Siyu Yao

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AREAS OF SPECIALIZATION

General Philosophy of Science, Philosophy of Artificial Intelligence, Philosophy of Astronomy

AREAS OF COMPETENCE

Philosophy of Cognitive Science, History of Science, Ethics and Value of Artificial Intelligence

EDUCATION

2019-2025 **Indiana University**
Ph.D., M.A., History and Philosophy of Science

- Dissertation: "Connecting the Stars: Narrative Knowledge, Coherence, and Productivity in Astronomy"
  Committee: Jordi Cat (chair), Jutta Schickore, Amit Hagar, Ann-Sophie Barwich
- Minor: Cognitive Science

2016-2019 **Peking University**
M.A., Philosophy of Science and Technology

- Master's Thesis: "F.W.J. Schelling's Critique and Development of Immanuel Kant's Theory of Dynamics"
  Advisor: Yongping Sun

2012-2016 **Peking University**
B.Sc., Chemistry

- Undergraduate Research Advisor: Junlong Zhang

PUBLICATIONS

Siyu Yao. Forthcoming. "The First Three Minutes: Cosmology, Astrophysics, and Particle Physics." In Aviezer Tucker and David Černín (eds.) Bloomsbury Handbook for the Philosophy of Big History and the Historical Sciences.

Siyu Yao and Amit Hagar. 2024. "Searching for Features with Artificial Neural Networks in Science: The Problem of Non-Uniqueness." International Studies in the Philosophy of Science, 37(1–2), 51–67. https://doi.org/10.1080/02698595.2024.2346871

Siyu Yao. 2023. "Excavation in the Sky: Historical Inference in Astronomy." Philosophy of Science, 90(5): 1385-1395. https://doi.org/10.1017/psa.2023.22

Siyu Yao, Joshua Nunley, Eduardo J. Izquierdo. 2023. "Go by Its Name: Evolution and Analysis of Conceptual Referential Communication." Proceedings of the 2023 Artificial Life Conference: 64-73. https://doi.org/10.1162/isal_a_00669

- Partially supported by NSF grant No. 1845322.

Yuan-Bo Cai, **Si-Yu Yao**, Mo Hu, Xiaoyun Liu, and Jun-Long Zhang. 2016. "Manganese protoporphyrin IX reconstituted myoglobin capable of epoxidation of the C=C bond with Oxone®," Inorg. Chem. Front., 3: 1236-1244.

Manuscripts:

Siyu Yao, Under Review. "Why is it (still) Difficult to Understand Black-Box Models? Explainable Artificial Intelligence and the Experimenters' Regress"

Siyu Yao, In Preparation. "From the 'Hot Jupiter' to Jupiter: What Narratives Contribute to Science Aside from a True Story"

Siyu Yao, In Preparation. "Narrative Triangulation and the Establishment of Cosmochronology"

Li, Dan, Ryan O'Loughlin, and **Siyu Yao**. In Preparation. "A Trip in Plato's Cave: Explainable Artificial Intelligence Methods and Their Epistemic Challenges"

PRESENTATIONS

Peer-Reviewed Conference Presentations:

Sep 2024	**Narrative Knowledge Beyond a True Story: Knowledge-How of Methods in Astronomy.** Rotman Graduate Student Conference 2024: Scientific Methodology. London, Canada.
May 2024	**Why is it (still) Difficult to Understand Black-Box Models? Explainable Artificial Intelligence and the Experimenter's Regress.** Society for Philosophy of Science in Practice (SPSP) 10th Biennial Meeting. Columbia, USA.
Apr 2024	**Narrative Knowledge from the Migration of the "Hot Jupiter."** Graduate Conference on the Historical and Philosophical Aspects of Astronomical Events. Indiana University, Bloomington, USA.
Jul 2023	**Go by Its Name: Evolution and Analysis of Conceptual Referential Communication.** The 2023 Conference on Artificial Life: Ghost in the Machine. Sapporo, Japan.
May 2023	**Why is it (still) Difficult to Understand Black-Box Models? Explainable Artificial Intelligence and the Experimenters' Regress.** Canadian Society for the History and Philosophy of Science (CSHPS) Annual Meeting. Toronto, Canada.

Nov 2022 **Excavation in the Sky: Historical Inference in Astronomy.** Philosophy of Science Association (PSA) 28th Biennial Meeting. Pittsburgh, USA.

