Core Francisco Park

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Email: corefranciscopark@g.harvard.edu
Google Scholar
GitHub

EDUCATION

Harvard University — Cambridge, MA, U.S.A.
Ph.D. in Physics, GPA: 3.945/4.0 — 2019–2025
Advisors: Dr. Aravinthan Samuel, Dr. Douglas Finkbeiner, Dr. Hidenori Tanaka, Dr. Michael Brenner

- Thesis: Deep Learning as a Scientific Tool and a Model Organism of Intelligence

SNU — Seoul, South Korea
Graduate Coursework — 2019

KAIST — Daejeon, South Korea
B.S. in Physics, Advanced Major, GPA: 4.08/4.3, Summa Cum Laude — 2015–2019

- Focus: Computational Physics

Ecole Polytechnique — Palaiseau, France
Exchange Student — 2017

CURRENT FOCUS

Understanding Fundamental Cognitive Capabilities of AI — Harvard University
Collaborators: Dr. Hidenori Tanaka, Dr. Ekdeep Singh Lubana — Feb 2024–Current

- **Understanding phase changes of in-context learning**: Understanding how AI models transition between different mechanisms for in-context learning depending on the data distribution and design choices.
- **Understanding inference scaling**: Understanding how in-context exemplars shape large language model's representation and mechanisms.
- **Understanding hidden emergence of capabilities**: Understanding hidden emergence of capabilities in text-to-image generative models: showed a hidden phase transition of a compositional capability.

Compositional Generalization in Spectral Space — Harvard University
Advisor: Dr. Cecilia Garraffo, Dr. Douglas Finkbeiner — Sep 2023–Current

- **MethaneSAT**: Developed a spectral classification and correction algorithm, *iterative logistic regression*, to classify cloud covered regions and correct for the effect of shadows on the observed spectra
- **TEMPO**: Currently developping a convolutional variational auto-encoder to jointly compress and segment hyperspectral data from TEMPO. The goal is to enhance prediction of NO densities, which is a major public health concern.

EMPLOYMENT

Harvard University — Cambridge, MA, U.S.A.
Postdoctoral Fellow — May 2025–Current

- **Supervisor**: Dr. Venkatesh Murthy, Dr. Hidenori Tanaka

Harvard University	Cambridge, MA, U.S.A.
Research Assistant	Jun 2020–May 2025

- **Supervisor**: Dr. Aravinthan Samuel, Dr. Douglas Finkbeiner, Dr. Cecilia Garraffo

NTT Research	Sunnyvale, CA, U.S.A.
Research Intern	Jan 2025

- **Supervisor**: Hidenori Tanaka
- **Project**: Understanding Mechanisms and Capabilities of AI

NTT Research	Sunnyvale, CA, U.S.A.
Research Intern	Jul 2024–Sep 2024

- **Supervisor**: Hidenori Tanaka
- **Project**: Understanding Mechanisms and Capabilities of AI

Harvard University	Cambridge, MA, U.S.A.
Teaching Assistant	Jan 2022–May 2022

- **Applied Physics 50**: Physics as a Foundation for Science and Engineering, Dr. Eric Mazur

Harvard University	Cambridge, MA, U.S.A.
Teaching Assistant	Sep 2021–Dec 2021

- **Physics 141**: The Physics of Sensory Systems in Biology, Dr. Aravinthan Samuel

TECHNICAL SKILLS

- **ML/AI Research:** Large Language Models, Reinforcement Learning, In-Context Learning, Compositional Generalization
- **Languages:** Python, JavaScript, Java, C++, SQL, Matlab, Julia
- **Computational Methods:** Real time DAQ, High Performance Computing, GPU computing, Cache Optimization
- **Data Analysis:** Fourier Analysis, Time Series Filtering, Bayesian Inference
- **DevOps:** Experience in full product building: frontend, backend, VM, Kubernetes
- **Experimental:** Hardware control, Experiment Automation, PID Control, Lab Optics

PUBLICATIONS

First authors are marked with a *.

