Dr. Tomer Barak

AI Research Scientist & Systems Architect

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Creator of ai-archive.io

Summary

PhD-level expert in Deep Learning Dynamics and Agentic Workflows. I bridge the gap between cognitive theory and scalable software. Expert in Test-Time Adaptation and Deep Learning dynamics, I apply this rigor to architect production-grade agentic ecosystems. Creator of a distributed scientific research platform, integrating MCP with agentic-loop runtimes to standardize autonomous research, enabling agents to generate, peer-review, and publish academic work at scale.

Technical Skills

AI Systems Engineering	Agentic Workflows (**MCP**, Multi-Agent Topologies), **LLM** Integration, Zero-dependency Architecture, Distributed Job Queues (**Redis**), Containerization (**Docker**).
Core ML & Research	**PyTorch**, Self-Supervised Learning (SSL), Contrastive Learning (InfoNCE), **Test-Time Adaptation**, Neural Dynamics (Chaos theory), Hybrid Architectures, Python Scientific Stack.
Web Development	Full-Stack JavaScript (**Node.js**, **Express**, **React**), **TypeScript**, SQL (**PostgreSQL**), Nginx, REST APIs, Git/GitHub Workflows.

Research Experience

2020–2025 **PhD Researcher**, *Hebrew University, ELSC*, Jerusalem

Lab of Prof. Yonatan Loewenstein | Computational Cognition & AI

- **Topic:** Modeled human fluid intelligence and adaptation using Deep Learning.
- **Self-Supervised Learning:** Implemented Contrastive Learning frameworks (utilizing InfoNCE loss) to model predictive coding and representation learning dynamics without labeled data.
- **Test-Time Adaptation:** Adapted neural networks to train *during* inference, demonstrating techniques now recognized as **Test-Time Adaptation**.
- **Relation Networks:** Utilized hybrid architectures (**CNN + FC**) to solve abstract reasoning tasks (Raven's Progressive Matrices) without prior training.
- **Dynamical Systems:** Applied physics-based analysis (Phase portraits, Fixed Points) to reduce complex neural dynamics to understandable mathematical frameworks.
- **Human Experiments:** Designed and conducted large-scale online behavioral experiments (1000+ participants via **Prolific**). Performed statistical analysis and iterative experimental design to validate theoretical models against human performance.

2019–2020 **Research Student**, *Hebrew University, ELSC*, Jerusalem

Lab of the late Prof. Naftali Tishby | Theory of Deep Learning

- **Information Theory:** Applied the **Information Bottleneck** principle to describe Deep Learning dynamics.
- Focused on probability theory, information theory, and deep learning systems.
- Simulated various neural substrates including **Hopfield networks** and **Integrate-and-Fire neurons**.

AI Systems & Engineering Experience

Aug 2025–Present **Creator & Lead Architect**, *AI-Archive*, Jerusalem

A comprehensive academic publishing platform enabling AI agents to autonomously research, write, and peer-review papers.

- **Model Context Protocol (MCP):** Built a custom MCP server that exposes platform capabilities (paper fetching, submission, review) as standardized tools, enabling any AI agent to interact seamlessly with the archive.
- **Consumer-Ready Agent Bundle:** Architected the "AI-Archive Bundle" wrapping the opencode CLI, our MCP server, and pre-configured **"Scientist Agents."** This provides researchers with a one-line installable AI staff capable of conducting independent literature reviews and peer feedback.
- **Production Infrastructure:** Built a full-stack ecosystem (**Node.js/Express**, **React**, **Postgres**) deployed via **Docker**. Architected an API orchestration layer handling 10+ external services.
- **Distributed Systems:** Implemented a **Redis**-based distributed job queue to allocate reviewing tasks across various machines and LLMs.

Jan 2025–Aug 2025 **R&D Engineer**, *Custom Multi-Agent Assistant System (Experimental)*

An agentic orchestration system built from first principles (no external SDKs).

- **Multi-Agent Design:** Architected a system of 7 specialized **autonomous agents** (Triage, Scheduler, IT, etc.) communicating via a shared interface without a central hub.
- **Zero-Dependency Architecture:** Engineered a raw agentic loop using only the **Chat Completions API** and Regex for tool execution, bypassing commercial frameworks to maximize control over state and latency.
- **Recursive Delegation Protocol:** Designed a "Synthetic User" topology where agents route complex tasks via a virtual helper interface, unifying human commands and agent-to-agent requests under a single chat schema.

Education

2017–2025 **PhD in Computational Cognition & AI**, *Edmond and Lily Safra Center for Brain Sciences (ELSC)*, Hebrew University

Thesis: *Modeling Fluid Intelligence via Real-Time Adaptation*

2012–2016 **BSc in Physics**, *Hebrew University of Jerusalem*

- Specialization: Mathematical modeling of physical systems and deduction frameworks.
- Projects: Modeled degassing dynamics of metal chambers in vacuum; Computational simulations of Chaos Theory and Fractals; Studying electrodynamic properties of Graphene.
- Final Grade: 91/100

Teaching & Leadership

2019–2024 **Co-Founder & Lead Lecturer**, *Practical Deep Learning Course*, ELSC

- **Leadership:** Identified a critical curriculum gap and co-founded the department's first accredited practical Deep Learning course from scratch.
- **Curriculum Design:** Structured and maintained the syllabus over 5 years (4 iterations), covering **PyTorch**, **Transformers**, Optimization dynamics (SGD → Adam), and Interpretability.
- **Impact:** Successfully secured departmental accreditation and established a recurring practical track for theoretical researchers.

2024 **Teaching Assistant**, *Neural Learning*, ELSC

2020, 2023 **Research Mentor**, *Undergraduate Research Projects*, ELSC

Mentored 3 undergraduate students in their final research projects, focusing on deep learning models.

2017–2019 **Teaching Assistant**, *Introduction to Information Processing and Learning*, ELSC

Selected Publications

2025 Barak, T., Loewenstein, Y. **Two pathways to resolve relational inconsistencies.** *Scientific Reports*, 15(1), 30738.

2024 Barak, T., Loewenstein, Y. **Untrained neural networks can demonstrate memorization-independent abstract reasoning.** *Scientific Reports*, 14(1), 27249.

2022 Barak, T., Loewenstein, Y. **Naive Few-Shot Learning: Uncovering the fluid intelligence of machines.** *arXiv preprint arXiv:2205.12013*.

2022 Barak, T., Loewenstein, Y. **Zero-Episode Few-Shot Contrastive Predictive Coding.** *arXiv preprint arXiv:2205.01924*.

2020 Barak, T., Avidan, Y., & Loewenstein, Y. **Naive Artificial Intelligence.** *arXiv preprint arXiv:2009.02185*.