Jeff Shrager jshrager@gmail.com

Chief Scientist, Bennu Climate, Inc.

Selected Papers from my most interesting projects (see below for my standard vita)**:**

- I'm currently chief scientist at Bennu Climate, Inc. a startup dedicated to methane removal:
  - Shrager, et al. (2024) Smog Chamber and Solarium Experiments in Ozone- vs Chlorine-based Methane Conversion. The 2024 Am. Geophysical Union conference in Washington DC. Dec. 14, 2024.

- I curate **elizagen.org**, a site dedicated to the genealogy of ELIZA and ELIZA-like chatbots. In 2021 we rediscovered Joseph Weizenbaum's original ELIZA code, and in 2023 we made it run:
  - Bell (2022) The History and Mystery Of Eliza (With Jeff Shrager), CORECURSIVE podcast #078; https://corecursive.com/eliza-with-jeff-shrager/
  - Lane, et al. (2025) ELIZA Reanimated: Restoring the mother or all chatbots on one of the world's first time-sharing systems. IEEE Annals of the History of Computing. Apr-Jun. Ed. (Also: http://arxiv.org/abs/2501.06707)

- Through the early 2020s I led a team at SLAC that applied cognitive engineering methods to instrument operations at LCLS, the world's largest x-ray laser:
  - Segal, et al. (2025) A Multi-Scale Cognitive Interaction Model of Instrument Operations at the Linac Coherent Light Source. Review of Scientific Instruments, 96(1), https://doi.org/10.1063/5.0239302
  - Shrager, Hu, & Fuoss (2022) A Cognitive Engineering Approach to Enhance the Efficiency of LCLS Experimental Operations; 14th Int.Conf. on Synchrotron Radiation Instrumentation.
  - Shrager, Hu WL, Fuoss P, et al. (2021) Cognitive Analytic Engines are Critical to Scientific User Facilities Reaching their Potential. Workshop on the Science of Scientific-Software Development and Use;U.S. DoE, Office of Advanced Scientific Computing Research; December 13 - 15, 2021.

- Around 2013 I proposed a new way to run clinical trials called "Global Cumulative Treatment Analysis" (GCTA). In 2023 we published the validation of this hypothesis:
  - Shrager, Shapiro, & Hoos (2019) Is Cancer Solvable? Towards Efficient and Ethical Biomedical Science. J Law Med and Ethics, 47 (2019): 362-368.
  - Wasserman, et al. (2022) Virtual Trials: Causally-validated treatment effects efficiently learned from an observational brain cancer registry. AI in Med.

- I co-founded and served as CTO, and director of engineering and research of CollabRx and xCures, AI-based biomedical startups. CollabRx was acquired in 2012 (CBRX was listed on the NASDAQ). xCures continues to grow:
  - Shrager & Tenenbaum (2014) Rapid Learning Precision Oncology. Nature Rev Clin Onc 11, 109-118.
  - Tenenbaum & Shrager (2011) Cancer: A computational disease that AI can cure. AI Mag, 2011.
  - Sweetnam, et al. (2018) Prototyping a precision oncology 3.0 rapid learning platform. BMC Bioinformatics, 19:341 doi:10.1186/s12859-018-2374-0
  - Shrager, et al. (2024) Platforms for Conducting Virtual Trials. US Patent #11,887,738(B2). 2024.

- in 2010, at Xerox PARC we developed an environment for distributed collaborative information analysis, based on a novel "Bayesian Community" model of collaboration:
  - Convertino, et al. (2008) The CACHE Study: Group Effects in Computer-supported Collaborative Analysis. Computer Supported Cooperative Work (CSCW), 17, 353-393.
  - Shrager, et al. (2009) Soccer science and the Bayes community: Exploring the cognitive implications of modern scientific communication. Topics in Cognitive Science, 2(1), 53-72.

- Between 2000 and 2008, as a visiting scholar at The Carnegie Institute of Washington, Dept. of Plant Biology, I led the BioBIKE (nee BioLingia) project that built world's first intelligent, through-the-web programmable scientific computing platform:
  - Elhai, et al. (2009) BioBIKE: A Web-based, programmable, integrated biological knowledge base. Nucleic Acids Research 2009; doi: 10.1093/nar/gkp354
  - Massar, et al. (2005) BioLingua: A programmable knowledge environment for biologists. Bioinformatics. 21(2), 199-207.

