

LESTER INGBER RESEARCH

Prof. Lester Ingber

lester@ingber.com ingber@alumni.caltech.edu

www.ingber.com

PROJECTS & INTERESTS

My InterNet archive <https://www.ingber.com> contains code and reprints documenting my statements, providing my optimization and nonlinear-stochastic algorithms which have been further developed and folded into my present codes. This archive is a representative sample of over 100 publications.

Statistical Mechanics of Neocortical Interactions (SMNI)

Over a span of three decades I have regularly developed Statistical Mechanics of Neocortical Interactions (SMNI), a theory of neocortical interactions across scales of mm to cm, with input only experimentally determined parameters of neocortex, and output detailed calculations permitting testing SMNI against data from short-term memory (STM) and electroencephalography (EEG) [1,2].

SMNI correctly calculates the stability and duration of STM, the observed 7 ± 2 capacity rule of auditory memory and the observed 4 ± 2 capacity rule of visual memory [3,4], the primacy versus recency rule [5], random access to memories within tenths of a second as observed, time for diffusion of localized information across columns, and Hick's law of linearity of reaction time with STM information [6].

Using the power of this formal structure, sets of EEG and evoked potential data from a separate NIH study, collected to investigate genetic predispositions to alcoholism, were fitted to an SMNI model on a lattice of regional electrodes to extract EEG brain "signatures" of STM [7,8].

SMNI scales up to develop variational Euler-Lagrange equations of the SMNI probability distribution to calculate conditions of oscillatory processing at frequencies consistent with observed EEG. A strong inference is drawn that physiological states of columnar activity receptive to selective attention support oscillatory processing in observed frequency ranges [9]. PATHINT (below) was used to evolve probability distributions of columnar activity with explicit oscillatory firings, and integrate such mesoscopic processes with global brain EEG activity [10]. Additional work at multiple scales includes neuron-astrocyte interactions into SMNI STM [11-14].

I was Principal Investigator, National Science Foundation resource The Extreme Science and Engineering Discovery Environment (<http://www.xsede.org>), "Electroencephalographic field influence on calcium momentum waves" [13-15]. This work has been recognized as an important contribution to neuroscience and to computational physics. Reviews were given in https://www.ingber.com/smni14_eeg_ca_JTB_reviews.txt and include press releases such as <https://www.xsede.org/mechanism-of-short-term-memory> and http://ucsdnews.ucsd.edu/pressrelease/the_mechanism_of_short_term_memory.

Adaptive Simulated Annealing (ASA) & Modelling

My optimization code, Adaptive Simulated Annealing (ASA) [16,17], is used worldwide in many disciplines for global optimization and sampling. I have experience leading teams in several disciplines, developing some powerful models and algorithms for extracting signal out of noise for some classes of systems, e.g., that typically arise in such diverse fields as finance [18-22], neuroscience [7-11,13,14,23-32], and combat simulations [33,34], utilizing my ASA C-code [16,17,35].

Trading in Risk Dimensions (TRD) & Risk-Management

Some of my previous work, mostly published, developed two-shell recursive trading systems. An inner-shell of trading indicators is adaptively fit to incoming market data. A parameterized trading-rule outer-shell uses my global optimization ASA code [16] to fit the trading system to historical data. A simple fitting algorithm, usually not requiring ASA, is used for the inner-shell fit.

Trading in Risk Dimensions (TRD) [36,37], adds an additional risk-management middle-shell to create a three-shell recursive optimization/sampling/fitting algorithm. Portfolio-level distributions of copula-transformed multivariate distributions (with constituent markets possessing different marginal distributions in returns space) are generated by Monte Carlo samplings. ASA is used to importance-sample weightings of these markets.

TRD processes Training and Testing trading systems on historical data, and consistently interacts with RealTime trading platforms -- all at minute resolutions. Faster or slower resolutions can be developed using the present structure of TRD. The code is written in vanilla C, and runs across platforms such as XP/Cygwin, SPARC/Solaris, i386/FreeBSD, i386/NetBSD, etc. TRD can be run as an independent executable or called as a DLL.

