

Alan Turing, John von Neumann and Solomon Marcus: Their Centennials and their Axioms*

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My Turing „phase”

You could mark my Turing phase by two occurrences: the announcement of the 2012 Alan Turing Centennial Conference at Cambridge University, and the 2011 visit by my beloved professor and mentor, Solomon Marcus, to Brown University in Providence, Rhode Island.

Part one was the announcement. I revered learning computer science from Turing, who of course provided pivotal inspiration for my PhD thesis, „Context-Sensitive Languages and Applications to Program Semantics and Number Theory,” for which Professor Marcus was my adviser, together with Professor Sergiu Rudeanu.

In preparation for the Centenary, I bought Turing’s computer science and mathematics complete works – three volumes – and began to outline paper projects.

That’s where Professor Marcus enters the story. In 2011, at my invitation Marcus paid an academic visit to the Center for Computational Molecular Biology, where I was director, and the Department of Computer Science. It was his second visit to Brown, his first being in 2008. During his two Brown visits, he delivered an extraordinary series of 12 lectures – soon to be published as a special issue of *Secolul XXI Volume (2025)*, part of the UNESCO Marcus Centennial Year 2025. The videos of the lectures are available on the of the Brown University Department of Computer Science YouTube channel [1].

During our time together in 2008, and then in 2011, I shared my fascination with Johnny von Neumann and described the activities I had been organizing at Brown that were inspired by

and honoring von Neumann’s memory. Professor Marcus admired von Neumann passionately, and our discussions about our mutual high regard of von Neumann and his work grew intense. When Professor Marcus visited again in 2011, I told him about the 2012 Turing Centennial Year and the conference at Cambridge and suggested that we consider writing a joint paper for it. He agreed enthusiastically, and we decided to write a paper about Turing and von Neumann.

With collaborators, we ended up submitting three papers, all of which were accepted to the Turing Centennial Conference:

„Alan Turing and John von Neumann: Their Brains and Their Computers” by S. I. and Solomon Marcus [3]. The inspiration for our title and paper structure was von Neumann’s book *The Computer and the Brain* (1958), the perfect paradigm for presenting our two heroes, the founding scientists of computer science. Professor Marcus presented the paper at the Centennial Conference. (Short video of a part of his talk is available [5].)

„Mental Experience and the Turing Test: This Double Face is the Face of Mathematics,” by Leon N. Cooper and S. I. The title is in part a nod to a beautiful von Neumann quote (see [2]). My coauthor, Leon Cooper, was Professor of Physics at Brown and received the Nobel Prize for the co-discovery of superconductivity. Leon was a beloved collaborator, friend, and mentor for me. We both started the John von Neumann Professors „Cluster” at Brown, along with Stuart Geman (Applied Math) and Roberto Serrano (Economics). We were in awe of Johnny von Neumann’s seminal scientific legacy. Leon said that I give colleagues a „von

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Neumann test”: I say to them „von Neumann,” and if the colleagues are not rolling their eyes in awe, they failed the test! Sadly, Leon passed away on October 23, 2024; may his memory be a blessing.

„Computer Science Through Urn Games: A Unified Framework for a Hierarchy of Solvable and Unsolvable Problems” by S. I. I wrote this paper in the spirit of Turing’s last published paper, where he popularized deep computer science concepts – unsolvable and solvable – through combinatorial games.

During the Centennial Conference, Marcus and I attended wonderful talks, dined at King’s College Formal Hall, and witnessed the official unveiling of the Turing Memorial Plaque at King’s College, Turing’s alma mater. We attended the Conference Keynote Lecture by Harvard University Professor Leslie Valiant, a Turing Award winner and King’s College graduate; and we were in the front row for the lecture by Andrew Hodges, who wrote the most comprehensive biography of Turing, *The Enigma*, (<http://www.turing.org.uk>). Marcus presented our paper, and I presented the other two papers. It was an academic family affair later at one dinner – my academic brother Cristi Calude and I dined with Professor Marcus, our academic father.