- Also at the CIWDPB we did the first complete genome build for Chlamydomonas reinhardtii, built a microarray, and did some important Chlamy science:
  - Eberhard, et al. (2005) Generation of an oligonucleotide array for analysis of gene expression in Chlamydomonas reinhardtii. Current Genetics. 03/2006; 49(2):106-24.
  - Zhang, et al. (2004) Insights into Global Effects of Sulfur Depletion on Wild-Type and Mutant Chlamydomonas reinhardtii. Eukaryot Cell. 2004 October; 3(5): 1331.1348.
  - Grossman, et al. (2003) Chlamydomonas reinhardtii at the Crossroads of Genomics Grossman et al. Eukaryotic Cell.2003; 2: 1137-1150.

- Also at the CIWDPB we did a bunch of important marine and freshwater phytoplankton environmental microbiology:
  - Bailey, et al. (2008) Alternative photosynthetic electron flow to oxygen in marine synechococcus. BBA - Bioenergetics, 1777(3), 269-276.
  - Berg, et al. (2011) Responses of hli, ptox and psbA genes to changes in irradiance in marine Synechococcus and Prochlorococcus. Aquatic Microbial Ecol. Vol. 65: 1 14, 2011
  - Tu, et al. (2004) Consequences of a Deletion in dspA on Transcript Accumulation in Synechocystis sp. Strain PCC6803. J Bact 186: 3889-3902.
  - Labiosa, et al. (2006) Examination of diel changes in global transcript accumulation in Synechocystis. J Phycology, 42(3), 622-636.

- Also at the CIWDPB I kept a cognitive diary as I transitioned from computers to biology, and studied the transition as an example of scientific training, via participant-observer analysis:
  - Shrager (2000) Diary of and Insane Cell Mechanic. Online Diary.
  - Shrager (2005) On being and becoming a molecular biologist: Notes from the diary of an insane cell mechanic. In Gorman, et al. (Eds.), Scientific and technological thinking. Mahwah, NJ: Erlbaum.

- Around 1999, I was the first employee of Afferent Systems. We developed an AI-based robotic drug discovery system that was used by many pharmas and biotechs to discover new drug leads. Afferent was acquired in 2000:
  - Shrager (2001) High throughput discovery: Search and interpretation on the path to new drugs. In K. Crowley, et al. (Eds.) Design for Science. Hillsdale, NJ: Lawrence Erlbaum. 325-348. [40]

- In the early 1990s, at CMU, we built an ANN model of how the computational subsystems of the human brain become organized. This model was a technical precursor to later DLNNs:
  - Shrager & Johnson (1995) Waves of Growth in the development of cortical function: A computational approach. In Julesz & Kovacs (Ed), Maturational windows and adult cortical plasticity. Addison-Wesley.
  - Shrager & Johnson (1996) Dynamic plasticity influences the emergence of function in a simple cortical network. Neural Networks, 9(6), 1119-1129.

- At Xerox PARC in the late 1980s we studied the power law of practice experimentally and computationally, validating a formal theory of how it arises as a combination of cognitive and contextual phenomena:
  - Agre & Shrager (1990) Routine evolution as the microgenetic basis of skill acquisition. Proc. Annual Conf. of the Cognitive Science Society. Hillsdale, NJ: Lawrence Erlbaum.
  - Shrager (2021) Practice Makes Better: A Classroom Investigation of Practice Effects. J. College Science Teaching, 50(3), 17-22.

- Also at PARC we proposed and validated the controlling math for Spreading Activation and the Power Law of Learning:
  - Shrager, Hogg, & Huberman (1988) A graph-dynamic model of the power-law of practice and the problem-solving fan effect. Science, 242: 414-416.
  - Shrager, Hogg, & Huberman (1987) Observation of phase transitions in spreading activation networks. Science, 236: 1092-1094.

- Also at PARC we studied children cooking and reading, and visiting a science museum, all with their parents. We were seeking to understand how children learn to interpret the world:
  - Shrager & Callanan (1991) Active language in the collaborative development of cooking skill. Proc. Annual Conf. of the Cognitive Science Society. Hillsdale, NJ: Lawrence Erlbaum.
  - Callanan, Shrager, & Moore (1995) Parent-child collaborative explanations: Methods of identification and analysis. J. Learning Sciences, 4(1): 105-129.
  - Crowley, et al. (2001) Shared scientific thinking in everyday parent-child activity. Science Education, 85(6): 712-732

- At CMU, in the early 1980s, we built a computational model of human exploratory learning built on a novel conceptual combination process called "View Application":
  - Shrager & Klahr (1986) Instructionless learning about a complex device: The paradigm and observations. Int. J. of Man-Machine Studies, 25: 153-189.
  - Shrager (1987) Theory change via view application in instructionless learning. Machine Learning, 2: 247-276.

