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Education

N/A (N/A), 1971-1972, University of California, Los Angeles (enrolled as high school senior)
B.S. (mathematical sciences), 1976, Stanford University (with distinction)
M.S. (computer science), 1978, Carnegie Mellon University
N/A (psychology), 1978-1979, University of California, San Diego (visiting graduate student)
Ph.D. (computer science), 1983, Carnegie Mellon University

Current Positions

Professor, Computer Science Department, University of Southern California, 1999-
Deputy Director, Center for Rapid Automated Fabrication Technologies, Information Sciences Institute,
University of Southern California, 2005-
Project Leader, Institute for Creative Technologies, University of Southern California, 2009-

Experience

Programmer, TRW Inc., 6/73 - 9/73, 6/74 - 9/74, Lockheed Missiles & Space Co., Inc., 6/75 - 9/75,
Amdahl Corp., 1/76 - 4/76, Systems Control Inc. 4/76 - 8/76.
Research Computer Scientist, Computer Science Department, Carnegie Mellon University, 1983-1984.
Acting Assistant Professor, Computer Science and Psychology Departments, Stanford University, 1984.
Assistant Professor, Computer Science and Psychology Departments, Stanford University, 1984-1987.
Assistant Professor, Computer Science Department (on leave), Stanford University, 1987-1989.
Project Leader, Intelligent Systems Division, Information Sciences Institute, University of Southern
California, 1987-1993.
Research Assistant Professor, Computer Science Department, University of Southern California, 1988-
1990.
Associate Professor, Computer Science Department, University of Southern California, 1991-1999.
Deputy Director, Intelligent Systems Division, Information Sciences Institute, University of Southern
California, 1993-2002.
New Directions, Information Sciences Institute, University of Southern California, 1998-2000.
Director, New Directions, Information Sciences Institute, University of Southern California, 2000-2002.
Associate Director, Information Sciences Institute, University of Southern California, 2002-2007.
Deputy Director, Information Sciences Institute, University of Southern California, 2007.

Memberships

American Association for Artificial Intelligence	Cognitive Science Society
American Assoc. for the Advancement of Science	IEEE Computer Society
Association for Computing Machinery	Sigma Xi

DARPA ISAT Study on “Total Recall: Combining Human & Digital Memory”, 2000.
 DARPA ISAT Study on “Massively Populated Persistent Worlds”, 2002.
 AAAI Report to ARPA on “Twenty First Century Intelligent Systems”, 1994.
 AAAI Report to NSF on “Intelligent Systems in the NII”, 1994-1995.
 DoD Working Group on “Computer Generated Forces”, 1998.
 Rapporteur: National Academy Research Briefing Panel on Cognitive Science & Artificial Intelligence, 1983.

PhD Dissertations Advised

Dirk Ruiz, *Learning and Problem Solving: What is Learned while Solving the Towers of Hanoi*, Stanford University, Department of Psychology, 1987.
 Milind Tambe, *Eliminating Combinatorics from Production Match*, Carnegie Mellon University, School of Computer Science, 1991. (Co-advised with Allen Newell)
 Andrew Golding, *Pronouncing Names by a Combination of Rule-Based and Case-Based Reasoning*, Stanford University, Department of Computer Science, 1991.
 Amy Unruh, *Using Automatic Abstraction for Problem-Solving and Learning*, Stanford University, Department of Computer Science, 1993.
 Soowon Lee, *Multi-Method Planning*, University of Southern California, Department of Computer Science, 1994.
 Robert Doorenbos, *Production Matching for Large Learning Systems*, Carnegie Mellon University, School of Computer Science, 1995. (Co-advised with Jill Fain Lehman)
 Benjamin Smith, *Induction as Knowledge Integration*, University of Southern California, Department of Computer Science, 1995.
 Jihie Kim, *Bounding the Cost of Learned Rules: A Transformation Approach*, University of Southern California, Department of Computer Science, 1996.
 Bonghan Cho, *Efficient Production System Match and Constraint Satisfaction Problem Solving*, University of Southern California, Department of Computer Science, 1996. (Co-advised with Milind Tambe)

Courses Taught

“Introduction to Computing B”, Carnegie Mellon University, Spring 1980.
 “Artificial Intelligence for Psychologists”, Stanford University, Fall 1984, Fall 1985.
 “Cognitive Architecture”, Stanford University, Spring 1985, Spring 1987.
 “Computer Science Colloquium”, Stanford University, Spring 1985.
 “Learning in Man and Machine”, Stanford University, Winter 1986.
 “Cognitive Introduction to Artificial Intelligence”, Stanford University, Winter 1987.
 “Machine Learning”, University of Southern California, Spring 1989.
 “Advanced Machine Learning”, University of Southern California, Spring 1990, Fall 1990, Spring 1991, Spring 1993.
 “Artificial Intelligence”, University of Southern California, Fall 1991, Fall 1994.
 “Integrated Intelligent Systems”, University of Southern California, Fall 1992.
 “Introduction to Artificial Intelligence”, University of Southern California, Fall 1993, Spring 2008.
 “New Perspective/Directions for Computing”, University of Southern California, Fall 2007.
 “Foundations of Artificial Intelligence”, University of Southern California, Spring 2008, Spring 2010.

Research Funding

Gift in support of research, Hughes Aircraft Company Research Laboratories, 1985, \$20,000.
 Gift in support of research, Hughes Aircraft Company Research Laboratories, 1987, \$25,000.
 “The SOAR Project”, Hughes Aircraft Company Research Laboratories, 3/1/1988 to 12/31/1988, \$20,044.¹

¹ A contract to Stanford University, with Nils Nilsson as the official PI (since I left Stanford), but with me still in charge of proposal writing and research guidance.

