William Wegman
Dog Duet, (still) 1975–1976
Videotape with sound
Duration: 2 minutes, 38 seconds
Courtesy the artist

Appendix A: Simplicity, in Mathematics and in Art

Allyn Jackson

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Simplicity is as hard to pinpoint in mathematics as it is in art. Certainly both subjects have their great exemplars of the quality. But is there a definition of simplicity? A criterion? A measure? Or a sure path to it? These kinds of questions were in the air at a conference called Simplicity: Ideals of Practice in Mathematics and the Arts, which took place at the Graduate Center of the City University of New York in early April 2013. Instead of trying to definitively answer such questions—surely a doomed prospect anyway—the participants gave in to the sheer joy of discussion in the stimulating atmosphere of each other's company. The conference featured lectures and panel discussions by an eclectic group of twenty-five artists, architects, art historians, mathematicians, and mathematically inclined philosophers, as well as a film program. The audience included academics from nearby institutions and local artists; as the conference offered easy and free online registration, a random smattering of folks wandered in out of curiosity.

Not an Absolute Notion

Simplicity often seems to be a timeless, absolute quality, and for good reason. Peter Sarnak, Institute for Advanced Study and Princeton University, offered Euclid's proof of the infinitude of primes as simplicity par excellence. The stark elegance of this ancient proof is as striking today as it must have been to people encountering

A. Jackson (✉)
Notices of the American Mathematical Society, Providence, RI, USA
e-mail: axj@ams.org

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it through the millennia. Of course, the proof is an exemplar of simplicity, not a definition. Indeed, Curtis Franks, University of Notre Dame, argued against the possibility of ever establishing for all time an absolute notion of simplicity. What we think of as simple emerges from conventions that are deeply embedded in how we live and how we see the world, and they have a long genetic history. "Our thinking occurs within those conventions," he said. "There is not really a way out of them." As conventions evolve, so do notions of simplicity. Franks mentioned Gauss's 1831 paper that established the respectability of complex numbers. The problem Gauss was working on—concerning quadratic and biquadratic residues—had only unsatisfyingly complicated and piecemeal solutions over $\mathbb{Z}$. Over $\mathbb{C}$, a far simpler solution emerged. The complex numbers revealed simplicity where previously there had seemed to be none. Mathematics is not engaged in a straightforward march toward absolute simplicity. Rather, by discovering simplicity anew, Franks said, "We will be more awake to the changing landscape of mathematical thought." He noted a parallel in art, where something new—like the work of Andy Warhol or Marcel Duchamp—acts as a sort of "shock treatment" that compels a new perspective. Several conference speakers mentioned the art of Fred Sandback, who used taut lengths of yarn to represent outlines of three-dimensional shapes. In photos, the works look unimpressive; as philosopher Juliet Floyd, Boston University, noted, they are "unphotographable". But walking around and through the constructions, she found them to be "extremely moving objects". Finnish architect Juhani Pallasmaa described how a Sandback construction, merely "a few lines stretched in space", sets off a chain reaction in the viewer's mind, causing the viewer to see figures of specific material shapes, to feel their weight and texture. "The air inside the imaginary figure seems to get denser and to have a slightly different consistency from the air outside," he said. Simple constructions that hold much complexity and meaning: That's just what mathematicians seek in their work. Pallasmaa's erudite lecture contained many striking quotations, including this one of Balthus: "The more anonymous painting is, the more real it is." The same can be said for architecture, Pallasmaa stated. Could a similar statement be made for mathematics? Are there mathematical results that are so natural, so pristine that one cannot perceive the fingerprints of the mathematicians who discovered them? Perhaps one example would be the previously mentioned proof of the infinitude of primes, its attribution to Euclid notwithstanding. Perhaps others are found in what Paul Erdős famously called "proofs from the Book". Pallasmaa also quoted the philosopher Gaston Bachelard, who in his book *The Philosophy of No: A Philosophy of the New Scientific Mind*, stated that scientific thought "develops along a predestined path, from animism through realism, rationalism, and complex rationalism, to dialectical rationalism." Pallasmaa did not say that mathematics develops in this way; his point rather was that art aspires to develop in the opposite direction, from the rational back towards "a unifying, mythical, and animistic experience". Perhaps mathematics shuttles back and forth between the two endpoints.