- At CMU in the early 1980s we built a hybrid (statistical+strategic) model of how children learn simple arithmetic. In the early 1990s we extended it to encompass strategy change:
  - Shrager & Siegler (1999) SCADS: A model of strategy choice and strategy discovery. Psych Science.
  - Siegler & Shrager (1984) Strategy choices in addition and subtraction: How do children know what to do? In C. Sophian (Ed.), Origins of cognitive skills. Hillsdale, NJ: Erlbaum.

- In the early 1980s, at Penn we built the world's first goal-recognizing, mixed-initiative, AI-based help system, a precursor of many future "wizard" systems (embarrassingly, including Clippy. :-)
  - Shrager & Finin (1982) An expert system that volunteers advice. In Proc. of the Annual Conference of the American Assoc. for Artificial Intelligence. 339-340.

- In the late 1970s at Penn we built and supported Univac Corp's APL environment, called APL.MS:
  - Otto, et al. (1980) APL.MS User's Guide. Univ. of Penn., and Univac Corp.

- In the early 1970s, while in middle school, I wrote a simple version of ELIZA in BASIC. This was published in Creative Computing in 1977. By virtue of mid-70's PC explosion, my ELIZA became one of the most popular and knocked-off programs in history:
  - Shrager (1973/1977) Eliza. A BASIC version of Weizenbaum's ELIZA program Creative Computing.
  - Shrager (2023) ELIZA in BASIC. In M Baranovska-Bölter, S Höltgen (Eds.) Hello, I'm ELIZA. 95-102.

- Books and Edited Volumes:
  - Marino, et al. (in press) Please Go On: The enduring influence of ELIZA in AI. MIT Press. To appear, April 2026.
  - Carver & Shrager (2012) The Psychology of Science, Science Education, and the Impact of David Klahr. In Carver & Shrager (Eds.), The journey from child to scientist: Integrating cognitive development and the education sciences. Washington, D.C.: American Psychological Association.
  - Shrager & Langley (1990) Computational Models of Scientific Discovery and Theory Formation. San Mateo, CA: Morgan Kaufmann.
  - Shrager & Bagley (1981) Learning Lisp. Prentice Hall: Gnosis. [Also in French, as: Apprendre Lisp.]

- Other fun papers that don't associate neatly with the above projects:
  - Travers, Massar, & Shrager (2005) KnowOS: The (Re)Birth of the Knowledge Operating System. Appearing in the 2005 International Lisp Conference (ILC2005)
  - Shrager (2003) The fiction of function. Bioinformatics, 19: 1934-1936.
  - Shrager (2015) Demandance. ArXiv:1507.01882.
  - Perini, et al. (2023) Weight Set Decomposition For Weighted Rank Aggregation: An Interpretable And Visual Decision Support Tool. Foundations of Data Science, 5(3) 321-339.

Jeff Shrager

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Chief Scientist, Bennu Climate, Inc.

Education

- 1980 **BSE with Honors Computer Science/Systems Engineering**
  University of Pennsylvania
  Member Tau Beta Pi; Recipient E. Stuart Eichert, Jr. Memorial Prize
- 1981 **MSE Computer Science/Artificial Intelligence**
  University of Pennsylvania
- 1982 **MS Cognitive and Developmental Psychology**
  Carnegie Mellon University
- 1985 **Ph.D Cognitive and Developmental Psychology**
  Carnegie Mellon University
  Recipient IBM Graduate Fellowship in Computer Science
- Post doctoral work in cognitive neuroscience and functional brain imaging, and phytoplankton molecular microbiology.

Current Positions and Projects (see below for historical projects)

- **Chief Scientist, Bennu Climate, Inc.:** I lead Bennu's atmospheric chemistry methane removal project, developing UV-based methods to oxidize atmospheric methane in situ.
- AI History Project: I curate **elizagen.org**, a site dedicated to the genealogy of programs arising from Joseph Weizenbaums original ELIZA. In 2021 I rediscovered the original ELIZA code, in MAD-SLIP, and in 2023 we made the original ELIZA run from that original code. We are now working on reanimating the earliest AI, due to Newell and co at RAND and CMU, in the 1950s

