

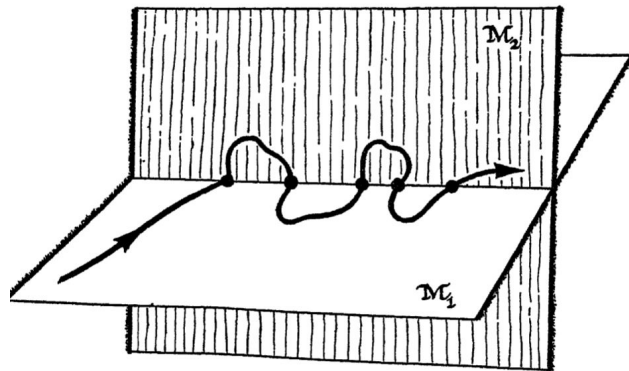
Philosophy and Psychology of Generalization and Creativity

1st Meeting “Intro” (9/18/24)

Simons Institute, Berkeley

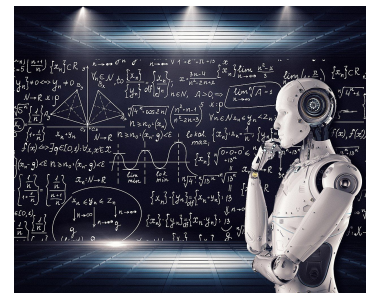
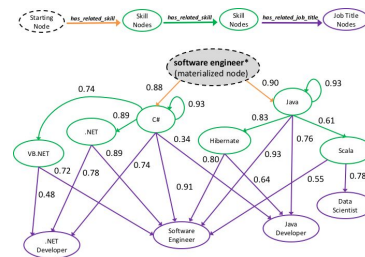
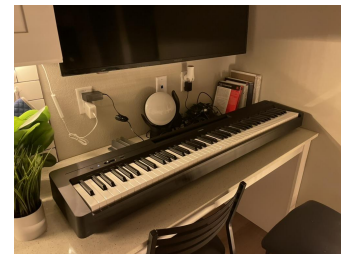
Why this reading group?

- To develop **new** mathematical tools for emerging generalization settings, we may have to **return to the old**: those fields which have been studying generalization for centuries.
- **My personal take** is that, in many circumstances, **the shortest path** to consistent mathematical theories explaining contemporary phenomena in AI is **not through math alone**, but rather through the interaction between disciplines: math + phil + psych + CS.



Brief Introductions (Who doesn't love icebreakers?) 🙄

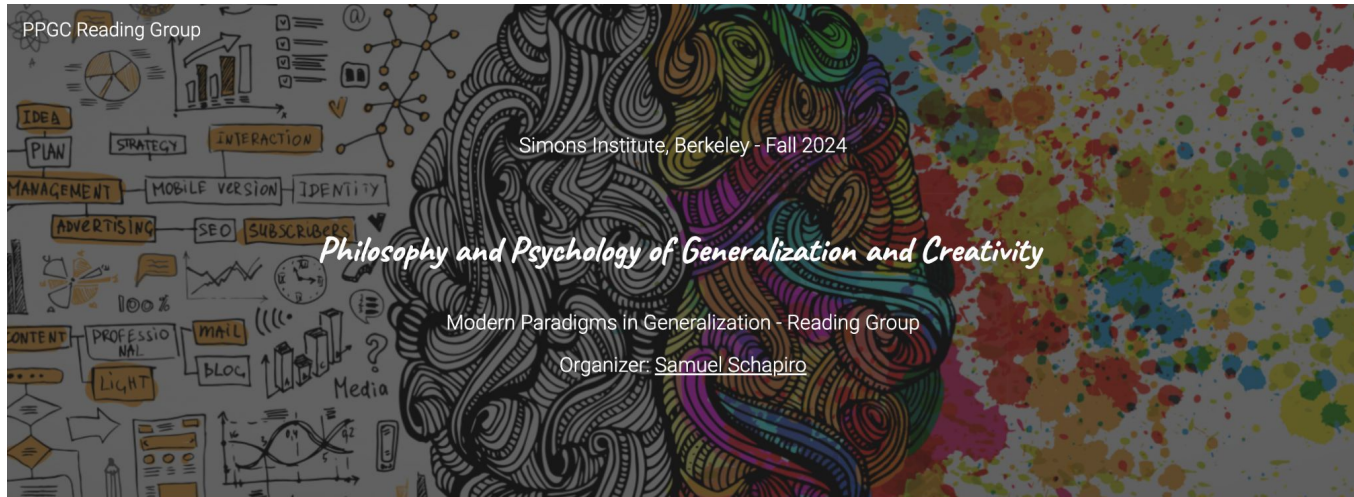
- To get started, we can share:
 - **Name**
 - Sam
 - **If I wasn't in academia I would probably be a...**
 - Musician.
 - **One thing in generalization I am really excited about right now is...**
 - Automated creative discovery
 - **After this reading group, I hope to have discovered/learned...**
 - The abstract building blocks of intelligence + generalization