Visceral Encounters

Bachelard's "predestined path" at times echoed through the conference in comments that seemed to derive from the misconception, common outside of mathematics, that the subject consists entirely of proofs, progressing inexorably from one logical step to the next. This misconception was vividly countered at various points during the conference. In an open microphone session, Blaise Heltai pointed out that mathematics and art are actually very similar in process: When you are thinking about a mathematical object, you are right inside the thing, trying to puzzle out its structure and secrets. You're not thinking about how to prove anything—that comes later. The puzzling-out resembles the conceptual part of doing art. Heltai has a special perspective, as he is a painter with a Ph.D. in mathematics; he makes a living as a management consultant. The kind of visceral encounter with mathematics that Heltai referred to emerged at various times, such as in the lecture of Dennis Sullivan, CUNY Graduate Center and Stony Brook University. When as a graduate student he was preparing for the preliminary examination, Sullivan studied John Milnor's book *Topology from the Differential Viewpoint*. Sullivan knew the book inside and out, every definition, every proof. The day before the exam, as he took a final glance through the book, it suddenly occurred to him that he could compress the contents into a single, simple picture. Moving back and forth across the stage, he used gesticulations to indicate a 2-sphere on one side, a 3-sphere on the other, and a "slinky" curve between them. This curve, representing the preimage of a regular value of a map from the 3-sphere to the 2-sphere, provided a mental image summarizing the Pontryagin-Thom construction. If one knows the language of manifolds and transversality, Sullivan claimed, one can reconstruct the whole theory of cobordism in differential topology just from the intuition conveyed by his slinky picture. This experience made him realize, "*That's* what it means to understand a piece of mathematics." The visceral component of mathematical work surely evokes strong feelings, but mathematicians usually do not discuss their feelings about their work, at least not in public lectures. In an earlier panel discussion, Riikka Stewen, Finnish Academy of Fine Arts, asked whether mathematicians have strong love/hate feelings about their work. "Yes, very strong feelings," came the immediate reply from a mathematician on the panel, Andrés Villaveces, National University of Colombia. There is a loneliness in the work of an artist, and much mathematical work shares this quality. Just as a painter faces an empty canvas, he said, "Mathematicians are up against the empty page every day." The longing, even desperation, that is implicit in the remarks of Villaveces also emerged in Sarnak's lecture, titled "Is there a place for 'ugly' mathematics?". Sarnak considered the situation where the only known route to a proof is ugly, in the sense of being strewn with long and complicated calculations and verifications. The question then becomes, How desperate are we for a proof? When Sarnak gave an example of an ugly calculation connected with a beautiful result in the theory of automorphic forms, Mikhail Gromov, Institut des Hautes Études Scientifiques and New York University, piped up to say: "Maybe the mathematics is fine, it's your mind that's

ugly." Then there was Gromov's lecture. A fish says: "You want to understand what water is? Jump in and find out." Instead of plunging in, you could study the chemical and physical properties of water. But without the experience of plunging into water, you have no frame in which to talk about what water really is. Similarly, when the experience of plunging into mathematics is absent, there is no frame in which to talk about what mathematics is—much less what simplicity in mathematics is. That's a verbose description of one moment that flashed by in an instant in Gromov's stream-of-consciousness lecture. He jumped into Descartes's timeless statement, "Cogito ergo sum [I think therefore I am]". The important thing here, Gromov said, is the *ergo*, the *therefore*. In a sense, dogs think: Much of what goes on in a human brain is very similar to what goes on in the brain of a dog. Surely dogs are. But dogs do not understand *ergo*. This *ergo* is a major source of the kind of thinking that is characteristic of humans, Gromov said. And yet, "it is completely hidden from us. And there is a good reason why it is hidden. If it surfaces, you die. You will not survive. It's against survival, it's against evolution, it's against [natural] selection." So it went. Gromov passed so quickly over so many topics, diving to the depths, all the while leavening the presentation with flashes of subversive humor. The effect was dizzying. Afterward, during the open microphone session, an audience member demanded a one-sentence summary—with an example. An impossible request to fulfill. Nevertheless it can be said that one of Gromov's main messages was: Guard against the delusion of false simplicity. Many things that we assume at first glance to be simple are in fact highly complex. After seeing Gromov's effervescent mind bubble over for 30 min, audience member Al Thaler, known to many for his long service at the National Science Foundation and now an adjunct faculty member at CUNY's Hunter College, commented, "I could never live like that."