TRD can robustly and flexibly interact with various trading platforms. I have developed a working Windows interface with TradeStation and other Linux platforms.

PATHTREE, PATHINT & Options

I have developed a full suite of options codes, which may be integrated with TRD, or used independently.

In the early 1990's I developed PATHINT to evolve multivariate probability distributions, defined by general nonlinear Gaussian Markovian processes — multiplicative noise, and published applications in several disciplines. In 2000, I created a faster algorithm PATHTREE, a binomial tree to evolve such probability distributions. PATHTREE was thoroughly tested and finally published [21]. Both PATHTREE and PATHINT have been applied to options codes, e.g., delivering full sets of Greeks based on such underlying probability distributions. Because of its speed of processing, PATHTREE has been used to fit the shape of distributions to strike data, i.e., a robust bottom-up approach to modeling dependence of strikes on volatilities. New codes, qPATHTREE and qPATHINT, have been developed for similar use in quantum complex-variable spaces under an XSEDE.org grant [38-40]. These codes have broad applications, e.g., ranging from computational neuroscience to computational physics to blockchains.

Theoretical Physics

My original professional experiences and publications were in theoretical nuclear physics, always focused on explaining experimentally verifiable data [41-44]. I also contributed to teaching methodologies in various disciplines, including physics [45-47] and karate [48-50].

Portfolio of Physiological Indicators (PPI)

Quite general portfolios of specialized constituents also can be addressed, as described in https://www.ingber.com/ingber_projects.html. For example, multiple synchronous imaging data, processed with the TRD copula analysis, and using SMNI models [1,2,51]. leads to a portfolio of physiological indicators (PPI) to enhance resolution of neocortical processing information [28].

Ideas by Statistical Mechanics (ISM)

“Ideas by Statistical Mechanics (ISM)”, integrates previous projects to model evolution and propagation of ideas/patterns throughout populations subjected to endogenous and exogenous interactions [52-54]. This product can be used for decision support for projects ranging from diplomatic, information, military, and economic (DIME) factors of propagation/evolution of ideas, to commercial sales, trading indicators across sectors of financial markets, advertising and political campaigns, etc.

Real Options for Project Schedules (ROPS)

Similar tools can be applied to price complex projects as financial options with alternative schedules and strategies. PATHTREE processes real-world options, including nonlinear distributions and time-dependent starting and stopping of sub-projects, with parameters of shapes of distributions fit using ASA to optimize cost and duration of sub-projects [55,56].

Statistical Mechanics of Combat (SMC)

As a Professor of Physics with the US Navy, and working with the US Army, I was PI of US Army Contract RLF6L, funded by the Deputy Under Secretary of the Army for Operations Research (DUSA-OR). I led a team of Officers and contractors to successfully baseline Janus(T) — a battalion-level war game with statistical details of performance characteristics of weapons, movement of men and machines across various terrains — to National Training Center (NTC) data obtained in the field [57-60].

The ROPS project was motivated by using such simulations to develop data to develop Real Options for the massive US Army project Future Combat Systems (FCS).

Education

In addition to developing and teaching undergraduate and graduate courses in academic institutions, I have created opportunities and organizations to educate people outside these institutions [45,47,49,50]. My XSEDE.org project helped to educate volunteers in selected topics in physics and neuroscience. I regularly address technical queries on papers in my <https://www.ingber.com> archive. Via reviewing for scores of scientific journals, I help authors as well as publishers develop their papers.

Recent Projects

Recent projects are described in https://www.ingber.com/lir_computational_physics_group.html .