- “Research on Abstraction in Soar”, Hughes Aircraft Company Research Laboratories, 1/1/1989 to 9/30/1989, \$24,325.¹
- “Proposal for Research on Soar: An Architecture for General Intelligence and Learning”, Defense Advanced Research Projects Agency (DARPA), 8/22/86 to 3/31/1990, \$487,859.
- “Research on Abstraction in Soar”, Hughes Aircraft Company Research Laboratories, 1/1/1990 to 6/30/1990, \$20,159.¹
- “Research on Soar”, National Aeronautics and Space Administration (NASA) Ames Research Center, 1/1/1988 to 12/31/1990, \$211,688.
- Gift in support of Neuro-Soar research, Hughes Aircraft Company Research Laboratories, 1990 to 1991, \$37,859.
- “Experiments in Skill Acquisition: Integrating explanation-based learning with abstraction, macro-operators, and nonlinear plans”, Defense Advanced Research Projects Agency (DARPA) and the Office of Naval Research (ONR), 5/1/1989 to 4/30/1992, \$431,013.
- Gift in support of Neuro-Soar research, Hughes Aircraft Company Research Laboratories, 1991 to 1992, \$30,000.
- Gift in support of research on simulation agents, Hughes Aircraft Company Research Laboratories, 1992, \$5,400.
- “Towards Knowledge-Based Simulated Agents”, Defense Advanced Research Projects Agency (DARPA), 6/18/1992 to 6/17/1993, \$138,278 (\$50,000 of this is a subcontract to Carnegie Mellon University).
- “Rosenbloom Powell 94”, Powell Foundation, 7/1/1993 to 9/30/1994, \$16,100.
- “Intelligent automated forces for SIMNET”, Office of Naval Research (ONR), 4/1/1991 to 12/31/1994, \$160,000.
- “Powell/Rosenbloom”, Powell Foundation, 1/1/1993 to 12/31/1994, \$11,500.
- “Learning to Use Devices”, National Aeronautics and Space Administration (NASA) Ames Research Center, 1/1/1991 to 5/31/1995, \$270,854.
- “Intelligent Automated Agents and Analysis Tools for Simulated Environments”, Advanced Research Projects Agency (ARPA) and Naval Research Laboratory (NRL), as a subcontract from the University of Michigan, 7/15/1992 to 7/14/1995, \$1,361,234.
- Grant in support of the Soar theory of human cognition, James S. McDonnell Foundation (by way of Carnegie Mellon University), 1992 to 1995, \$20,000.
- “Assessment of Soar for Command Decision Making”, US Army Artificial Intelligence Center, 6/19/1996 to 9/19/1996, \$7,500.
- “Intelligent Forces for Simulated Environments”, Defense Advanced Research Projects Agency (DARPA) and the Naval Command, Control, and Ocean Surveillance Center, RDTE Division (NRaD), 2/15/1995 to 2/14/1998, \$5,244,988.
- “Adaptive Agent and Agent-Group Modeling for Automated Target Identification”, Wright-Patterson AFB, as a subcontract from Sverdrup Technology, Inc., 1/1/1997 to 6/30/1998, \$99,991. (co-PI)
- “Flexible Group Behavior”, Defense Advanced Research Projects Agency (DARPA), as a subcontract from The University of Michigan, 4/28/1997 to 9/30/1999, \$1,525,683.
- “Adaptive Synthetic Forces”, Office of Naval Research (ONR), 1/1/1998 to 12/31/2000, \$304,032.
- “Digital Government: Responding to the Unexpected”, National Science Foundation (NSF), 3/15/02 to 2/29/04, \$232,633.
- “Heterogeneous, Peer-to-Peer, Robot-Agent-Person (RAP) Teams”, Defense Advanced Research Projects Agency (DARPA), 7/1/2002 to 10/27/2003, \$450,000.
- “CCT Provost Collaborative and Interdisciplinary Research”, USC Centers for Creative Technologies (CCT), 6/1/2008-6/30/2010, \$336,419.
- “Virtual Human Cognitive Architecture Research”, U.S. Army RDECOM, 11/1/2009-10/31/2011, \$795,671.

Publications

Doctoral Dissertation

Rosenbloom, P. S. (1983). *The Chunking of Goal Hierarchies: A Model of Practice and Stimulus-Response Compatibility*. , Carnegie-Mellon University. (Available in Laird, J. E., Rosenbloom, P. S., and Newell, A. *Universal Subgoaling and Chunking: The Automatic Generation and Learning of Goal Hierarchies*, Hingham, MA: Kluwer, 1986.)

Books and Proceedings

Laird, J. E., Rosenbloom, P. S. & Newell, A. (1986). *Universal Subgoaling and Chunking: The Automatic Generation and Learning of Goal Hierarchies*. Hingham, MA: Kluwer Academic Publishers.

Laird, J. E., Langley, P., Mitchell, T. M. & Rosenbloom, P. S. (Eds.). (1991). *Working Notes of the AAAI Spring Symposium on Integrated Intelligent Architectures*. Stanford, CA: AAAI. (Appeared as a special section of *SIGART Bulletin*, Vol. 2, Num. 4, August 1991.)

Rosenbloom, P. S., Laird, J. E. & Newell, A. (Eds.). (1993). *The Soar Papers: Research on Integrated Intelligence (Volume One)*. Cambridge, MA: MIT Press.

Rosenbloom, P. S., Laird, J. E. & Newell, A. (Eds.). (1993). *The Soar Papers: Research on Integrated Intelligence (Volume Two)*. Cambridge, MA: MIT Press.

Arens, Y. & Rosenbloom, P. (Eds.). (2002). *Responding to the Unexpected: Report of the Workshop Held in New York City, February 27 – March 1, 2002*. (Available from USC/ISI or at <http://www.isi.edu/crue>.)

Books in Progress

Rosenbloom, P. S. (In Preparation). *What is Computing? The Architecture of the Fourth Great Scientific Domain*.

Rigorously Refereed Journal Articles

Rosenbloom, P. S. (1982). A world-championship-level Othello program. *Artificial Intelligence*, 19, 279-320.

Rosenbloom, P. S., Laird, J. E., McDermott, J., Newell, A. & Orciuch, E. (1985). R1-Soar: An experiment in knowledge-intensive programming in a problem-solving architecture. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 7, 561-569.

Laird, J. E., Rosenbloom, P. S. & Newell, A. (1986). Chunking in Soar: The anatomy of a general learning mechanism. *Machine Learning*, 1, 11-46.

Laird, J. E., Newell, A., & Rosenbloom, P. S. (1987). Soar: An architecture for general intelligence. *Artificial Intelligence*, 33, 1-64.

