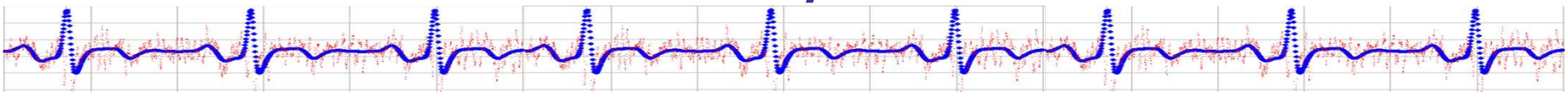
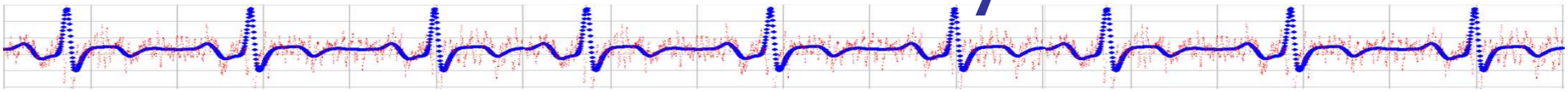
Empirical Research Methods in Information Science

IS4800 / CS6350



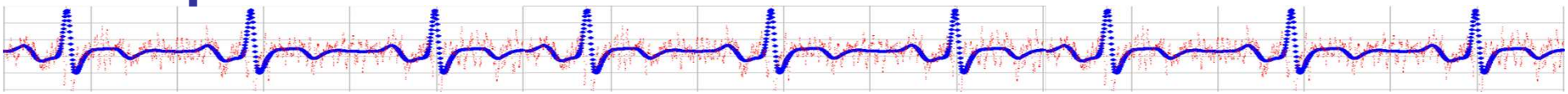
Lecture 2

Overview for today

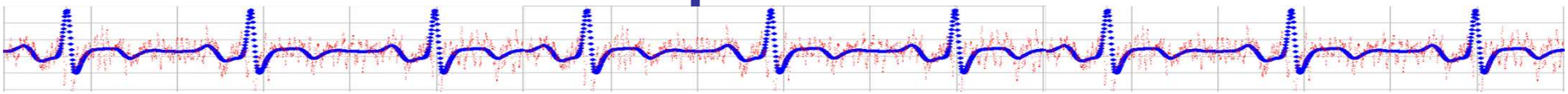


- The scientific method
- Doing background research
- Sample research plan (if time)

Review: Why care about research methodology, even if you don't plan to become a researcher?

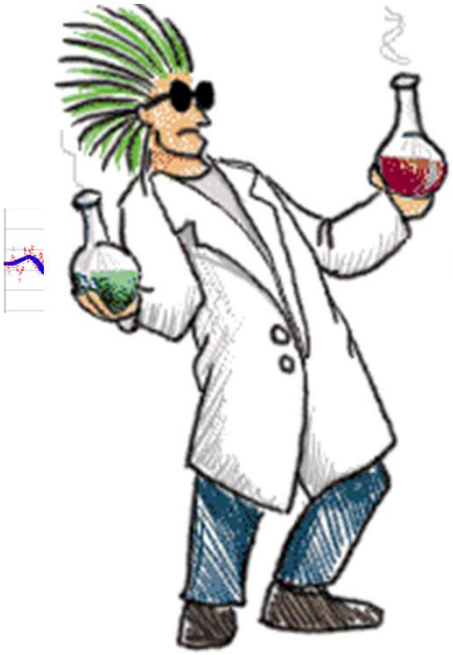


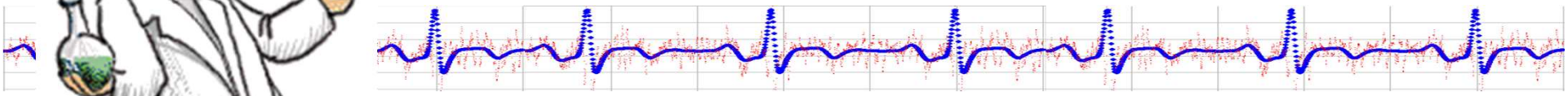
B&A Ch 1:
Scientific explanations



Why important?

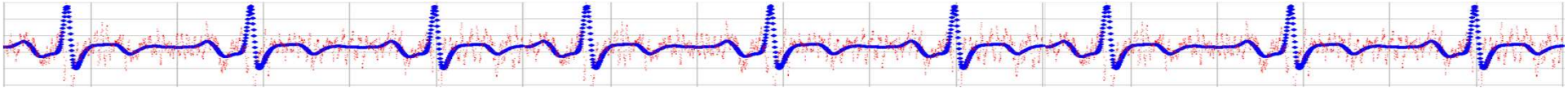
What is science?





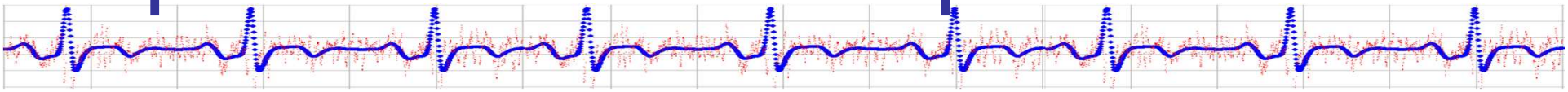
A set of methods used to collect information about phenomena in a particular area of interest, and build a reliable knowledge base about them

Some functions of science



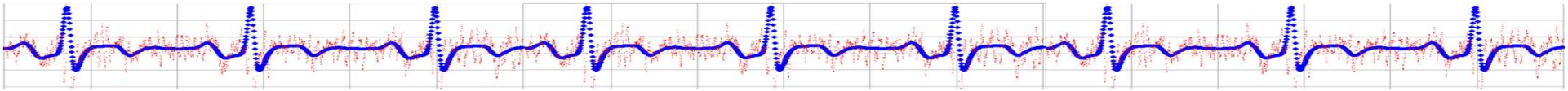
- Describe the world
- Explain phenomena
- Predict phenomena

Science vs. non-science vs. pseudoscience vs. protoscience



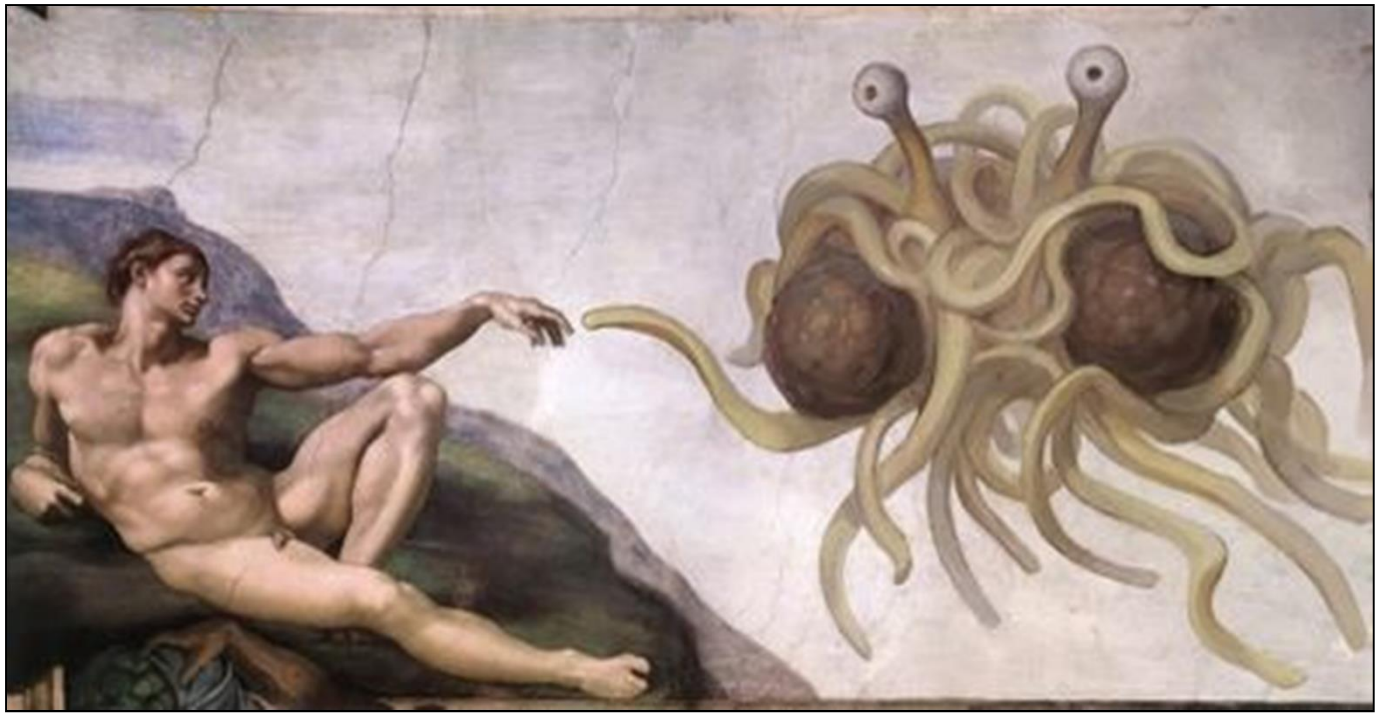
- Science – generally follows scientific method
- Non-science – doesn't follow scientific method but is up front about it (e.g., philosophy)
  - Commonsense explanation
  - Belief-based explanation
- Pseudoscience – doesn't follow scientific method, but tries to pass off as science (e.g., phrenology)
- Protoscience (alchemy -> chemistry)

Other examples of non-science? Pseudoscience? Protoscience?

