

Research Methods

Quantitative, Qualitative Methods and
Experimental Computer Science



Topics of Interest

- Teaching is dangerous
- Categories of Research
- Problems with these categories
- The monkey analogy
- Why Research?



Teaching is Dangerous

- You are responsible for the 3 pillars as an academic.
- One of the pillars is teaching and can take up all your available time.
- But it is also very rewarding and can tempt you into the life of teaching focus.
- (It shames me to say) this decision would be a mistake in our current system.



**Research
Career**

Research Method Categories

- We have to thank Psychology for helping us with this.
- Research methods are generally categorized as either
 - *Quantitative, or*
 - *Qualitative*
- This may or may not be applicable to your work



Qualitative Research

- Concentrates on collecting and analyzing subjective data
- Usually the perceptions of the people involved
- Intention is to illuminate perceptions and, thus, gain
 - greater insight (explain why) and
 - Knowledge (reproduce or recognize).

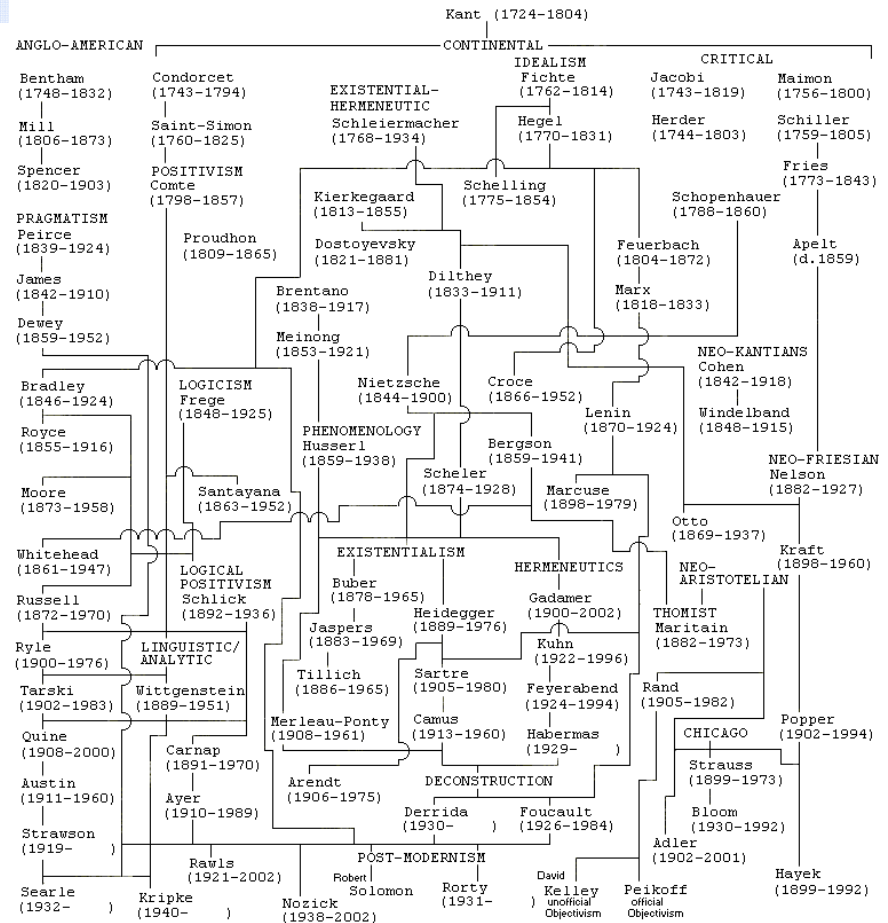


Complexity Problem

- Research indicating influences of philosophers on one another after Kant (1724-1804)

FLOW CHART OF MODERN PHILOSOPHY AFTER KANT

[A connection sometimes indicates membership in the school rather than direct influence.]



Subjectivity Problem

- What this monkey doing?



