

Artistic Thinking in Scientific Research

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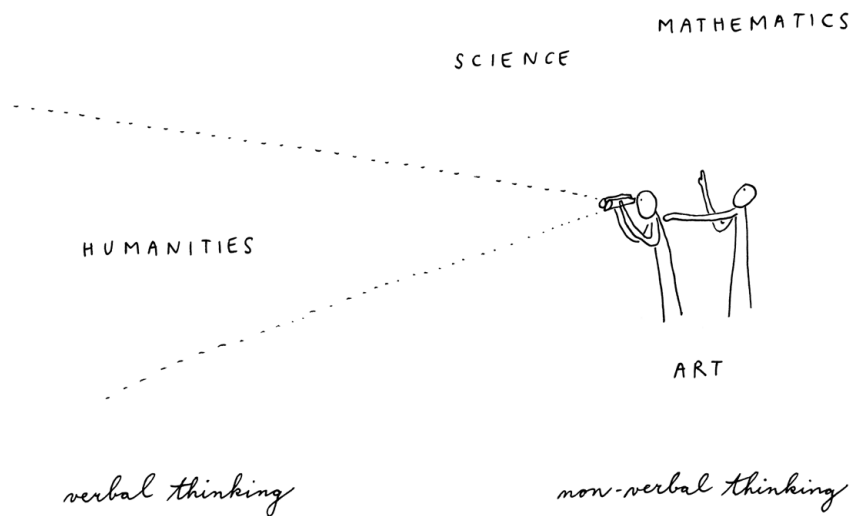
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Doctoral programs in the fine arts, instead of coming up with their own ways of doing things, tend to adopt standards from the humanities, which themselves tend to adopt standards from science. Because of being preoccupied with trying to look like other disciplines, artistic thinking within artistic doctorates gets suppressed. But if we look into science directly and not through this second-hand approach, we can find aspects of scientific thinking that are closer to art than to the humanities.

In this paper, I give examples of artistic thinking in the work of various scientists and mathematicians: a non-fiction book that uses fiction (Douglas Hofstadter's book *Gödel, Escher, Bach*), a linguistic analysis that concludes with a story (Livia Polanyi's book *Telling the American Story*), scientific lectures with unusual formal aspects (Roger Penrose's "VJing" of multiple layers of foils through an overhead projector, David Deutsch's *Lectures on Quantum Computation*), and a collective hiding behind a fictional mathematician (Nicolas Bourbaki). I also briefly introduce the problem of verbal overshadowing and the effects it may have on the creative process in art.

Keywords: artistic thinking, mathematics, science, non-verbal thinking, verbal overshadowing.

Visual abstract



1. (Visual abstract)



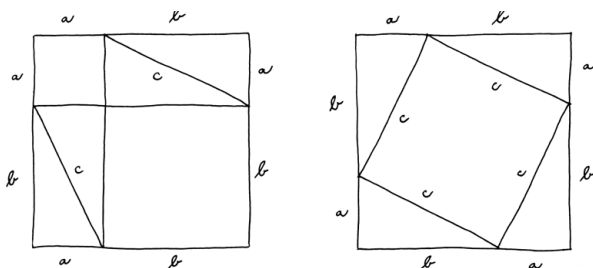
2. (A research paper)

Let's not think about research through its standardized formalities of an academic text. What's essential for research should remain even without those standardized formalities.

Non-verbal thinking

The humanities give the impression that doing research consists primarily of reading and writing. But if you are a co-author of a scientific paper, it doesn't necessarily mean that you wrote the paper. It's even possible that you hadn't read the paper before it was published (some papers in physics and biology have hundreds or even thousands of authors¹). Being an author means that you participated in the research that the paper communicates.

In geometry, a picture proof is as valid as an algebraic proof. Here is, for example, visual proof of the Pythagorean theorem ($\forall \Delta ABC: \gamma = 90^\circ \Rightarrow a^2 + b^2 = c^2$):



3. Visual proof of the Pythagorean Theorem.

But also in geometry, there was a time when pictures were not appreciated.² The mathematician Tadashi Tokieda, in one of his lectures about topology and geometry, says that:

- 1 Davide Castelvocchi, "Physics paper sets record with more than 5,000 authors", *Nature* (2015), May 15, 2015, <https://doi.org/10.1038/nature.2015.17567>.
- 2 Michel Broué illustrates the tendency to verbalize everything by the following anecdote: "Claude Chevalley gave a course which was very formal, and because he didn't prepare much, sometimes he would get stuck. One day I saw him, we all laughed about it, he didn't know how to continue his demonstration, so he went to a corner of the blackboard and, hiding it, he drew a diagram. He thought about it and understood, he erased the drawing, then he returned to his algebraic demonstration. It made us laugh. He could have at least left us the drawing." In a documentary by David New, *The Man Who Saved Geometry*, starting at 40:48.