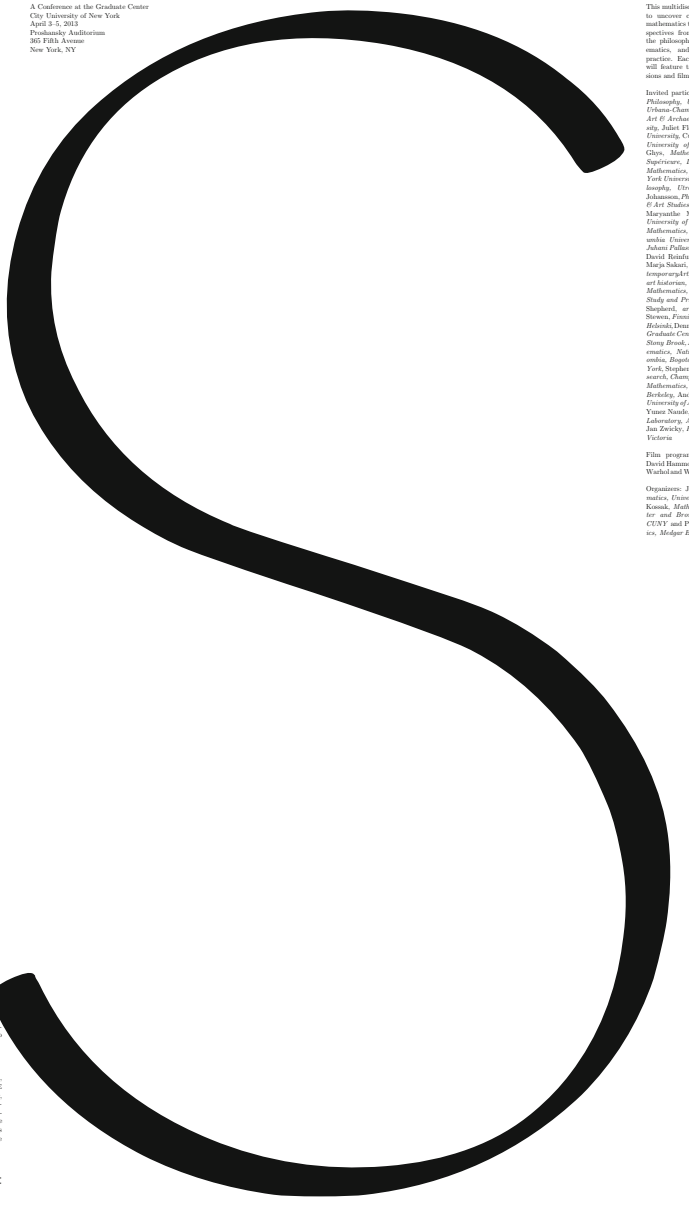
Contrasting Groups

The Simplicity conference was the brainchild of mathematician Juliette Kennedy, University of Helsinki, and two CUNY mathematicians, Roman Kossak of the Graduate Center and Philip Ording of Medgar Evers College. The conference was something of a follow-up to a 2007 symposium called Aesthetics and Mathematics, which took place in Utrecht and was organized by Kennedy and two University of Utrecht mathematicians, Rosalie Iemhoff and Albert Visser (Iemhoff was one of the lecturers at Simplicity). Participants in the 2007 symposium could drop in at an art exhibition at the Mondriaanhuis, Logic Unfettered—European and American Abstraction Now, which was curated by Kennedy. In addition to the film program at the Simplicity conference, there was an installation of a few works by artist Kate Shepherd in the lobby outside the hall where the lectures were given (Shepherd also participated in one of the panel discussions). But space constraints there, as well as the difficulty of securing exhibit space in New York City, meant that Simplicity offered few opportunities to experience art. As a result, art was represented mainly through the presence and words of the artists themselves.

By contrast, the mathematicians could actually present pieces of mathematics by using a computer and a beamer, or even just a blackboard, in the case of Sullivan. They tried mightily to avoid technical details, with imperfect success. Another contrast was socio-economic. As Kennedy pointed out in a panel discussion, the mathematicians and philosophers at the conference all work in academia, which provides economic security and social acceptability, while artists often lead far more precarious lives on the fringes of society. She noted the "heroic" efforts that many artists must put forth in order to carry out their work. What did each group absorb from the other? It's difficult to say. One participant observed that mathematicians tend to have a high opinion of themselves and their own knowledge and are therefore not so open to new ideas, while artists are pretty much the opposite: Receptiveness to impressions and influences from a wide variety of sources is the artist's lifeblood. One artist who attended Simplicity, Miyuki Tsushima, said she didn't follow all the details of the math lectures. She could simply sit and let the impressions wash over her as she made some sketches for her latest work. An inspiration for the conference was the so-called twenty-fourth problem of David Hilbert. This problem, which Hilbert considered adding to his famous list of twenty-three problems that he presented at the International Congress of Mathematicians in Paris in 1900, was unearthed by Rüdiger Thiele, University of Leipzig, from papers at the library of the University of Göttingen. Part of Hilbert's description of the problem reads: "Criteria of simplicity, or proof of the greatest simplicity of certain proofs. Develop a theory of the method of proof in mathematics in general. Under a given set of conditions there can be but one simplest proof" (translation by Thiele from his article "Hilbert's 24th Problem", American Mathematical Monthly, January 2003). Étienne Ghys, École Normale Supérieure de Lyon, pointed out the naiveté of imagining that such ultimate simplicity is possible. Yet, as the conference highlighted, simplicity as a dream, as an ideal, remains a powerful guiding light in mathematics and the arts. As Franks said, there are no absolute notions of simplicity. But do not relinquish the quest. "On the contrary, I want to say yes, find criteria for simplicity, continue to do so," said Franks. Don't imagine that the matter will ever be settled definitively; rather, "return to the task often."

Simplicity: *Ideals of Practice in Mathematics & the Arts*

A Conference at the Graduate Center
City University of New York
April 3–5, 2013
Proshansky Auditorium
365 Fifth Avenue
New York, NY



This multidisciplinary conference aims to uncover criteria of simplicity in mathematics that are informed by perspectives from art and architecture, the philosophy and history of mathematics, and current mathematical practice. Each day of this conference will feature talks, roundtable discussions and film screenings.