Entrepreneurship

- **Bennu Climate, Inc.:** 2023-Present: **Co-founder and Chief Scientist.** I lead the atmospheric chemistry arm of BDC's methane removal project, developing UV-based methods to oxidize atmospheric methane in situ.
- **xCures**: 2018-2022: **Co-Founder and Director of Research**. My work supported clinical problem solving in oncology, including novel bioNLP techniques, AI-based genomic pathway analysis, and Global Cumulative Treatment Analysis.
- **CollabRx**: 2008-2012: **Co-Founder, Chief Technology Officer, and Director of Engineering.** CollabRx was engaged in omics-based personalized oncology. It was briefly traded on the NASDAQ as CLRX.
- **Afferent Systems:** 1997-2000: **First Employee and Director of Engineering.** Founded by David Chapman, Afferent developed AI-based software to support drug discovery via high throughput robotic chemistry and proto-drug screening. It was acquired by MDL around 2000.

Academic and Industrial Positions (non-entrepreneurial)

- **Adjunct Professor, Symbolic Systems Program, Stanford University**: 2000-2025: My core course focused on human learning about, use of, and interaction with complex engineered systems, ranging from airplanes to AIs. I also taught occasional courses on computational biology and cognitive science.
- **Commerce.Net**: 2007-2023 (on and off): **Senior Research Fellow**. CN fellows often spin out startups from CN and are employed by those until they either succeed or fail, at which point the fellow may return to CN. I've done this twice, with CollabRx (2008-2012) and xCures (2018-2022). See Entrepreneurship, below for more detail.)
- **Cancer Commons**: 2012-2018: **Director of Research**. My work focused on clinical problem solving in oncology, including novel bioNLP techniques, AI-based genomic pathway analysis, and Global Cumulative Treatment Analysis.
- **SRI International AI Center:** 2012-2013: **Computer Scientist, The AURA Project,**
- **Institute for the Study of Learning and Expertise:** 1999-2006: **Senior Scientist**. I headed ISLE's research on computational discovery of metabolic and regulatory models, combining knowledge and microarray RNA expression data. We also worked in other scientific domains to extend and refine an existing model of, for example, the Earth ecosystem based on ground and satellite measurements of spatio-temporal variables.
- **Xerox Palo Alto Research Center (PARC):** 1985-1994 and 2003-2005: **Member of the Research Staff**. I developed intelligent information access and automated discovery systems, adaptive interface technologies, and computational simulations of complex systems, including one of the world's first intelligent search engines, and analytical solutions to fundamental problems of learning and memory.
- **The APL Project, University of Pennsylvania:** 1976-1980: **Manager and Lead Programmer.**

Historical Postdoctoral and Visiting Scholar Positions

- 2020-2024: **SLAC/LCLS:** LCLS, located at the SLAC National Accelerator Laboratory, is one of the world's largest x-ray lasers. At LCLS I study scientists as users of complex scientific instruments, with the goal of improving the efficiency of experimental operations at LCLS.
- 1992-1997: **Visiting Faculty in Cognitive and Developmental Neuroscience and Functional NeuroImaging at the University of Pittsburgh and Carnegie-Mellon University**. I directed research teams combining EEG, functional MRI, and computational modeling to study brain development in children, and in adults engaged in complex learning.
- 1999-2007: **Visiting Scholar in Marine Molecular Microbiology, The Carnegie Institute of Washington, Department of Plant Biology** (at Stanford). Our lab studied how marine and freshwater phytoplankton and algae, such as Cyanobacteria and Chlamydomonas, adapt to environmental change, both metabolically and evolutionarily, combining laboratory molecular biology, wide-scale microarray analysis, and computational models of both the cellular systems and of the dynamics of evolution and adaptation. We developed novel AI/ML-based methods for genome assembly, and for microarray and biological pathway analysis.