Tambe, M., Newell, A. & Rosenbloom, P. S. (1990). The problem of expensive chunks and its solution by restricting expressiveness. *Machine Learning*, 5, 299-348.

Rosenbloom, P. S., Laird, J. E., Newell, A. & McCarl, R. (1991). A preliminary analysis of the Soar architecture as a basis for general intelligence. *Artificial Intelligence*, 47, 289-325.

Golding, A. & Rosenbloom, P. S. (1993). A comparison of Anapron with seven other name-pronunciation systems. *Journal of the American Voice I/O Society*, 14, 1-21.

Tambe, M. & Rosenbloom, P. S. (1994). Investigating production system representations for non-combinatorial match. *Artificial Intelligence*, 68, 155-199.

Golding, A. R. & Rosenbloom, P. S. (1996). Improving accuracy by combining rule-based and case-based reasoning. *Artificial Intelligence*, 87, 215-254.

Tambe, M. & Rosenbloom, P. S. (1996). Event tracking in a dynamic multi-agent environment. *Computational Intelligence*, 12, 499-521.

Kim, J. & Rosenbloom, P. S. (2000). Bounding the cost of learned rules. *Artificial Intelligence*, 120, 43-80.

Rosenbloom, P. S. (2004). A new framework for Computer Science and Engineering. *IEEE Computer*, 37, 31-36.

Rosenbloom, P. S. (2006). A cognitive odyssey: From the power law of practice to a general learning mechanism and beyond. *Tutorials in Quantitative Methods for Psychology*, 2, 43-51.

Rosenbloom, P. S. (2009). The great scientific domains and society: A metascience perspective from the domain of computing. *The International Journal of Science in Society*, 1 (1), 133-144.

Submitted Journal Articles

Rosenbloom, P. S. (Submitted). Rethinking cognitive architecture via graphical models. Submitted to *Cognitive Systems Research*.

Other Publications in Journals and Magazines

Rosenbloom, P. S. (1984). Review of "The Modularity of Mind" by J. A. Fodor. *American Scientist*, 72, 634.

Rosenbloom, P. S. (1987). Weak versus strong claims about the algorithmic level: Commentary on "Methodologies for studying human knowledge" by J. R. Anderson. *The Behavioral and Brain Sciences*, 10, 490.

Laird, J. E., Hucka, M., Huffman, S. B., & Rosenbloom, P. S. (1991). An analysis of Soar as an integrated architecture. *SIGART Bulletin*, 2, 98-103.

Rosenbloom, P. S. (1991). Climbing the hill of cognitive-science theory. *Psychological Science*, 2, 308-311.

Laird, J. E. & Rosenbloom, P. S. (1991, Winter). Report on the AAAI 1991 Spring Symposium on "Integrated Intelligent Architectures". *AI Magazine*, 12, 35-36.

Laird, J. E. & Rosenbloom, P. S. (1992, Winter). In pursuit of mind: The research of Allen Newell. *AI Magazine*, 13, 17-45.

Rosenbloom, P. S. & Laird, J. E. (1993). On *Unified Theories of Cognition*: A response to the reviews. *Artificial Intelligence*, 59, 389-413.

Tambe, M., Johnson, W. L., Jones, R. M., Koss, F., Laird, J. E., Rosenbloom, P. S. & Schwamb, K. B. (1995, Spring). Intelligent agents for interactive simulation environments. *AI Magazine*, 16, 15-39.

Arens, Y. & Rosenbloom, P. S. (2003). Responding to the Unexpected. *Communications of the ACM*, 46, 33-35.

Denning, P. J. & Rosenbloom, P. S. (2009). Computing: The fourth great domain of science. *Communications of the ACM*, 52, 27-29.

Other Journal and Magazine Articles in Preparation

Rigorously Refereed Conference Papers

Rosenbloom, P. S. & Newell, A. (1982). Learning by chunking: Summary of a task and a model, *Proceedings of the National Conference on Artificial Intelligence* (pp. 255-257). Pittsburgh, PA: AAAI.