Invited participants: Andrew Arana, *Philosophy, University of Illinois at Urbana-Champaign*, Rachael DeLue, *Art & Archaeology, Princeton University*, Juliet Floyd, *Philosophy, Boston University*, Curtis Franks, *Philosophy, University of Notre Dame*, Etienne Ghys, *Mathematics, Ecole Normale Supérieure, Lyon*, Mikhael Gromov, *Mathematics, IHES, Paris and New York University*, Rosalie Iemhoff, *Philosophy, Utrecht University*, Hanna Johansson, *Philosophy, History, Culture & Art Studies, University of Helsinki*, Maryanthe Malliaris, *Mathematics, University of Chicago*, Dusa McDuff, *Mathematics, Barnard College, Columbia University*, Juhani Pallasmaa, *Juhani Pallasmaa Architects, Helsinki*, David Reinfurt, *designer, New York*, Marja Sakari, *Kiasma Museum of Contemporary Art, Helsinki*, Amy Sandback, *art historian, New York*, Peter Sarnak, *Mathematics, Institute for Advanced Study and Princeton University*, Kate Shepherd, *artist, New York*, Riikka Stewen, *Finnish Academy of Fine Arts, Helsinki*, Dennis Sullivan, *Mathematics, Graduate Center, CUNY and SUNY at Stony Brook*, Andrés Villaveces, *Mathematics, National University of Colombia, Bogotá*, Dan Walsh, *artist, New York*, Stephen Wolfram, *Wolfram Research, Champaign, IL*, Hugh Woodin, *Mathematics, University of California, Berkeley*, Andrea Worm, *Art History, University of Augsburg*, Norma Claudia Yunes Nunde, *Cognitive Neuroscience Laboratory, Aix-Marseille University*, Jan Zwicky, *Philosophy, University of Victoria*

Film program: Andy Goldsworthy, David Hammons, Richard Serra, Andy Warhol and William Wegman

Organizers: Juliette Kennedy, *Mathematics, University of Helsinki*, Roman Kossak, *Mathematics, Graduate Center and Bronx Community College, CUNY* and Philip Ording, *Mathematics, Medgar Evers College, CUNY*

Conference admission is free and open to the public, but registration is required. For more information and to register, please visit

http://www.s-i-m-p-l-i-c-i-t-y.org/

Sponsors: Clay Mathematics Institute, Finnish Cultural Foundation; FRAME Foundation, The Graduate Center, CUNY (Advanced Research Collaborative, Committee for Interdisciplinary Science Studies, Comparative Literature Program and Mathematics Program) and the National Science Foundation

THE GRADUATE CENTER CUNY

Clay Mathematics Institute

FRAME

David Reinfurt
Conference poster, 2013
Courtesy the artist

Appendix B: Conference Program

The conference "Simplicity: Ideals of Practice in Mathematics & the Arts" took place in the Proshansky Auditorium of the Graduate Center of the City University of New York over three days, April 3–5, 2013. This appendix documents the schedule of talks, abstracts, panels, arts programs, and acknowledgements. The names of the panelists are followed by some questions raised for discussion. Please note that participant affiliations and biographical information has not been updated. Additional materials, including video footage, are available on the conference website: http://s-i-m-p-l-i-c-i-t-y.org/

Wednesday, April 3

MORNING SESSION

Étienne Ghys, École Normale Supérieure, Lyon.
Inner simplicity vs. outer simplicity.

I have always been struck by the fact that some mathematical ideas or theorems are crystal clear for me and very difficult to explain to others. Understanding and explaining are different concepts, especially in maths. As a result, one can distinguish two notions of simplicity. I will discuss some examples...

Rachael DeLue, Princeton University.
Simplicity, Doubt, and Desire in the Visual Arts.

This talk considers different forms of abstraction in the visual arts in order to develop an account of simplicity as an aesthetic criterion that both aligns with and unsettles conventional definitions of that term across disciplines, including mathematics. Indeed, by considering simplicity in art, where it operates on a visual register, alongside simplicity within mathematics, where the visual may be less important, the stakes of simplicity in both arenas emerge transformed. In art, for instance, simplicity or economy of means turns out to be at times blinding

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rather than enlightening, obfuscating rather than truth-giving, thus purposefully articulating failure rather than insight or knowledge gained. And in both art and mathematics, desire constitutes a driving force.

David Reinfurt, O-R-G design studio.
Mathematical Typography.

"I will be speaking today about work in progress, instead of completed research; this was not my original intention when I chose the subject of this lecture, but the fact is I couldn't get my computer programs working in time. Fortunately it is just as well that I don't have a finished product to describe to you today, because research in mathematics is generally much more interesting while you're doing it than after it's all done." When invited to give the Josiah Willard Gibbs lecture to the American Mathematical Society (AMS) in 1978, Stanford computer science professor Donald Knuth chose to speak not directly about mathematics, but instead about the shapes of letters. In "Mathematical Typography," Knuth discussed the typographic evolution of the AMS Journal and his own attempts to realize a computer automated typesetting system. Ten years later his programming efforts yielded the discipline-standard TeX and its helper program, MetaFont. This talk will begin where the previous ends.