Lester

REFERENCES

- [1] L. Ingber, “Statistical mechanics of neocortical interactions. I. Basic formulation,” *Physica D* **5**, 83-107 (1982). [URL https://www.ingber.com/smni82_basic.pdf]
- [2] L. Ingber, “Statistical mechanics of neocortical interactions. Dynamics of synaptic modification,” *Physical Review A* **28**, 395-416 (1983). [URL https://www.ingber.com/smni83_dynamics.pdf]
- [3] L. Ingber, “Statistical mechanics of neocortical interactions. Derivation of short-term-memory capacity,” *Physical Review A* **29**, 3346-3358 (1984). [URL https://www.ingber.com/smni84_stm.pdf]
- [4] L. Ingber, “Statistical mechanics of neocortical interactions: Stability and duration of the 7+-2 rule of short-term-memory capacity,” *Physical Review A* **31**, 1183-1186 (1985). [URL https://www.ingber.com/smni85_stm.pdf]
- [5] L. Ingber, “Statistical mechanics of neocortical interactions: Constraints on 40 Hz models of short-term memory,” *Physical Review E* **52**, 4561-4563 (1995). [URL https://www.ingber.com/smni95_stm40hz.pdf]
- [6] L. Ingber, “Statistical mechanics of neocortical interactions: Reaction time correlates of the g factor,” *Psychology* **10**, (1999). [Invited commentary on The g Factor: The Science of Mental Ability by Arthur Jensen. URL https://www.ingber.com/smni99_g_factor.pdf]
- [7] L. Ingber, “Statistical mechanics of neocortical interactions: Applications of canonical momenta indicators to electroencephalography,” *Physical Review E* **55**, 4578-4593 (1997). [URL https://www.ingber.com/smni97_cmi.pdf]
- [8] L. Ingber, “Statistical mechanics of neocortical interactions: Training and testing canonical momenta indicators of EEG,” *Mathematical Computer Modelling* **27**, 33-64 (1998). [URL https://www.ingber.com/smni98_cmi_test.pdf]

- [9] L. Ingber, “Statistical mechanics of neocortical interactions: Nonlinear columnar electroencephalography,” *NeuroQuantology Journal* **7**, 500-529 (2009). [URL https://www.ingber.com/smni09_nonlin_column_eeg.pdf]
- [10] L. Ingber and P.L. Nunez, “Neocortical Dynamics at Multiple Scales: EEG Standing Waves, Statistical Mechanics, and Physical Analogs,” *Mathematical Biosciences* **229**, 160-173 (2010). [URL https://www.ingber.com/smni10_multiple_scales.pdf]
- [11] L. Ingber, “Columnar EEG magnetic influences on molecular development of short-term memory,” in *Short-Term Memory: New Research*, ed. by G. Kalivas and S.F. Petralia (Nova, Hauppauge, NY, 2012), p. 37-72. [Invited Paper. URL https://www.ingber.com/smni11_stm_scales.pdf]
- [12] L. Ingber, “Computational algorithms derived from multiple scales of neocortical processing,” in *Pointing at Boundaries: Integrating Computation and Cognition on Biological Grounds*, ed. by A. Pereira, Jr., E. Massad, and N. Bobbitt (Springer, New York, 2011), p. 1-13. [Invited Paper. URL https://www.ingber.com/smni11_cog_comp.pdf and <http://dx.doi.org/10.1007/s12559-011-9105-4>]