Our Turing-von Neumann paper

Our paper focused on tracing the intellectual trajectory across disciplines by the pioneering scientists and luminaries of mathematics, physics, and computer science Leibniz, Boole, Bohr and Turing to Shannon, McCulloch-Pitts and von Neumann towards the emergence of the *Information Paradigm*. [3]

In the paper we presented the Turing and von Neumann axioms:

Axiom 0. Be an automata theorist

Axiom 1. Work on most theoretical and most practical at the same time

Axiom 2. Be a mathematician of the discrete and continuous

Axiom 3. Be intra-math, inter-sciences, cross-cultures scientist

Axiom 4. Work on the hardest problems

Axiom 5. And in the end, the love you take is equal to the love you make.

Our paper was published in the Proceedings

of the 2012 Conference on Membrane Computing, an annual conference devoted to the seminal theory of „Membrane Computing” that was pioneered by my academic brother George Paun.

John Conway, Kenneth Arrow and Solomon Marcus

Professor Henri Lucian, Vice President for International Affairs, emeritus, of the University „Alexandru Ioan Cuza” has been a most inspiring colleague, close friend and distinguished professor of computer science. I must thank Henri and my former late professor and beloved mentor Calin Ignat from the bottom of my heart for my return trips to Romania after emigration, after a pause of 22 years! Henri brought me back again and again to my native country and my beloved alma mater, the University “Al. I. Cuza.” He founded and served as scientific leader for the Doctoral Summer School on Evolutionary Computing, Optimization and Data Mining (ECODAM) in the Computer Science Department at the University „Al. I. Cuza.” I had the great pleasure and privilege to participate, give lectures, and enjoy being part of wonderful conference atmosphere and hospitality at my beloved alma mater, in many ECODAMs over the years; ECODAM 2025 will celebrate its 20th anniversary, coinciding with the Marcus 100 Year!

In 2013 the Grigore Moisil Institute for Computer Science and Applications was founded at the University of Iasi by Professors Luchian, Marcus, and me; along with the President of University of Iasi – Professor of Economics Vasile Isan – and the President of the University of Bucharest.

The Institute’s official opening included the inaugural Grigore Moisil Distinguished Lecture, delivered by Professor of Economics at Stanford University Kenneth Arrow. He was an American economist, mathematician and political scientist who received the Nobel Prize in Economic Sciences in 1972. It is not hard to argue that Professor Arrow was at that time the seminal scientist at the pinnacle of Economic Sciences. Four of his former students have gone on to become Nobel Prize winners. And one more thing: When I invited Professor Arrow to Brown University to give a von Neumann Lecture in 2010, I discovered in our conversations, to my excitement, that both of his parents were born in

Romania! I proposed to Henri that it would be just beautiful if Professor Arrow, who had received every scientific award possible, received one more from his parents' native land. Professor Arrow received Doctor Honoris Causa in Economic Sciences from the University Al. I. Cuza in a memorable university-wide ceremony attended by professors from University of Bucharest as well, and notably by Mugur Isarescu, the Governor of the Bank of Romania.

In 2014 the Institute's second Grigore Moisil Distinguished Lecture was given by Professor John Conway, the John von Neumann Professor of Mathematics at Princeton University. It was not hard to see that Professor Conway was arguably the most famous mathematician alive. Thanks to Henri's powerful leadership again, Professor Conway was given the title of Doctor Honoris Causa in Mathematics by the University Al. I. Cuza. The entire university celebrated. I met Conway at Sandia Labs in the 1980s, and we became lifelong friends and collaborators. He was the guest of honor at my son Larry's bar mitzvah in the Stanislaw Ulam Ballroom in the Doubletree Hotel in Albuquerque, New Mexico.