Stephen Wolfram, Wolfram Research.
Perspectives on Mathematics and Aesthetics from the Computational Universe.

Fig. 1 Panel 1. From *left*: Philip Ording, Amy Baker Sandback, Rachael DeLue, and Étienne Ghys. Photo by Alejandro Martín Maldonado

PANEL

Amy Baker Sandback, international curator and writer, a director of Artforum magazine, the International Print Center of New York, and the McDowell Colony.
Rachael Z. DeLue, author of *George Inness and the Science of Landscape*, faculty member of Princeton's American Studies Program, Reviews Editor for *The Art Bulletin*.

Étienne Ghys, French mathematician of geometry and dynamical systems, member of the French Académie des Sciences, co-author of computer graphics mathematical movies *Dimension* and *Chaos*.

Philip Ording (moderator), co-organizer of the conference.

- The conference prospectus asserts that "simplicity and economy of means are powerful impulses in the creation of artworks." Have we got that right? What examples come to mind, current or historical?
- Do mathematicians agree that simplicity has come to represent such an important ideal in mathematical practice? How did this come about?
- Do mathematicians take more confidence from results that are simply stated? What, if any, is the relationship between simplicity and truth? Is simplicity truth-conducive? Or merely conducive of the truths we can apprehend?
- Do curators or artists speak in terms of truth? One hears the word "honesty," but "truth?"
- Mathematicians are ever aware of the truth value of a proposition. But outside of peer review reports, there is little in the way of public critical discourse. Unlike the arts, math does not seem to have a critical press. Where is the public critique of the exposition, quality, or style of mathematical work? Are mathematicians too polite? Where is the "art" of mathematics to be found?
- Where do artistic and mathematical practices intersect? What words, images, mental images, or questions could artists and mathematicians share? Be they in the past, present, future? Have we gotten past M.C. Escher?

FILM PROGRAM 1

William Wegman
Drinking Milk, 1974–1975
Videotape transferred to DVD, with sound
Duration: 1 minute, 55 seconds
Courtesy the artist

David Hammons
Phat Free, 1995–1999
Videotape transferred to DVD, with sound
Duration: 5 minutes, 2 seconds
Courtesy David Zwirner, New York/London

Richard Serra
Color Aid, 1970–1971
16 mm color film transferred to DVD, with sound
Duration: 36 minutes
Courtesy the Circulating Film Library of the Museum of Modern Art, New York

AFTERNOON SESSION

Andrea Worm, University of Augsburg.
Constructing the Timeline: Simplicity and Order as Guiding Principles for the Visualisation of History.

The timeline is a visual concept of fundamental relevance to the western apprehension of the world and also a key concept in mathematics. In graphs, time is usually represented as an axis, running from left to right, subdivided into regular intervals. However, the timeline is so deeply embedded within western culture that its genesis and history are seldom reflected. In essence, the timeline is a conceptualization that originated in Western Europe during the Middle Ages and is the result of a very specific mind-set. This paper will focus on the early history of the timeline, and present some ideas on how a sense of order and simplicity was of fundamental importance for how the enormous and confusing amount of historical data was put into a visually persuasive structure.

Dusa McDuff, Barnard College, Columbia University.
Thinking in Four Dimensions.

I will try to explain some simplifying ideas that make it possible for me to think about four dimensional space.

Thursday, April 4

MORNING SESSION

Juliet Floyd, Boston University.
Aesthetics, Mathematics, and Philosophy: Is there an Intersection?

I shall explore some of the difficulties surrounding talk of aesthetics (or taste) in mathematics. The focus will be on the notion of simplicity. (1) Shall we take "simple," as a term of criticism, to be truly "aesthetic"? (2) Can simplicity be considered epistemologically relevant? (3) How systematic do we take mathematicians' and artists' uses of this notion to be? (4) What might it mean, philosophically, to regard mathematical structures, concepts, and objects as aesthetic objects? I approach these questions through discussion of relevant works and remarks by Kant, Wittgenstein, Sheffer, Gödel, Turing, as well as artists Mel Bochner and Fred Sandback.

Rosalie Iemhoff, Utrecht University.
Simple proofs.

Beauty and simplicity play an important role in the design of proof systems. Even to the effect that forms of inference that lack them are usually treated with caution. In proof theory one can distinguish simple from complex proofs in a precise and fundamental way. On the other hand, many elementary questions regarding the form of proofs remain open. This talk will be about simplicity and complexity in proof theory.

Curtis Franks, University of Notre Dame.
The complexity of simplicity.

