

Strong Inference (Laboratory)

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Research Methods for
Empirical Computer Science
CMPSCI 691DD



Systems are not experiments or theories

“We cannot explain the behavior of a program just by opening it up and perusing its structure

Running a program does not constitute an experiment, programs are part of the laboratory apparatus with which we answer questions

Experimental questions provide evidence about research questions and experimental questions that aren't motivated by research questions are generally dull”



Systems are not experiments or theories

(continued)

“Research questions and theories will inevitably contain ill-defined terms if they are to have any generality

Finally, the formulation of general theories relating program behavior to architecture, tasks, and environments is our goal.”



Activity is not necessarily research

- Don't confuse *substantial scholarly activity* with *effective research*
 - *Activity* — Building systems, proving theorems, writing articles, getting cited, giving talks, obtaining grants, and graduating students
 - *Research* — Improved prediction, understanding, and control of computational artifacts
- Activity is an *imperfect* indicator of effective research
- Many researchers are active.
A subset of them do effective research
- How large is that subset? What work does it contain?

The Emperor's New Clothes



The Courtier's Reply

“I have considered the impudent accusations of Mr Dawkins with exasperation at his lack of serious scholarship.

He has apparently not read the detailed discourses of Count Roderigo of Seville on the exquisite and exotic leathers of the Emperor's boots, nor does he give a moment's consideration to Bellini's masterwork, *On the Luminescence of the Emperor's Feathered Hat*.

We have entire schools dedicated to writing learned treatises on the beauty of the Emperor's raiment, and every major newspaper runs a section dedicated to imperial fashion...

Dawkins arrogantly ignores all these deep philosophical ponderings to crudely accuse the Emperor of nudity.”

– PZ Myers



Initial questions for ‘strong inference’

- **Ontology** — What is the task, system, and environment? What are the relevant entities, relations, and variables?
- **Behavior** — What sort of behaviors does the system exhibit when performing these tasks in these environments?
- **Theory** — What general theoretical frameworks exist now to predict, explain, and control this behavior?
- **Hypotheses** — What hypotheses could you form based on those theories? What type of hypotheses are these? Can you push yourself higher on the ontological ladder?
- **Falsifiability** — How falsifiable are these hypotheses? How could they be sharpened to be more falsifiable?
- **Multiple hypotheses** — Can you devise additional hypotheses that address the same behavior?

Case Studies

Non-stationary rewards in reinforcement learning

William Dabney

- “The system of Reinforcement Learning has been extensively studied, and most would argue that the fundamental behaviors of the system are well understood. However, classical reinforcement learning has, in the majority of cases, *avoided non-stationary reward functions.*”
- “Thus, a study of the actual effects of differing degrees of non-stationarity in a reward function would be beneficial to RL as a field as well as specifically for research on intrinsically motivated RL.”

Distributed Image Search in Camera Sensor Networks

Tingxin Yan

- “In this project, we describe a novel general distributed image search architecture comprising a wireless camera sensor network where each node is a local search engine that senses, stores and searches images. The system is designed to accurately and energy efficiently achieve image search in sensor networks. Our search engine is made possible by the use of compact image representations for efficient communication and search, and the re-design of fundamental data structures for efficient flash-based storage and search.”

Platt — “Strong Inference”