Throughout each event at the Grigore Moisil Institute for Computer Science and Applications, Professor Marcus's participation was explosive and passionate, his happiness contagious. During the Ken Arrow Days in Iasi, he gave a talk about the Romanian contributions to Arrow's pioneering Impossibility Theorem about individual values versus social choice, voting theory's mathematical impossibilities. His talk covered impossibility theorems contributed by Gheorghe Paun, another of my academic brothers through the „Marcus school.” During the John Conway Days at Iasi, Professor Marcus prepared – as always with his thorough critical eye – a set of literally 100+ questions to ask Conway. Indeed, the Q&A session with Conway and Marcus was a once-in-a-lifetime event, an academic exchange from critical to sublime and a showcase of mutual admiration. It remains a treasured spectacle.

My Essays and Their Axioms

I began writing storytelling essays about my scientific life and journey when I arrived as professor of Computer Science at Brown University. My first was written at the request of the De-

partment of Computer Science, which wanted me to tell the story of my journey from Romania to Brown. I co-wrote the essay with Tracie Sweeney, a senior editor I initially met in 2005 when she was assigned to write brief bios about Brown's newest faculty members. This essay, „Randomness is Beautiful: In Search of von Neumann,” appeared in the Department of Computer Science magazine, CONDUIT, Spring/Summer 2006 [2]. I ended the essay with a section called „Axioms,” lessons I'd learned from inspiring professors and some of my heroes – above all Johnny von Neumann – and I wanted to share these with my students.

The „random walk” outlined in my essay about my journey to Brown ended with my last three jobs at what I call „Camelot” institutions – Sandia National Labs, Celera Genomics, and Brown University -- because each in turn changed my life in exciting ways.

Here are my axioms for such Camelot places, the way I thought my hero Johnny von Neumann would define:

Axiom 1. Randomness is beautiful

Axiom 2. Work on the hardest problems

Axiom 3. Continuously search for teachers

Axiom 4. Scientific teams are fragile

Axiom 5. A crisis is a terrible thing to waste

Axiom 6. And in the end, the love you take is equal to the love you make.

Ken Arrow enjoyed my essay: „I enjoyed very much your article in CONDUIT, with its light, yet penetrating touch into some deep thoughts on computing.”

I continued writing essays inspired by my professors and collaborators: Solomon Marcus, Edsger Dijkstra, Eric Davidson, Michael Waterman, Alberto Apostolico and Albert Meyer [2] – each with their “axioms.” Each essay was inspired by one of my professors, either based on my interactions with them, or (especially in the case of von Neumann; I hosted his daughter Marina von Neumann Whitman at Brown where she gave fascinating lectures about her father) through their published work and storytelling about them, being in abundance in our cultural archive. I concluded each essay with a section on the professor's „axioms.” I wanted to capture the essence of what I learned from them, in particular the ones that

excite me and drive me to aspire to be like them when I grow up.

Here are Professor Solomon Marcus's Axioms:

Axiom 0. Be a language theorist

Axiom 1. Be a first-class scientist in at least one of the disciplines of your interdisciplinary research

Axiom 2. Be a mathematician of the continuous and discrete

Axiom 3. Be an intra-math, inter-sciences, and cross-cultures scientist

Axiom 4. Be the guardian of high standards

Axiom 5. Know a lot – really a lot – of mathematics

Axiom 6. Be a storyteller [Moldovenii sunt povestitori].

Several axioms of other professors turned out to also be “Marcus aspirational” -- we can call them „marcusisms,” i.e., they eloquently highlight Marcus's teachings and lessons learned. Here is a sample of such „marcusisms” together with the professors who inspired them [2]:

Eric Davidson „Serious people do thing seriously”

Eric Davidson „Have inexhaustible optimism, inexhaustible curiosity, inexhaustible energy and inexhaustible honesty!”