Aug 2022 **Excavation in the Sky: Historical Inference in Astronomy and the Concept of Trace.** The Future of the Past: Philosophical Issues in the "Historical Sciences". Jerusalem, Israel.

Jul 2022 **Who Makes the Choice? Artificial Neural Networks in Science and the Non-Uniqueness Problem.** Society for Philosophy of Science in Practice (SPSP) 9th Biennial Meeting. Ghent, Belgium.

May 2022 **Excavation in the Sky: Historical Inference in Astronomy and the Concept of Trace.** Canadian Society for the History and Philosophy of Science (CSHPS) Annual Meeting. Online.

Colloquium Presentations:

Oct 2022 **Excavation in the Sky: Historical Inference in Astronomy.** Norwood Russell Hanson Prize Lecture, Department of History and Philosophy of Science and Medicine, Indiana University Bloomington, USA.

Jun 2018 **Goethe's ad hominem Approach in Natural Philosophy.** Graduate Student Conference, Department of Philosophy and History of Ideas, Aarhus University, Denmark.

Peer-Reviewed Poster Presentations:

Nov 2024 **Narrative Triangulation and the Establishment of Cosmochronology.** Philosophy of Science Association (PSA) 29th Biennial Meeting. New Orleans, USA.

Nov 2022 **Explanatory Correlate vs Explanation: Theory, Practice, and Research Program for Consciousness.** Philosophy of Science Association (PSA) 28th Biennial Meeting. Pittsburgh, USA.

Jul 2022 **Dynamic or Mechanistic Explanation? Theory and Practice in the Explanation of Consciousness.** Society for Philosophy of Science in Practice (SPSP) 9th Biennial Meeting. Ghent, Belgium.

2020/2021 **The Concept of Minimal Self-Consciousness in Psychological Disorders.** Philosophy of Science Association (PSA) 27th Biennial Meeting. Online.

TEACHING EXPERIENCE

Instructor of Record:

Fall 2023 **CLLC-L220 Uses of the Past: The Scientist as Storyteller**, Self-proposed, Collins Living-Learning Center, College of Arts and Sciences, Indiana University

Spring 2023 **HPSC-X200 Scientific Reasoning**, History and Philosophy of Science and Medicine, Indiana University

Fall 2020 **COLL-X101 Experimental Topics: Cyberpunk History and Philosophy**, Co-proposed and taught with Jared Neumann, College of Arts and Sciences, Indiana University

Associate Instructor:

Spring 2024 **HPSC-X102 Revolutions in Science: From Plato to NATO**, History and Philosophy of Science and Medicine, Indiana University
Fall 2020-22 **HPSC-X200 Scientific Reasoning**, History and Philosophy of Science and Medicine, Indiana University
Spring 2021-22 **COLL-C104 Critical Approaches, Social and Historical: What is Science and Who Cares?** College of Arts and Sciences, Indiana University
Fall 2017 **Dialectics of Nature**, Philosophy and Religious Studies, Peking University

AWARDS, FELLOWSHIPS, AND GRANTS

2024-25	**Dissertation Completion Fellowship**, College of Arts and Sciences, Indiana Univ. ($ 25,000)
2024	**NSF Travel Grant Award**, Philosophy of Science Association 29th Biennial Meeting ($ 250)
2024	**Mikal Lynn Sousa Award for Excellence in Graduate Scholarship**, Dept. of History and Philosophy of Science, Indiana Univ. ($ 750)
2023	**Course Enhancement Grant**, for my self-proposed course "The Scientist as Storyteller," College of Arts and Sciences, Indiana Univ. ($ 350)
2022	**Norwood Russell Hanson Prize for Outstanding Graduate Student Papers**, Dept. of History and Philosophy of Science, Indiana Univ.
2022	**NSF Travel Grant Award**, Philosophy of Science Association 28th Biennial Meeting ($ 360)
2022	**Graduate Travel Award**, College of Arts and Sciences, Indiana Univ. ($ 500)
2019-20	**Graduate Fellowship**, College of Arts and Sciences, Indiana Univ. ($ 21,500)
2019	**Graduate Special Scholarship**, Peking University (¥ 1,000)
2018	**Summer School Fellowship**, International Centre for Philosophy in North-Rhine-Westphalia (€ 1,000)
2016-2019	**Graduate Academic Scholarship**, Peking University (¥ 81,000)
2014-15	**Funding for Undergraduate Research**, Peking University Education Foundation (¥ 1,000)
2012	**New Undergraduate Student Fellowship**, Peking University (¥ 1,000)