- [13] L. Ingber, M. Pappalepore, and R.R. Stesiak, “Electroencephalographic field influence on calcium momentum waves,” *Journal of Theoretical Biology* **343**, 138-153 (2014). [URL https://www.ingber.com/smni14_eeg_ca.pdf and <http://dx.doi.org/10.1016/j.jtbi.2013.11.002>]
- [14] L. Ingber, “Calculating consciousness correlates at multiple scales of neocortical interactions,” in *Horizons in Neuroscience Research*, ed. by A. Costa and E. Villalba (Nova, Hauppauge, NY, 2015), p. 153-186. [ISBN: 978-1-63482-632-7. Invited paper. URL https://www.ingber.com/smni15_calc_conscious.pdf]
- [15] L. Ingber, “Statistical mechanics of neocortical interactions: Large-scale EEG influences on molecular processes,” *Journal of Theoretical Biology* **395**, 144-152 (2016). [URL https://www.ingber.com/smni16_large-scale_molecular.pdf and <http://dx.doi.org/10.1016/j.jtbi.2016.02.003>]
- [16] L. Ingber, “Adaptive Simulated Annealing (ASA),” Global optimization C-code, Caltech Alumni Association, Pasadena, CA, 1993. [URL <https://www.ingber.com/#ASA-CODE>]
- [17] L. Ingber, “Adaptive Simulated Annealing,” in *Stochastic global optimization and its applications with fuzzy adaptive simulated annealing*, ed. by H.A. Oliveira, Jr., A. Petraglia, L. Ingber, M.A.S. Machado, and M.R. Petraglia (Springer, New York, 2012), p. 33-61. [Invited Paper. URL https://www.ingber.com/asa11_options.pdf]
- [18] L. Ingber, “Statistical mechanical aids to calculating term structure models,” *Physical Review A* **42**, 7057-7064 (1990). [URL https://www.ingber.com/markets90_interest.pdf]
- [19] L. Ingber, “Canonical momenta indicators of financial markets and neocortical EEG,” in *Progress in Neural Information Processing*, ed. by S.-I. Amari, L. Xu, I. King, and K.-S. Leung (Springer, New York, 1996), p. 777-784. [Invited paper to the 1996 International Conference on Neural Information Processing (ICONIP’96), Hong Kong, 24-27 September 1996. ISBN 981-3083-05-0. URL https://www.ingber.com/markets96_momenta.pdf]
- [20] L. Ingber, “High-resolution path-integral development of financial options,” *Physica A* **283**, 529-558 (2000). [URL https://www.ingber.com/markets00_highres.pdf]
- [21] L. Ingber, C. Chen, R.P. Mondescu, D. Muzzall, and M. Renedo, “Probability tree algorithm for general diffusion processes,” *Physical Review E* **64**, 056702-056707 (2001). [URL https://www.ingber.com/path01_pathtree.pdf]
- [22] L. Ingber and R.P. Mondescu, “Automated internet trading based on optimized physics models of markets,” in *Intelligent Internet-Based Information Processing Systems*, ed. by R.J. Howlett, N.S. Ichalkaranje, L.C. Jain, and G. Tonfoni (World Scientific, Singapore, 2003), p. 305-356. [Invited paper. URL https://www.ingber.com/markets03_automated.pdf]
- [23] L. Ingber, “Statistical mechanics of neocortical interactions: A scaling paradigm applied to electroencephalography,” *Physical Review A* **44**, 4017-4060 (1991). [URL https://www.ingber.com/smni91_eeg.pdf]