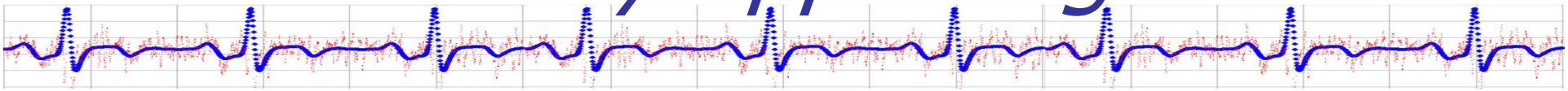


Pseudoscience: Flying spaghetti monster

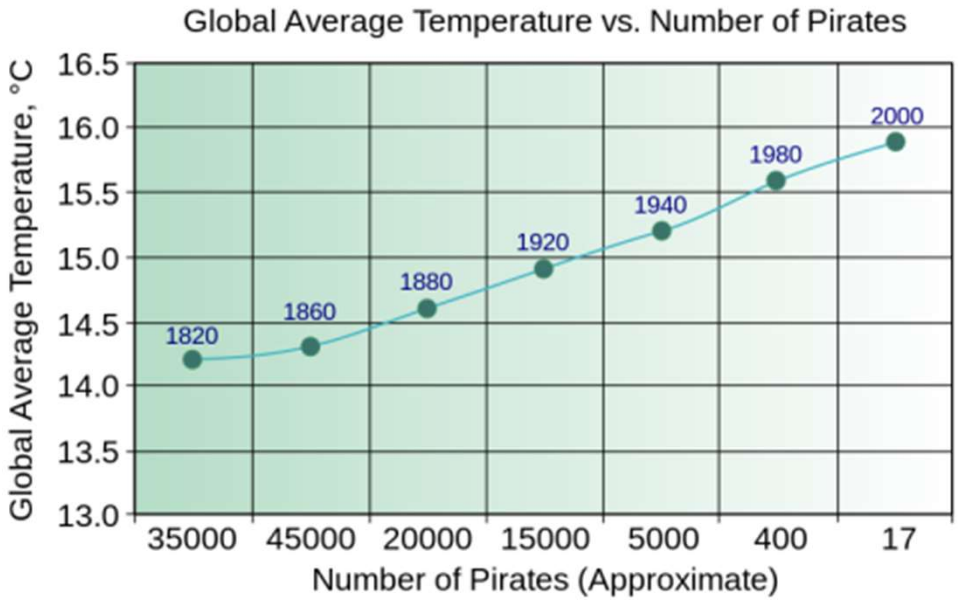
- Pastafarianism
- A parody religion to counter creationism



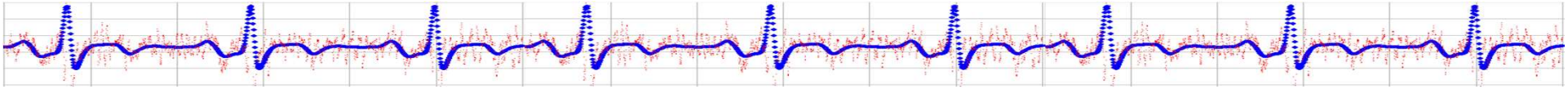
Global warming as proof of *His Noodly Appendage*

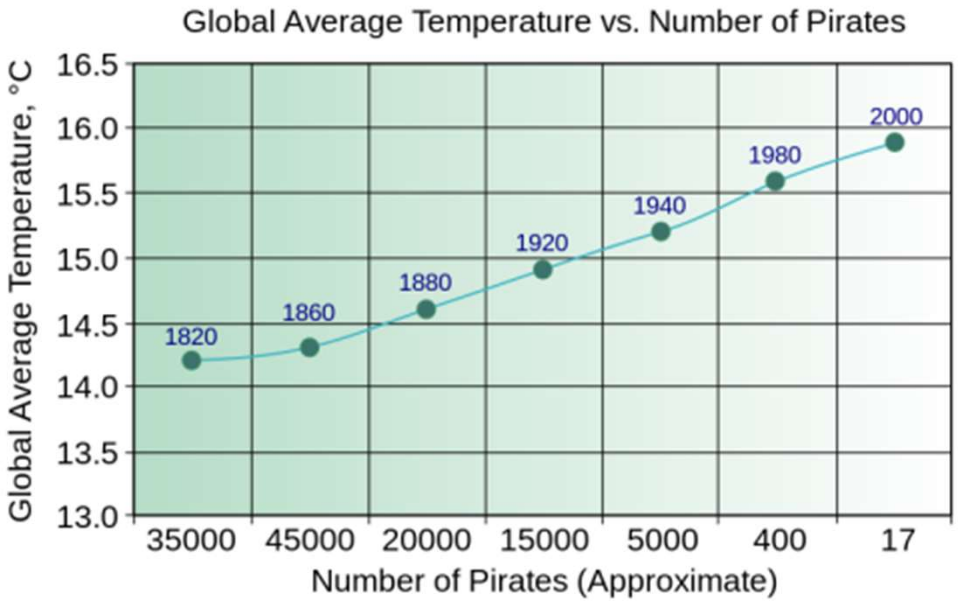


- Pirates are "absolute divine beings" and the original Pastafarians.
- Global warming, earthquakes, hurricanes, and other natural disasters are a direct effect of the shrinking numbers of pirates since the 1800s.

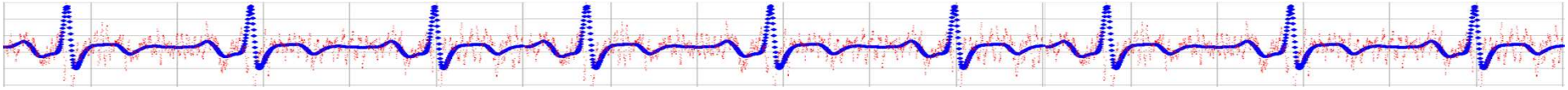


Correlation does not imply causation!





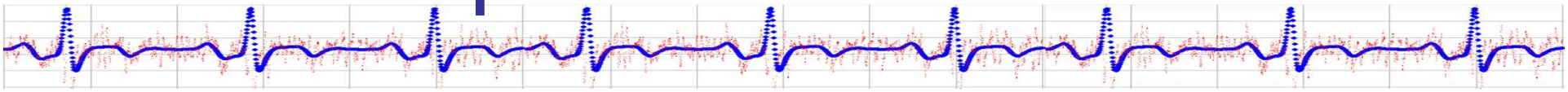
Protoscience



- "Fringe science"
- Science at the edges of our current understanding

- E.g., Complementary and alternative medicine
- Now: NIH Center for Complementary and Integrative Health

What kinds of explanations do these provide?

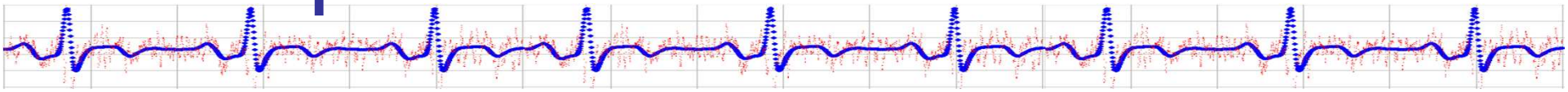


- Astrology
- Medicine
- Personal experience
- Philosophy
- Phrenology
- Physics
- Religion
- Creationism
- Mathematics

- Describe
- Explain
- Predict

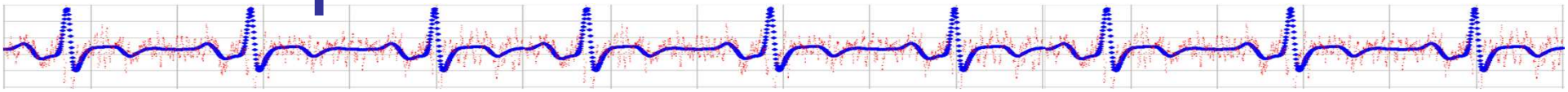
- Science
- Non-science
- Pseudoscience
- Protoscience

Characteristics of scientific explanations



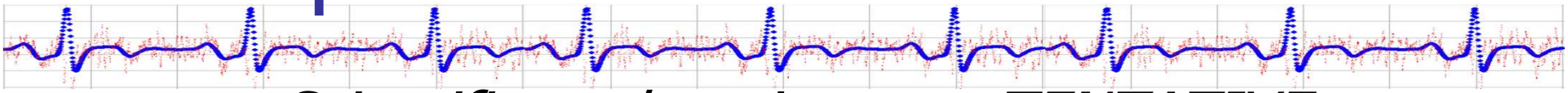
- *Scientific explanations are EMPIRICAL*
  - Based on objective, systematic observations
- *Scientific explanations are TESTABLE*
  - Verifiable through observation and can be disproved
- *Scientific explanations are RATIONAL*
  - Follow the rules of logic; and are consistent with known facts

Characteristics of scientific explanations



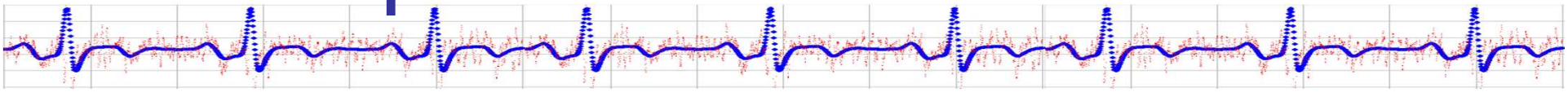
- *Scientific explanations are GENERAL*
  - Apply beyond the original observations on which they are based
- *Scientific explanations are PARSIMONIOUS*
  - Provide the simplest explanation using the fewest possible assumptions

Characteristics of scientific explanations



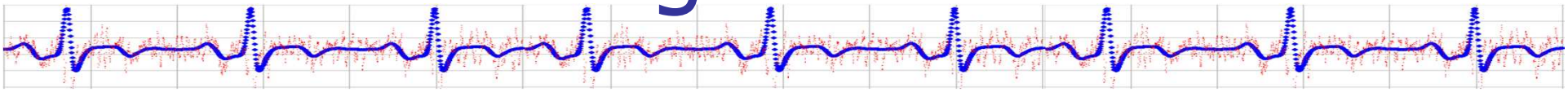
- *Scientific explanations are TENTATIVE*
  - Never accepted as absolutely correct
- *Scientific explanations are RIGOROUSLY EVALUATED*
  - Constantly evaluated for consistency with evidence, generality, and parsimony

Why the emphasis on "empirical" and "testable"?