Resources: Website

- Our [website](https://sites.google.com/berkeley.edu/generalization-phil-and-psych) has a beautiful background photo that is really fun to look at.
 - More importantly, it has our schedule in case you get lost.

<https://sites.google.com/berkeley.edu/generalization-phil-and-psych>



Resources: [Google Doc](#) - Schedule

- Any other guest speakers you would like to see?

Meeting Date	Topic	Link to Slides	Presenters?
9/18/24	Introduction (Topics, Goals, Structure, Social Activities, etc.)		N/A
10/1/24*	Generalization in Children and Adults (Ontogenetic Perspective): Part 1/2		
10/8/24*	Generalization in Children and Adults (Ontogenetic Perspective): Part 2/2		
10/15/24*	Exceptional Cases of Generalization in Creative Scientists (Phylogenetic Perspective): Part 1/2		
10/22/24*	Exceptional Cases of Generalization in Creative Scientists (Phylogenetic Perspective): Part 2/2		
10/29/24*	Philosophical Foundations and Limits of Generalization (Epistemological Perspective): Part 1/2		
11/5/24*	Philosophical Foundations and Limits of Generalization (Epistemological Perspective): Part 2/2		
11/19/24*	Hybrid slot		
November	Talk From Paul Thagard on Creativity in Generative AI (day, time TBD)		
11/26/24*	Futures of Generalization: Automated Discovery, Computational Creativity, and Foundation Models: Part 1/2		
12/10/24*	Futures of Generalization: Automated Discovery, Computational Creativity, and Foundation Models: Part 2/2		



Talk on Creativity

Paul Thagard

8 languages

Article Talk

Read Edit View history Tools

From Wikipedia, the free encyclopedia

Paul Richard Thagard /ˈθaɪɡɑːrd/; born 1950) is a Canadian philosopher who specializes in cognitive science, philosophy of mind, and the philosophy of science and medicine. Thagard is a professor emeritus of philosophy at the [University of Waterloo](#). He is a writer, and has contributed to research in analogy and creativity, inference, cognition in the history of science, and the role of emotion in cognition.

In the philosophy of science, Thagard is cited for his work on the use of computational models in explaining conceptual revolutions;^[4] his most distinctive contribution to the field is the concept of [explanatory coherence](#), which he has applied to historical cases.^{[5][6][7]} He is heavily influenced by pragmatists like C. S. Peirce, and has contributed to the refinement of the idea of [inference to the best explanation](#).^[8]

In the [philosophy of mind](#), he is known for his attempts to apply [connectionist](#) models of coherence to theories of human thought and action.^[9] He is also known for HOTCO ("hot coherence"), which was his attempt to create a computer model of cognition that incorporated emotions at a fundamental level.^[10]

Paul Thagard

FRSC

Born
Paul Richard Thagard
28 September 1950 (age 73)
Yorkton, Saskatchewan,
Canada

Education
[University of Saskatchewan](#)
(B.A., 1971)
[University of Cambridge](#) (M.A.,
1973)
[University of Toronto](#) (Ph.D.,
1977)
[University of Michigan](#) (M.S.,
1985)

Spouse
Ziva Kunda (died 2004)

Era
Contemporary philosophy

Region
Western philosophy

School
[Naturalism](#)^[1]

[Epistemic coherentism](#)^[2]

Thesis
Explanation and Scientific

Resources: [Manuscript](#)

During the reading group, we can document our perspectives in a manuscript that taxonomizes the many forms of generalization, addressing especially those recognized as having importance in:

- Children and adults
- Exceptional scientists and inventors
- Epistemology, philosophy of science, and metaphysics
- Successful machine learning and AI systems

These are the main themes of the semester... more on these in the next 4 slides...