Historical Major Projects

- **Need to add RetroAI projects: ELIZA and IPL-V**
- **Need to add SLAC/LCLS**
- **Cancer Commons Knowledge Pipeline**: Symbolic biocomputing services in support of cancer research and clinical problem solving, including a controlled NLP service, NCI Thesaurus ontology server, Treatment Explorer treatment ranking and evidence service. Thousands of lines of lisp code.
- **GCTA** in PO3.0 (Global Cumulative Treatment Analysis in Precision Oncology 3.0): A highly efficient approach to clinical trials that combines n-of-1 and adaptive bayesian methods. Multi-agent simulation of science, written primarily in Lisp. In 2016 GCTA was chosen among the 10 finalists from 150 submissions in the Harvard Business School Precision Trials Challenge.
- **cTRACS** (the Cancer Treatment Rationale Archiving and Communication System) -- This is a Cancer Commons project, funded by DARPA among others. Its overall goal is to provide AI-based decision support services to Molecular Tumor Boards; that is, to oncologist engaged in clinical reasoning and problem-solving about targeted therapies for advanced cancer patients. The overall CTRACS has many technologies and subprojects. The ones that I lead are: (a) encoding case data from oncologists' written summaries (essentially an NLP project), and (b) simulation of Global Cumulative Treatment Analysis.
- **CollabRx**: At CollabRx, Inc., where I was co-founder and CTO, I envisioned, managed, and participated in the development of the the numerous complex software components underlying the company's cancer treatment finder.
- **CACHE and the Bayes Community model**: CACHE (the Collaborative Analysis of Competing Hypotheses Environment) supports multi-staged analysis by a community of scientists (who may be widely separated in space and time) through a novel hybrid of decision matrices, Bayes networks, and semantic nets.
- **BioBike** (formerly BioLingua and BioLisp): Between 1999 and 2008, I led a team of engineers and biologists in the development of a web-based programmable biological knowledge-base, called BioBike. BioBike, originally built on my BioLisp code base, was a complete knowledge-based computational biology resource, enabling biologists to manipulate biological knowledge and data, and providing a platform for computer scientists working on methods in computational biology to develop their methods and deploy them immediately to working biologists. BioBike was built on **KnowOS**, the Knowledge Operating System, an operating system for graphs of objects.
- **Carnegie Institute of Washington, Department of Plant Biology**: Between 1999 and about 2008 I was the project lead and principal engineer for a number of Computational Biology projects at CIW/DPB, and the Inst. for the Study of Learning and Expertise. These are funded variously by The Carnegie, NSF, NASA, and others. Principal projects included: Chlamydomonas cDNA sequencing and microarray development (identified over 9000 of Chlamydomonas' 12,000-15,000 genes on 17 chromosomes). I designed and implemented all of the algorithms, protocols, and robot programs for this work, including a novel gene assembly protocol, complete 'semantic' annotation analysis, and pathway modeling; Semi-autonomous qualitative and quantitative reasoning and discovery in regulatory and metabolic networks (esp. using microarray data); autonomous "cyclostatic" methods for the analysis of the dynamic effects of environmental stress (esp. light and nutrient stressors) on algae and Cyanobacteria. These methods include simulation of diurnal light regimes at any latitude, automated data collection and analysis, and integration of data gathered from long-term time-course experiments with microarray regulatory data describing the expression response of the stressed organisms; Biological natural language processing (with James Evans, Stanford). We are analyzing a database of papers relating to plant molecular biology to produce a network analysis of relationships between laboratories, biological concepts, techniques, and organisms; Formalization of biological process

semantics. Laura McIntosh and I have been developing a formal semantics for principal biological concepts, such as regulation and inhibition, and applying these semantics to meta-analysis of biological knowledge bases, esp. Kegg, BioCyc, the Transpath family of knowledge bases; A multi-organism pathway knowledge base (based upon SRI's EcoCyc knowledge base) for photosynthetic bacteria, and novel reasoning and discovery methods that integrate pathway knowledge with microarray expression data; Novel method for combining nucleotide or amino acid sequence data with organismic/phylogenetic information to form phylogenetic trees, including reprogramming the Phylip PROTPARS program, and working out the underlying statistical basis for the method. (MS in preparation.); Novel statistical methodologies for analysis of Cyanobacteria environmental stress microarray experiments.