LABORATORY RESEARCH

2022-2023	**Evolutionary Robotics Laboratory**, Indiana University PI: Eduardo J. Izquierdo

SERVICE

Additional Academic Employments and Services:

Nov 2024	**Session Chair**, Philosophy of Science Association 29th Biennial Meeting.
Spring 2024	**Organizer**, Department of History and Philosophy of Science and Medicine Writing Group. Indiana Univ.
Spring 2024	**Organizer**, Philosophy and Cognitive Science Reading Group. Journal: *Trends in Cognitive Science*. Indiana Univ.
2022-24	**Awards Committee Member**: reviewer for travel and research grant proposals, *Graduate and Professional Student Government*, Indiana Univ.
Spring 2023	**Co-organizer**, Department of History and Philosophy of Science and Medicine Student Conference, Indiana Univ. Speaker: Christopher Pincock.
Summer 2021	**Organizer**, History and Philosophy of Science Reading Group, Indiana Univ. Book: Cailin O'Connor and James Owen Weatherall, *The Misinformation Age: How False Beliefs Spread*.
Summer 2020	**Student Assistant**: Archived abstracts and paper submissions, The Integrated HPS (&HPS) Conferences.
2017-18	**Student Assistant**: Organized and documented academic conferences; built websites and produce scholar handbooks, Institute of Humanities and Social Sciences, Peking Univ.
2017-18	**Local Organizing Assistant**, World Congress of Philosophy (WCP) 2018. Peking Univ.
2013-15	**Undergraduate Research Assistant**, Bioinorganic Laboratory, College of Chemistry and Molecular Engineering, Peking Univ.

Department Committees and Services:

2024-25	**Faculty Liaison**, Department Graduate Student Association. HPS, Indiana Univ.
2022-24	**Graduate and Professional Student Government Coordinator**, Department Graduate Student Association. HPS, Indiana Univ.
2021-22	**Graduate Student Social Coordinator**, Department Graduate Student Association. HPS, Indiana Univ.

Outreach:

Apr 2024	**Curator and Presenter**, "Einstein, Eddington, and Eclipse: An Extra-Ordinary Test of an Extraordinary Theory," in the *Science Fest for 2024 US Solar Eclipse*, Indiana Univ.

MEMBERSHIPS

Philosophy of Science Association
DEI Caucus of Philosophy of Science Association
The Canadian Society for the History and Philosophy of Science

REFERENCES

Jordi Cat (Supervisor), Professor of History and Philosophy of Science, Indiana University. jcat@iu.edu

Jutta Schickore, Ruth N. Halls Professor of History and Philosophy of Science and Medicine, Indiana University. jschicko@iu.edu

Amit Hagar, Professor of History and Philosophy of Science and Medicine, Indiana University. hagara@iu.edu

Ann-Sophie Barwich, Assistant Professor of Cognitive Science & History and Philosophy of Science, Indiana University. abarwich@iu.edu

Melissa Jacquart, Assistant Professor of Philosophy, University of Cincinnati. melissajacquart@gmail.com

Eduardo J. Izquierdo, Associate Professor of Electrical and Computer Engineering, Rose-Hulman Institute of Technology. izquierd@rose-hulman.edu

LANGUAGE AND SKILLS

English: Fluent
Mandarin: Native
Japanese: JLPT-N2
German: Ph.D. required foreign language
Latin: 2 years of study
Programming: Python and Matlab

DISSERTATION ABSTRACT

Connecting the Stars: Narrative Knowledge, Coherence, and Productivity in Astronomy

Narratives serve important cognitive functions in everyday life, literature, and history. A growing interest is to investigate their unique roles in science. Mary Morgan (2022) characterizes narratives as a "technology of sense-making." In this view, narratives are a cognitive tool to connect and order diverse scientific elements, such as concepts, theories, models, and data from different sources, to create coherent knowledge. Several features make narratives advantageous in the study of complex interdisciplinary phenomena. Narratives are looser in organization than theories and models. They can forge plausible connections despite gaps, incorporate contingent changes, and stitch phenomena from different domains. Despite this, skeptics insist that narratives are not legitimate representations or explanations because they may produce just-so stories and present them as plausible. A narrative, therefore, needs to be verified by independent evidence to qualify as scientific knowledge. This puts narratives in a dilemma: an insufficiently warranted narrative does not benefit science; when narratives provide scientific knowledge, it is because of their verification rather than the distinctively narrative features such as loose organization. The question is how to account for the epistemic and methodological benefits of the narrative form.