In mathematical education, we have been all bullied into thinking that pictures are not rigorous... That you can't trust the pictures, you should say everything in words, and so on... Well, sometimes you can make mistakes in pictures, but just as well you can make mistakes in words, formulas, and calculations. I would say most of the time the pictures are far more rigorous than words and formulas.³

And what he means by using pictures is not merely using pictures to communicate. The thinking itself takes place in pictures.⁴ So it's not that the problem is first solved by verbalizing and then the result is translated into visual language for illustrative purposes. The research itself is non-verbal.^{5,6}

When I was applying to a bachelor's program in photography at an art school in 1998, I had to submit visual responses to various assignments, as well as samples of my work, that altogether encompassed around fifty photographs and drawings but no text – no artist statement, no motivation letter, no study objectives. Today, texts are an obligatory part of any application in the art world. And while text may help in some ways, there also might be a fundamental problem with it – it may suppress visual thinking. Psychologist Jonathan Schooler and his colleagues have been studying *verbal overshadowing*, a phenomenon where a verbal description of a non-verbal memory impairs the non-verbal memory. They have shown this effect in several studies of visual memories of faces, colors, visual forms (except

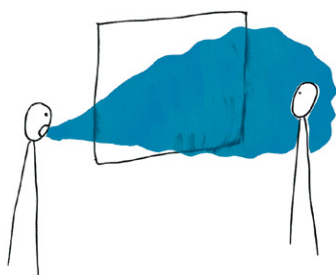
3 Tadashi Tokieda, *Topology & Geometry*, Lecture 1, Part 02/02, starting at 9:40.

4 For another account about thinking in pictures, see the first chapter of the engineer Temple Grandin's book *Thinking in Pictures*, 21. "I don't need a fancy graphics program that can produce three-dimensional design simulations. I can do it better and faster in my head."

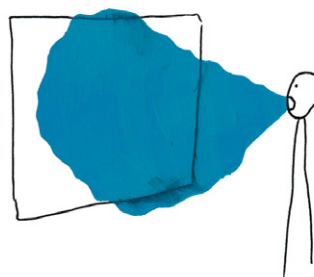
5 The neuroscientist Karl Friston "prefers not to speak with other human beings before noon. (At home, he will have conversed with his wife and three sons via an agreed-upon series of smiles and grunts.)" Shaun Raviv, "The Genius Neuroscientist Who Might Hold the Key to True AI", *Wired*, Nov 13, 2018, <https://www.wired.com/story/karl-friston-free-energy-principle-artificial-intelligence/>.

6 I touched the problem of the dominant influence of humanities on artistic doctorates and the use of visual thinking in science in some subchapters that are included in "Zpráva o uměleckém výzkumu pro AVU (2020)" by Ondřej Buddeus and Magda Stanová. This current paper allows me to express those ideas in a more pronounced way and with examples that go beyond visual thinking.

those that are easy to name), and maps.⁷ If the same phenomenon applies to verbal descriptions of artworks (it would be surprising if it didn't), it is something we should be wary about, not only because it can weaken visual memories of already existing artworks but because it can be detrimental to the creative process itself. Fragile visual ideas for artworks that haven't been realized yet could be suppressed when we're trying to describe them verbally, for example, when writing a project proposal.

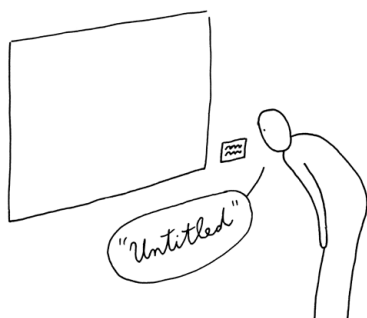


4. (Verbal overshadowing 1)



5. (Verbal overshadowing 2)

Text tends to be patronizing to visual thinking.



6. Untitled.

7 For a more detailed description and a list of literature about verbal overshadowing, see the webpage of the META Lab (Memory Emotion Thought Awareness) of the Department of Psychological & Brain Sciences at the University of California Santa Barbara, <https://labs.psych.ucsb.edu/schooler/jonathan/research/verbal-overshadowing>.