Sergiu Rudeanu „Critical feedback based on uncompromising high standards is fundamental to science”

Albert Meyer „Only major [computer science] results matter”

Edsger Dijkstra „Proofs are more important than theorems”

Michael Waterman „You know a man by his heroes”

John von Neumann „Work at the same time on the most abstract and most practical problems”

I learned from Marcus to continuously search for new intellectual challenges where mathematics could provide a deeper understanding, unveiling the unresolved problems at the heart of the challenge, and which become exciting open problems to work on. I learned that once we reach a senior level, we have responsibility to act as a force for good, both in the open or behind the scenes, as he did so many times. His drive and focus on

many concurrent projects were a signature of his personality; the interdisciplinarity of his projects was a source of multiple intuitions and the merging of theories from different scientific domains. His eloquence, technical strength and erudition in many domains of science was manifested in his „marcusian” style of writing mathematical papers about unique problems proposed by his scientific heroes inspired all of us.

In my research work, in my work as a professor, in my work as a member of a scientific community, in my intellectual life, Marcus is always a model. At my turn, I work towards being a force for good, leading new centers and projects, and – most of all – teaching and inspiring brilliant talented students to work on the hardest problems and to support them to reach new academic heights after Brown. Of beloved „marcusian” resonance, my vision at Brown University has been: „Engaging the world, one inspiring course, one innovative student, one influential research leader at a time.”

Marcus rooted so many of us in the great mathematics tradition, giving us genealogical „links” to the greatest mathematicians of the past. Everything we got through Marcus: (visualized in the attached Adviser Genealogy tree) I have 10 links (directed arrow student-to-advisor) to Euler, and 13 links to Leibnitz! I also have Erdos number 2 via my paper with Marcus on Turing and von Neumann (Marcus has Erdos number 1 by his paper P. Erdős, S. Marcus: Sur la décomposition de l'espace Euclidien en ensembles homogenes (in French), Acta Math. Acad. Sci. Hungar. 8 (1957), 443–452). (One more thing: I also have Erdos postcard number 1 – sent from Albuquerque, NM, co-signed with Paul Erdos, and mailed to – who else? – Marcus.) I also have Einstein number 4.

Marcus and chatGPT

When I find myself in times of trouble, Marcus's spirit comes to me speaking words of wisdom. I asked myself often, „What would Marcus say?” about a shockingly new problem, witnessing a deadlock in our understanding of problem-solving apparatus, a problem of an entirely novel difficulty. „What would Marcus do?” in the face of powerful new computational methods of significant practical impact, but for which we do not understand their mathematical foundations?

One such event occurred in 2022 with the arrival of the generative artificial intelligence chatbot chatGPT based on Deep Learning computational technology for Natural Language Processing (NLP). The technology is based on Large Language Models (LLM) using enormous data, enormous computational speed, and enormous dimensional spaces for the mathematics representation: all three „enormous” are trillions! The LLM (machine learning) was trained on terabytes of data (a database of text containing *trillions* of letters); the computation involved was done using a supercomputer (built of Graphical Processing Units (GPUs) capably of highly parallel computations) that performs *trillion* of arithmetic operations per second; and the mathematical statistical model had one trillion of parameters, which is to say, a mathematical space with its dimensions in the *trillions*. chatGPT marked a phase transition in computer science, and Natural Language Processing (NLP). Marcus was the master of the universe of the most complex system of all complex systems, „The Language,” a revered founding scientist of computational linguistics, mathematical poetics, and semiotics. chatGPT turned out to provide new revolutionary computational methods for generating language, although we have a very poor understanding on how it works, and its mathematical foundations are not well understood. I miss Marcus very much; I would have liked to hear what he thinks about chatGPT. I guess he would start analyzing the many un-rigorous components of deep learning transformers to make progress towards uncovering rigorous mathematical foundations.

I believe Marcus would have smiled broadly at one aspect of chatGPT: „Mise en abyme” [French for „placing into the abyss”]. Marcus was a storyteller of high stature, and part of his rock-star status among his peers was due in no small measure to his superb, substantive and intellectually inspiring storytelling skills. One of Marcus’s axioms, Axiom 6, refers to storytelling: „Moldovenii sint povestitori” – in translation „The people of Romania’s Moldova district have storytelling in their genes!”