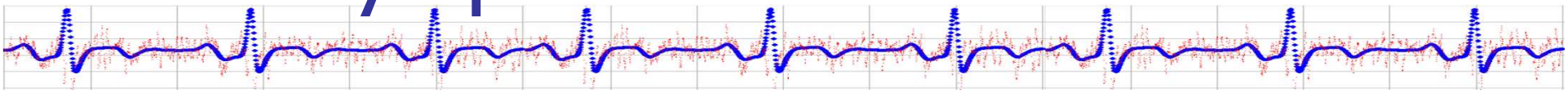
- Minimizes subjectivity
- Studies are fallible – replication must be possible

In what ways can study results be general?



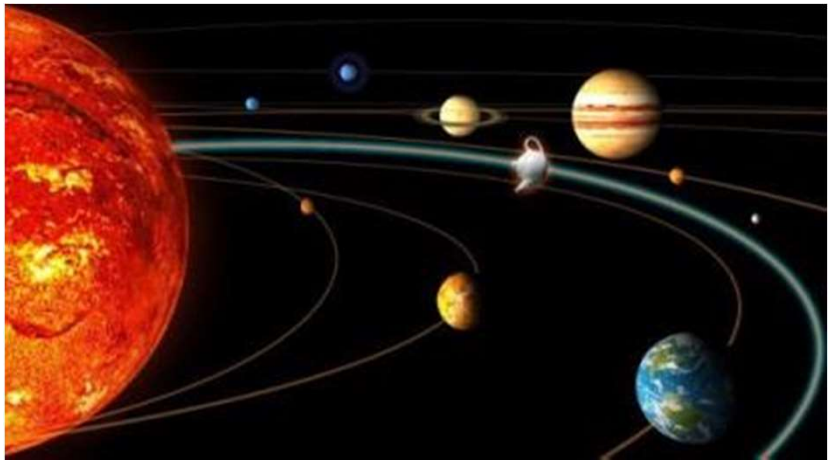
- First: Think about what are possible "units of study" in information science?
- Next, think about how ideas might generalize across units

Why "parsimonious"?



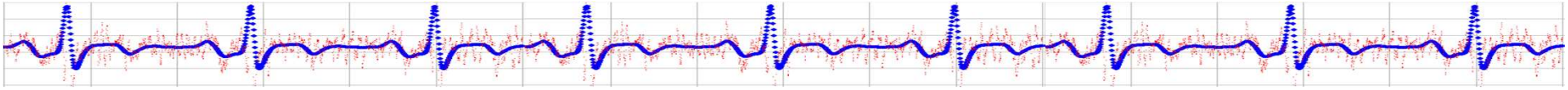
- Usually more general
  (vs. holds *except for the 3rd Tue*sday or *except for people weighing over 300 lbs, …*)
- Follows bent of positivism that a small set of rules explain everything
  - An aside: true in machine learning too

Russel's teapot



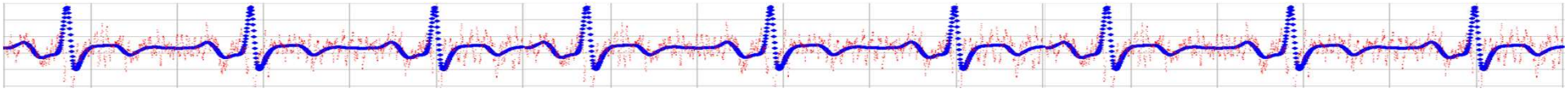
If one asserts, without proof, that a teapot orbits the sun between Earth and Mars, that person should not be expected to be believed, even though the assertion cannot be proved wrong

Scientific vs. nonscientific explanations



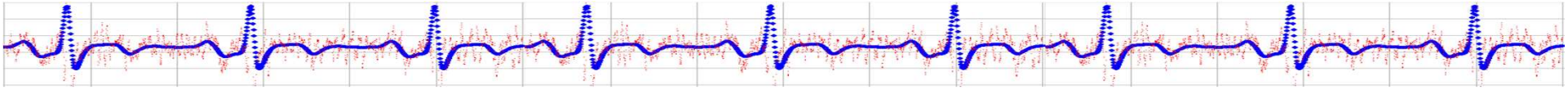
Explanation Type	Empirical	Rational	Testable	Parsimony	General	Tentative	Rigorously Evaluated
Scientific	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Belief Based	No	No	No	No	No	No	No
Common-sense	Usually	No	No	No	No	No	No

Research method



A strategy of inquiry, which moves from underlying philosophical assumptions to a research design

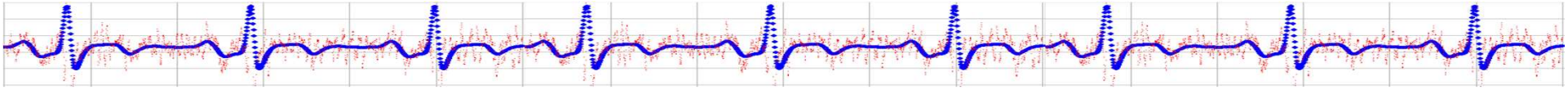
Research methods



Different disciplines have different methods and techniques

- Ethnography and conversation analysis study individuals in detail
  - A single sample is worthy of study
  - Generality not an issue

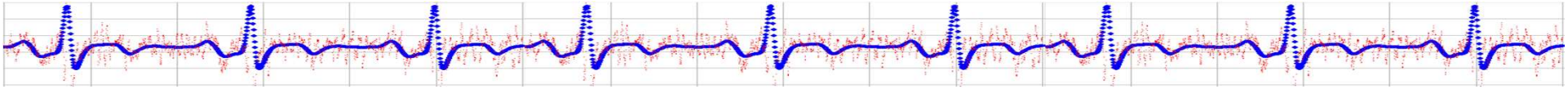
Research methods



- Method of authority
  - Authoritative source (e.g., book or expert) consulted
  - Useful in early stages of science

- *Is this always a good approach?*
  - Source truly authoritative?
  - Source have a biased point of view?
  - Source make a mistake?

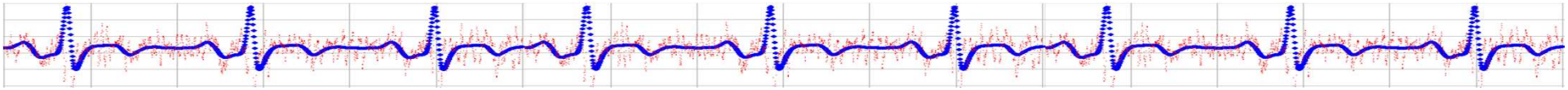
Research methods



- The rational method
  - Self-evident truths (axioms)
  - Logical reasoning

- *Thoughts on this approach?*
  - What is a "self-evident" truth?
    (Does the Earth is flat count?)
  - Are there many of them?

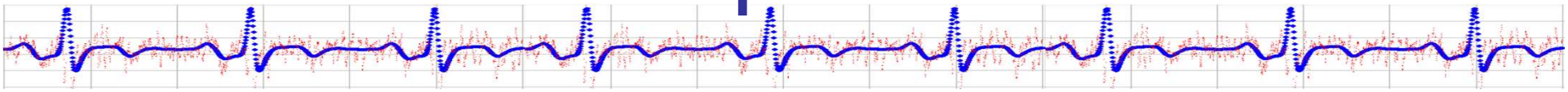
Research methods: The scientific method



Steps?

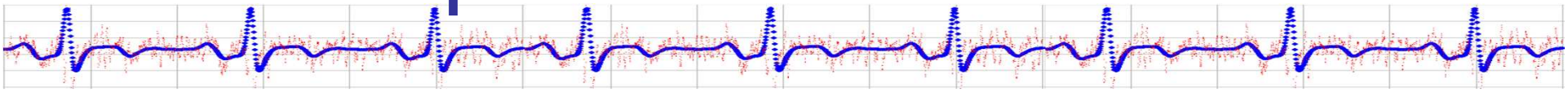
1. Observe a phenomenon
2. Formulate testable explanations (hypotheses)
3. Further observe and experiment
4. Refine and retest explanations

The scientific method: First two steps

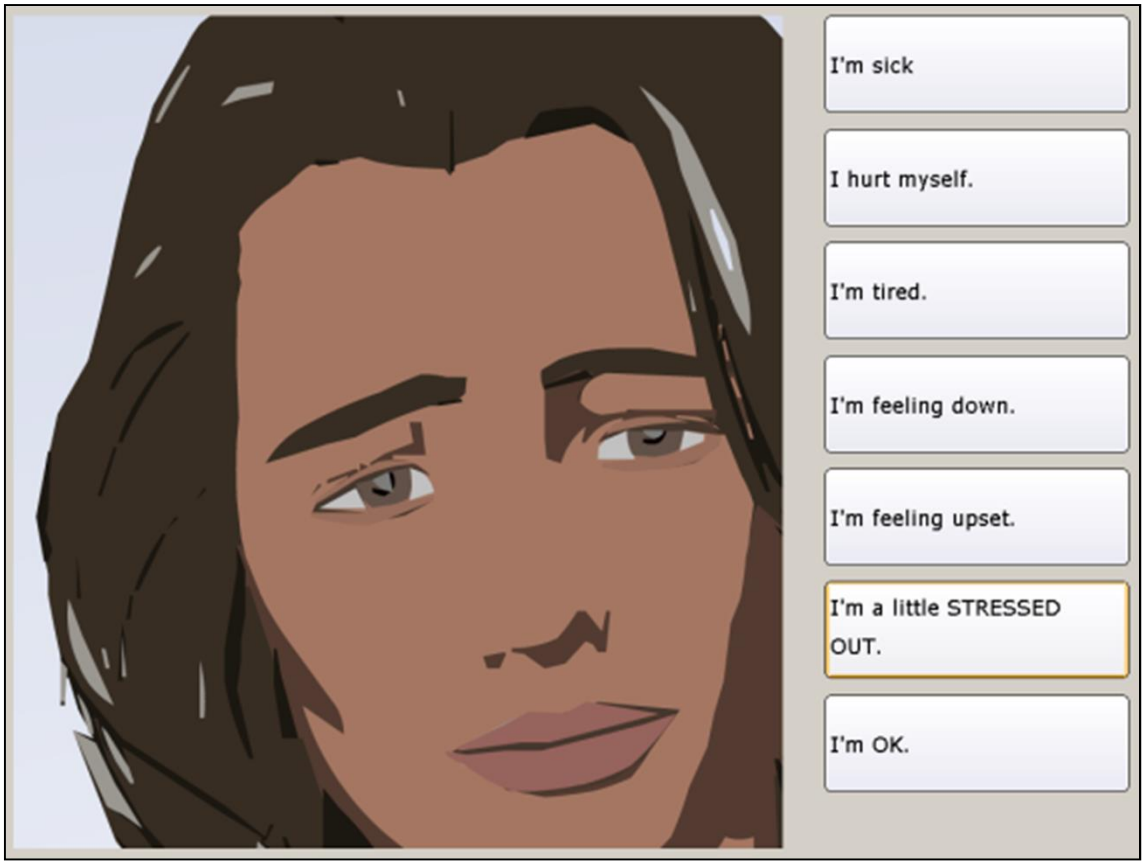


- *Observing a phenomenon*
  - While observing a phenomenon, you identify the VARIABLES that appear important in explaining behavior
- *Formulating tentative explanations*
  - Initial observations allow you to develop a HYPOTHESIS, or tentative statement, about the relationships among the variables identified