5.1 First Author or Significant Contribution

1. **C.F. Park***, T. Qin*, M. Kwun, A. Walsman, E. Malach, N. Anand, H. Tanaka, D. Alvarez-Melis; " Decomposing Elements of Problem Solving: What "Math" Does RL Teach? "; preprint

2. **C.F. Park***, Z. Zhang*, H. Tanaka; "New News: System-2 Fine-tuning for Robust Integration of New Knowledge"; preprint

3. **C.F. Park***, E.S. Lubana*, H. Tanaka; "Competition Dynamics Shape Algorithmic Phases of In-Context Learning"; ICLR 2025 Spotlight

4. **C.F. Park***, A. Lee*, E.S. Lubana*, Y. Yang*, M. Okawa, K. Nishi, M. Wattenberg, H. Tanaka; "ICLR: In-Context Learning of Representations"; ICLR 2025

5. Y. Yang*, **C.F. Park**, E.S. Lubana, M. Okawa, W. Hu, H. Tanaka; "Dynamics of Concept Learning and Compositional Generalization"; ICLR 2025

6. **C.F. Park***, E.S. Lubana, H. Tanaka; "Understanding the Transient Nature of In-Context Learning: The Window of Generalization"; NeurIPS 2024 Workshop on Scientific Methods for Understanding Deep Learning, Dec 2024

7. **C.F. Park***, A. Lee*, E.S. Lubana, K. Nishi, M. Okawa, H. Tanaka; "Structured In-Context Task Representations"; preprint;*NeurIPS 2024 Workshop on Symmetry and Geometry in Neural Representations*, Dec 2024

8. **C.F. Park***, M. Okawa*, A. Lee, H. Tanaka, E.S. Lubana; "Emergence of Hidden Capabilities: Exploring Learning Dynamics in Concept Space"; NeurIPS 2024 Spotlight, Dec 2024

9. **C.F. Park***, M. Okawa, A. Lee, E.S. Lubana, H. Tanaka; "Hidden Learning Dynamics: Capability Emerges Before Behavior in Compositional Generalization"; ICML 2024 Workshop on High-dimensional Learning Dynamics, Jul 2024

10. **C.F. Park***, N. Mudur, C. Cuesta-Lazaro, Y. Ni, V. Ono, D.P. Finkbeiner; "3D Reconstruction of Dark Matter Fields with Diffusion Models: Towards Application to Galaxy Surveys"; ICML 2024 Workshop: AI for Science, Jul 2024

11. V. Ono*, **C.F. Park**, N. Mudur, Y. Ni, C. Cuesta-Lazaro, F. Villaescusa-Navarro; "Debiasing with Diffusion: Probabilistic reconstruction of Dark Matter fields from galaxies with CAMELS"; The Astrophysical Journal 970 (2), 174, Jul 2024

12. **C.F. Park***, M.B. Keshteli*, K. Korchagina, A. Delrocq, V. Susoy, C.L. Jones, A.D.T. Samuel, S.J. Rahi; "Automated neuron tracking inside moving and deforming animals using deep learning and targeted augmentation"; *Nature Methods*, Jan 2024

13. **C.F. Park***, V. Ono, C. Cuesta-Lazaro, Y. Ni, N. Mudur; "Probabilistic reconstruction of Dark Matter fields from galaxies using diffusion models"; NeurIPS 2023 Workshop on Machine Learning and the Physical Sciences, Oct 2023

14. **C.F. Park***, C. Garraffo; "Hyperspectral shadow removal with iterative logistic regression and latent Parametric Linear Combination of Gaussians"; NeurIPS 2023 Workshop on Tackling Climate Change with Machine Learning, Oct 2023

15. Y. Meirovitch*, **C.F. Park***, L. Mi*, P. Potocek*, S. Sawmya, Y. Li, Y. Wu, R. Schalek, H. Pfister, R. Schoenmakers, M. Peemen, J.W. Lichtman, A.D.T. Samuel, N. Shavit; "SmartEM: machine-learning guided electron microscopy";*Under Review at Nature Methods*, Oct 2023

16. N. Mudur*, **C.F. Park**, D.P. Finkbeiner; "Stellar Reddening Based Extinction Maps for Cosmological Applications"; The Astrophysical Journal 949 (2), 47, May 2023

17. **C.F. Park***, E. Allys, F.V. Navarro, D.P. Finkbeiner; "Quantification of high dimensional non–Gaussianities and its implication to Fisher analysis in cosmology"; The Astrophysical Journal 946 (2), 107, Apr 2023