Artistic thinking⁸

What's sometimes summarized as the artistic approach, artistic mode of thinking, art thinking, artistic sensitivity, artistic ability, or artistic thinking largely overlaps with various aspects of non-verbal thinking (e.g., the person making decisions according to aesthetic criteria, the use of intuition, selecting a combination of colors and materials in their mind) but encompasses other important components. These can be hard to express and are often communicated to art students through the means of gestures, facial expressions, a melody, or sometimes proverb-like sentences:

"We do not take ourselves completely seriously."⁹

"The beautiful can be clever."¹⁰

"The worse, the better."¹¹

"You can't take a good photograph in a false way."¹²

"A song helps us clarify words."¹³

"That what is the most important must be discovered by the student themselves."¹⁴

- 8 One of the reviewers suggested that the article is about "creative thinking" rather than "artistic thinking." But the word "creative" became associated with corporations and a capitalistic mode of thinking (instead of culture, there is the "creative industry"; instead of artists, there are "creatives"), without the quirkiness, weirdness (which has a positive value in art), nuances, or non-utilitarian character that are embedded in "artistic thinking" and the examples I give.
- 9 From the description of the studio Intermedia 2 lead by Dušan Záhoranský and Pavla Sceřanková at the Academy of Fine Arts in Prague, accessed April 24, 2022, <https://avu.cz/departments/intermedia-2>.
- 10 From the description of the studio Painting 1 lead by Robert Šalanda and Lukáš Machalický at the Academy of Fine Arts in Prague, accessed April 24, 2022, <https://avu.cz/departments/painting-1>.
- 11 Said by Milota Havráňková, the head of a photography studio at the Academy of Fine Arts and Design in Bratislava, during studio meetings, around 2005. Translated from Slovak: "Čím horšie, tým lepšie."
- 12 Said by Milota Havráňková during studio meetings, around 2005. Translated from Slovak: "Falošne nikdy neurobiš dobrú fotografiu."
- 13 Said by a participant of the Listening as a Shared and Social Practice conference, University of Regina, Saskatchewan, Canada, October 7–8, 2022.
- 14 From the description of the studio Printmaking 2 lead by Vladimír Kokolia at the Academy of Fine Arts in Prague, accessed April 24, 2022, <https://avu.cz/oddeleni/grafika-2>. Translated from Czech: "[T]o hlavní si musí student objevit sám."

“Leave the depth of the artwork you made to the viewer.”¹⁵

“We have learned something, but we don’t know what we have learned.”¹⁶

Descriptions of studios on the Academy of Fine Art in Prague’s website, from which some of the previous sentences were taken, include objectives like cultivating trust for the image, refining perception, risking, or finding new presentation formats.

In what follows, I will give some examples of artistic thinking in science.

Aesthetics-driven research

We may think that aesthetics is the domain of art and not of the exact sciences, but some mathematicians see it otherwise. Beauty is something to aspire to. Gian-Carlo Rota writes that “the first proof of a difficult theorem is seldom beautiful. Strangely, mathematicians do not like to admit that much mathematical research consists precisely of polishing and refining statements of known results.”¹⁷ One of the aims of this polishing may be what another mathematician, James W. McAllister, describes as a quality of a mathematical proof: it should be “sufficiently short and simple that a mathematician could grasp it in a single act of mental apprehension”¹⁸ or in other words, “to perceive all its steps in one mental image.”¹⁹ This is akin to what Edgar Allan Poe considers a “vastly important artistic element” – a reader should be able to read a poem in one sitting; otherwise, its build-up is compromised, the poem loses its unity, and its effect is weakened.²⁰

15 From the description of the studio Painting 1 lead by Robert Šalanda and Lukáš Machalický at the Academy of Fine Arts in Prague, accessed April 24, 2022, <https://avu.cz/oddeleni/malba-1>. Translated from Czech: “Hloubku předkládaného díla nechat na divákovi.”

16 Said by Tony Labat, a professor at the San Francisco Art Institute, as remembered by Radim Labuda during the conference When, What and How? A 12-hour (performative) reflection on artistic research, Academy of Fine Arts in Prague, December 12, 2022.

17 Gian-Carlo Rota, “The Phenomenology of Mathematical Beauty”, in *The Visual Mind II*, ed. Michele Emmer (Cambridge, MA: MIT Press, 2005), 10.