Simplicity in reasoning served as a focal point in mathematical research from Aristotle until the height of the foundations movement in the early twentieth century. The idea always was that topically pure demonstrations, by unearthing the simple truths on which a fact depends, do more than convince us of its truth: they provide its grounds. Modern mathematics betrays this ideal in several ways. Most obviously, impure proofs are often more explanatory than their counterparts precisely because they reveal hidden connections across topics. More crucially, our judgements of a single proof's simplicity or complexity often change in light of adjustments in the broader mathematical landscape (adjustments that we make in efforts to contextualize and foster an understanding of an initially complex proof). And in both cases, it is most natural to see relatively high level phenomena explaining more basic facts. Mathematical discovery rarely respects our preconceived notions of a problem's topic. What we deem simple thus changes in the course of our efforts to cope with innovation and does not reflect any criterion isolable independent of those very efforts. Reflecting on this, we can begin to appreciate that our judgements of simplicity are often underwritten by highly complex practices and prior understanding. We can trace this reversal of the foundational attitude familiar more generally in contemporary social science and aesthetics to some early remarks of David Hilbert himself. Hilbert asked that we shift our attention from the "objective" fetish of topical purity and towards its "subjective" counterpart.

Andrés Villaveces, National University of Colombia, Bogotá.
Simplicity via complexity via simplicity? Sandboxes for simplicity.

The one-way direction going from complicated proofs to their simplifications has been advocated by many [Rota, etc.] and seems to be addressed with some success in branches of mathematical logic. However, there is an interesting back-and-forth movement between the simple and the complex (and back to the simple) when one considers the question not just from the perspective of proofs but from the perspective of questions and proofs generating more questions and more proofs. Some disciplines have generated what could be called "simplicity sandboxes": special conditions under which a simpler "answer" may be tested (in the absence of a proof) and then transferred (with luck) to situations without the special conditions. In this case, the first "proof" may seem much simpler than later proofs (apparently reversing the one-way direction), but is also only a proof under "rarefied" conditions. I will present a couple of examples of the back-and-forth movement from simple to complex to simple and of the "simplicity sandboxes."

Fig. 2 Panel 2. From *left*, Riikka Stewen, Juliette Kennedy, María Clara Cortés, Kate Shepherd, Grigor Sargsyan, Juliet Floyd, Andrés Villaveces, Dan Walsh, and Hanna Johansson. Photo by Alejandro Martín Maldonado

Juhani Pallasmaa, Juhani Pallasmaa Architects, Helsinki.
The Complexity of Simplicity: the Inner Structure of the Artistic Image.

We think of simplicity and complexity as exclusive opposites. Yet, in artistic works this opposition disappears as the two notions merge. Artistic works are fundamentally about the world and human life. As Merleau-Ponty suggests, "We come to see not the work of art, but the world according to the work." The entire complexity of life becomes thus part of the simplest of artistic works. The viewer's imagination and autonomous search for meaning sets in motion a process of association and interpretation. A profound work is always a never ending rhizome.

PANEL

María Clara Cortés, National University of Colombia, Bogotá; artist and art historian.
Juliet Floyd, Boston University; philosopher.
Hanna Johansson, University of Helsinki; art historian.
Juliette Kennedy, (moderator) co-organizer of conference.
Grigor Sargsyan, Rutgers University; mathematician.
Kate Shepherd, artist.
Riikka Stewen, University of Helsinki; art historian.
Andrés Villaveces, National University of Colombia, Bogotá; mathematician.
Dan Walsh, artist.

- What relationship if any is there between simplicity and the artistic movement *Minimalism*?

- One way that you might hear someone distinguish a mathematician's sketch from an artist's sketch is to say that the former is objective while the latter is subjective. Is this fair? Beyond selecting one's chosen field of study in mathematics, is subjectivity present in mathematics?
- Do mathematicians have a fundamental love/hate relationship with the objects they study?
- Do you have in art that idea that someone sees your art and they understand it or do you have to explain your work even to people close to you?
- Mathematicians suffer the disparity between the elegance of a theorem and the ugliness of its justification or proof. Is there anything like that duality in what artists do?
- How individual or collaborative is an act of mathematics or art?

FILM PROGRAM 2

William Wegman
Spelling Lesson, 1973–1974
Videotape transferred to DVD, with sound
Duration: 49 seconds
Courtesy the artist

Richard Serra
Frame, 1969
16mm black and white film transferred to DVD, with sound
Duration: 14 minutes, 29 seconds
Courtesy the Circulating Film Library of the Museum of Modern Art, New York

Andy Goldsworthy
Two Rain Shadows / Waterfall.
Sante Fe.16 August 2008 / 17 August 2008
Unique HD video diptych, with sound
Duration: 16 minutes, 9 seconds
Courtesy Galerie Lelong, New York

AFTERNOON SESSION

Hugh Woodin, University of California, Berkeley.
Simplicity and the quest for ultimate (mathematical) truth.

Simplicity considerations can and have been used to justify axioms, however this has always occurred after the axioms have been generally accepted for other reasons. Can simplicity considerations actually play a role in the discovery of new axioms, or even be the source of new conjectures? The emerging evidence is that such considerations can play a vital role.

Peter Sarnak, Institute for Advanced Study & Princeton University.
Is there a place for "ugly" mathematics?

One of Hardy's well-known quotes is "... Beauty is the first test: there is no permanent place in the world for ugly mathematics." If by ugly he means complicated and not transparent, I will argue by way of some examples from number theory that at least as far as the proofs go, his claim may be too strong. On the other hand the truths that are being established must surely be simple, if they are to survive the test of time.