But chatGPT messed up storytelling badly. In a recent New York Times essay, „The art of the steal: We’re living in the Golden Age of the

plagiarism plot. Copy that,” author Emily Yakin highlights the paradigm of „Mise en abyme” [Oxford dictionary: The double-mirroring effect created by placing an image within an image and so on, repeating infinitely (infinite regression), a reflexive strategy where the content of a medium is the medium itself, a story within a story]. It is the method of „recursion” used in mathematics, defined by self-reference. Asking chatGPT to rewrite an author’s text in the style of another author makes such possibilities fascinating. The chatbots era revisits fascinating facts about the life of storytelling that I believe would excite Marcus: „... more philosophical than moral: However hard we try to police the boundaries of storytelling, by instilling codes of ethics and enforcing copyright law, stories by their very nature want to be free – free to circulate through us and among us, undergoing revision and transformation in an endlessly generative and unstoppable process.” The age-old conundrum of originality and authorship has now reimaged, stolen, infinite regress of appropriations and remaking, making characters in stories more notional than human, simultaneously as plausible human beings and dramatic conventions. It is that „chatbots don’t invent stories; they simply repurpose pieces of one in their possession, an act for which no author is required.” From literary criticism perspective, „the death of the author” is now complemented by the “no human author.”

Here is where Marcus appealed to genetics to conjecture that the axiom of human storytelling is in the genes! In the genes of the people of Romania’s Moldova. Such complex traits as inspiring storytelling are genetically driven by many human genes.

A modest proposal

We should name the first storytelling gene discovered after its visionary mathematician and predictor: Solomon Marcus. We could use the customary naming for biological species (although the gene-naming problem is a complex challenge) – the taxonomic binary nomenclature: the genus, and the specific epithet within the genus.

We should honor him and name the first storytelling gene: *Marcus povestius*.

Dear Professor Marcus,

Today, March 1, 2025, at your Centennial Conference, I would like to say, thank you for everything!

And in the end, the love you take is equal to the love you make.

Yours ever,
Sorin

References

[0] I would like to thank Professor Miha-Maria Rusu and the academic community of Apollonia University for the honor to be invited to the XXXV edition of the International Congress „Preparing the Future by Promoting Excellence,” (February 27-March 1, 2025) and for her enthusiastic and wonderful invitation to contribute to the „Marcus 100 UNESCO Volume,” to be launched at the Congress. Thank you, Professor Rusu, for being a force for good for keeping alive over many years the inspiring memory of our beloved mentor Solomon Marcus and organizing extraordinary Apollonia University International Congresses in his memory.

[1] S. Istrail (ed) „Professor Marcus’s Brown University Lectures: I am at age zero!” to be published as Special Issue of Secolul XXI Volume (2025), part of the UNESCO Marcus Centennial Year 2025. The videos of the 12 Lectures are available on Brown University Computer Science Department YouTube channel https://www.youtube.com/channel/UCF8rtgYF7jhZfk_oFNk-kSYw/videos

[2] My essays (<https://istrail-lab.github.io/sorin-istrail/>):

(a) Sorin Istrail and Tracie Sweeney „Randomness is Beautiful: In Search for von Neumann” Brown University, Computer Science Department Magazine CONDUIT (2006), p. 10-15

(b) Sorin Istrail „Professor Solomon Marcus’ Axioms”, in „Întâlniri cu Solomon Marcus/ Meetings with Solomon Marcus”, (2010), Spandugino Publishers

(c) Sorin Istrail „Eric Davidson: Master of the universe” Developmental Biology 412 (2016) S47–S54

(d) Sorin Istrail „Storytelling About Lighthouses: Criticizing Professor Dijkstra Considered Harmless”, Brown University, Computer Science Department Magazine CONDUIT (2008), p.10-17;

(e) Sorin Istrail „Storytelling About Lighthouses: When Professor Dijkstra Slapped Me in the Quest for Beautiful Code, Brown University, Computer Science Department Magazine CONDUIT (2010), p.10-17