18. **C.F. Park***; "Real time DAQ setup and dead-time measurement for CAPP 18T Dark Matter Axion Search and its first results"; B.S. Thesis; Dec 2018

5.2 Contributing Authored Publications

1. M.I. Pérez-Carrasco, M. Nasr, S. Roche, C.C. Miller, Z. Zhang, **C.F. Park**, E. Walker, C. Garraffo, D. Finkbeiner, R. Gautam, S. Wofsy; "Deep Learning for Clouds and Cloud Shadow Segmentation in Methane Satellite and Airborne Imaging Spectroscopy"; SSRN, Jun 2025

2. D. Wurgaft*, E.S. Lubana*, **C.F. Park**, H. Tanaka, G. Reddy, N.D. Goodman; "In-Context Learning Strategies Emerge Rationally"; arxiv, Jun 2025

3. L. Phan et al. ; "Humanity's last exam"; arxiv, Jan 2025

4. X. Wan, T. Zhou, V. Susoy, **C.F. Park**, A. Groaz, J.F. Brady, A.D.T. Samuel, P.W. Sternberg; "Efficient pheromone navigation via antagonistic detectors"; bioarxiv, Nov 2024

5. Y. Li*, **C.F. Park**, D. Xenes, C. Bishop, D.R. Berger, A.D.T. Samuel, B. Wester, J.W. Lichtman, H. Pfister, W. Li, Y. Meirovitch; "EM-Compressor: Electron Microscopy Image Compression in Connectomics with Variational Autoencoders"; Medical Optical Imaging and Virtual Microscopy Image Analysis @ MICCAI 2024, Jul 2024

6. E.C. Pavarino*, E. Yang*, N. Dhanyasi, M. Wang, F. Bidel, X. Lu, F. Yang, **C.F. Park**, M.B. Renuka, B. Drescher, A.D.T. Samuel, B. Hochner, P.S. Katz, M. Zhen, J.W. Lichtman, Y. Meirovitch; "mEMbrain: an interactive deep learning MATLAB tool for connectomic segmentation on commodity desktops"; Front. Neural Circuits Vol 17, June 2023

7. L. Mi*, T. He*, **C.F. Park**, H. Wang, Y. Wang, N. Shavit; "Revisiting Latent-Space Interpolation via a Quantitative Evaluation Framework"; arxiv, Oct 2021

8. V. Susoy*, W. Hung, D. Witvliet, J.E. Whitener, M. Wu, **C.F. Park**, B.J. Graham, M. Zhen, V. Venkatachalam, A.D.T. Samuel; Natural sensory context drives diverse brain-wide activity during C. elegans mating; Cell, Sep 2021

TALKS & ORAL PRESENTATIONS

1. **C.F. Park**; "Exploring Compositional Generalization of Neural Networks through Synthetic Experiments"; *Invited Tutorial Speaker*, Astro AI Workshop 2025, July 10 2025

2. **C.F. Park**; "New News: System-2 Fine-tuning for Robust Integration of New Knowledge"; *Invited Speaker*, Prague Synapse 2025, July 10 2025

3. **C.F. Park, T. Qin**; "Decomposing Elements of Problem Solving: What "Math" does RL Teach?"; *Talk at NVIDIA*, Slides (keynote), Jun 13 2025

4. **C.F. Park, T. Qin**; "Decomposing Elements of Problem Solving: What "Math" does RL Teach?"; *Talk at NVIDIA*, Slides (keynote), Jun 13 2025

5. **C.F. Park**; "In-Context Learning: From toy models to practice."; *Seminar talk, Department of Physics, Korea Advanced Institute of Science and Technology*, Slides (keynote), May 13 2025

6. **C.F. Park**; "In-Context Learning: Algorithms and Representations"; *Seminar talk, Department of Physics, University of Tokyo*, Slides (keynote), May 1 2025

7. **C.F. Park**; "Deep Learning as a Scientific Tool and a Model Organism of Intelligence"; *Ph.D. Defense*, Slides (keynote), Apr 21 2025

8. **C.F. Park**; "Fundamental Abilities and In-abilities of AI"; *Seminar talk, Marks and Sander Lab, Harvard Medical School*, Slides (keynote), Feb 28 2025