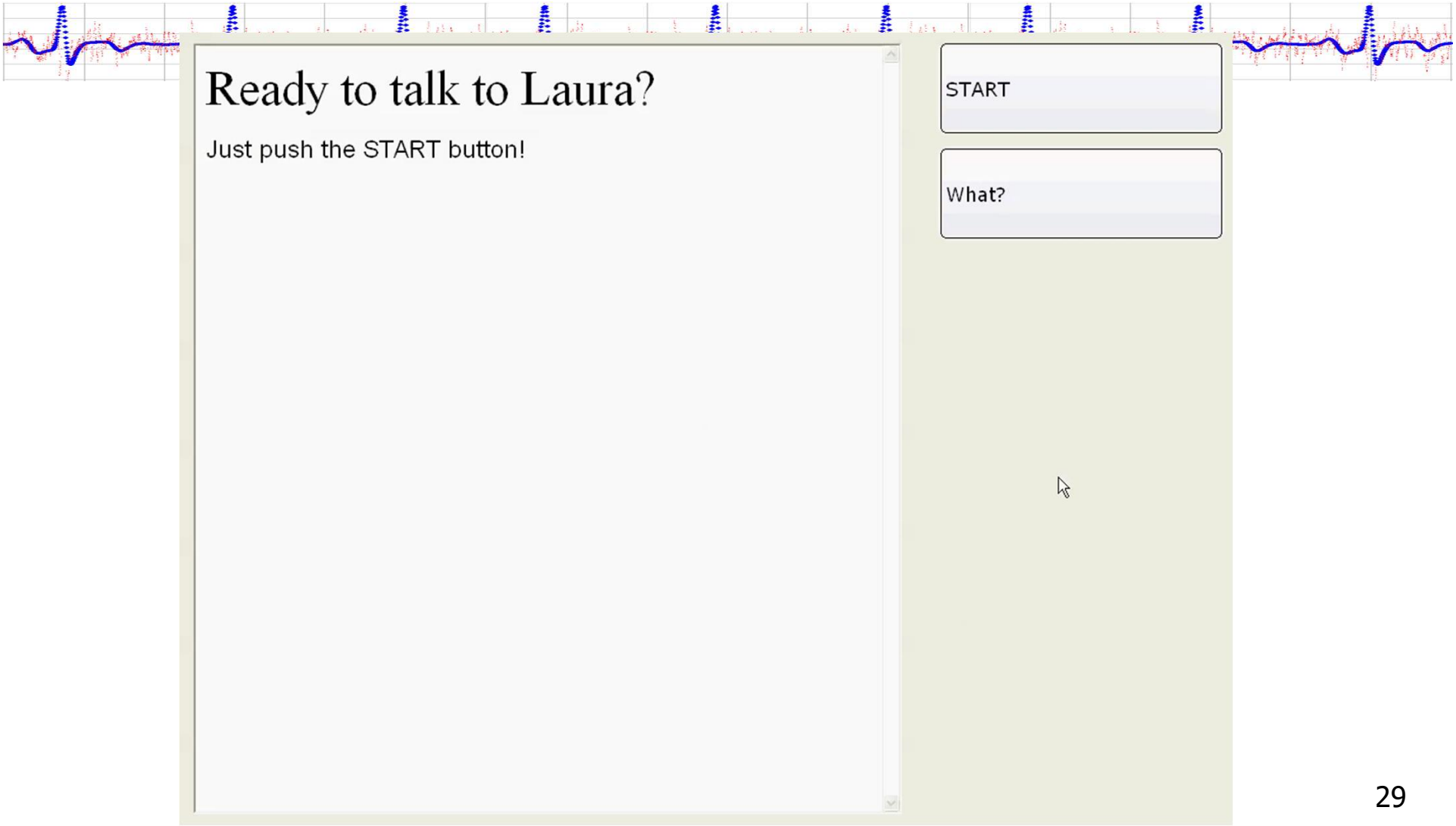
Example



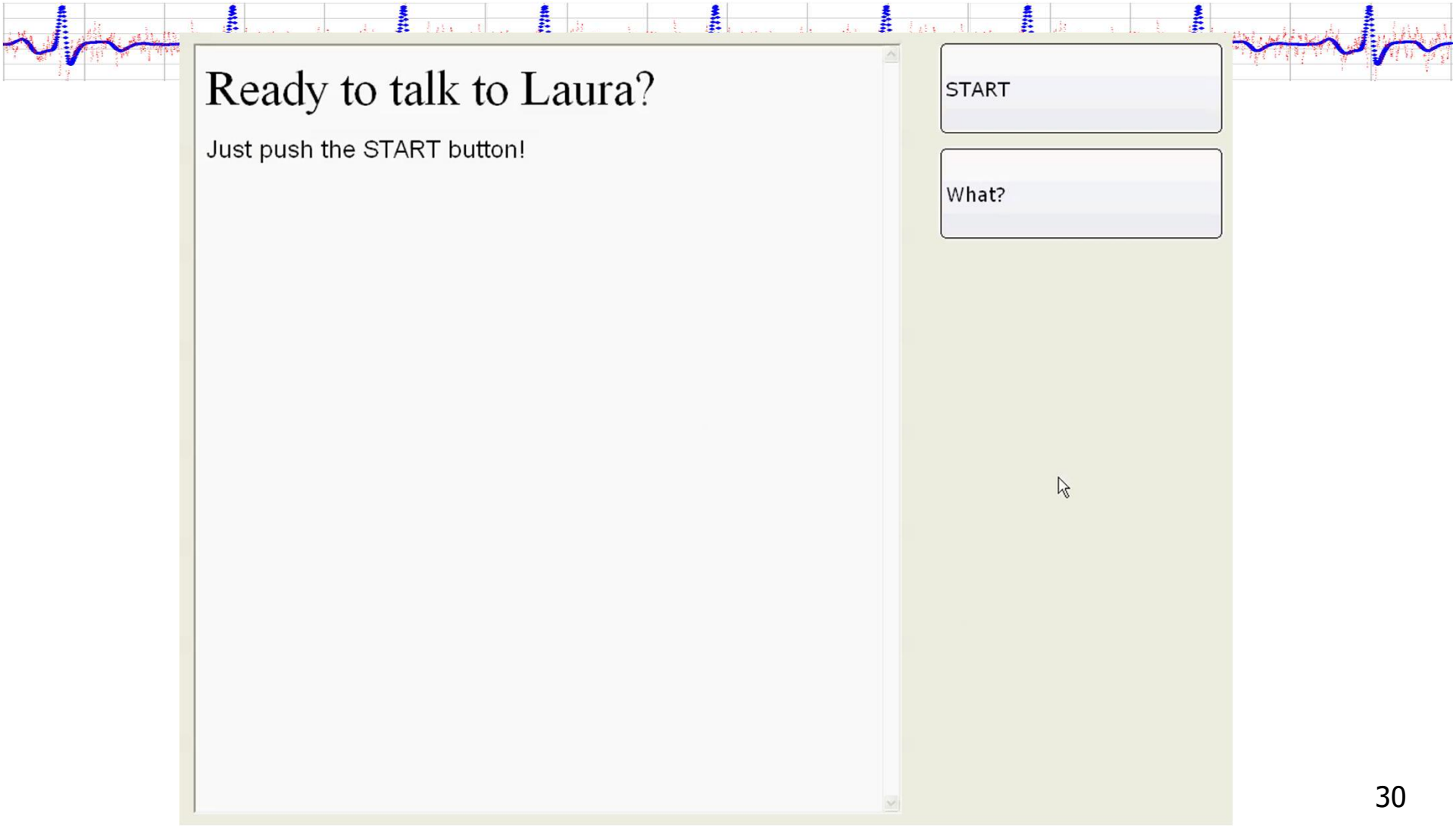
Prof. Bickmore's relational agent work....