I defend the central role of narratives in scientific knowledge, focusing on 20-21 century astronomy. Traditionally depicted as a mathematical-physical science, astronomy recently presents itself also as a historical and interdisciplinary science. A novel philosophical topic arises as to how one obtains knowledge about the universe's unobservable past. I argue that narrative construction is a key solution. Rejecting narrative skepticism's assumption that the only type of knowledge contributed by narratives is true stories, I argue that narratives provide a special kind of knowledge even when they are not warranted, the *knowledge-how* about using scientific methods or tools such as measurements, models, and algorithms. To show how the narrative format contributes to knowledge-how, I perform a novel conceptual analysis of narrative coherence that includes its ontological, structural, and pragmatic aspects.

I then make my argument using three cases in astronomy that involve different types of tools. First, narratives enable the establishment of time measurement in the universe. I propose the idea of narrative triangulation, where a story is necessary for coordinating and evaluating different measurement methods. Narratives played two roles in facilitating convergent results from discrepancy. Constructing master narratives about the history of the universe helped to compare time indicators that did not strictly measure the same quantity, and alternative narratives built upon different measurement results served as the unit for measurement evaluation and selection. Second, narrative-making enriches the knowledge-how of using models. In astronomers' first account of the exoplanet Hot Jupiter, constructing a plausible narrative for its orbital migration brought together multiple models that were designed for other purposes, adjusted them to this specific phenomenon, developed supplementing mechanisms, and explored the models' outcome space. The narrative thereby provided astronomers with a toolkit for studying similar phenomena. Finally, I argue that when astronomers integrate a data-driven method, machine learning, into scientific research, narratives provide a solution to a difficult epistemic situation of non-uniqueness when algorithms for a general purpose proliferate, but scientists do not know how to select and use them in a specific context. I argue that the best way to incorporate machine learning in astronomy is through an iterative process of identifying patterns in data and constructing a narrative that explains them.

To conclude, my dissertation explicates the concept of narrative and demonstrates its power as a meta-method for science in a way immune to criticisms against its truth-conduciveness. This also helps to understand important discoveries in 20-21 century astronomy and provides methodological lessons for its continuing success as a historical and interdisciplinary science.

GRADUATE LEVEL COURSEWORK

Philosophy of Science
Modern Philosophy of Science – Cat (Indiana)
Philosophy of Science – Lloyd (Indiana)
Climate, Values, and Objectivity – Lloyd (Indiana)
Philosophy of Physics and Chemistry – Cat (Indiana)
Scientific Method: How Science Really Works – Schickore (Indiana)
Science and Values – Lloyd (Indiana)
The Robot Scientist: AI and the Science of Science – Hagar (Indiana)
Philosophical Foundations of Cognitive and Information Science – Barwich (Indiana)
Mechanism and Mechanistic Explanation in Cognitive Science – Barwich (Indiana)
Science, Medicalization, and Authority – Sholl (Aarhus)

General Philosophy
First-Order Logic - Liu (Peking)
Philosophy of Mind – Schechter (Indiana)
Collective Action and Responsibility – Ludwig (Indiana)
Idealism and Post-Idealism – Kreis (Aarhus)
German and French Phenomenology – Wu (Peking)
Selected Readings of German Idealism – Liu (Peking)

History of Science
History of Science up to 1750 – Newman (Indiana)
History of Science since 1750 – Gliboff (Indiana)

Cognitive Science
Machine Learning – Tiganj (Indiana)
Models in Cognitive Science – Busemeyer (Indiana)
Networks of the Brain – Sporns (Indiana)
Neural Networks and the Brain – Newman (Indiana)
Modeling Evolutionary and Adaptive Systems – Izquierdo (Indiana)