- Laird, J. E., Rosenbloom, P. S. & Newell, A. (1984). Towards chunking as a general learning mechanism, *Proceedings of the National Conference on Artificial Intelligence* (pp. 188-192). Austin, TX: AAAI.
- John, B. E., Rosenbloom, P. S. & Newell, A. (1985). A theory of stimulus-response compatibility applied to human-computer interaction. In L. B. a. B. Curtis (Ed.), *Proceedings of CHI '85, Human Factors in Computing Systems* (pp. 213-219). San Francisco, CA: ACM/SIGCHI.
- Rosenbloom, P. S. & Laird, J. E. (1986). Mapping explanation-based generalization onto Soar, *Proceedings of the Fifth National Conference on Artificial Intelligence* (pp. 561-567). Philadelphia, PA: AAAI.
- Golding, A. R., Rosenbloom, P. S. & Laird, J. E. (1987). Learning general search control from outside guidance, *Proceedings of the Tenth International Joint Conference on Artificial Intelligence* (pp. 334-337). Milan, Italy: IJCAII.
- Rosenbloom, P. S., Laird, J. E. & Newell, A. (1987). Knowledge level learning in Soar, *Proceedings of Sixth National Conference on Artificial Intelligence* (pp. 499-504). Seattle, WA: AAAI.
- Nayak, P., Gupta, A. & Rosenbloom, P. S. (1988). Comparison of the Rete and Treat production matchers for Soar (a summary), *Proceedings of the Seventh National Conference on Artificial Intelligence* (pp. 693-698). St. Paul, MN: AAAI.
- Tambe, M. & Rosenbloom, P. S. (1989). Eliminating expensive chunks by restricting expressiveness, *Proceedings of the Eleventh International Joint Conference on Artificial Intelligence* (pp. 731-737). Detroit, MI: IJCAII.
- Unruh, A. & Rosenbloom, P. S. (1989). Abstraction in problem solving and learning, *Proceedings of the Eleventh International Joint Conference on Artificial Intelligence* (pp. 681-687). Detroit, MI: IJCAII.
- Laird, J. E. & Rosenbloom, P. S. (1990). Integrating execution, planning, and learning in Soar for external environments, *Proceedings of the Eighth National Conference on Artificial Intelligence* (pp. 1022-1029). Boston, MA: MIT Press.
- Rosenbloom, P. S. & Aasman, J. (1990). Knowledge level and inductive uses of chunking (EBL), *Proceedings of the Eighth National Conference on Artificial Intelligence* (pp. 821-827). Boston, MA: MIT Press.
- Smith, B. D. & Rosenbloom, P. S. (1990). Incremental Non-Backtracking Focusing: A polynomially bounded generalization algorithm for version spaces, *Proceedings of the Eighth National Conference on Artificial Intelligence* (pp. 848-853). Boston, MA: MIT Press.
- Tambe, M. & Rosenbloom, P. S. (1990). A framework for investigating production system formulations with polynomially bounded match, *Proceedings of the Eighth National Conference on Artificial Intelligence* (pp. 693-700). Boston, MA: MIT Press.
- Cho, B., Rosenbloom, P. S. & Dolan, C. P. (1991). Neuro-Soar: A neural-network architecture for goal-oriented behavior, *Proceedings of the Thirteenth Annual Conference of the Cognitive Science Society* (pp. 673-677). Chicago, IL: Lawrence Erlbaum Associates.
- Golding, A. & Rosenbloom, P. S. (1991). Improving rule-based systems through case-based reasoning, *Proceedings of the Ninth National Conference on Artificial Intelligence* (pp. 22-27). Anaheim, CA: MIT Press.
- Kim, J. & Rosenbloom, P. S. (1993). Constraining learning with search control, *Machine Learning: Proceedings of the Tenth International Conference* (pp. 174-181). San Mateo, CA: Morgan Kaufmann.
- Lee, S. & Rosenbloom, P. S. (1993). Granularity in multi-method planning, *Proceedings of the Eleventh National Conference on Artificial Intelligence* (pp. 486-491). Washington, D.C.: AAAI.
- Tambe, M. & Rosenbloom, P. S. (1993). On the masking effect, *Proceedings of the Eleventh National Conference on Artificial Intelligence* (pp. 526-533). Washington, D.C.: AAAI.
- Tambe, M. & Rosenbloom, P. S. (1995). RESC: An approach for real-time, dynamic agent tracking, *Proceedings of the 14th International Joint Conference on Artificial Intelligence* (pp. 103-110). Montréal, Canada: IJCAII.

Kim, J. & Rosenbloom, P. S. (1996). Learning efficient rules by maintaining the explanation structure, *Proceedings, Thirteenth National Conference on Artificial Intelligence* (pp. 763-770). Portland, OR: AAAI.

Hill, R. W., Chen, J., Gratch, J., Rosenbloom, P. S. & Tambe, M. (1997). Intelligent agents for the synthetic battlefield: A company of rotary wing aircraft, *Proceedings, Ninth Conference on Innovative Applications of Artificial Intelligence* (pp. 1006-1012). Providence, RI: AAAI.

Hill, R., Gratch, J. & Rosenbloom, P. (2000). Flexible group behavior: Virtual commanders for synthetic battlespaces. In C. Sierra, M. Gini & J. S. Rosenschein (Eds.), *Proceedings of the Fourth International Conference on Autonomous Agents* (pp. 31-38). Barcelona, Spain: ACM Press.

Scerri, P., Pynadath, D. V., Johnson, L., Rosenbloom, P., Schurr, N. & Tambe, M. (2003). A prototype infrastructure for distributed robot-agent-person teams. In *Proceedings of the Second International Joint Conference on Autonomous Agents & Multiagent Systems* (pp. 433-440). Melbourne, Australia: ACM Press.

Rosenbloom, P. S. (2009). Towards a new cognitive hourglass: Uniform implementation of cognitive architecture via factor graphs. *Proceedings of the 9th International Conference on Cognitive Modeling (ICCM 2009)*.

Submitted Conference Papers

Rosenbloom, P. S. (Submitted). An integrated implementation of rule, semantic, episodic and constrain memories via factor graphs and a Bayesian decision cycle. *Submitted to the 24th AAAI Conference on Artificial Intelligence*.

Book Chapters

Newell, A. & Rosenbloom, P. S. (1981). Mechanisms of skill acquisition and the law of practice. In J. R. Anderson (Ed.), *Cognitive Skills and their Acquisition* (pp. 1-55). Hillsdale, NJ: Erlbaum.

Rosenbloom, P. S. & Newell, A. (1986). The chunking of goal hierarchies: A generalized model of practice. In R. S. Michalski, J. G. Carbonell & T. M. Mitchell (Eds.), *Machine Learning: An Artificial Intelligence Approach, Volume II* (pp. 247-288). Los Altos, CA: Morgan Kaufmann Publishers, Inc.

Rosenbloom, P. S., Laird, J. E., Newell, A., Golding, A. & Unruh, A. (1986). Current research on learning in Soar. In T. M. Mitchell, J. G. Carbonell & R. S. Michalski (Eds.), *Machine Learning: A Guide to Current Research* (pp. 281-290). Boston, MA: Kluwer Academic Press.

Rosenbloom, P. S. & Newell, A. (1987). Learning by chunking: A production-system model of practice. In D. Klahr, P. Langley & R. Neches (Eds.), *Production System Models of Learning and Development* (pp. 221-286). Cambridge, MA: Bradford Books/MIT Press.

Rosenbloom, P. S. (1987). Best-first search. In S. C. Shapiro (Ed.), *Encyclopedia of Artificial Intelligence* (pp. 998-1000). New York, NY: John Wiley and Sons.

Rosenbloom, P. S. (1988). A world-championship-level Othello program. In D. N. L. Levey (Ed.), *Computer Games II* (pp. 365-405). New York, NY: Springer-Verlag. (Reformatted reprint of Rosenbloom, P. S., 1982, in *Artificial Intelligence*, Vol. 19, pp. 279-320.)

Rosenbloom, P. S. & Newell, A. (1988). An integrated computational model of stimulus-response compatibility and practice. In G. H. Bower (Ed.), *The Psychology of Learning and Motivation, Volume 21* (pp. 1-52). San Diego, CA: Academic Press.