- [24] L. Ingber, "Generic mesoscopic neural networks based on statistical mechanics of neocortical interactions," *Physical Review A* **45**, R2183-R2186 (1992). [URL https://www.ingber.com/smni92_mnn.pdf]
- [25] L. Ingber and P.L. Nunez, "Statistical mechanics of neocortical interactions: High resolution path-integral calculation of short-term memory," *Physical Review E* **51**, 5074-5083 (1995). [URL https://www.ingber.com/smni95_stm.pdf]
- [26] L. Ingber, R. Srinivasan, and P.L. Nunez, "Path-integral evolution of chaos embedded in noise: Duffing neocortical analog," *Mathematical Computer Modelling* **23**, 43-53 (1996). [URL https://www.ingber.com/path96_duffing.pdf]
- [27] L. Ingber, "Statistical mechanics of neocortical interactions: Multiple scales of EEG," in *Frontier Science in EEG: Continuous Waveform Analysis (Electroencephal. clin. Neurophysiol. Suppl. 45)*, ed. by R.M. Dasheiff and D.J. Vincent (Elsevier, Amsterdam, 1996), p. 79-112. [Invited talk to Frontier Science in EEG Symposium, New Orleans, 9 Oct 1993. ISBN 0-444-82429-4. URL https://www.ingber.com/smni96_eeg.pdf]
- [28] L. Ingber, "Statistical mechanics of neocortical interactions: Portfolio of physiological indicators," Report 2006:PPI, Lester Ingber Research, Ashland, OR, 2006. [URL https://www.ingber.com/smni06_ppi.pdf]
- [29] L. Ingber, "Statistical mechanics of neocortical interactions: Portfolio of physiological indicators," *The Open Cybernetics Systemics Journal* **3**, 13-26 (2009). [URL <http://dx.doi.org/10.2174/1874110x00903010013>]
- [30] L. Ingber, "Influence of macrocolumnar EEG on Ca waves," *Current Progress Journal* **1**, 4-8 (2012). [URL https://www.ingber.com/smni12_vectpot.pdf]
- [31] P.L. Nunez, R. Srinivasan, and L. Ingber, "Theoretical and experimental electrophysiology in human neocortex: Multiscale correlates of conscious experience," in *Multiscale Analysis and Nonlinear Dynamics: From genes to the brain*, ed. by M.M. Pesenson (Wiley, New York, 2013), p. 149-178. [URL <http://dx.doi.org/10.1002/9783527671632.ch06>]
- [32] L. Ingber, "Electroencephalographic (EEG) influence on Ca²⁺ waves: Lecture plates," Report 2013:LEFI, Lester Ingber Research, Ashland, OR, 2013. [2nd World Neuroscience Online Conference 18 June 2013. URL https://www.ingber.com/smni13_eeg_ca_lect.pptx and https://www.ingber.com/smni13_eeg_ca_lect.pdf]
- [33] L. Ingber, "Statistical mechanics of combat and extensions," in *Toward a Science of Command, Control, and Communications*, ed. by C. Jones (American Institute of Aeronautics and Astronautics, Washington, D.C., 1993), p. 117-149. [ISBN 1-56347-068-3. URL https://www.ingber.com/combata93_c3sci.pdf]
- [34] L. Ingber, "Data mining and knowledge discovery via statistical mechanics in nonlinear stochastic systems," *Mathematical Computer Modelling* **27**, 9-31 (1998). [URL https://www.ingber.com/path98_datamining.pdf]
- [35] L. Ingber, "Adaptive simulated annealing (ASA): Lessons learned," *Control and Cybernetics* **25**, 33-54 (1996). [Invited paper to Control and Cybernetics on Simulated Annealing Applied to Combinatorial Optimization. URL https://www.ingber.com/asa96_lessons.pdf]
- [36] L. Ingber, "Trading in Risk Dimensions (TRD)," Report 2005:TRD, Lester Ingber Research, Ashland, OR, 2005. [URL https://www.ingber.com/markets05_trd.pdf]
- [37] L. Ingber, "Trading in Risk Dimensions," in *The Handbook of Trading: Strategies for Navigating and Profiting from Currency, Bond, and Stock Markets*, ed. by G.N. Gregoriou (McGraw-Hill, New York, 2010), p. 287-300.
- [38] L. Ingber, "Path-integral quantum PATHTREE and PATHINT algorithms," *International Journal of Innovative Research in Information Security* **3**, 1-15 (2016). [URL https://www.ingber.com/path16_quantum_path.pdf]
- [39] L. Ingber, "Evolution of regenerative Ca-ion wave-packet in neuronal-firing fields: Quantum path-integral with serial shocks," *International Journal of Innovative Research in Information Security*