18 James W. McAllister, “Mathematical Beauty and the Evolution of the Standards of Mathematical Proof”, in *The Visual Mind II*, ed. Michele Emmer (Cambridge, MA: MIT Press, 2005), 19.

19 *Ibid.*, p. 21.

20 Edgar Allan Poe, “The Philosophy of Composition”, in *The Fall of the House of Usher and Other Writings*, ed. David Galloway (London: Penguin, 2003), 432.

Rota also notes that beauty in mathematics is attributed to theorems, proofs, and theories but that mathematicians are reluctant to say the same about definitions. It seems to me that art theory, and the humanities in general, spends too much time tinkering with definitions and that the lack of enthusiasm towards such a pursuit is another thing that mathematicians and artists have in common.

Performative moments

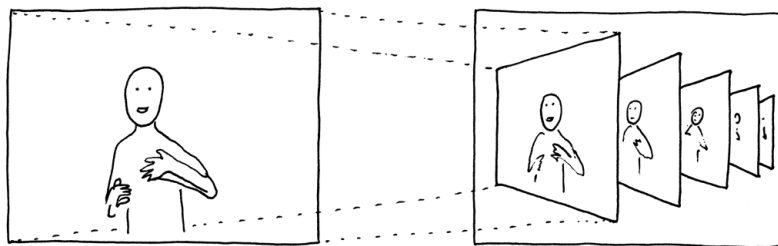
Roger Penrose, mathematician and philosopher of science with a Nobel Prize in Physics, doesn't prepare PowerPoint presentations for his lectures. Instead, he uses one or two overhead projectors for which he writes and draws transparencies by hand using a wide range of colors far beyond the black-blue-red-green office standard.²¹ In one lecture,²² explaining the Schrodinger's cat thought experiment, he uses seven layers of transparencies: laser, dead cat, alive cat, the environment of the dead cat (represented with dispersed dots), the environment of the alive cat ("If you remembered where all those dots were last time, they're actually in slightly different places this time."), unhappy observer, happy observer. His shuffling of transparencies recalls VJing.

Lectures on Quantum Computation is a series of six video lectures by physicist David Deutsch intended for graduate and undergraduate physics students. As the subject gets increasingly counterintuitive with each lecture, the light in the room gets, intentionally, increasingly weird. Also, in lecture



7. Video stills from the *Lectures on Quantum Computation* by David Deutsch – one screenshot from each of the six videos (the lighting within a single lecture doesn't change). Courtesy of David Deutsch.

- 21 Many mathematicians demand from their institutions to have installed in their offices chalkboards instead of whiteboards. Jessica Wynne's book *Do Not Erase* contains photos of blackboards of more than a hundred mathematicians along with their accounts of why chalkboards are so important in their creative processes.
- 22 Roger Penrose, "Consciousness and the Laws of Physics", filmed April 13, 2014, posted October 2015 as "Sir Roger Penrose - Keynote Speech at Towards a Science of Consciousness 2014", starting at 48:19, <https://www.youtube.com/watch?v=dFs-N-XFkQ0&>.



8. Video effect used in lecture 1 of the *Lectures on Quantum Computation* by David Deutsch, starting at 3:05. Sketch by Magda Stanová.

1, in the part where Deutsch explains the Many-Universes Interpretation, a video effect is put in use that helps explaining what he is saying. This might have been the only time when a 90s video effect was used in a way that makes sense.

As a part of the program of the second conference of the European Society for Mathematics and the Arts in Cagliari in 2013, a theater piece was performed by researchers from the local mathematics and informatics department. The play didn't take place at the university but at a theater in the city center, so the researchers needed to move all of the props there. One prop was a sculpture that didn't fit into a car, so two people carried it to the theater in the same way the statues of saints are carried around Cagliari and other places in southern Italy during feasts. What's more, since the conference participants also needed to relocate to the theater, the statue happened to be followed by a small crowd. I don't know if they planned it as a performance, but I'm sure they recognized it as such once it turned out that way.



9. Photograph from the second conference of the European Society for Mathematics and the Arts in Cagliari in 2013. Courtesy of Gianluca Bande.



10. Photograph from the second conference of the European Society for Mathematics and the Arts in Cagliari in 2013. Courtesy of Gianluca Bande.



11. A statue of a saint is carried around the town of Montescaglioso in southern Italy during the feast of San Rocco. Photo by Magda Stanová.

