting is *not just a visualization* of normal distributed spots. "The translation continues but the equilibrium has been modified."[25] The painting as a whole is reminiscent to something experienced, observed, something actual; but, of course, the pattern displayed still represents realizations of a bivariate normal distribution. That is why the betrayal is not entire.

Q: *And now what about the performativity?*

A: Take a look at the diagrams I have prepared here:

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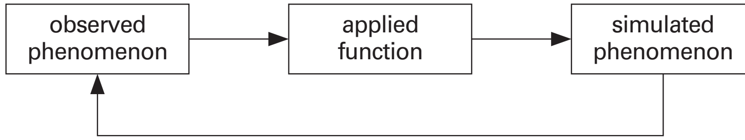
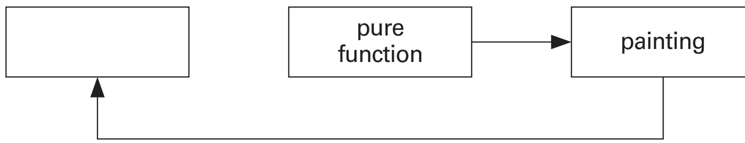
24 Karl Weick, "Enacted Sensemaking in Crisis Situations," *Journal of Management Studies* 25:4 (1988), p. 306.

25 Callon, pp. 222-224



performativity of mathematical models



exploration of performativity of normal distribution

To repeat, the principle of mathematical modeling in general provides a potentiality for performativity, the model can affect the origin, a feedback occurs, so to speak. Now within my exploration, there is also sort of a back reference; a reference to something organic, natural, actual. But there was no origin. So, "why should there be anything at all?"[26] I claim therefore that the normal distribution – via a chain of translations that culminates in a treason which is turned into a sort of collaboration – is performative. But of course, that is my reading.

Q: *Okay. – Having now exhaustively discussed your motives and your working process I would like to address your work as a series. Every painting is different; in color or scale or number and/or size of deformations.*

A: The series is like an iteration of the algorithm that produces one painting and I sort of test this algorithm, this "machine," with different parameters or reset parameters if the test fails.

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26 Bernard J. F. Lonergan, *Understanding and Being: The Halifax Lectures on Insight: An Introduction and Companion to Insight (Collected Works of Bernard Lonergan)* (Toronto: University of Toronto Press, 2nd ed., 1990), p. 244. This is a reformulation of Leibniz' "pourquoi il y a plus tôt quelque chose que rien?" from *Principes de la nature et de la grâce fondé en raison (§7, 1714)* (Paris: Presses Universitaires de France, 5th ed., 2002), p. 45.

Q: *What are the criteria for a positive or negative test result?*

A: Such a painting has to balance or equilibrate its constructive and its intuitive origin. Else it does not make sense for me and then I have to either repaint or destroy it.

Q: *This "principle of seriality" that you work with, a sort of scientific approach, is of course a well known principle in art, especially with artists of the 60ies era, think of Josef Albers' series "Homage to the Square," or conceptual artist Joseph Kosuth's "Freud" series and many more…*

A: …now why do you think is there this quote at the beginning of this article?

Q: *Point taken. – Now let us talk for a moment about another aspect of your work: chance as composing element. The local deformations on your canvases are randomly positioned, but their distribution still follows a certain rule. It reminds me of Ellsworth Kelly's painting "Seine" that is composed of hundreds of black and white squares. Their location on the painting also depends on a probability distribution, one that Kelly "invented": he drew tiny numbered notes from a box thereby following a rule he had framed.*[27]

A: I know this work and its history. Recently I even read online about a talk some physicist gave at the University of Pennsylvania in 2011. He related the painting to a statistical physics model called "gradient percolation."[28] One could say the way Kelly generated chance is the antetype for a mathematical model. In any event, Kelly used "analog technique," but his method veers

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27 Yve-Alain Bois, Jack Cowart and Alfred Pacquement. *Ellsworth Kelly: The Years in France, 1948-1954* (Washington, DC: National Gallery of Art, 1992), p. 43.

28 Bryan Gin-ge Chen's talk on "The River Banks of Ellsworth Kelly's Seine," University of Pennsylvania, Arts and Sciences, Department of Physics and Astronomy, May 2011, from http://www.sas.upenn.edu/~chb/kelly/chen_bryan_artofresearch.pdf (accessed November 15, 2014).

towards calculated chance. Still, what is definitely different to my work is: Kelly used chance to compose the image of an observation he had made. This is basically an example for the principle of mathematical modeling.

Q: *The use of random number generators for chance production is naturally a specialty in computer art where it is oftentimes used for composition. It substitutes the intuition of the human artist, as Herbert W. Franke pointed out.*[29]

A: I agree. Between you and me…I think the "cyber-intuition" of the normal distribution is better than mine. Nevertheless, one must not forget that random number generators produce pseudo-random numbers as they use a determinate mathematical algorithm. There is no tiny person sitting in a computer that rolls the dice.