- 4, 14-22 (2017). [URL https://www.ingber.com/path17_quantum_pathint_shocks.pdf]
- [40] L. Ingber, "Options on quantum money: Quantum path-integral with serial shocks," *International Journal of Innovative Research in Information Security* **4**, 7-13 (2017). [URL https://www.ingber.com/path17_quantum_options_shocks.pdf]
- [41] L. Ingber, "Nuclear forces," *Physical Review* **174**, 1250-1263 (1968). [URL https://www.ingber.com/nuclear68_forces.pdf]
- [42] J.R. Buchler and L. Ingber, "Properties of the neutron gas and applications to neutron stars," *Nuclear Physics A* **170**, 1-11 (1971).
- [43] W.R. Frazer, L. Ingber, C.H. Mehta, C.H. Poon, D. Silverman, K. Stowe, and H. Yessian, "High energy multiparticle reactions," *Reviews Modern Physics* **44**, 284-319 (1972).
- [44] L. Ingber, "Riemannian contributions to short-ranged velocity-dependent nucleon-nucleon interactions," *Physical Review D* **33**, 3781-3784 (1986). [URL https://www.ingber.com/nuclear86_riemann.pdf]
- [45] L. Ingber, "Editorial: Learning to learn," *Explore* **7**, 5-8 (1972). [URL https://www.ingber.com/smni72_learning.pdf]
- [46] I. Assimov, A. Baker, M. Bickford, G. Burbidge, G. Choppin, M. Chriss, D. Eisenberg, J. Fowler, H. Gray, A. Holden, L. Ingber, R. Kolenkow, C. Lee, P. Lonsdale, G. Morgan, M. Rotenberg, M. Sands, A. Schawlow, V. Weisskopf, and G. Wetherill, *Physical Science Today* (CRM Books, Del Mar, CA, 1973). [ISBN 0-394-30281-8]
- [47] L. Ingber, "Attention, physics and teaching," *Journal Social Biological Structures* **4**, 225-235 (1981). [URL https://www.ingber.com/smni81_attention.pdf]
- [48] L. Ingber, *The Karate Instructor's Handbook* (Physical Studies Institute-Institute for the Study of Attention, Solana Beach, CA, 1976). [URL https://www.ingber.com/karate76_book.html]
- [49] L. Ingber, *Karate: Kinematics and Dynamics* (Unique, Hollywood, CA, 1981). [ISBN 0-86568-025-6. URL https://www.ingber.com/karate81_book.txt]
- [50] L. Ingber, *Elements of Advanced Karate* (Ohara, Burbank, CA, 1985). [ISBN 0-89750-127-6. URL https://www.ingber.com/karate85_book.html]
- [51] L. Ingber, "Statistical mechanics of neocortical interactions (SMNI): Testing theories with multiple imaging data," *NeuroQuantology Journal* **6**, 97-104 (2008). [URL Invited paper. https://www.ingber.com/smni08_tt.pdf]
- [52] L. Ingber, "Ideas by statistical mechanics (ISM)," Report 2006:ISM, Lester Ingber Research, Ashland, OR, 2006. [URL https://www.ingber.com/smni06_ism.pdf]
- [53] L. Ingber, "Ideas by Statistical Mechanics (ISM)," *Journal Integrated Systems Design and Process Science* **11**, 31-54 (2007). [Special Issue: Biologically Inspired Computing.]
- [54] L. Ingber, "AI and Ideas by Statistical Mechanics (ISM)," in *Encyclopedia of Artificial Intelligence*, ed. by J.R. Rabunal, J. Dorado, and A.P. Pazos (Information Science Reference, New York, 2008), p. 58-64. [ISBN 978-1-59904-849-9]
- [55] L. Ingber, "Real Options for Project Schedules (ROPS)," Report 2007:ROPS, Lester Ingber Research, Ashland, OR, 2007. [URL https://www.ingber.com/markets07_rops.pdf]
- [56] L. Ingber, "Real Options for Project Schedules (ROPS)," *SGI Reflections International Journal of Science, Technology & Management* **2**, 15-20 (2010). [Invited paper. URL <http://sgi.ac.in/colleges/newsletters/1146080820111637301.pdf>]
- [57] L. Ingber, "Mathematical comparison of computer models to exercise data: Comparison of JANUS(T) to National Training Center data," in *1988 JDL C2 Symposium: Naval Postgraduate School, Monterey, CA, 7-9 June 1988*, (SAIC, McLean, VA, 1988), p. 541-549.
- [58] L. Ingber, "Mathematical comparison of computer models to exercise data," in *1989 JDL C2 Symposium: National Defense University, Washington, DC, 27-29 June 1989*, (SAIC, McLean, VA, 1989), p. 169-192.

- [59] L. Ingber, "Mathematical comparison of JANUS(T) simulation to National Training Center," in *The Science of Command and Control: Part II, Coping With Complexity*, ed. by S.E. Johnson and A.H. Levis (AFCEA International, Washington, DC, 1989), p. 165-176.
- [60] M. Bowman and L. Ingber, "Canonical momenta of nonlinear combat," in *Proceedings of the 1997 Simulation Multi-Conference, 6-10 April 1997, Atlanta, GA*, (Society for Computer Simulation, San Diego, CA, 1997). [URL https://www.ingber.com/combat97_cmi.pdf]

\$Id: ingber_projects_brief,v 1.64 2017/07/10 01:26:57 ingber Exp \$