Fuzzy authorship

What I was writing above about mathematicians using visual language doesn't apply²³ to Nicolas Bourbaki, active since the 1930s. The reason I'm mentioning him is because of a different similarity with artistic work. It is not unusual for artists and writers to exhibit/publish under pseudonyms, but such practice may seem incompatible with science (with the exception when a person must protect themselves against bias or repression). Nicolas Bourbaki published many textbooks and some papers but never showed up for a conference.²⁴ Only later it came out that he is not a real person but a secret collective of French mathematicians.

Bourbaki's papers are now available through JSTOR and other scientific depositories, where they are still attributed to the single author Nicolas Bourbaki, and they include his invented bio and affiliations with

23 Indeed, it was Nicolas Bourbaki who largely contributed to images being considered inferior. This, however, doesn't mean that visual thinking doesn't apply to him – the man secretly making a drawing in note 2, Claude Chevalley, was a founding member of Bourbaki.

24 His keynote at the Eleventh Meeting of the Association for Symbolic Logic in 1949, written in the first person singular, was read for him by André Weil.

fictional universities (the Royal Poldavian Academy and the University of Nancago). If written today, such practice would be considered unethical by most academic journals even though it doesn't corrupt the quality of the research itself.

Form that in itself shares the content

Douglas R. Hofstadter wrote the non-fiction book *Gödel, Escher, Bach: An Eternal Golden Braid* only a couple years after he finished his PhD in physics. In the book, he combines knowledge from various fields: mathematics, neuroscience, music, programming, genetics, metamathematics, and others. The argument of the book is very complex (it revolves around formal systems referring to themselves in strange loops and, sometimes, becoming conscious), but the reason I'm bringing this book up is not its content but its form – the form which in itself speaks about the content.

The chapters are alternated with dialogues of Achilles, Tortoise, and occasionally other characters. Some of the dialogues mimic musical genres. For example, the “Crab Canon” dialogue mimics Johann Sebastian Bach’s canon of the same name, where the same musical line runs from the beginning to the end and from the end to the beginning. In the dialogue, the same thing happens with the lines of the text.

Tortoise : ——— Good day, Mr. A.
 Achilles : ——— So nice to run into you.
 T. : ——— That echoes my thoughts.
 A. : ——— Well, same to you.
 T. : ——— Good day, Mr. A.
 A. : ———

In another dialogue, “Aria with Diverse Variations”, which is a dialogue mainly about finite, infinite, and impossible-to-know-whether-finite-or-infinite-until-the-program-stops searches (*halting problem*), Tortoise and Achilles talk about how the physical length of a book spoils its content (if only a couple of pages are left in, say, a detective novel, there probably won’t be another plot twist). To overcome this problem, they have the idea to add to a book pages filled with text that is not, at first sight, distinguishable from the rest of the text in the book – the main characters continue to appear, but the story suddenly becomes about something else. When this happens, the reader realizes that the actual story has already finished. As Tortoise and Achilles discuss this, a cop walks in to arrest Achilles. In that moment, we, the readers of Hofstadter’s book, experience what we’ve just been reading about.

Telling the American Story: A Structural and Cultural Analysis of Conversational Storytelling is a 1985 book by the linguist Livia Polanyi, in which she extracts cultural primitives – a set of basic beliefs that stands in the background of stories from one culture – from dinner-table conversations. The book starts, as academic books do, with an introduction and a description of the context and continues with methodology and rigorous analysis that leads us step-by-step to the pivotal chapter – Chapter 6: An American Story. It has eight pages that look like this:

ADULTS are INDIVIDUAL PEOPLE WHO KNOW HOW to DO what they MUST DO; CAN DO what they MUST DO; and DO it. They UNDERSTAND that “There are two profound choices in life: to accept things as they exist or to accept the responsibility for changing them” (Koberg & Bagnall, 1976, p. 41). They HAVE the CHOICE the HAVE the KNOWLEDGE and they CHANGE and DO to SATISFY their NEEDS. They HAVE the RESPONSIBILITY for DOing and the RIGHT to CHOOSE what and how they should live, manage their affairs, and SATISFY their NEEDS. Their NEEDS SATISFIED, they FEEL GOOD about themselves and HAVE EARNED the RIGHT to PLEASURE and HAPPINESS.²⁵

25 Livia Polanyi, *Telling the American Story: A Structural and Cultural Analysis of Conversational Storytelling* (Norwood, NJ: Ablex Publishers, 1985), 133.