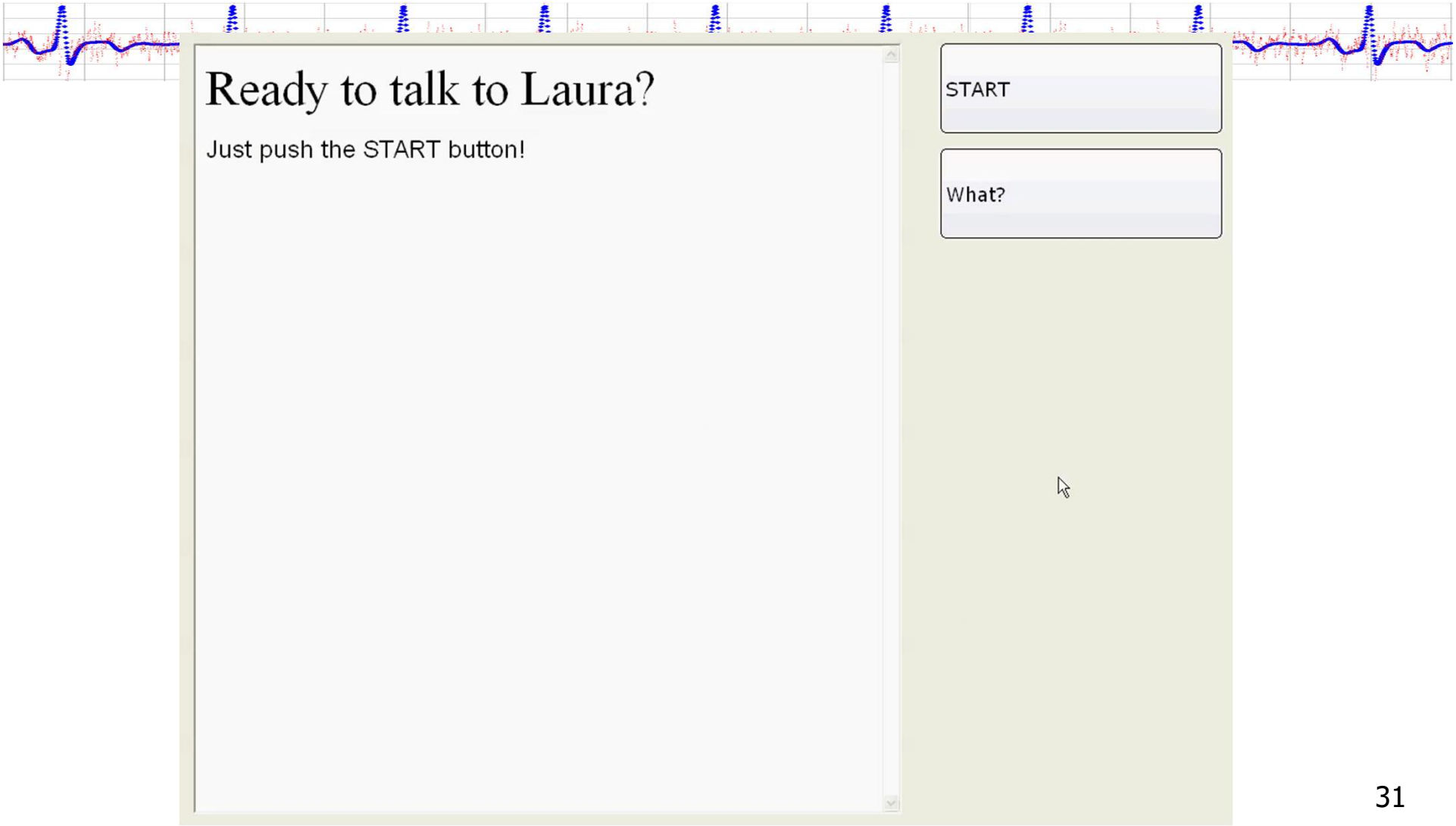
Example: Repetitiveness in counseling agents – Day 1



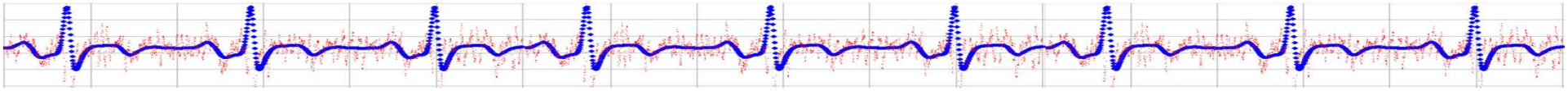
Example: Repetitiveness in counseling agents – Day 2



Example: Repetitiveness in counseling agents – Day 3



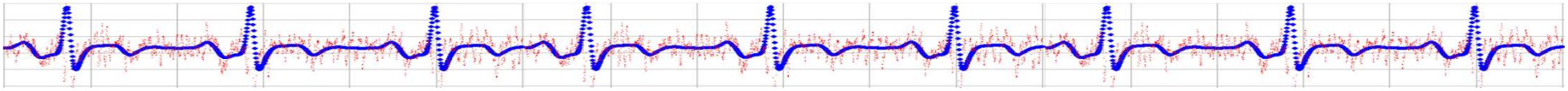
Example: Repetitiveness in counseling agents



"The first couple of days I was impressed by it. But, there didn't seem to be a lot of variety going on after that, so it kind of lost my interest, it lost the engagement factor. Maybe, six or seven days into the study I could almost predict what she was going to say, and once the engagement was lost you sort of lose the power of the animated instructor. ..."

"In the beginning I was extremely motivated to do whatever Laura asked of me, because I thought that every response was a new response. Whereas, towards the end I could tell what she was going to say to a couple of my responses."

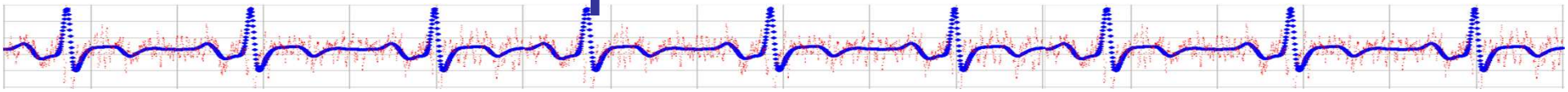
Example: Repetitiveness in counseling agents



Hypotheses:

H1. Reduced superficial variability increases perceived repetitiveness
H2. Reduced superficial variability decreases engagement
H3. Reduced superficial variability has negative effect on outcomes

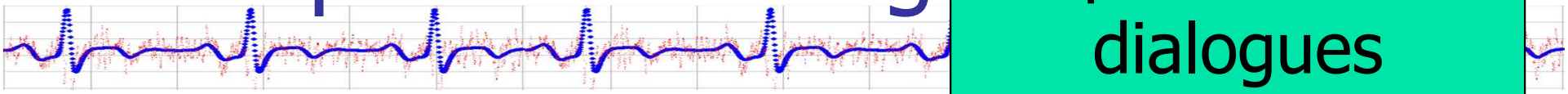
The scientific method: Third step



- *Further observe and experiment*

Thoughts on how you might do this?

Example: Repetitiveness experiment desig

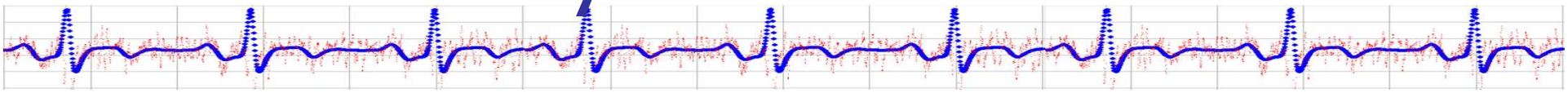


- Physical activity interv
  daily walking
- Between-subjects, 2 conditions

1. **NONVARIABLE**: agent uses exactly the same dialogue structure and language in every situation
2. **VARIABLE**: dialogue structure, surface form, and background image are randomly varied.

Important: Two dialogues "functionally identical"

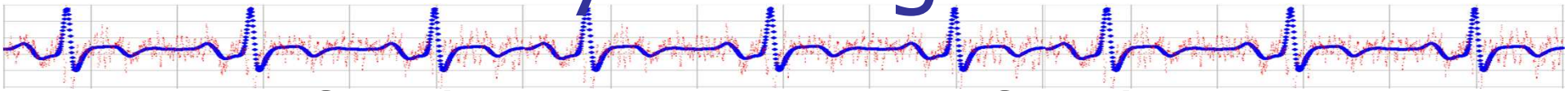
Example: Repetitiveness variability: Surface form



"Looks like you met your exercise goal of 5,000 steps. Great job!"

"Looks like you got your walking in and met your goal of 5,000 steps!"

Example: Repetitiveness variability: Dialogue structure



1. Greeting
2. Weather talk
3. Past event talk
4. Read pedometer
5. Follow up on behavior
6. Ask enjoyment
7. Get commitment
8. Upcoming event talk
9. Farewell

1. Greeting
2. Read pedometer
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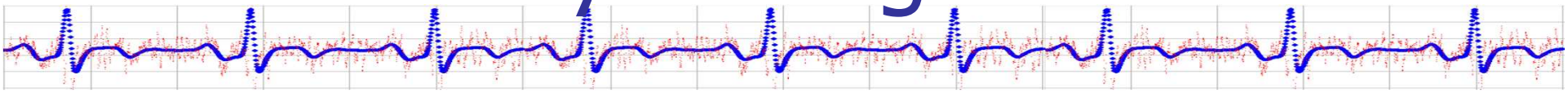
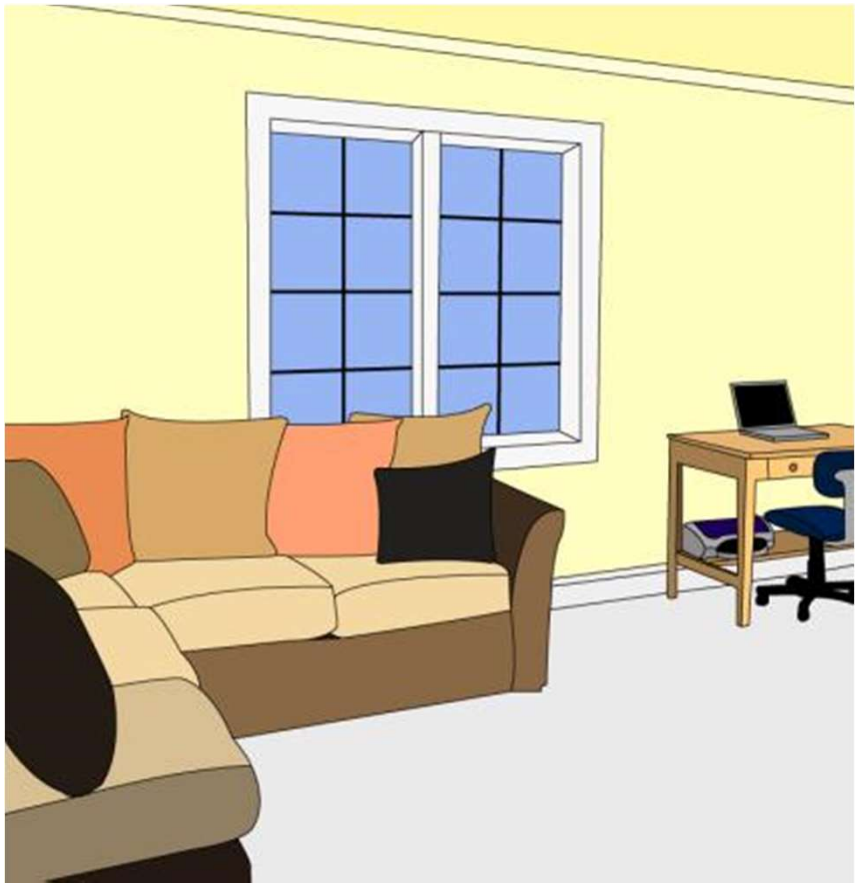
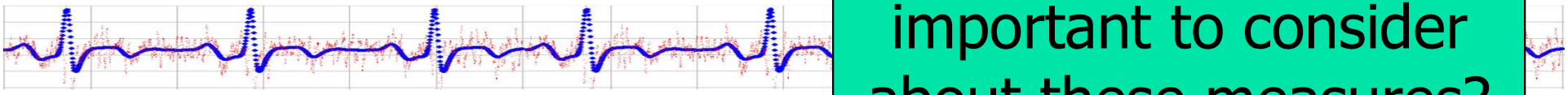
Example: Repetitiveness variability: Background