The screenshot shows a LaTeX manuscript editor with a code editor on the left and a preview on the right. The code editor displays LaTeX source code for a document class, including packages like `documentclass`, `font`, `palatino`, `times`, `mathpazo`, `geometry`, `letterpaper`, `margin`, `geometry`, `natbib`, `microtype`, `graphics`, `booktabs`, `hyperref`, `amsmath`, `amsthm`, `amssymb`, `amsopn`, `algorithm`, `algorithmic`, `float`, `bbe`, `bn`, `enumerate`, `color`, `multitrow`, and `gensymb`.

The preview on the right shows the rendered document. It includes a section titled "3.2 Phylogenetic Perspectives on Generalization: Scientists and Inventors" with a list of references. Below this is a section titled "3.3 Philosophical Perspectives on Generalization: Epistemology and Philosophy of Science". This section contains two tables. The first table, "Table 1: Caption", has two columns: "Generalization Level" and "Description". The second table, "Table 2: Caption", has two columns: "Developmental Stage" and "Description".

Generalization Level	Description
None	
Local	
Broad	
Extreme	
Universal	

Table 1: Caption

Developmental Stage	Description
First Pre-Operational Level	
Second Pre-Operational Level	
First Concrete Stage	
Second Operational Stage	
Formal Operations	

Table 2: Caption

3.4 Generalization in Machine Learning

Forms of domain adaptation (closed set DA, open set DA, partial DA, open-partial DA), compositional generalization, length generalization

Content: Generalization in Children and Adults [10/1, 10/8]

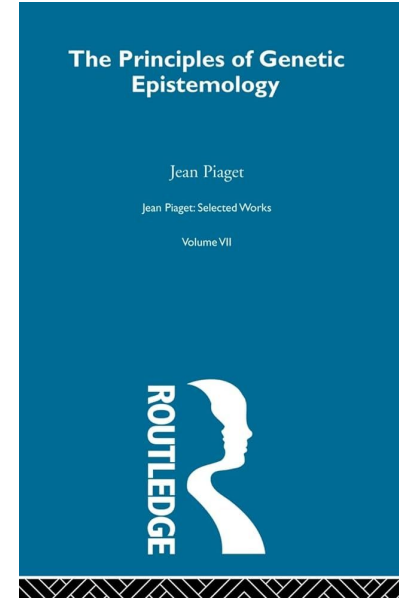
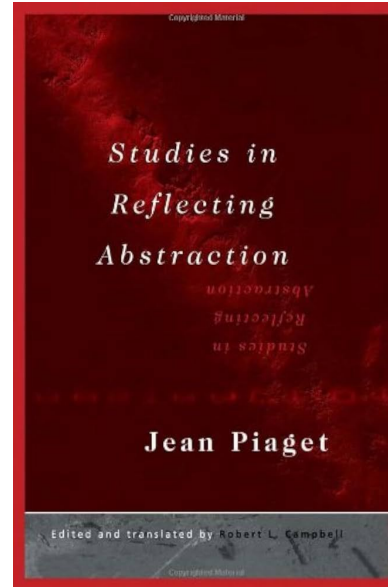
- A main resource here is the developmental psychologist Jean Piaget. A central theme here will probably be in distinguishing what is innate vs. learned

1. Generalization in Children and Adults (Ontogenetic Perspective) [10/1,10/8]

- Principles of Genetic Epistemology - Jean Piaget
 - Chapter 1 "Psychogenesis" (33 pages)
- Studies in Reflecting Abstraction - Jean Piaget
 - Chapter 1: Abstraction, Differentiation, and Integration in the Use of Elementary Arithmetic Operations (22 pages)
 - Chapter 4: Abstraction and Generalization During Transfers of Units (18 pages)
- **The Role of Innatism in Human Generalization**
 - [Argument from the Poverty of the Stimulus](#)
- **Generalization in Adults**
 - Empirical human generalization behavior on sequence processing tasks (e.g. <https://arxiv.org/pdf/1901.04587>)

1.1 Key Questions:

- 1.1.1 How do children generalize as they form knowledge? What is learned and what is innate?
- 1.1.2 What are the limits, scope, and forms of generalization in adults?