This final chapter is followed only by a one-page-long conclusion in the same style (“The history of AMERICA is the Story of EXACTLY who HAS the RIGHT to DECIDE EXACTLY who HAS the RIGHT to DECIDE.”²⁶), a short and more personal afterword, a bibliography, an author index, and a subject index.

Conclusion

The examples of artistic thinking in scientific research that I showed here are typically a couple of decades old. I’m wondering whether it’s only a coincidence, or whether science (as well as the humanities and art) have changed since then under the pressure of standardization and bureaucracy.²⁷ There is, as Karolina Majewska-Güde said about artistic research at the conference in Vilnius, “too much of should.” Bureaucratic gamification of science and art (e.g., the more papers/exhibitions, the better; registers of scientific and artistic outcomes that divide journals and institutions into more and less important) makes an internal motivation for research be overridden by an external motivation. Within this game, it is often forgotten what’s actually important in research: curiosity, open-endedness, the joy of finding things out. And these are the things that art and science have in common. If we stop trying to emulate the humanities and stop worrying about looking academic formally, we could employ artistic thinking in research more freely, as the scientists I write about do.

P. S.: It may seem that what I’m describing as artistic thinking is actually inherently scientific and not exclusive to artists, and it therefore shouldn’t have “artistic” in its description. But when scientists refer to such aspects of their thinking, they themselves describe it with the adjective “artistic.”²⁸

Received — 23 01 2023

26 Livia Polanyi, *Telling the American Story: A Structural and Cultural Analysis of Conversational Storytelling* (Norwood, NJ: Ablex Publishers, 1985), 141.

27 Can you imagine a TV ad for an art school like the one made in 1982 by Guido Sarducci for the San Francisco Art Institute? See the ad at <https://www.youtube.com/watch?v=M-KOITXBWpHE> (accessed April 24, 2022).

28 “[What] differentiate scientists is purely an artistic ability to discern what is a good idea, what is a beautiful idea, what is worth spending time on, and, most importantly, what is a

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problem that is sufficiently interesting yet sufficiently difficult that hasn't yet been solved, but the time for solving it has come now." —Savas Dimopoulos, theoretical physicist at the Stanford University, in the documentary *Particle Fever*, dir. Mark Levinson (Anthos Media, 2013), starting at 9:02.

Wynne, Jessica. *Do Not Erase. Mathematicians and Their Chalkboards*. Princeton, NJ: Princeton University Press, 2021.

Meninės krypties mąstymas moksliniame tyrime

Magda Stanová

Reikšminiai žodžiai: meninės krypties mąstymas, matematika, mokslas, neverbalinis mąstymas, nustelbimas kalba.

Užuot vysčiusios savo pačių metodikas, meno krypties doktorantūros programos taiko iš gamtos mokslų perimtus humanitarinių mokslų standartus. Dėl tokio menų bandymo supanėšėti su kitomis disciplinomis meno doktorantai yra priversti represuoti savo meninės krypties mąstymą. O pažvelgę į pačius gamtos mokslus atrasime, kad mokslinis mąstymas kartais panašesnis į meninį nei į humanitarinį.

Šiame straipsnyje pateikiu meninės krypties mąstymo pavyzdžių, randamų įvairių mokslininkų ir matematikų darbuose: neliteratūrinio žanro knygas, kuriose naudojama literatūrinė kalba (Douglaso Hofstadterio knyga *Gödelis, Escheris, Bachas*, kurioje naudojami įvairius muzikos žanrus iliustruojantys dialogai), istoriškai rezumuojamą lingvistinę analizę (Livia'os Polanyi knyga *Pasakojant Amerikos istoriją*), performatyvias mokslinio turinio paskaitas (Rogerio Penrose'o „VJ-javimas“ su ant daugiasluoksnės folijos iš viršaus projektuojamais vaizdais; Davido Deutcho *Paskaitos apie kvantinį skaičiavimą*, kuriose, temai darantis vis mažiau suprantamai, patalpos apšvietimas tampa vis keistesnis), anoniminę autorių grupę, publikuojančią knygas ir tyrimų tekstus išgalvoto matematiko Nicolaso Bourbakio vardu ir dirbančią su geometriniais atvaizdais (vaizdinį įrodymą jie prilygina algebriniam įrodymui), bei į estetiką orientuotą matematinį tyrimą (grožiu paremtų jau įrodytų teoremų išraiškų paieškas). Straipsnyje taip pat kalbu apie kalbos galią nustelbti neverbalinį turinį ir šio fenomeno apraiškas kūrybiniame vizualinio meno procese.