- **Afferent**: Between 1997 and 2000 I was the first employee and director of engineering of Afferent Systems, Inc (acquired by MDL in 2000). Afferent developed Artificial Intelligence-based software tools for combinatorial drug discovery, including: robot control, virtual chemistry, large-scale scientific database management, and analytic tools. I designed and wrote the entire database and object-model substructure for all Afferent products, including ODBC integration, and the entire analytical chemistry module of the Afferent flagship product. Our software is used by most of the world's largest pharmaceutical companies. I also did *all* of Afferent's user-support engineering, regularly interacting with biologists and chemists to adapt our products to their needs.
- **Mnemotheque**: In 1999 and 2000 my sister, Monique, and I developed an explorable multimedia record of our mom's family's life in France during the holocaust. A large part of my mother's side of my family, including my grandparents, was killed by the Nazis. The system, called "Mnemotheque", includes photographs, audio, music, and digital video interviews with my mom and aunts. It uses Spreading Activation to enable the user to explore the space of these mementos through conceptual links, in a way analogous to the way that human memory links one concept to another. Mnemotheque was presented in Paris at two public forums, including one that took place at the Centre Pompidou et Musée National d'Art Moderne. I did all the engineering for the system, which was written entirely in Java 2 with JMF. My sister was the media editor and producer, and played the largest role in conceiving the project. She was assisted by a small team of students in Paris.
- **The Adaptive Place Advisor**: ~1997, at Daimler Research in Palo Alto, Pat Langley, Afsaneh Haddadi, and I built a conversational agent that used a place database to identify local restaurants, etc., and would carry on a conversation regarding, for example, where you wanted to eat lunch and learn the user's preferences.
- **fMRI tools:** Between 1995 and 1997, at the University of Pittsburgh Learning Research and Development Center, I participated in the development of one of the first integrated data-capture and analysis systems for functional neuroimaging (fMRI).
- **Cortical Parcellation Model (an early Deep Learning model)**: ~1995, Mark Johnson and I, at CMU, developed a neural network model of how the cortex of the mammalian brain, which begins in a relatively undifferentiated state, differentiates into functional systems and subsystems with a particular organization. We introduced the concept of a "wave of growth", which has been observed by neuroscientists. The resulting model is a predecessor of what is now called "Deep Learning" [deep learning and the brain].
- **Aphrodite** (1990-1995): I developed an intelligent search assistant at Xerox PARC, for a large distributed multimedia database (what we call "the web" these days). The system learned how to conduct searches based upon observation of users' search activity, and could offer search guidance for new tasks.
- **IE - The Instructionless Experimenter** (1981-1985): I developed one of the first autonomous discovery systems. IE conducted experiments on complex domains and formed theories about them, using a mental model reformulation mechanism called View Application.

- **Cognitive Simulations of Arithmetic Strategy Learning** (1983/84 and 1997/98): Bob Siegler and I developed cognitive simulations of how children learn and select arithmetic strategies, combining symbolic and sub-symbolic mechanisms. These succeeded in closely modeling children's use and discovery of strategies.
- **Wizard** (~1980): Tim Finin and I developed the world's first *Computer Wizard*, a program that observes users' behavior and offers assistance and advice. This is one of the earliest examples of present-day computer wizards (Here is some amusing press coverage that appeared when the Wizard paper was presented at AAAI in 1982.)
- **APL/MS (**1978-1981): I was lead programmer and project manager for The APL Project at the University of Pennsylvania, developers and supporters of Univac's APL interpreter. Starting out as a junior programmer, I eventually became lead programmer and project manager, responsible for all aspects of the project, including interaction with Univac business units, and support of world-wide users. I had managerial responsibility for five programmers.

Significant Publications **(Excludes old versions and those superseded by journal publications)**

1. Marino, et al. (in press) Please Go On: The enduring influence of ELIZA in AI. MIT Press. To appear, April 2026. (ISBN:0262052482)
2. Braithwaite, DW, Shrager, J (2025) Higher-Level Domain-General Skills in Maths Problem Solving. To appear in Thinking and Reasoning. DOI: 10.1080/13546783.2025.2570690
3. Rousell, R, Shrager, J (2025) A Small Math Model: Recasting Strategy Choice Theory in an LLM-Inspired Architecture. NeurIPS MATH-AI 2025 workshop, San Diego, CA. Dec 2025. Also: https://arxiv.org/abs/2509.24068
4. Shrager, J (2025) First report on the reanimation of the original Logic Theory Machine, the world's first AI, in IPL-V. Youtube: https://youtu.be/qmE5o2ezqBg
5. Shrager, et al. (2025) *ELIZA33* [installation] Musée Jeu de Paume, Paris. [Repo]
6. Lane, et al. (2025) ELIZA Reanimated: Restoring the mother or all chatbots on one of the world's first time-sharing systems. IEEE Annals of the History of Computing. Apr-Jun. Ed. (Also: http://arxiv.org/abs/2501.06707)
7. Shrager, et al. (2024) Smog Chamber and Solarium Experiments in Ozone- vs Chlorine-based Methane Conversion [...]. Poster presented at the 2024 Am. Geophysical Union conference in Washington DC. Dec. 14, 2024.
8. Segal, et al. (2025) A Multi-Scale Cognitive Interaction Model of Instrument Operations at the Linac Coherent Light Source. Review of Scientific Instruments, 96(1), https://doi.org/10.1063/5.0239302
9. Shrager (2024) ELIZA Reinterpreted: The world's first chatbot was not intended as a chatbot at all. https://arxiv.org/abs/2406.17650
10. Shrager, et al. (2024) Platforms for Conducting Virtual Trials. US Patent #11,887,738(B2). Issued Jan. 30, 2024.
11. Shapiro MA, Stuhlmiller TJ, et al. AI-Augmented Clinical Decision Support in a Patient-Centric Precision Oncology Registry. AI in Precision Oncology. Published Online:17 Oct 2023. https://doi.org/10.1089/aipo.2023.0001
12. Shrager, et al. (2023) Finding ELIZA – The Rediscovery of Weizenbaum's Source Code. In M Baranovska-Bölter, S Höltgen (Eds.) Hello, I'm ELIZA. 247-284.
13. Shrager (2023) ELIZA in BASIC. In M Baranovska-Bölter, S Höltgen (Eds.) Hello, I'm ELIZA. 95-102.
14. T Perini, et al. (2023) Weight Set Decomposition For Weighted Rank Aggregation: An Interpretable And Visual Decision Support Tool. Foundations of Data Science, 5(3) 321-339.
15. Shrager, Hu WL, Fuoss P (2022) A Cognitive Engineering Approach to Enhance the Efficiency of LCLS Experimental Operations; 14th Int.Conf. on Synchrotron Radiation Instrumentation.