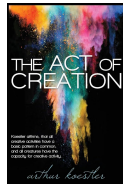
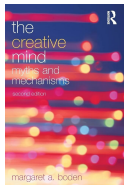


Content: Generalization in Scientists and Inventors [10/15, 10/22]

- Lots of perspectives here! This should be a fun and creative time. Notable experts on this topic are Dean Simonton, Margaret Boden, Paul Thagard.

2. Generalization in Scientists and Inventors (Phylogenetic Perspective) [10/15,10/22]

- **Bisociation:** [The Act of Creation - Arthur Koestler](#)
 - Chapter 5 “Moments of Truth” (20 pages)
 - Chapter 6 “Three Illustrations: Gutenberg’s printing press, Kepler’s synthesis of astronomy and physics, and Darwin’s natural selection” (24 pages)
- **Combinatorial Creativity:** Creativity in Science: Chance, Logic, Genius, and Zeitgeist - Dean Simonton
 - Chapter 3 “Combinatorial Processes” (36 pages)
 - Chapter 5 “Creative Scientists” (38 pages)
- **Abductive Reasoning:** [From da Vinci’s Flying Machines to a Theory of the Creative Process](#)
- **Blind Variations:** [The Blind Variation and Selective Retention Theory of Creativity](#) - Dean Simonton (15 pages)
- **Four Mental Operations in Creative Cognition: The Importance of Abstraction**



- **Janusian, Homospatial, and Sep-Con Articulation Thinking:** [Flight From Wonder: An Investigation into Scientific Creativity - Albert Rothenberg](#)
 - Chapter 3-4: Janusian Thinking
 - Chapter 5: Homospatial Thinking
 - Chapter 6: Sep-Con Articulation
- **Associative and Combinatorial Basis of Creativity**
 - [Creative Combination of Representations: Scientific Discovery and Technological Innovation](#) - Paul Thagard (23 pages)
 - [The Associative Basis of the Creative Process](#) - Sarnoff Mednick (13 pages)
 - [Forward Flow: A new measure to quantify free thought and predict creativity](#)
- **Exploratory Basis of Creativity**
 - [The Creative Mind: Myth and Mechanism](#) (34 pages)
 - Chapter 4 “Maps of the Mind”

2.1 Key Questions:

- 2.1.1 What are historical instances of exceptional generalization from creative scientists? What made them so creative?
- 2.1.2 What cognitive processes facilitated these creative discoveries?
- 2.1.3 How many forms of creativity are there? Can we unite them into one comprehensive theory?

Content: Philosophical Limits of Generalization [10/29, 11/5]

- Mainly drawing from philosophy of science, epistemology, and — when we are brave — metaphysics

3. Philosophical Foundations and Limits of Generalization (Epistemological Perspective) [10/29, 11/5]

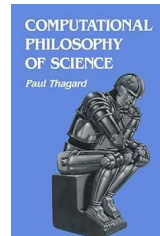
- An Essay Concerning Human Understanding - John Locke (1689) (tentative)
- An Enquiry Concerning Human Understanding - David Hume (1748) (tentative)
- Critique of Pure Reason - Immanuel Kant (1781)
 - The *Transcendental Aesthetic* (synthetic à priori judgments, e.g., <http://www.philosophypages.com/hy/5f.htm>) and the rebuttal from Quine (Two Dogmas of Empiricism, 1951);
 - *The Transcendental Analytic* (pure categories of understanding);
 - *The Transcendental Deduction of the Categories* (Causality, logic, etc. are not learned but belong to a class of à priori human faculties whose acquisition is not derivable through experience but for which experience is a necessary condition for their acquisition); and
 - *The Transcendental Schemata* (derives how the pure categories of understanding apply to experience to form intelligence)
- Ontological Relativity and Other Essays - W. V. Quine (1969)
- Computational Philosophy of Science - Paul Thagard (1988)
 - Chapter 3 “Theories and Explanations” (15 pages)
 - Chapter 4 “Discovery and the Emergence of Meaning” (22 pages)
 - Chapter 5 “Theory Evaluation” (24 pages)
- Abstraction and Representation - Peter Damerow (1996)
 - Chapter 2 “Representation and Meaning” (25 pages)