Friday April 5

MORNING SESSION 1

Jan Zwicky, University of Victoria.
The Experience of Meaning.

Once the question of truth is settled, and often prior to it, what we value in a mathematical proof or conjecture is what we value in a work of lyric art: potency of meaning. An absence of clutter is a feature of such artifacts: they possess a resonant clarity that allows their meaning to break on our inner eye like light. But this absence of clutter is not tantamount to "being simple": consider Eliot's *Four Quartets* or Mozart's late symphonies. Some truths are complex, and they are simplified at the cost of distortion, at the cost of ceasing to be truths. Nonetheless, it's often possible to express a complex truth in a way that precipitates a powerful experience of meaning. It is that experience we seek—not simplicity *per se*, but the flash of insight, the sense we've seen into the heart of things. I'll first try to say something about what is involved in such recognitions and then something about why an absence of clutter matters to them.

CURRENT/RECENT STUDENT PANEL

Terrence Blackman, Mathematics PhD, Graduate Center, CUNY, 2011; currently Dr. Martin Luther King, Jr. Visiting Assistant Professor of Mathematics, MIT and Assistant Professor of Mathematics, Medgar Evers College, CUNY.

Patrick Delahoy, Architecture M.Arch., Yale University, 2011; currently at Cannon Design in New York.

Spencer Gerhardt, Logic MS, University of Amsterdam; currently Mathematics PhD student, University of Southern California.

Helena Kauppila, Mathematics PhD, Columbia University, 2010; now pursuing a career in the arts.

Rachel Levanger, first year PhD student in Mathematics, Rutgers University; undergraduate degree in Mathematics with a minor in Art History.

Philip Ording (moderator), co-organizer of the conference.

Adriana Renero, fourth year PhD student in Philosophy, Graduate Center, CUNY.

Samuel Stewart-Halevy, Architecture M.Arch., Princeton University, 2012; currently works at Guy Nordenson and Associates in New York.

Fig. 3 Current/recent student panel. From *left*: Adriana Renero, Spencer Gerhardt, Patrick Delahoy, Rachel Levanger, Samuel Stewart-Halevy, Helena Kauppila, and Terrence Blackman. Photo by María Clara Cortés

- What makes a question simple? Are there aesthetics to the questions we ask?
- How does simplicity play a role in art forms that are necessarily collaborative?
- What is the relationship between simplicity and rationality? Simplicity and naiveté?
- How is simplicity connected to abstraction? How is simplicity connected to vagueness?
- What is the intent behind appeals to simplicity? What's at stake?
- To what extent is economy of means a criterion of simplicity?

MORNING SESSION 2

Marja Sakari, Kiasma Museum of Contemporary Art, Helsinki.
The art of being bored.

Susan Sontag said: "Boredom is just the reverse side of fascination: both depend on being outside rather than inside a situation, and one leads to the other." Can this be true? In my paper I will be looking at minimalist artworks that use simplicity to express meaning. I will frame a phenomenological approach to the question how such works touch us as viewers.

Maryanthe Malliaris, University of Chicago.
What simplicity isn't.

We will look at several examples in specific mathematical structures such as graphs, models, and ultrapowers.

Mikhail Gromov, Institut des Hautes Études Scientifiques and NYU.
Ergologic and Interfaces Between Languages.

We want to discuss possible mathematical models for how mathematics is perceived by/generated in a human brain/mind and expressed in a "quasi-natural language."

Fig. 4 Mathematics panel. From *left*: Roman Kossak, Marjorie Senechal, Grigor Sargsyan, Étienne Ghys, Hugh Woodin, Adrés Villaveces, Dusa McDuff, and Rosalie Iemhoff. Photo by María Clara Cortés

The first 15 min of the talk will be dedicated to a brief (highly) critical overview of possibilities/limitations/deficiencies of approaches in the contexts of mathematical/formal logic, experimental psychology, and artificial intelligence. Then I shall indicate an alternative frame and point toward mathematics that may be helpful for solving the problem.

MATHEMATICS PANEL

Étienne Ghys, École Normale Supérieure, Lyon; geometry and dynamical systems.
Rosalie Iemhoff, Utrecht University; proof theory, constructive theories, and the computational content of classical theories.
Roman Kossak (moderator) co-organizer of conference.
Dusa McDuff, Barnard College, Columbia University; symplectic geometry.
Grigor Sargsyan, Rutgers University; set theory.
Marjorie Senechal, Smith College; history of science and technology, discrete geometry, mathematical crystallography.
Andrés Villaveces, National University of Colombia, Bogotá; model theory.
Hugh Woodin, University of California, Berkeley; set theory

- In simple terms, describe your area of specialty in mathematics.
- Hilbert asked for "Criteria of simplicity, or proof of the greatest simplicity of certain proofs. Develop a theory of the method of proof in mathematics in general. Under a given set of conditions there can be but one simplest proof." He wrote that in 1900, well before formal proof theory was established. As formulated in the later Hilbert's Program, his goal was to formalize mathematics axiomatically, establish a complete proof system and then go on to prove

various metamathematical statements, such as mathematics is consistent. What is the role of formalism in your branch of mathematics? How "formal" is it in practice? Could there be informal, but somehow rigorous, measures of simplicity in your discipline?