Q: *Obviously; and the subject chance or randomness is a matter of its own that would fill a whole book.*[30] *Let us talk about another more obvious feature of your works – their three-dimensionality. The paintings with intrusions undeniably resemble Lucio Fontana's series "Concetto Spaziale: Attese."*

A: I know! Who would have thought?

Q: *There is a mathematical aspect in Fontana's works. Already in 1946 the "manifesto blanco" stipulated a new four-dimensional art.*

A: The reaching-out-into-the-third-dimension-from-the-canvas-plane has definitely a mathematical connotation: topology and the concept of two-dimensional manifolds or surfaces. Now above all the difference between Fontana's and my paintings is: he constructs space by puncturing or cutting

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29 Herbert W. Franke and Kunstverein München, *Impulse Computerkunst – Ausstellungskatalog* (München: Kunstverein München, 1970), p. 19.

30 e.g. Peter Gendolla and Thomas Kamphusmann, ed. *Die Künste des Zufalls* (Frankfurt am Main: Suhrkamp, 1999).

the plane, by creating a passage, a non-compact surface; my surfaces are not ruptured, they are deformed in a broader sense; my new constructed surfaces are still two-dimensional "closed" manifolds; only they are not flat anymore but sort of unfold themselves in space. My work is less about creating space and more about the original function leaving an imprint in the canvas. Then again, this topological angle of my works meshes nicely with the overall mathematical theme. Apart from that, Fontana's action was an expression of his desire to overcome the limits of the canvas plain surface. He was an innovator.

Q: *Talking about innovators, are you familiar with William Anastasi's "Drop Drawing" series? Don't they give the impression of a normal distribution?*

A: I know them. There is at least one titled "No Breath, No Bother" and if you contemplate this title and consider Anastasi's other works, it is obvious that there is no mathematics used here. Nevertheless there seems to be a similarity to a normal distribution, I agree. It could be interesting to locate all those spots and test on normality. Maybe I will do that some day.

Q: *But if the test result was positive, one could be tempted to say: Mr. Anastasi is the vehicle that ideal mathematics uses to free ride to our actualized world. – Let us now conclude with an artist that, like you, meditated on a mathematical principle, Mario Merz and his passion for the Fibonacci numbers.*

A: The Fibonacci sequence is indeed derived from a pretty simple recurrence relation and that this sequence is intimately connected to the golden ratio is meanwhile a matter of common knowledge. Merz' representations of the growth pattern or the illustrations of the number sequence are rather figurative. In regard to my work, I think along different lines, but I can appreciate his passion.

Q: *Thank you for the discussion!*

Keywords

Mathematical Modeling(수학적 모델), Normal Distribution(정상분배), Performativity(수행성), Sculptural Paintings(조각회화), Translation(번역)

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Mathematics as Motive, Means and Method in Art: An Example

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The paper at hand reflects on the intertwinement of mathematics and art using the example of the author's art project: a meditation on the principle of mathematical modeling by means of exploring the performativity of the normal distribution. The article comprises of a description of the artworks, an account of their manufacturing process and an analysis of the mathematical aspects in both the artworks themselves and their genesis. The analysis part is presented in form of a dialogue between a fictitious questioner and the artist. It embraces the artist's motives and the different levels on which mathematics comes into play. Referring to actor-network-theorist Michel Callon the production process will be delineated as a chain of "translations" where the artwork by and by becomes the "spokesman" of a mathematical formula, however, in the end commits treason. The analysis part is rounded out with a brief discussion of artists that employ mathematics.

예술에 있어서의 동기, 수단, 방법으로서의 수학

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저자는 자신의 작업을 중심으로 수학과 미술의 연결고리, 즉 정상분배의 수행성을 탐구하는 수단으로서 수학적 모델의 원리를 고찰한다. 본 논문은 자신의 작업과 제작과정 에 대한 기술과 작업과 제작과정 모두에 작용하는 수학적 측면에 대한 분석으로 구성되어 있다. 분석의 부분은 작가 자신과 가상의 질의자 간의 문답 형식으로 제시되고, 작가의 동기와 수학이 작업과정에 작용하는 상이한 면들을 포괄하여 진행된다. 행위자 연결망 이론가인 미셸 칼론의 이론에 따라 제작과정은 '번역'의 연쇄망으로 기술될 것이며, 예술작품이 점점 수학적 공식의 대변인이 되지만 결국 전복하는 과정을 보여준다. 이 분석 부분은 수학을 사용하는 작가들의 간략한 토론으로 마무리된다.