9. **C.F. Park**; "Understanding Fundamental Abilities of AI with synthetic experiments"; *Astro AI Lunch Seminar, Center for Astrophysics*, Video, Slides (keynote), Jan 27 2025

10. **C.F. Park**; "Towards a Neuroethology of AI: AI as a model system of intelligent phenomena"; *CBS-NTT Fellow Candidate Talk*, Video, Slides (keynote), Nov 26 2024

11. **C.F. Park**; "Understanding Compositional Generalization with Synthetic Data"; *Talk at the Stanford Institute for Theoretical Physics*, Slides (keynote), Nov 13 2024

12. **C.F. Park**; "Understanding Compositional Generalization with Synthetic Data"; *Talk at the Insight+Interaction Lab at Harvard*, Slides (keynote), Nov 13 2024

13. **C.F. Park**; "Scaling and In-Context Learning of Large Language Models"; *NTT Physics&Informatics Laboratory Journal Club*, Slides, Jul 25 2024

14. **C.F. Park**; "Probabilistic Completion of Astrophysical Fields for Robust Statistics with Diffusion Models"; *EAS 2024, Padova*; Jul 2 2024; Slides

15. **C.F. Park**; "3D probabilistic reconstruction of the local dark matter from galaxies", *Astro AI Workshop 2024, Center for Astrophysics*; Jun 20 2024; Video; Slides

16. **C.F. Park**; "Debiasing with Diffusion: Probabilistic reconstruction of Dark Matter fields from galaxies"; *ITC Lucheon Talk, Center for Astrophysics*; Mar 7 2024; Video; Slides

17. **C.F. Park**; "Reconstruction of the local dark matter using diffusion models"; *Workshop on AI-driven Discovery in Physics and Astrophysics at Kavli IPMU*; Jan 23 2024; Slides

18. **C.F. Park**; "Diffusion Models for Cosmology"; *AstroAI Lunch Talk, Center for Astrophysics*; Oct 30 2023; Slides

19. **C.F. Park**; "How is AI used in the Physical Sciences?"; *Hansung Science High School Mentoring Talk @ Harvard University*; Oct 13 2023; Slides (Korean)

20. **C.F. Park**; "Mstar2Mcdm using Diffusion Models: Generating Cold Dark Matter density fields conditioned on stellar mass fields using Denoising Diffusion Probabilistic Models"; *Camels Virtual Telecoms hosted by the Flatiron Institute*, Sep 20 2023; Slides

21. **C.F. Park**, S. Rahi, A.D.T. Samuel, M.B. Keshteli, K. Korchagina, A. Delrocq, V. Susoy, C. Jones; "Automated neuron tracking using deep learning and targeted augmentation allows fast collection of C. elegans whole brain calcium activity during behavior", *American Physical Society March Meeting 2023*

22. **C.F. Park**, Erwan Allys, Francisco Villaescusa-Navarro, Douglas Finkbeiner; "On the Gaussianity of Non-Gaussian probes of Large Scale Structure"; *American Astronomical Society 240 (2022)*

23. **C.F. Park**; "Dark Matter Axion Search Experiment using 18T HTS Magnet"; *Stockholm International Youth Science Seminar 2018*; Video

POSTER PRESENTATIONS

1. **C.F. Park***, E.S. Lubana, H. Tanaka; "Understanding the Transient Nature of In-Context Learning"; NeurIPS 2024 Workshop on Scientific Methods for Understanding Deep Learning, Dec 2024

2. **C.F. Park***, A. Lee*, E.S. Lubana, K. Nishi, M. Okawa, H. Tanaka; "In-Context Learning of Representations"; NeurIPS 2024 Workshop on Symmetry and Geometry in Neural Representations, Dec 2024

3. **C.F. Park***, M. Okawa*, A. Lee, H. Tanaka, E.S. Lubana; "Emergence of Hidden Capabilities: Exploring Learning Dynamics in Concept Space"; NeurIPS 2024 Spotlight, Dec 2024

4. **C.F. Park**, E.S. Lubana, H. Tanaka; "Emergence of In-Context Learning Beyond Bayesian retrieval: A mechanistic study"; New England Mechanistic Interpretability Workshop 2024, Aug 2024