Rosenbloom, P. S., Laird, J. E. & Newell, A. (1988). Meta-levels in Soar. In P. Maes & D. Nardi (Eds.), *Meta-Level Architectures and Reflection* (pp. 227-240). Amsterdam, Netherlands: North Holland.

Rosenbloom, P. S., Laird, J. E. & Newell, A. (1989). The chunking of skill and knowledge. In B. A. G. Elsendoorn & H. Bouma (Eds.), *Working Models of Human Perception* (pp. 391-410). London, England: Academic Press.

- Newell, A., Rosenbloom, P. S. & Laird, J. E. (1989). Symbolic architectures for cognition. In M. I. Posner (Ed.), *Foundations of Cognitive Science* (pp. 93-131). Cambridge, MA: Bradford Books/MIT Press.
- Rosenbloom, P. S. (1989). A symbolic goal-oriented perspective on connectionism and Soar. In R. Pfeifer, Z. Schreter, F. Fogelman-Soulie & L. Steels (Eds.), *Connectionism in Perspective* (pp. 245-263). Amsterdam, Netherlands: Elsevier (North-Holland).
- Laird, J. E., Rosenbloom, P. S. & Newell, A. (1990). Chunking in Soar: The anatomy of a general learning mechanism. In J. W. S. a. T. G. Dietterich (Ed.), *Readings in Machine Learning* (pp. 555-572). San Mateo, CA: Morgan Kaufmann. (Reprint of Laird, Rosenbloom, and Newell, 1986, in *Machine Learning*, Vol. 1, pp. 11-46.)
- Mitchell, T. M., Buchanan, B. G., DeJong, G. F., Dietterich, T. G., Rosenbloom, P. S. & Waibel, A. H. (1990). Machine learning. In J. F. Traub, B. J. Grosz, B. W. Lampson & N. J. Nilsson (Eds.), *Annual Review of Computer Science, Volume 4* (pp. 417-433). Palo Alto, CA: Annual Reviews Inc.
- Newell, A., Yost, G. R., Laird, J. E., Rosenbloom, P. S. & Altmann, E. (1991). Formulating the problem space computational model. In R. F. Rashid (Ed.), *CMU Computer Science: A 25th Anniversary Commemorative* (pp. 255-293). New York, NY: ACM Press/Addison-Wesley.
- Rosenbloom, P. S., Laird, J. E., McDermott, J., Newell, A. & Orciuch, E. (1991). R1-Soar: An experiment in knowledge-intensive programming in a problem-solving architecture. In O. N. Garcia & Y. T. Chen (Eds.), *Knowledge-Based Systems: Fundamentals and Tools* (pp. 353-361). Los Alamitos, CA: IEEE Computer Society Press. (Reprint of Rosenbloom *et al*, 1985, in *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 7, pp. 561-569.)
- Rosenbloom, P. S., Newell, A. & Laird, J. E. (1991). Towards the knowledge level in Soar: The role of the architecture in the use of knowledge. In K. VanLehn (Ed.), *Architectures for Intelligence* (pp. 75-111). Hillsdale, NJ: Erlbaum.
- Rosenbloom, P. S., Laird, J. E., Newell, A. & McCarl, R. (1992). A preliminary analysis of the Soar architecture as a basis for general intelligence. In D. Kirsh (Ed.), *Foundations of Artificial Intelligence* (pp. 289-325). Cambridge, MA: Bradford Books/MIT Press. (Reprint of Rosenbloom *et al*, 1991, in *Artificial Intelligence*, vol. 47, pp. 289-325.)
- Golding, A. & Rosenbloom, P. S. (1993). Improving rule-based systems through case-based reasoning. In B. G. Buchanan & D. C. Wilkins (Eds.), *Readings in Knowledge Acquisition and Learning: Automating the Construction and Improvement of Expert Systems* (pp. 759-764). San Mateo, CA: Morgan Kaufmann. (Reprint of Golding and Rosenbloom, 1991, in *Proceedings of the Ninth National Conference on Artificial Intelligence*, pp. 22-27.)
- Laird, J. E., Rosenbloom, P. S. & Newell, A. (1993). Chunking in Soar: The anatomy of a general learning mechanism. In B. G. B. a. D. C. Wilkins (Ed.), *Readings in Knowledge Acquisition and Learning: Automating the Construction and Improvement of Expert Systems* (pp. 518-535). San Mateo, CA: Morgan Kaufmann. (Reprint of Laird, Rosenbloom, and Newell, 1986, in *Machine Learning*, Vol. 1, pp. 11-46.)
- Rosenbloom, P. S. & Newell, A. (1993). Symbolic Architectures: Organization of Intelligence. In T. A. Poggio & D. A. Glaser (Eds.), *Exploring Brain Functions: Models in Neuroscience* (pp. 225-231). Chichester, England: John Wiley and Sons.
- Rosenbloom, P. S., Lee, S. & Unruh, A. (1993). Bias in planning and explanation-based learning. In S. Minton (Ed.), *Machine Learning Methods for Planning* (pp. 197-232). San Mateo, CA: Morgan Kaufmann.
- Rosenbloom, P. S., Lee, S. & Unruh, A. (1993). Bias in planning and explanation-based learning. In S. Chipman & A. L. Meyrowitz (Eds.), *Foundations of Knowledge Acquisition: Cognitive Models of Complex Learning* (pp. 269-307). Hingham, MA: Kluwer Academic Publishers. (Reformatted reprint of a version of Rosenbloom, P. S., Lee, S. and Unruh, A., 1993, in *Machine Learning Methods for Planning*.)
- Washington, R. & Rosenbloom, P. S. (1993). Applying Problem Solving and Learning to Diagnosis. In P. S. Rosenbloom, J. E. Laird & A. Newell (Eds.), *The Soar Papers: Research on Integrated Intelligence (Volume One)* (pp. 674-687). Cambridge, MA: MIT Press.

Polk, T. A. & Rosenbloom, P. S. (1994). Task-independent constraints on a unified theory of cognition. In F. B. a. J. Grafman (Ed.), *Handbook of Neuropsychology, Volume 9* (pp. 393-407). Amsterdam, Netherlands: Elsevier.