Example: Repetitiveness measures



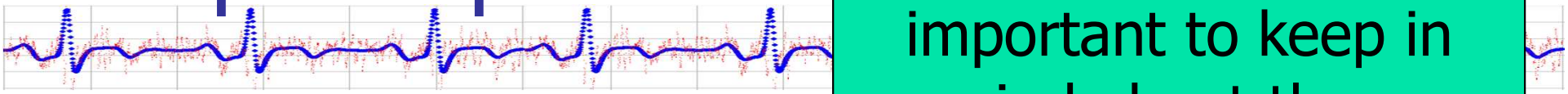
What would be important to consider about these measures?

- Steps per day (Omron HJ-720ITC pedometer)
- Desire to continue (5-item rating scale)
- Perceived repetitiveness (5-item rating scale)

Steps assessed daily

Self-report assessed each session (up to daily)

Example: Repetitiveness study participants



- N=24
- 17 female, 7 male
- Ages 55-75
- Not currently regularly exercising
- 40-120 days of interaction with the system (mean 82.25)

What would be important to keep in mind about these people when evaluating results?

Prof. Bickmore's NSF "Virtual Lab" Study

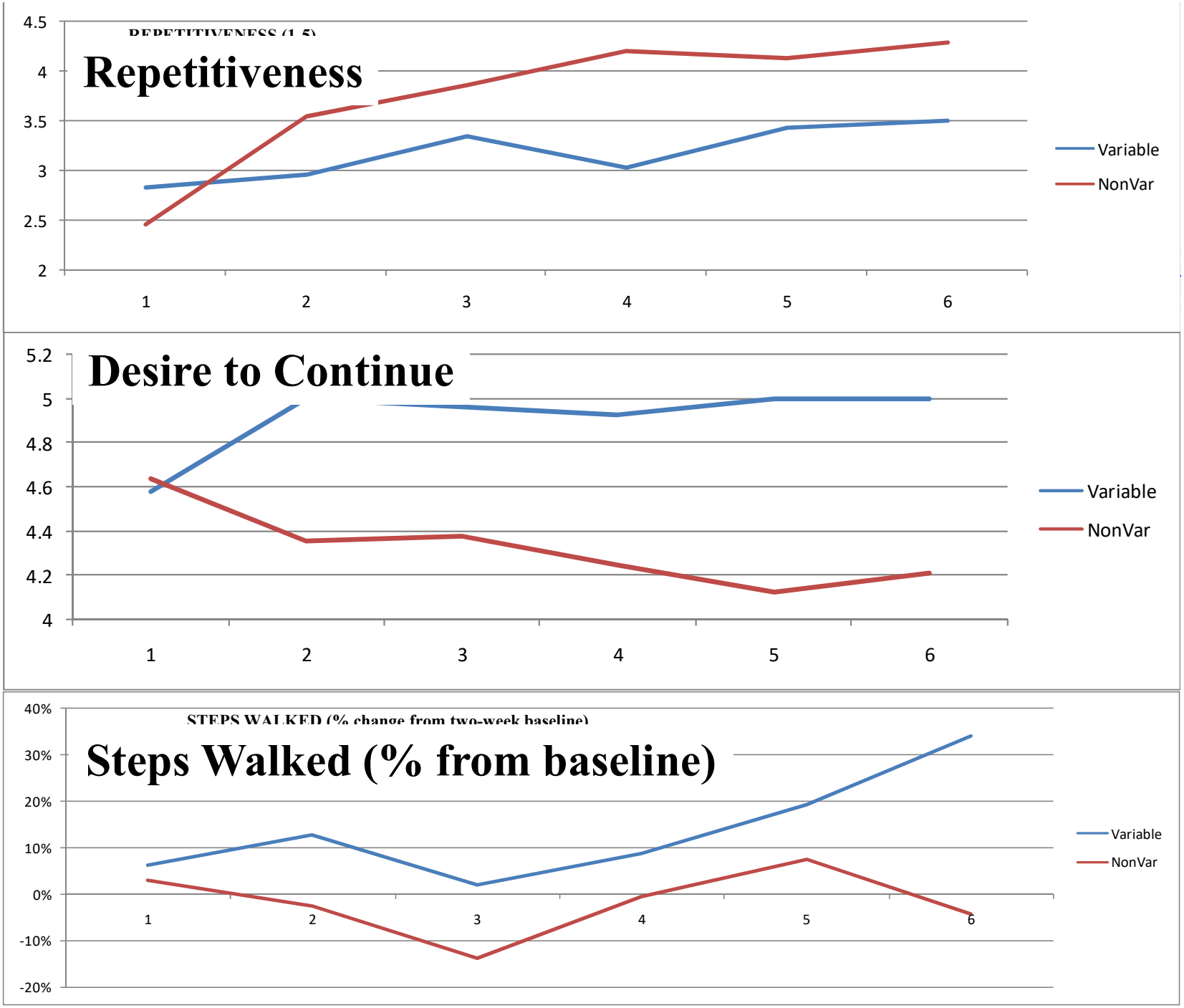
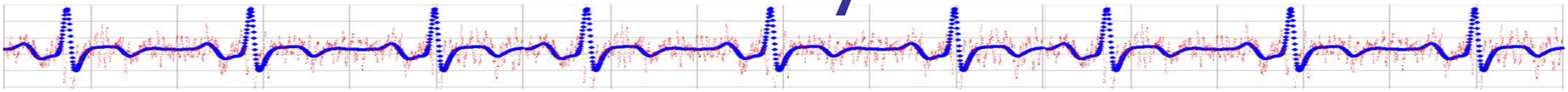


Figure 3. Results from Variability Study (daily data averaged by week)

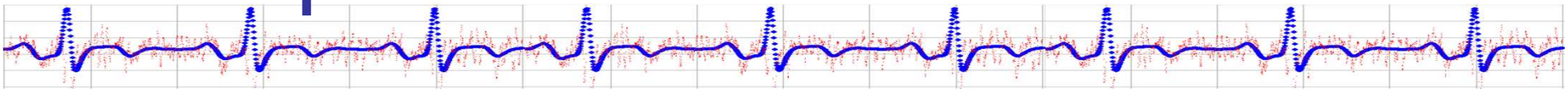
Example: Repetitiveness Statistical Analysis

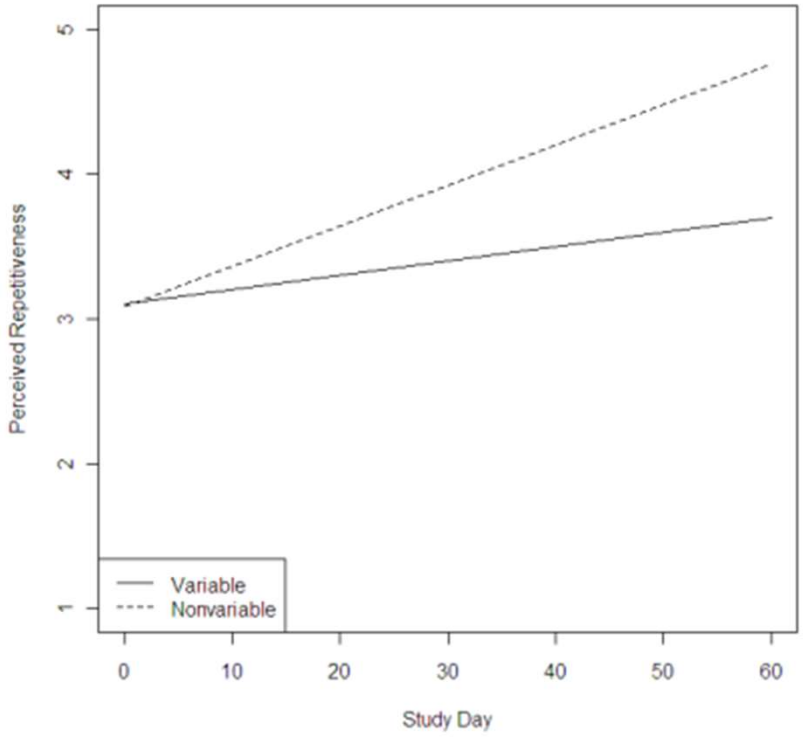


- For some outcome *y* for subject *i* at time *j:*
- Start with a linear model of change over time
- Add random effects to account for clustered data (multiple measurements per subject):
  - γ_{0i} and γ_{1i} model individual differences in intercept and slope.
  - We assume that both are normally distributed.