5. **C.F. Park**, M. Okawa, A. Lee, E.S. Lubana, H. Tanaka; "Hidden Learning Dynamics: Capability Emerges Before Behavior in Compositional Generalization"; *NeurIPS 2023 Workshop on Machine Learning and the Physical Sciences*, ICML 2024 Workshop on High-Dimensional Learning Dynamics, Jul 2024

6. **C.F. Park**, N. Mudur, C. Cuesta-Lazaro, Y. Ni, V. Ono, D.P. Finkbeiner; "3D Reconstruction of Dark Matter Fields with Diffusion Models: Towards Application to Galaxy Surveys"; ICML 2024 Workshop: AI for Science, Jul 2024

7. **C.F. Park**, V. Ono, C. Cuesta-Lazaro, Y. Ni, N. Mudur; "Probabilistic reconstruction of Dark Matter fields from galaxies using diffusion models"; NeurIPS 2023 Workshop on Machine Learning and the Physical Sciences, Dec 2023

8. **C.F. Park**, M. Nasr, M. Perez-Carrasco, E. Walker, D. Finkbeiner, C. Garraffo, "Hyperspectral shadow removal with iterative logistic regression and latent Parametric Linear Combination of Gaussians", NeurIPS 2023 Workshop on Tackling Climate Change with Machine Learning, Dec 2023

9. **C.F. Park**, Y. Meirovitch, P. Potocek, S. Sawmya, Y. Li, R. Schalek, J.W. Lichtman, M. Peeman, A.D.T. Samuel, N. Shavit, "SmartEM: Faster Connectomics Using Deep Error Prediction Based Rescanning"; ICML 2023 Workshop for Computational Biology, Jul 2023

10. **C.F. Park**, H. Casademunt, V. Susoy, A.D.T. Samuel, "Freely Moving Whole Brain Imaging of C. elegans under a thermal stimulus", *International C.elegans conference 2023*, Jun 2023

11. **C.F. Park**, M.B. Keshteli, Vladislav Susoy, K. Korchagina, A. Delrocq, A.D.T. Samuel, S.J. Rahi, "Automated neuron tracking inside moving and deforming animals using deep learning and targeted augmentation", *COSYNE 2023*, Mar 2023

12. **C.F. Park**, K. Kim, J. Yoo "Data acquisition system for dark matter Axion search experiment using 18 T HTS magnet at CAPP/IBS", *Korean Physical Society Meeting 2018*, Oct 2018

Past Projects

Deep Learning and Computer Vision for Neuroscience — Harvard University
Advisor: Dr. Aravinthan Samuel, Dr. Jeff Lichtman — Aug 2020–Sep 2024

- Few-shot 3D volumetric tracking, developed targettrack.
- Machine learning driven accelerated connectomics, co-developed SmartEM.
- Image compression using deep learning, co-developed EM-Compressor.

Emulating the structure of the universe using diffusion models — Harvard University
With: Dr. Carolina Cuesta-Lazaro — Aug 2023–Aug 2024

- Probabilistic emulation, debiasing and completion of the large scale structure of matter distribution using diffusion models.

Whole Brain Imaging — Harvard University
Advisor: Dr. Aravinthan Samuel — Apr 2021–May 2023

- Identifying neural circuits for C.elegans thermotaxis via automated whole brain imaging.

Astro-statistics — Harvard University
Advisor: Dr. Douglas Finkbeiner — Sep 2020–Oct 2022

- Fourier space sparse wavelet transform on the GPU
- Quantifying the non–Gaussianity of high–dimensional statistics
- Estimating correlations of large scale structure and galactic dustmaps

Experimental Particle Physics — KAIST
Advisor: Dr. Jonghee Yoo — Dec 2018–Feb 2019

- Real-time DAQ system for the CAPP18T Axion Dark Matter Experiment

Membership

Sigma-Xi

Jun 2025–Current

Reviewing

Total: 30 papers

- NeurIPS 2025 (6 papers) — 2025
- ICML 2025 HiDL (3 papers) — 2025
- ICML 2025 MOSS (2 papers) — 2025
- CoLM 2025 (2 papers) — 2025
- ICLR 2025 Workshop on Tackling Climate Change with Machine Learning (2 papers) — 2025
- ICLR 2025 (4 papers) — 2024
- NeurIPS 2024 Workshop on Scientific Methods for Understanding Deep Learning (4 papers) — 2024
- ICML 2024 Workshop on Mechanistic Interpretability (3 papers) — 2024
- ICLR 2024 Workshop on Tackling Climate Change with Machine Learning (4 papers) — 2024