Rosenbloom, P. S. & Laird, J. E. (1994). On *Unified Theories of Cognition: A response to the reviews*. In W. J. Clancey, S. W. Smoliar & M. J. Stefik (Eds.), *Contemplating Minds: A Forum for Artificial Intelligence* (pp. 141-165). Cambridge, MA: MIT Press. (Reprint of Rosenbloom and Laird, 1993, in *Artificial Intelligence*, vol. 59, pp. 389-413.)

Laird, J. E., Newell, A. & Rosenbloom, P. S. (1995). Soar: An architecture for general intelligence. In N. S. a. A. J. Chapman (Ed.), *Cognitive Science (Volume I)*: Edward Elgar Publishing Ltd. (Reprint of Laird, Newell, and Rosenbloom, 1987, in *Artificial Intelligence*, Vol. 33, pp. 1-64.)

Unruh, A., Washington, R., and Rosenbloom, P. (1995). A framework for automatic abstraction. In M. Ghallab and A. Milani (Eds.), *New Directions in AI Planning* (pp. 203-216), Amsterdam, The Netherlands: IOS Press.

Laird, J. E. & Rosenbloom, P. S. (1996). The evolution of the Soar cognitive architecture. In D. M. Steier and T. M. Mitchell (Ed.), *Mind Matters: A Tribute to Allen Newell* (pp. 1-50). Mahwah, NJ: Lawrence Erlbaum Associates.

Rosenbloom, P. S. (1996). Learning matters. In D. M. Steier & T. M. Mitchell (Eds.), *Mind Matters: A Tribute to Allen Newell* (pp. 111-118). Mahwah, NJ: Lawrence Erlbaum Associates.

Tambe, M. & Rosenbloom, P. S. (1996). Architectures for agents that track other agents in multi-agent worlds. In M. Wooldridge, J. P. Müller & M. Tambe (Eds.), *Intelligent Agents II - Agent Theories, Architectures, and Languages* (pp. 156-170): Springer.

Lehman, J. F., Laird, J. E. & Rosenbloom, P. S. (1998). A gentle introduction to Soar, an architecture for human cognition. In S. S. a. D. Scarborough (Ed.), *An Invitation to Cognitive Science (Second Edition), Volume 4: Methods, Models and Conceptual Issues* (pp. 211-253). Cambridge, MA: MIT Press.

Rosenbloom, P. S., Laird, J. E., Newell, A. & McCarl, R. (1998). A preliminary analysis of the Soar architecture as a basis for general intelligence. In A. Clark & J. Toribio (Eds.), *Cognitive Architectures in Artificial Intelligence: The Evolution of Research Programs*. New York, NY: Garland Publishing. (Reprint of Rosenbloom *et al*, in *Artificial Intelligence*, vol. 47, pp. 289-325.)

Rosenbloom, P. S., Laird, J. E., Newell, A. & McCarl, R. (2000). A preliminary analysis of the Soar architecture as a basis for general intelligence. In R. Chrisley & S. Begeer (Eds.), *Artificial Intelligence: Critical Concepts in Cognitive Science*. London, England: Routledge. (Reprint of Rosenbloom *et al*, in *Artificial Intelligence*, vol. 47, pp. 289-325.)

Macedonia, M. R. & Rosenbloom, P. S. (2001). Entertainment technology and virtual environments for training and education. In M. Devlin, R. Larson & J. Meyerson (Eds.), *The Internet and the University: 2000 Forum* (pp. 79-95). Boulder, CO: EDUCAUSE

Rosenbloom, P. S., Laird, J. E., Newell, A. & McCarl, R. (2002). A preliminary analysis of the Soar architecture as a basis for general intelligence. In T. A. Polk & C. M. Seifert (Eds.), *Cognitive Modeling*. Cambridge, MA: MIT Press. (Abridged version of Rosenbloom *et al*, in *Artificial Intelligence*, vol. 47, pp. 289-325.)

Other Publications

Rosenbloom, P. S. & Newell, A. (1983). The chunking of goal hierarchies: A generalized model of practice. In R. S. Michalski, J. G. Carbonell & T. M. Mitchell (Eds.), *Proceedings of the International Machine Learning Workshop* (pp. 183-197). Champaign-Urbana, IL. (Same as Rosenbloom and Newell, 1986, in *Machine Learning: An Artificial Intelligence Approach, Volume II*.)

Rosenbloom, P. S., Laird, J. E., McDermott, J., Newell, A. & Orciuch, E. (1984). R1-Soar: An experiment in knowledge-intensive programming in a problem-solving architecture, *Proceedings of the IEEE Workshop on Principles of Knowledge-Based Systems* (pp. 65-72). Denver, CO: IEEE Computer Society.

(Early version of Rosenbloom *et al*, 1985, in *IEEE Transactions on Pattern Analysis and Machine Intelligence*.)

Rosenbloom, P. S., Laird, J. E., Newell, A., Golding, A. & Unruh, A. (1985). Current research on learning in Soar. In T. M. Mitchell, J. G. Carbonell & R. S. Michalski (Eds.), *Proceedings of the Third International Machine Learning Workshop* (pp. 163-172). Skytop, PA. (Same as Rosenbloom *et al*, 1986, in *Machine Learning: A Guide to Current Research*.)

Rosenbloom, P. S., Laird, J. E. & Newell, A. (1986). Meta-levels in Soar, *Proceedings of the Workshop on Meta-Level Architecture and Reflection*. Alghero, Sardinia. (Early draft of Rosenbloom, Laird, and Newell, 1988, in *Meta-Level Architectures and Reflection*.)

Laird, J. E., Rosenbloom, P. S. & Newell, A. (1986). Overgeneralization during knowledge compilation in Soar. In T. G. Dietterich (Ed.), *Proceedings of the Workshop on Knowledge Compilation* (pp. 46-57). Otter Crest, OR: AAI/Oregon State U.

Steier, D. M., Laird, J. E., Newell, A., Rosenbloom, P. S., Flynn, R., Golding, A., Polk, T. A., Shivers, O. G., Unruh, A. & Yost, G. R. (1987). Varieties of Learning in Soar: 1987. In P. Langley (Ed.), *Proceedings of the Fourth International Workshop on Machine Learning* (pp. 300-311). Los Altos, CA: Morgan Kaufmann Publishers, Inc.