$$y_{ij} = \beta_0 + \beta_1 day_{ij} + \beta_2 cond_i + \beta_3 day_{ij} cond_i + \varepsilon_{ij} + \gamma_{0i} + \gamma_{1i} day_{ij}$$

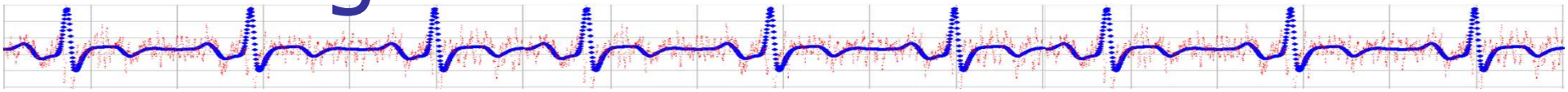
Results: Perceived repetitiveness

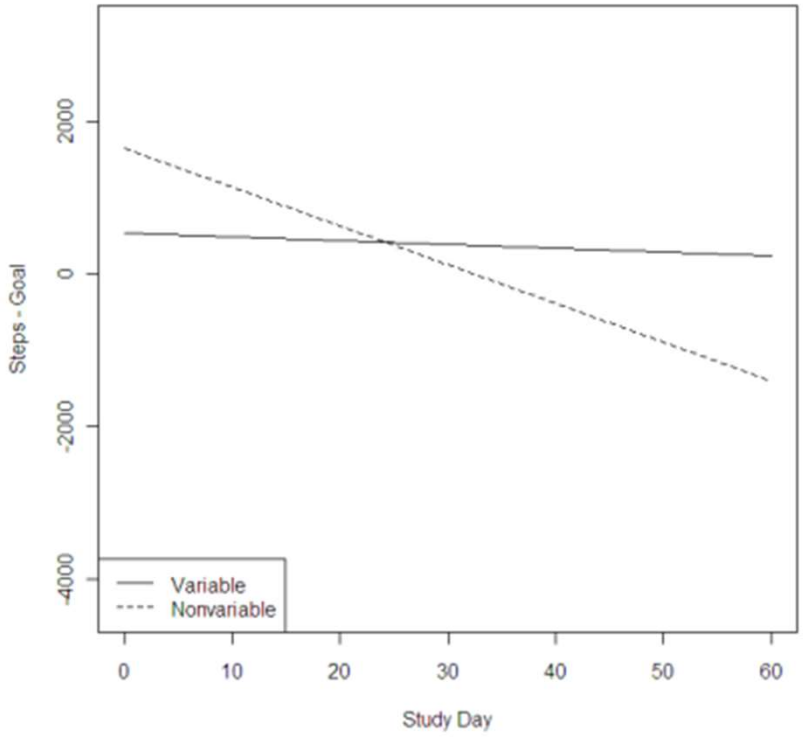




- Near-significantly greater increase in perceived repetitiveness in NONVARIABLE
  - B=0.018, p≈0.051

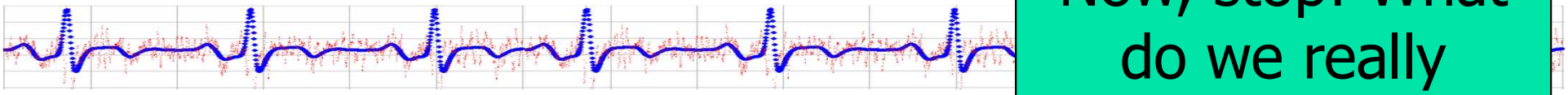
Results: Performance relative to goals





- Significantly greater decrease in performance over time in NONVARIABLE
  - B=-45.77, p<0.01

Example: Repetitiveness in counseling agents



Now, stop! What do we really know? (Caveats?)

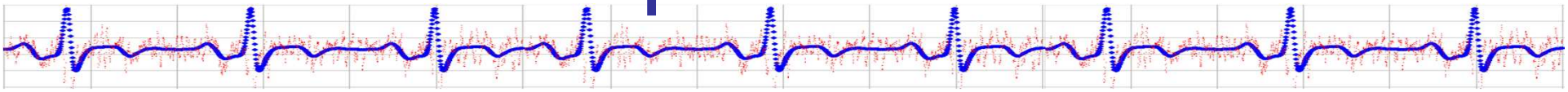
Hypotheses:

√ H1. Reduced superficial variability increases perceived repetitiveness

x H2. Reduced superficial variability decreases engagement

√ H3. Reduced superficial variability has negative effect on outcomes

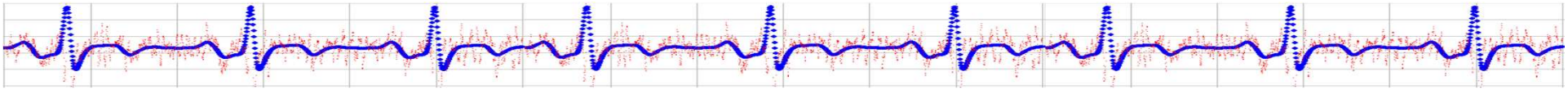
The scientific method: Fourth step



- *Refine and retest explanations*

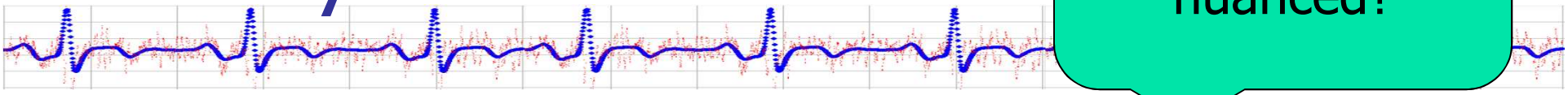
Thoughts on how you might do this?

The scientific method



1. Observe a phenomenon
2. Formulate testable explanations (hypotheses)
3. Further observe and experiment
4. Refine and retest explanations

Feynman's model



How might this be more nuanced?

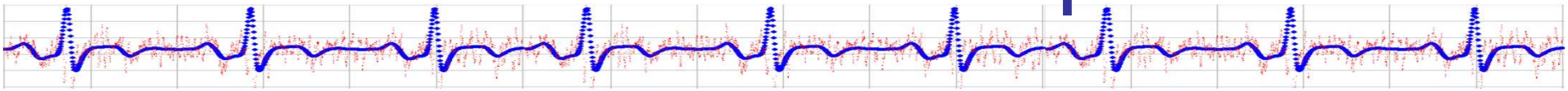
> "If it disagrees with experiment, it's wrong. In that simple statement is the key to science."
>
> — *Richard Feynman*

Guess → Compute Consequences → Compare to Experiment

"falsifiability criterion"

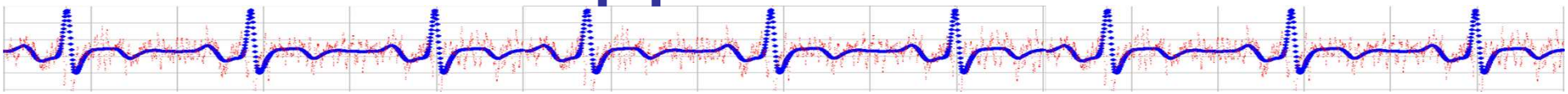
Watch Feynman: https://fs.blog/2009/12/mental-model-scientific-method/

The scientific method: Third and fourth step

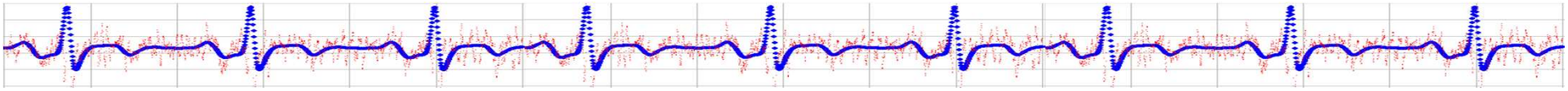


- ***Further*** *Observing and Experimenting*
  - You carry out more detailed OBSERVATIONS of the behavior of interest
    - These observations are directed at testing your hypothesis
- *Refining and Retesting Explanations*
  - Supported hypotheses are often REFINED and subjected to further exploration
    - Disconfirmed hypotheses may be reworked and RETESTED

Is the relational agent study basic or applied research?



Exercise



- Two minutes: Your boss says that someone complained to her that your company website is lousy and that it was causing the company to lose customers. How would you use the scientific method to investigate this?
- Pair up and discuss your answers for eight minutes
- Two-minute report to the group