Scholarships

- Purcell Fellowship, Harvard University   2019–2020
- Doctoral Study Abroad Scholarship, KFAS   2019–Current
- Physics Department Honorary Scholarship, KAIST   2018
- Undergraduate Student Scholarship, KFAS   2017–2019
- Korea Presidential Science Scholarship, KOSAF   2015–2019
- Full Tuition Scholarship, KAIST   2015–2019

Awards

- Second Place in Citadel Datathon, Virtual   2023
- Best Machine Learning Project Award, KIAS   2019
- Summa Cum Laude, KAIST   2019
- Best Project Award Physics Winter Camp, KIAS   2018
- Dean's List, KAIST Physics   2017
- Best Buddy Award, KAIST International Office   2016
- Fall Dean's List, KAIST   2015
- Spring Dean's List, KAIST   2015

Extracurricular Activities

- Harvard AI Safety Team   2024
  Member
- KITP Neurophysics of Locomotion School   2022
  Summer Student
- APCTP-POSTECH Biophysics School   2019
  Summer Student
- KIAS-SNU Physics Winter Camp   2018
  Best Project Award: Accretion of Supermassive Black Holes
- Stockholm International Youth Science Seminar   2018
  Korean Representative
- APCTP-NIMS-KISTI-KASI Summer School on Numerical Relativity,   2018
  Summer Student
- APCTP-POSTECH Biophysics School   2018
  Summer Student
- KAIST International Discovery Program   2017
  Selected Team
- Asian Science Camp   2014
  Korean Representative
- Molecular Frontiers Symposium   2013
  School Representative

Teaching

- **Teaching Fellow** at Harvard University   Spring 2022
  Physics as a Foundation for Science and Engineering
- **Teaching Fellow** at Harvard University   Fall 2021
  Physics of Sensory systems
- **Teaching Assistant** at Seoul National University   Spring 2019
  Physics Lab I
- **General Physics Tutor** at KAIST   Fall 2018
  General Physics 2
- **General Physics Tutor** at KAIST   Spring 2018
  General Physics 1
- **General Physics Tutor** at KAIST   Spring 2017
  General Physics 1
- **General Physics Tutor** at KAIST   Fall 2016
  General Physics 2
- **General Physics Tutor** at KAIST   Spring 2016
  General Physics 1

Languages

- **Korean:** Native
- **English:** Native
- **TOEFL:** 114/120
- **TOEIC:** 985/990
- **French:** Semi-Native
- **TCF:** 599 C1/C2/C1
- **Spanish:** Novice

References

- Research Advisor: Hidenori Tanaka   CBS-NTT Program in Physics of Intelligence, Harvard, 2024–Current
  hidenori_tanaka@fas.harvard.edu
- Research Advisor: Douglas Finkbeiner   Department of Physics, Harvard, 2020–Current
  dfinkbeiner@cfa.harvard.edu
- Research Advisor: Cecilia Garraffo   Center for Astrophysics, Harvard, 2023–Current
  cgarraffo@cfa.harvard.edu
- Past Research Advisor: Aravinthan Samuel   Department of Physics, Harvard, 2021–Current
  samuel@g.harvard.edu
- Collaborator: Ekdeep Singh Lubana   CBS-NTT Program in Physics of Intelligence, Harvard, 2024–Current
  ekdeeplubana@fas.harvard.edu
- Collaborator: Carolina Cuesta-Lazaro   Center for Astrophysics, Harvard, 2023–2024
  carolina.cuesta-lazaro@cfa.harvard.edu
- Collaborator: Yaron Meirovitch   Center for Brain Science, Harvard, 2022–2024
  yaronmr@fas.harvard.edu
- Past Research Advisor: Daniel Eisenstein   Department of Astronomy, Harvard, 2019–2021

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- Past Research Advisor: Jonghee Yoo Department of Physics, KAIST, 2018–2019
yoo.jonghee@kaist.ac.kr
- Past Academic Advisor: Hawoong Jeong Department of Physics, KAIST, 2015–2019
hjeong@kaist.edu