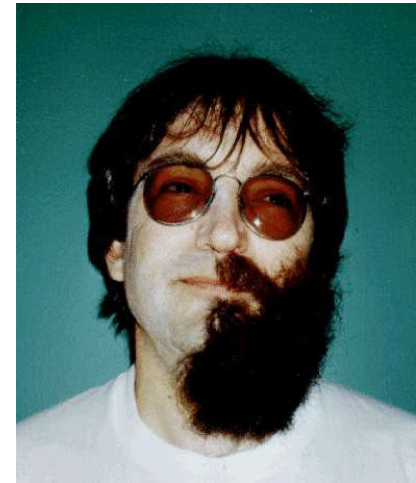
Quantitative Research

- Concentrates on what can be measured.
- Involves collecting and analyzing objective data
- Usually involves some form of math
 - Statistical
 - Calculus
 - Discrete



Causality Problem

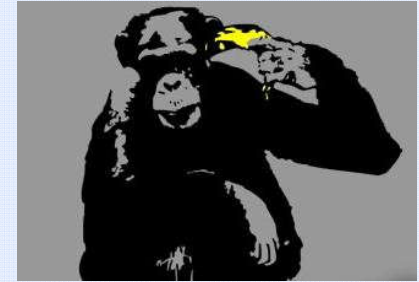
- Data taken from 20 year study of 2438 middle-aged Welsh men's shaving habits discovered that the unshaven are;
 - Less likely to be married
 - More likely to be blue-collar
 - Had a 45% higher death rate
 - Had a 70% higher risk of stroke
 - Were shorter
 - More likely to suffer from Angina
- Conclusion: Not shaving causes these problems?



Quantity vs. Quality

	Qualitative Research	Quantitative Research
Type of reasoning	<i>Inductive (infer general from specific)</i>	<i>Deductive (infer specific from general)</i>
Link with concepts	<i>identifies concepts from situation</i>	<i>Has predetermined concepts and investigates relationships</i>
Action	<i>Usually only describes the action in a situation</i>	<i>tests relationships between concepts on performing an action</i>
Outcome	<i>illuminates the situation by adding examples</i>	<i>accepts or rejects proposed theory</i>
Approach to validity	<i>truth seen as context bound (socially constructed)</i>	<i>truth seen as objective and universal</i>

Quantity vs Quality



- Quantitative

- We have an hypothesis that monkeys will put bananas to their ears
- We gave bananas to monkeys
- If we say banana to ear == “Monkeycide”
- We counted xx instances of Monkeycide over yy trials
- Our hypothesis is accepted if $xx > 0$

- Qualitative

- We saw monkeys pick up bananas
- We observed the monkeys placing bananas to their ears
- From observation we have the concept: “Monkeycide”
- Monkeys Jenny, Irene and Blake exhibited Monkeycide

Why Research?

- Research is conducted to solve problems
 - Descriptive (*find facts*)
 - Exploratory (*identify patterns*)
 - Analytical (*explain why or how*)
 - Predictive (*forecast the likelihood of particular events*)
 - Problem Solving (*improve current practice*)

Descriptive Research

- Purpose
 - To describe the way things are or were accurately
- Two main types
 - Surveys
 - Observations

Surveys

- Two reasonable ways of doing it
 - Questionnaire
 - Relies on carefully composed questions
 - Interview
 - Face-to-face
 - Electronically (phone, chat, email, etc.)

Situational Observation

- Set up a situation and talk to people about what they are doing when they are dealing with the situation.
- You are not a participant
- Setting can be
 - Naturally occurring
 - Simulated
 - Something in between

The Setting

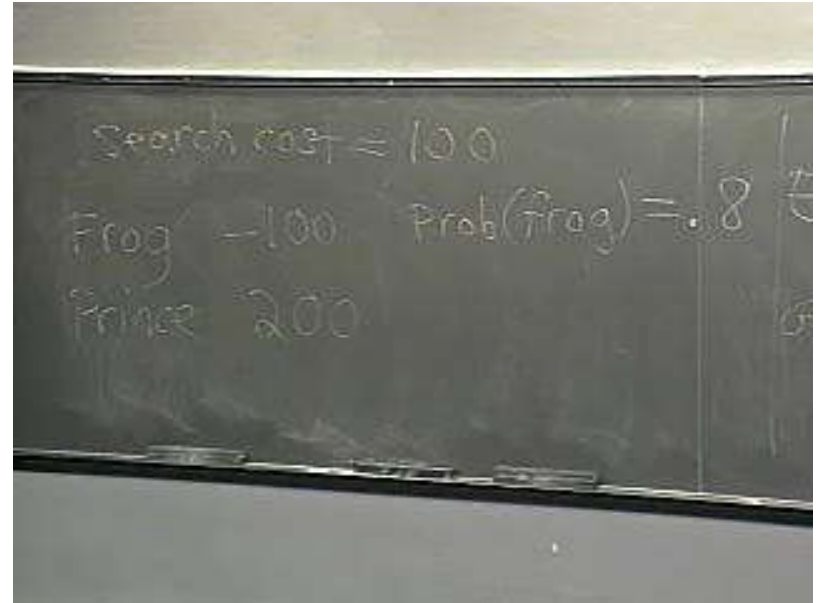


Time = 0



Exploratory Research

- Done when a problem is not clearly defined
- Exploratory research helps determine the best
 - research design,
 - data collection method and
 - selection of subjects.