- How about simplicity of concepts? The epsilon-delta definition of limit has been removed from some calculus texts, as the concept was declared too complex for certain levels of instruction. In 1950s Andrzej Mostowski proved a beautiful theorem which essentially implies that the concept of limit cannot be defined with fewer than three alternating quantifiers. It is indeed complex. This sheds some light on the question of simplicity/complexity of concepts. Are there examples in your area, where intuitively clear concepts require complex logical definitions? If there are, is this evidence that the concepts are complex or perhaps that the formal language we use to describe them is not quite adequate?
- Is it really so that original proofs of important (all?) results are rather messy, and as they are clarified and improved, one comes close to the ideal "simplest" proof? If true, why is it so? If one is looking for a proof, why is it harder to find a simple one?

FILM PROGRAM 3

William Wegman
Dog Duet, 1975–1976
Videotape transferred to DVD, with sound
Duration: 2 minutes, 38 seconds
Courtesy the artist

Andy Warhol
Empire, 1964
16 mm black and white film, silent
Duration: 46 minute excerpt of 8 hours, 5 minutes
Courtesy the Circulating Film Library of the Museum of Modern Art, New York

AFTERNOON SESSION

Andrew Arana, University of Illinois at Urbana-Champaign.
Simplicity and the interface of algebra and geometry.

In the seventeenth century, there was a striking broadening of geometrical methods to include algebraic methods. Descartes, who was chiefly responsible for this broadening, claimed that the new curves admitted by his geometry were just as simple as those studied by the ancients and thus were equally legitimate for geometrical study. I will firstly consider in what ways simplicity was a criterion of geometricity for ancient and Cartesian geometry. I will then explain how algebraic methods posed a challenge to this way of delineating geometry, and how Descartes resolved this challenge. If time permits, I will also consider the repercussions of this limitation for contemporary geometry.

Dennis Sullivan, Graduate Center, CUNY and SUNY at Stony Brook.

Simplicity Is the Point.

There is a famous theory due to René Thom in France and Lev Pontryagin in Russia that can be seen to directly evolve from one simple geometric picture. The feeling one has as a beginning topologist on realizing this is: "Now I know what it means to really understand a part of mathematics." Mathematicians often feel a mathematical story is not over until one sees the entire structure evolving painlessly from a quite small number of simple starting points. Four consequences: (1) One can research any fertile field of mathematics not so rendered to try to find its simplicity sources. One usually begins by thinking "What is really going on here?" (2) Sometimes some rather sophisticated heights are constructed from which the structure of the desired mathematical landscape is simply revealed. (3) The relative simplicity just described becomes pure simplicity when the sophisticated heights are gently lowered into the foundations by becoming part of any early study of the subject. (4) At this point one may be able to satisfy Hilbert's criterion: "Someone only really understands a mathematical subject if they can tell it to the person on the street." The talk will offer a few more comments/examples.

Art Installation

PROSHANSKY LOBBY

Kate Shepherd
String Drawings, 2013
Courtesy Galerie Lelong, New York

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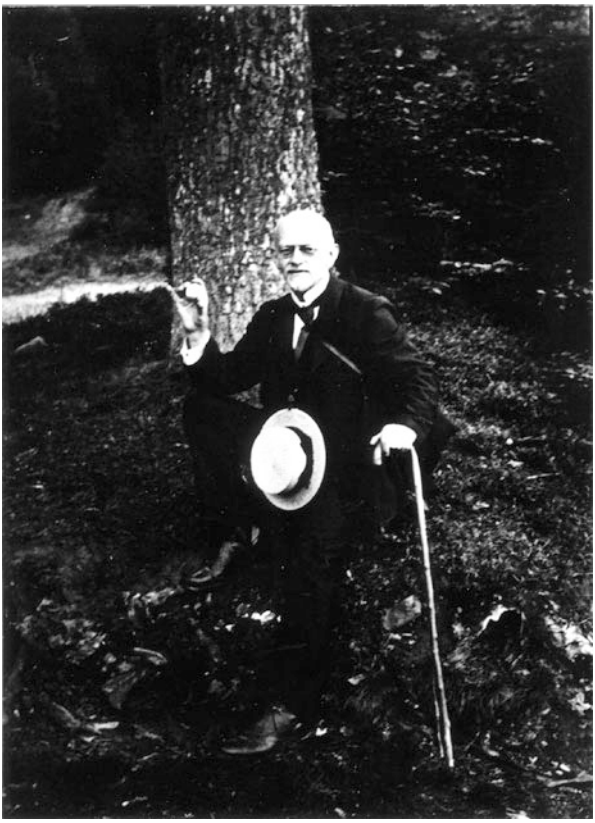

David Hilbert, undated
Photographer unknown
Courtesy Konrad Jacobs and the archives of the Mathematisches Forschungsinstitut Oberwolfach

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