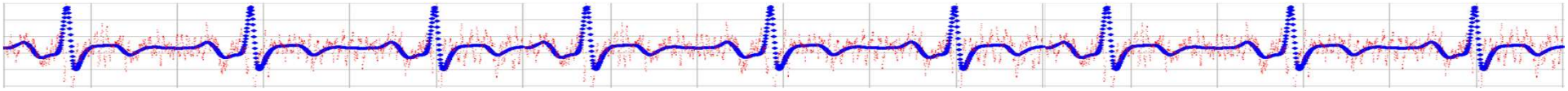
Science gone bad

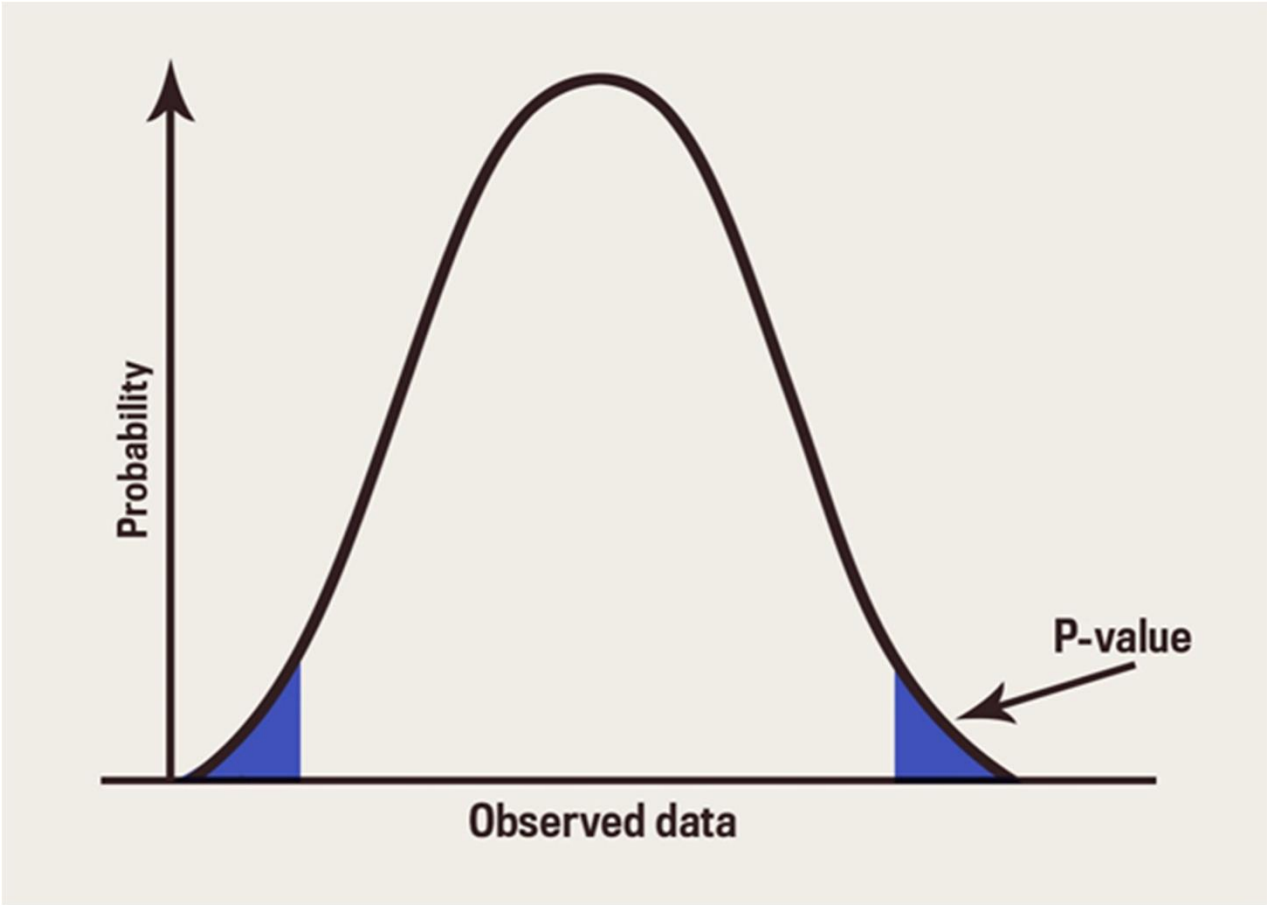
When do scientific explanations fail?

- Intentionally
  - Psuedoscience
  - Fraud
- Unintentionally
  - Examples?

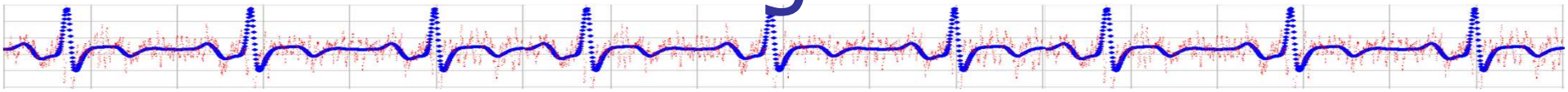
Is this science?

Even with best practices, mistakes 5% of the time!





The scientific method is self-correcting

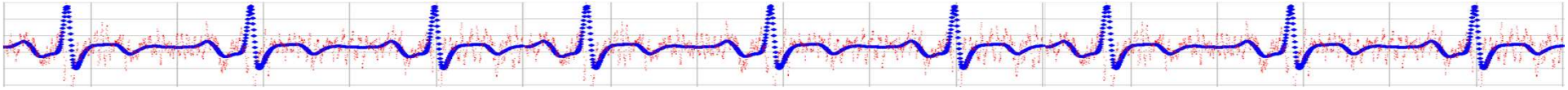


- We acknowledge we will make mistakes, and reach incorrect conclusions
- Future studies will identify and correct these errors

So what if you are the only person to do a study?

Implications?

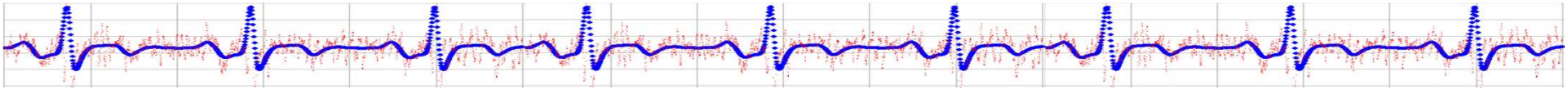
Reliability of the scientific method



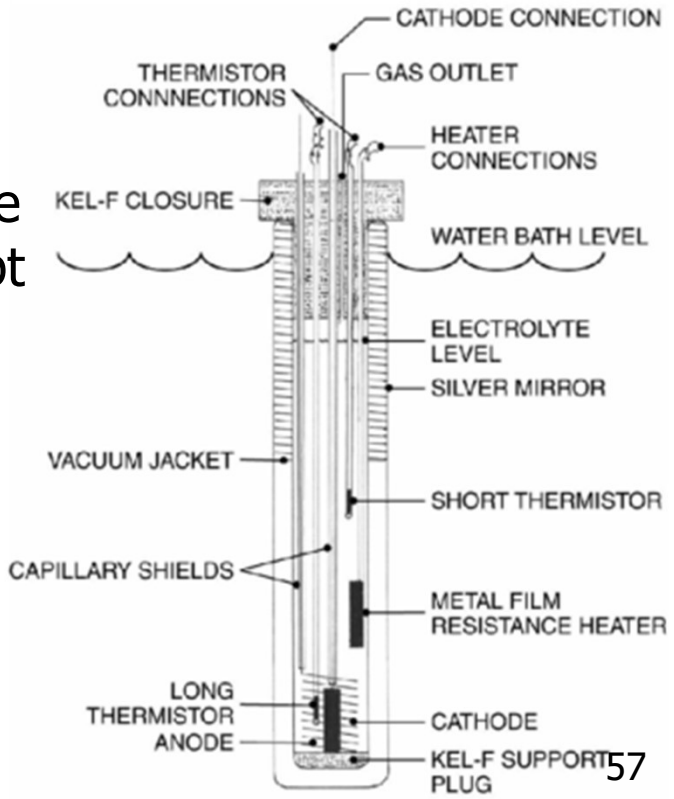
- Reliability = ability to get same results under the same conditions.
- Experiments are repeatable.
- Subsequent failures to repeat earlier results invalidate "proven" hypotheses.

- The scientific method is self-correcting.
- Examples?

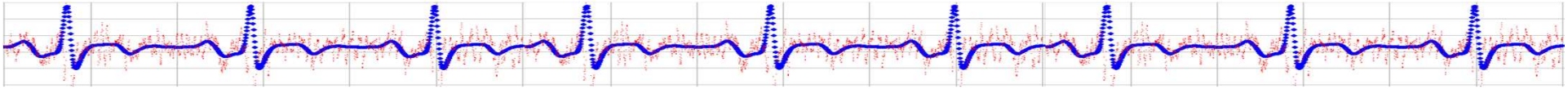
Cold Fusion



- A nuclear reaction that occurs at room temperature.
- Gained attention after reports in 1989 by Pons and Fleischmann, that their apparatus had produced "excess heat", of a magnitude they asserted would defy explanation except in terms of nuclear processes.
- They reported measuring small amounts of nuclear reaction byproducts, including neutrons and tritium.



Cold Fusion

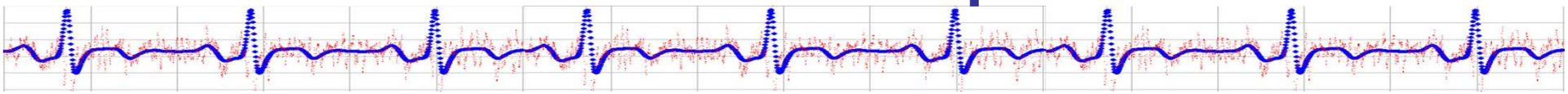


- Results received wide media att
  raised hopes of a cheap and ab
  energy
- Many scientists tried to r
- Evidence against
  - Large number of negative rep
  - Withdrawal of many positive re
  - Discovery of flaws in the original experiment
  - Discovery that Fleischmann and Pons had not actually detected nuclear reaction byproducts

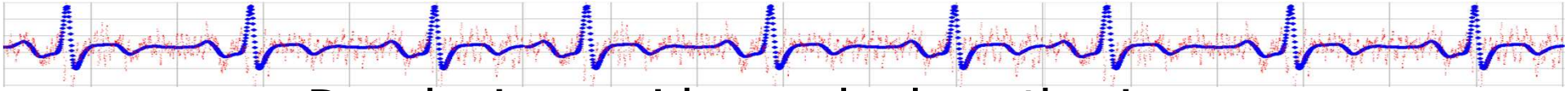
Took < 9 months! (Why so fast?)

If true, would have delivered a world-wide, economic shock

The research process

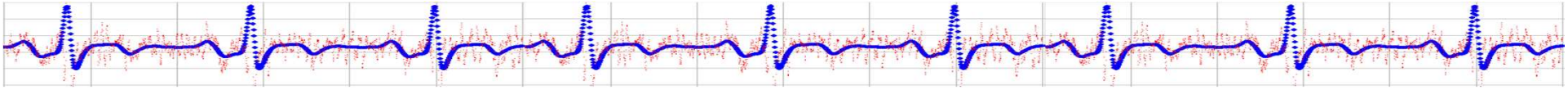


The Steps of the Research Process



1. Developing an idea and a hypothesis
2. Doing background research
3. Choosing an appropriate research design
4. Choosing an appropriate unit of study (e.g., which human subjects, which organizations, which systems, etc.)
5. Deciding on what to measure and how
6. Writing research plan
7. Conducting a study
8. Analyzing data
9. Reporting results

Homework



- Read B&A Ch 6 & 7 (human subjects)
- Read NU IRB Policy for Student Research