The “Oh Crap!” moment

Analytical Research

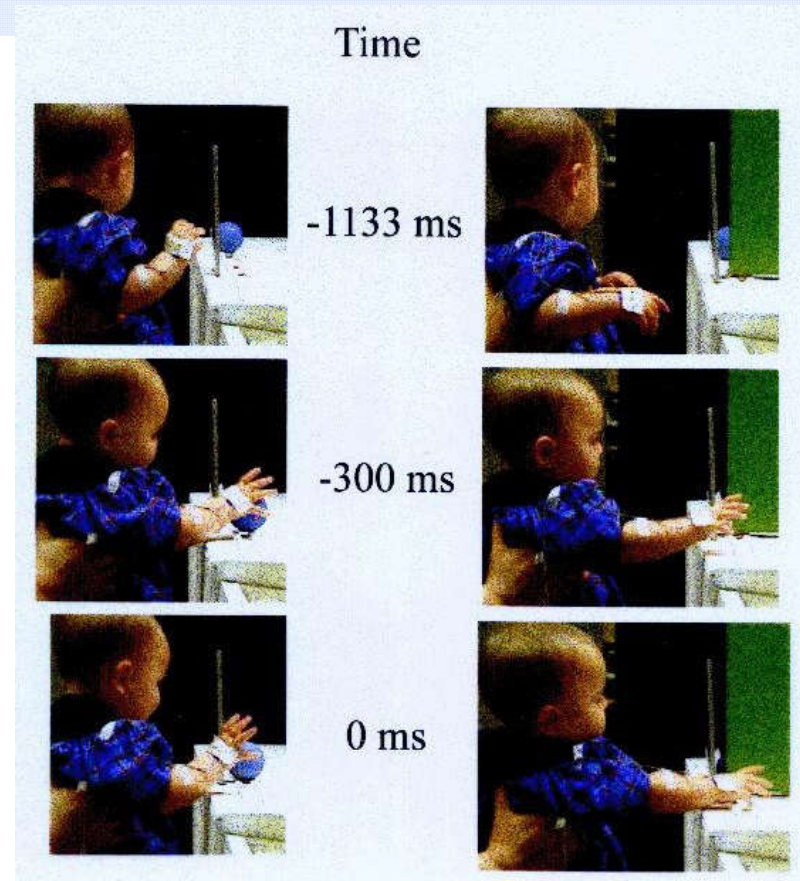
- Seeks to explain the reasons behind a particular occurrence by discovering causal relationships.
- Once causal relationships have been discovered, the search then shifts to factors that can be changed (variables) in order to influence the chain of causality.
- You poke at it to see what makes it tic!

This may not be easy



Predictive Research

- Seeks to forecast the likelihood of particular phenomena occurring under the given circumstances.



Problem Solving Research

- A form of problem solving based on increasing knowledge through observation and reflection, then following this with a deliberate intervention intended to improve practice.
- You examine current practices and change them (not necessarily for the better)
- Mostly a Social Science format

Computer Science Contribution to Research Methods

- Experimental Computer Science (ECS)
- ECS is the creation of, or the experimentation on HW/SW systems
 - Known as computational artifacts (CA).



Artifacts

- People-created things with
 - Meaning (the thing has a name and expectations)
 - Functionality (the thing does something)
 - Observability (the thing has an observable behaviour)
- Representative of
 - a class of similar things
 - Subject of a study
 - Apparatus for a study



Example Computational Artifacts

- computers, phones, robots...
- compilers, editors, FB
- Programming languages, architectures, protocols, and methodologies (object-orientation, ...)
- Normally Complex
 - Hard to make
 - Dynamic behaviour



What do we use CAs for?

- Measurement and Experimentation tool (quantitative results)
 - Example: implementation of algorithms
- Proof of concept
 - Example: “Cut, Copy, Paste” metaphors
- Proof of existence
 - Example: computer mouse

Our process (generally) is:

- Form a hypothesis
- Construct a model
- Make a prediction
- Design an experiment
- Collect data
- Analyze results with respect to prediction

Challenges

- What if the result does not match the prediction?
 - Change the predictions based on the evidence
 - Do nothing
 - Learn something
- What if I don't want to experiment at all?
 - Early CS study of 400 papers showed that <40% had any experimental validation (50% for SE papers)