- Since this is 1 ½ months away, the resources listed here are more **tentative**. Following Max Raginsky’s talk, we should include some additional works on **induction/deduction in phil of sci.**

- Chapter 3 “Philosophical and Pedagogical Remarks on the Concept ‘Abstract’” (15 pages)
- Ben Recht: <https://www.argmin.net/p/meehls-philosophical-probability>

3.1 Key Questions:

- 3.1.1 What are the epistemological necessities for generalization?
- 3.1.2 What role does generalization play in science?



Content: Futures of Generalization [11/26, 12/10]

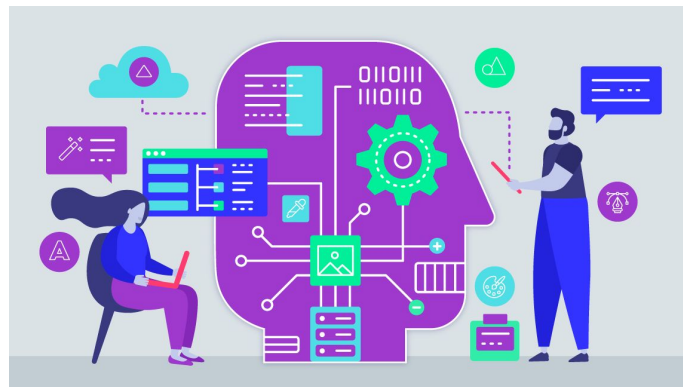
4. Looking Ahead to the Future of Generalization: Automated Discovery, Computational Creativity, and Foundation Models [11/26,12/10]

- **Automated Scientific Discovery and Computational Creativity**
 - [Survey on Automated Scientific Discovery](#)
 - BACON + Rest of [Pat Langley's work](#)
 - Computational Drug Discovery
 - [Creativity in MDPs](#)
- **Forms of OOD Generalization**
- **Creativity of Foundation Models:**
 - [The AI Scientist](#)
 - What are the strengths and weaknesses, and -- knowing what we know now about generalization and creativity -- where is there room for improvement?
 - [Can ChatGPT make explanatory inferences? Benchmarks for Abductive Reasoning - Paul Thagard](#)
 - [Artificial Scientists & Artists Based on the Formal Theory of Creativity, Formal Theory of Creativity, Fun, and Intrinsic Motivation](#) - Jürgen Schmidhuber
 - [Assessing and Understanding Creativity in Large Language Models](#)
 - [On the Creativity of Large Language Models](#)

4.1 Key Questions:

- 4.1.1 How have automated discovery systems been structured historically, and what were they able to accomplish?
- 4.1.2 To what extent are foundation models creative? In which circumstances can foundation models generalize but humans cannot, and vice versa?
- 4.1.3 What does the future of generalization look like?

- **My personal take** is that the future of generalization is in automated creative and scientific discovery, which (again, personal take) will completely revolutionize what science, industry, and art look like in our lifetimes.



Summary

- Mottos of this reading group:
 - “explain the new by studying the old”
 - “build the artificial by studying the natural”
- Our three main resources are the: 1) [website](#), 2) [manuscript](#), 3) [google doc](#)
- The four main themes of the semester are:
 - 1) Studying generalization in children and adults
 - 2) Studying exceptional generalization in scientists and inventors (creativity)
 - 3) Studying the philosophical foundations and limits of generalization
 - 4) Pontificating on futures of generalization

Hope you enjoy this semester! :)