16. Shapiro M, et al. (2022) AI-Augmented Clinical Decision Support in a Patient-Centered Precision Oncology Registry.MedRxiv. https://doi.org/10.1101/2022.03.14.22272390
17. Collins, H, Shrager, et al. (2022) Hyper-normal science and its significance. Perspectives on Science, MIT Press, *Perspectives on Science* 1–45.
18. Shrager, Hu WL, Fuoss P, et al. (2021) Cognitive Analytic Engines are Critical to Scientific User Facilities Reaching their Potential. Position paper for Workshop on the Science of Scientific-Software Development and Use; Sponsored by the U.S. Department of Energy, Office of Advanced Scientific Computing Research; December 13 - 15, 2021.
19. Stuhlmiller T, et al. (2021) XCELSIOR: A real-time, real-world learning platform for patients with advanced cancer. Society for NeuroOncology (SNO 2021) Annual Meeting. Boston, MA.
20. Wasserman, A, et al. (2022) Virtual Trials: Causally-validated treatment effects efficiently learned from an observational brain cancer registry. AI in Medicine. doi: 10.1016/j.artmed.2022.102450
21. Shrager, (2021) Practice Makes Better: A Classroom Investigation of Practice Effects. J. College Science Teaching, 50(3), 17-22
22. Waserman, et al. (2020) A Multilevel Bayesian Model for Precision Oncology. PROBPROG2020, April 23-25, 2020, Cambridge, MA, USA.
23. Rahib, et al. (2020) Use of a real-world data registry to rapidly generate outcomes data following a case study of a novel treatment combination in pancreatic adenocarcinoma. Presented at the AACR Precision Medicine Conference, January 2020 [110]
24. Shrager, Shapiro, Hoos (2019) Is Cancer Solvable? Towards Efficient and Ethical Biomedical Science. J Law Med and Ethics, 47 (2019): 362-368. DOI: 10.1177/1073110519876164
25. Sweetnam, et al. (2018) Prototyping a precision oncology 3.0 rapid learning platform. BMC Bioinformatics, 19:341 doi:10.1186/s12859-018-2374-0
26. Shrager (2017) Forget Moonshots: Biomedicine Needs an Air Traffic Control System (Blog posting). CollabRx Blog (Lundberg, G, Ed.)
27. Roitman L, Shrager, Winograd T (2017) A Comparative Analysis of Augmented Reality Technologies and their Marketability in the Consumer Electronics Segment. J Biosens Bioelectron 8:236. doi: 10.4172/2155- 6210.1000236
28. Shrager (Sep. 2016) Precision medicine: Fantasy meets reality. Letters; Science 353(6305)
29. Aleyasen A, Starov O, Au AP, Schiffman AM, Shrager (Oct. 2015) On the Privacy Practices of Just Plain Sites. Presented at WPES 2015 (Workshop on Privacy in the Electronic Society). Denver, CO. (Also: arXiv:1507.00790 [cs.CY])
30. Shrager (2015) Demandance. ArXiv:1507.01882.
31. Chaudhri, V et al. (2014) Inconsistency Monitoring in a Large Scientific Knowledge Base. In Proceedings of the 19th International Conference on Knowledge Engineering and Knowledge Management (EKAW). Linkoping, Sweden.
32. Kang, Y, Shrager, Schiffman, A (2014) RAPPD: A language and prototype for recipient-accountable private personal data. IEEE-S&P 2014 DUMA Workshop. [100]
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Additional publications that are significantly based on my work, although I am not a named co-author:
(Usually this is because, although my work was a significant influence, usually with appropriate acknowledgement, I was not directly involved in writing these specific papers and books.)