Rosenbloom, P. S., Laird, J. E. & Newell, A. (1987). A preliminary analysis of the Soar architecture as a basis for general intelligence. In D. Kirsh & C. Hewitt (Eds.), *Proceedings of the Workshop on Foundations of Artificial Intelligence*. Dedham, MA. (Early version of Rosenbloom *et al*, 1991, in *Artificial Intelligence*.)

Unruh, A., Rosenbloom, P. S. & Laird, J. E. (1987). Dynamic abstraction problem solving in Soar, *Proceedings of the Third Annual Aerospace Applications of Artificial Intelligence Conference* (pp. 245-256). Dayton, OH.

Laird, J. E. & Rosenbloom, P. S. (1987). Research on learning in Soar, *Proceedings of the Second Annual Artificial Intelligence Research Forum* (pp. 240-253). Palo Alto, CA: NASA Ames Research Center.

Rosenbloom, P. S. (1988). Beyond generalization as search: Towards a unified framework for the acquisition of new knowledge. In G. F. DeJong (Ed.), *Proceedings of the AAI Symposium on Explanation-Based Learning* (pp. 17-21). Stanford, CA: AAI.

Golding, A. R. & Rosenbloom, P. S. (1989). Combining Analytical and Similarity-Based CBR, *Proceedings: Case-Based Reasoning Workshop* (pp. 259-263). Pensacola Beach, FL.

Cohen, P. R. & Rosenbloom, P. S. (1990). Architectures. In L. D. Erman (Ed.), *Intelligent Real-Time Problem Solving (IRTPS): Workshop Report* (pp. 19-28). Santa Cruz, CA. (Cimflex Teknowledge Report TTR-ISE-90-101.)

Lewis, R. L., Huffman, S. B., John, B. E., Laird, J. E., Lehman, J. F., Newell, A., Rosenbloom, P. S., Simon, T. & Tessler, S. G. (1990). Soar as a unified theory of cognition: Spring 1990, *Proceedings of the 12th Annual Conference of the Cognitive Science Society* (pp. 1035-1042). Cambridge, MA.

Unruh, A. & Rosenbloom, P. S. (1990). Two new weak method increments for abstraction. In T. Ellman (Ed.), *Working Notes of the AAI-90 Workshop on Automatic Generation of Approximations and Abstractions* (pp. 78-86). Boston, MA: AAI.

Rosenbloom, P. S., Lee, S. & Unruh, A. (1990). Responding to impasses in memory-driven behavior: A framework for planning, *Proceedings of the Workshop on Innovative Approaches to Planning, Scheduling, and Control* (pp. 181-191). San Diego, CA: DARPA.

Rosenbloom, P. S., Laird, J. E., Newell, A. & McCarl, R. (1990). A preliminary analysis of the Soar architecture as a basis for general intelligence, *Proceedings of the Workshop on Innovative Approaches to Planning, Scheduling, and Control* (pp. 468-489). San Diego, CA: DARPA. (Same as Rosenbloom *et al*, 1991, in *Artificial Intelligence*, vol. 47, pp 289-325.)

Laird, J. E., Hucka, M., Huffman, S. B. & Rosenbloom, P. S. (1991). An analysis of Soar as an integrated architecture. In J. E. L. a. P. L. a. T. M. M. a. P. S. Rosenbloom (Ed.), *Working Notes of the AAI Spring*

- Symposium on Integrated Intelligent Architectures* (pp. 88-94). Stanford, CA: AAAI. (Same as Laird *et al*, 1991, in *SIGART Bulletin*.)
- Lee, S. & Rosenbloom, P. S. (1992). Creating and coordinating multiple planning methods, *Proceedings of PRICAI '92* (pp. 89-95). Seoul, Korea.
- Tambe, M., Kalp, D. & Rosenbloom, P. S. (1992). An efficient algorithm for production systems with linear-time match, *Proceedings of the 4th International IEEE Conference on Tools with Artificial Intelligence* (pp. 36-44): IEEE.
- Milnes, B. G., Pelton, G., Doorenbos, R., Hucka, M., Laird, J., Rosenbloom, P. & Newell, A. (1992). *A Specification of the Soar Cognitive Architecture in Z*, Technical Report CS-92-169, Carnegie Mellon University Computer Science Department.
- Jones, R. M., Tambe, M., Laird, J. E. & Rosenbloom, P. S. (1993). Intelligent automated agents for flight training simulators, *Proceedings of the Third Conference on Computer Generated Forces and Behavioral Representation* (pp. 33-42). Orlando, FL: STRICOM/DMSO/IST.
- Rosenbloom, P. S., Lehman, J. F. & Laird, J. E. (1993). Overview of Soar as a unified theory of cognition: Spring 1993. In L. E. Associates (Ed.), *Proceedings of the Fifteenth Annual Conference of the Cognitive Science Society* (pp. 98-101). Boulder, CO.
- Rosenbloom, P. S., Hirsh, H., Cohen, W. W. & Smith, B. D. (1993). Two frameworks for integrating knowledge in induction. In K. Krishen (Ed.), *Seventh Annual Workshop on Space Operations, Applications, and Research (SOAR '93)* (pp. 226-233). Houston, TX: Space Technology Interdependency Group. (NASA Conference Publication 3240.)
- Stobie, I., Tambe, M. & Rosenbloom, P. S. (1993). Flexible integration of path-planning capabilities. In W. J. Wolfe & W. H. Chun (Eds.), *Mobile Robots VII* (pp. 52-61). Boston, MA. (Proceedings SPIE 1831.)
- Golding, A. R. & Rosenbloom, P. S. (1994). The evaluation of Anapron: A case study in evaluating a case-based system, *Working Notes of the AAAI-94 Workshop on Case-Based Reasoning* (pp. 84-90). Seattle, WA.
- Jones, R. M., Laird, J. E., Tambe, M. & Rosenbloom, P. S. (1994). Generating behavior in response to interacting goals, *Proceedings of the Fourth Conference on Computer Generated Forces and Behavioral Representation* (pp. 317-324). Orlando, FL: STRICOM/DMSO/IST.
- Rosenbloom, P. S., Johnson, W. L., Jones, R. M., Koss, F., Laird, J. E., Lehman, J. F., Rubinoff, R., Schwamb, K. B. & Tambe, M. (1994). Intelligent automated agents for tactical air simulation: A progress report, *Proceedings of the Fourth Conference on Computer Generated Forces and Behavioral Representation* (pp. 69-78). Orlando, FL: STRICOM/DMSO/IST.
- Tambe, M., Jones, R. M., Laird, J. E. & Rosenbloom, P. S. (1994). Building believable agents for simulation environments. In J. Bates (Ed.), *Working Notes of the AAAI Spring Symposium on Believable Agents* (pp. 82-85). Stanford, CA: AAAI.
- Tambe, M. & Rosenbloom, P. S. (1994). Event tracking in complex multi-agent environments, *Proceedings of the Fourth Conference on Computer Generated Forces and Behavioral Representation* (pp. 473-484). Orlando, FL: STRICOM/DMSO/IST.
- Tambe, M. & Rosenbloom, P. S. (1994). Event tracking for an intelligent automated agent. In S. Goodwin & H. J. Hamilton (Eds.), *Proceedings of the Time94 International Workshop on Temporal Representation and Reasoning* (pp. 60-69). Pensacola, FL.
- Hendler, J., Carbonell, J., Lenat, D., Mizoguchi, R. & Rosenbloom, P. (1995). VERY large knowledge bases - Architecture vs engineering, *Proceedings for the Fourteenth International Joint Conference on Artificial Intelligence* (pp. 2033-2036). Montreal, Canada. (Panel report.)
- Laird, J. E., Johnson, W. L., Jones, R. M., Koss, F., Lehman, J. F., Nielsen, P. E., Rosenbloom, P. S., Rubinoff, R., Schwamb, K. B., Tambe, M., Dyke, J. V., Lent, M. v. & Wray, R. (1995). Simulated Intelligent Forces For Air: The Soar/IFOR Project 1995, *Proceedings of the Fifth Conference on Computer Generated Forces and Behavioral Representation* (pp. 27-36). Orlando, FL: STRICOM/DMSO/IST.