(f) Sorin Istrail „Michael Waterman: A National Treasure!” in “Michael Waterman’s Contributions to Computational Biology and Bioinformatics”, P. Pevzner, M. Vingron, C. Reidys, F. Sun, S. Istrail (Eds) *Journal of Computational Biology* vol 29, No. 7, p. 1-15, (2022)

[3] Istrail, S., Marcus, S. (2013). „Alan Turing and John von Neumann - Their Brains and Their Computers”. In: Csuhaj-Varjú, E., Gheorghie, M., Rozenberg, G., Salomaa, A., Vaszil, G. (eds) *Membrane Computing. CMC* (2012). *Lecture Notes in Computer Science*, vol 7762, pages 25-35. Springer, Berlin, Heidelberg.

[4] E. Yakin „The art of the steal: We’re living in the gold age of the plagiarism plot. Copy that.” *The New York Times Book Review*” January 2, (2025)

[5] Sorin Istrail Lab website <https://istrail-lab.github.io/sorin-istrail/>



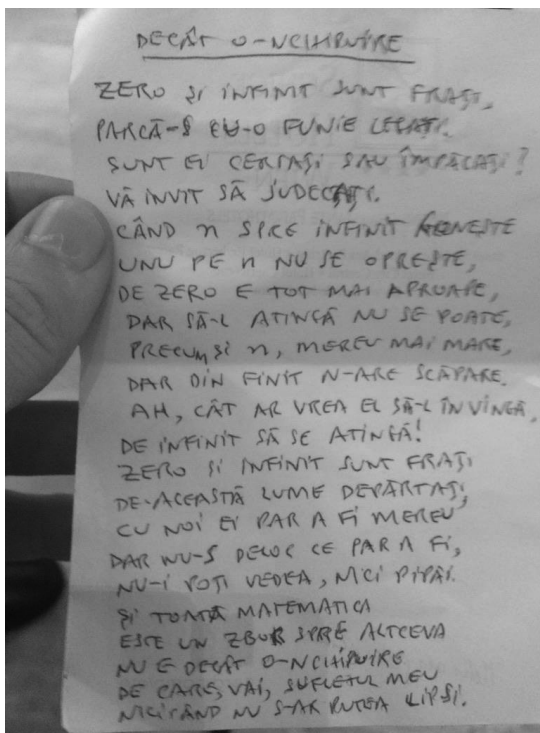
Sorin, Marcus and Professor Viorel Barbu



Professor Sanda Galopentia (Brown University, emeritus) and her husband, Sorin, Marcus, Erin Klopfenstein (Sorin's executive assistant who provided extraordinary administrative support to Professor Marcus on his visits to Brown) and a student



Marcus talking to Ken Arrow at the Doctor Honoris Causa ceremony for Professor Arrow, 2013



Poet Solomon Marcus ... „Zero și infinit sunt frați, Parcă-s cu-o funie legați ...”



Sorin's PhD committee: (left to right) Professors Dragos Vaida, Solomon Marcus, Sorin, and Sergiu Rudeanu

ADVISOR GENEALOGY

Solomon Marcus

Solomon Marcus (b. March 1, 1925) is a Romanian mathematician, member of the Mathematical Section of the Romanian Academy (a full member of the latter since 2001) and Emeritus Professor of the University of Bucharest's Faculty of Mathematics. His main research was in the fields of mathematical analysis, mathematical and computational linguistics and computer science, but he also published numerous papers on various cultural topics: poetics, linguistics, semiotics, philosophy and history of science and education.

Source: Wikipedia
Advisor Chronology verified with the Mathematics Genealogy Project



Henri Luchian, the founder and Chairman of ECODAM, and Sorin and faculty and students; In 2025, ECODAM will celebrate 20 years anniversary! Congratulations Henri and the Faculty of Informatics at University Al. I. Cuza, Iași!