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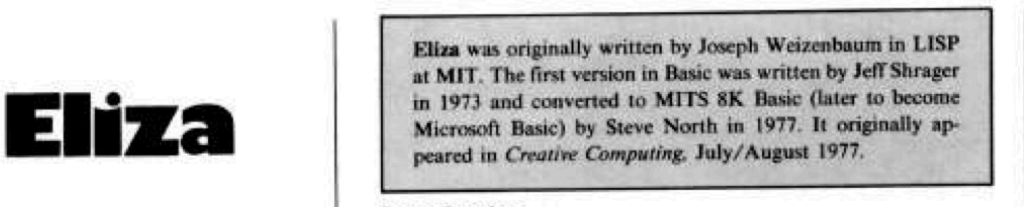
Early Works (Just for Fun)

- **Learning Lisp**: Around 1978 Steve Bagley and I wrote a Lisp textbook for internal use at the Moore School at Penn. Our friend, Steve Cherry, who wrote an Apple II Lisp, called PLisp, adapted our textbook as the PLisp user's guide, and a bit later managed to get it published as the book: Learning Lisp, by Gnosis, an imprint of Prentice Hall. There are several weird and funny stories around all this. For example, there is no listed author on the Gnosis book; Steve Bagley and I are acknowledged in the preface as the original authors, although my name is mis-spelled. Also, the book was translated into French (as "Apprendre Lisp"), which my cousin accidentally came across in a French bookstore.
- Around 1978 I developed several user-level utilities for the Univac 90/70 series computer (TSOS operating system) at the University of Pennsylvania, including that community's first email program and electronic bulletin board. Ira Winston and I also built a user-level help system for that community.
- **Filer:** Around 1977 I wrote "Filer", a regular expression-like meta-command processor (a sort of combination of unix sed and xargs, but with a significantly simpler interface). Filer quickly became among the most useful and often-used program for that operating system. I still think that this is the most useful program I ever wrote, and its equivalent does not yet exist in the world of Windows, Mac, or Unix (although, as above, you can do this sort of thing in Unix, but it's clunky).
- Around 1976 (in high school), I worked with Dr. John Myers of Villanova University Dept. of Chemical Engineering to optimize a complex chemical manufacturing process, described by about 10 rather complex equations. I used the Nelder-Mead simplex optimization algorithm (which I wrote from scratch) in Fortran on a PDP-8.
- **EDT:** Around 1974 I wrote a "programmable" text editor for PDP-8 in BASIC called EDT. Although it was a line editor (as most were at that time!) you could do simple TECO-like macros, although they were pretty clunky. (TECO's macros were pretty clunky too!)
- **MIMIC:** Around 1973 Eric Jacobs and I, at Haverford Junior High School, developed an interpreter for a programming language of our own design, called MIMIC (the Machine Independent Mathematical Instructional Code), in Fortran IV on an IBM 1130 computer. MIMIC was essentially a simplified version of BASIC (although we didn't know BASIC at the time, only Fortran and assembly!), and ran on the popular IBM 1130 platform.
- **BASIC ELIZA:** In 1973 I wrote a BASIC version of Eliza, which appeared in Creative Computing in 1977. The original Eliza was written by Joseph Weizenbaum in the mid '60s in SLIP, and translated into Lisp by Bernie Cossell at BBN. 1977 was the dawning of the Personal Computer age, and few folks knew Lisp, but everyone knew BASIC, so my version of Eliza was hugely influential. Hundreds of knock-offs have appeared since that time, and my Eliza has even been translated back into Lisp! This image is from the Big Computer Games Edited by David H. Ahl, published 1984:



- **LOGIX:** Around 1972, the first serious computer program that I remember writing was a simple natural language interpreter and theorem prover, called LOGIX, written in Fortran IV on that same IBM 1130 in my junior high school. You could enter statements like: "All men are mortal" and "Socrates is a man", and LOGIX would compute the logical consequents and report them in natural language.