- Tambe, M. & Rosenbloom, P. S. (1995). Agent tracking in complex multi-agent environments: New results, *Proceedings of the Fifth Conference on Computer Generated Forces and Behavioral Representation* (pp. 125-133). Orlando, FL: STRICOM/DMSO/IST.
- Tambe, M., Rosenbloom, P. S. & Schwamb, K. B. (1995). Constraints and design choices in building intelligent pilots for simulated aircraft: Extended abstract, *Working Notes of the AAAI Spring Symposium on Lessons from Implemented Software Architectures for Physical Agents* (pp. 203-212). Stanford, CA: AAAI.
- Tambe, M., Schwamb, K. B. & Rosenbloom, P. S. (1995). Building intelligent pilots for simulated rotary wing aircraft, *Proceedings of the Fifth Conference on Computer Generated Forces and Behavioral Representation* (pp. 39-44). Orlando, FL: STRICOM/DMSO/IST.
- Tambe, M. & Rosenbloom, P. S. (1995). Agent tracking in real-time dynamic environments: A summary of results. In M. Wooldridge, K. Fisher, P. Gmytrasiewicz, N. R. Jennings & J. P. M. a. M. Tambe (Eds.), *Working notes of the IJCAI-95 Workshop on Agent Theories, Architectures, and Languages* (pp. 173-185). Montréal, Canada.
- Smith, B. D. & Rosenbloom, P. S. (1996). Induction as Knowledge Integration. In R. S. Michalski & J. Wnek (Eds.), *Proceedings of the Third International Conference on Multistrategy Learning* (pp. 39-51). Harpers Ferry, WV: AAAI Press.
- Kim, J. & Rosenbloom, P. S. (1996). A transformational analysis of the EBL utility problem, *Proceedings, Thirteenth National Conference on Artificial Intelligence* (pp. 1394). Portland, OR: AAAI. (Student Abstract.)
- Cho, B., Rosenbloom, P. S. & Tambe, M. (1997). Efficient production match algorithm and its implication for dynamic constraint satisfaction problems, *Proceedings, Fourteenth National Conference on Artificial Intelligence* (pp. 825). Providence, RI: AAAI. (Student Abstract.)
- Hill, R. W., Chen, J., Gratch, J., Rosenbloom, P. S. & Tambe, M. (1998). Soar-RWA: Planning, teamwork, and intelligent behavior for synthetic rotary wing aircraft, *Proceedings of the Seventh Conference on Computer Generated Forces and Behavioral Representation* (pp. 177-188). Orlando, FL.
- Hill, R., Gratch, J. & Rosenbloom, P. (2000). Flexible group behavior: Lessons learned about creating autonomous commanders, *Proceedings of the Ninth Conference on Computer Generated Forces and Behavioral Representation*. Orlando, FL.
- Macedonia, M. R. & Rosenbloom, P. S. (2000). Entertainment technology and virtual reality, *Proceedings of the NATO Research and Technology Organization Workshop (Human Factors and Medicine Panel)*. The Hague, Netherlands.
- Pynadath, D. V., Tambe, M., Arens, Y., Chalupsky, H., Gil, Y., Knoblock, C., Lee, H., Lerman, K., Oh, J., Ramachandran, S., Rosenbloom, P. S. and Russ, T. (2000). Electric Elves: Immersing an agent organization in a human organizations, *Working Notes of the AAAI Fall Symposium on Socially Intelligent Agents – The Human in the Loop*.
- Scerri, P., Johnson, L., Pynadath, D. V., Rosenbloom, P., Schurr, N., Si, M. and Tambe, M. (2003). Getting robots, agents and people to cooperate: An initial report, *Working Notes of the AAAI Spring Symposium on Human Interaction with Autonomous Systems in Complex Environments*. Stanford, CA: AAAI.
- Rosenbloom, P. S. (2009). A graphical rethinking of the cognitive inner loop. *Proceedings of the IJCAI International Workshop on Graphical Structures for Knowledge Representation and Reasoning*.
- Rosenbloom, P. S. (2009). Towards uniform implementation of architectural diversity. *Proceedings of the AAAI Fall Symposium on Multi-Representational Architectures for Human-Level Intelligence* (pp. 32-33).

Other Submitted Publications