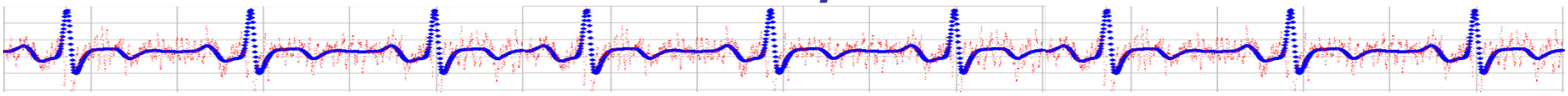
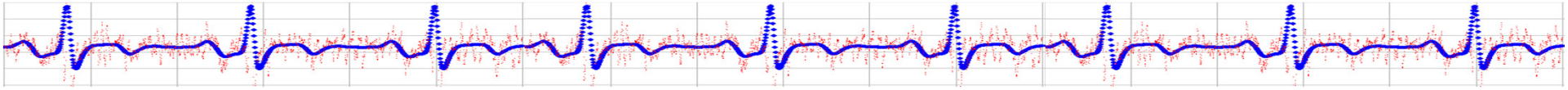
Empirical Research Methods in Information Science

IS 4800 / CS6350



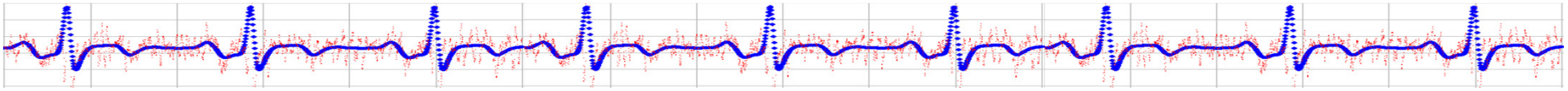
Lecture 18

Outline



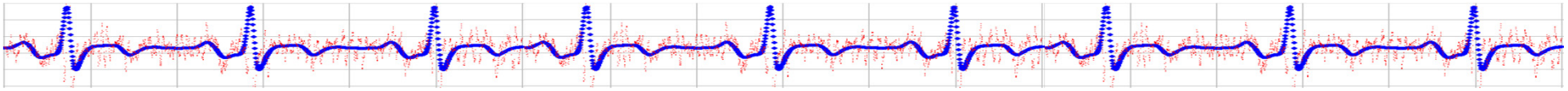
- Presentation tips for T2
- Theory/finding a research topic
- Single-subject studies
- Within-subject studies (start)

T1



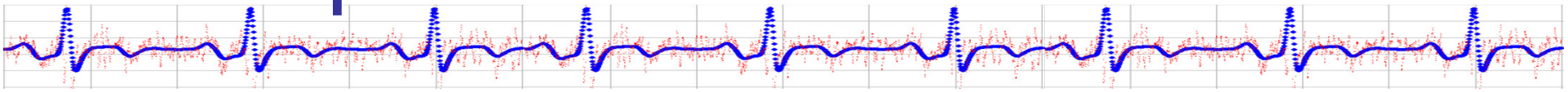
- Team assessment using Teammates
- Due tonight

T2



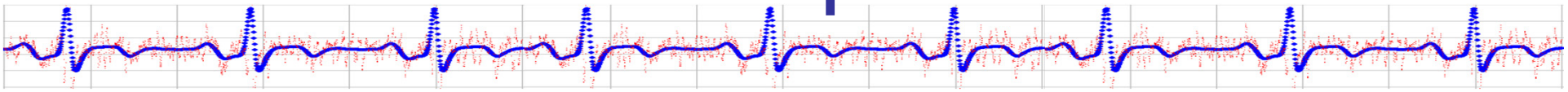
- Email me project proposal by EOD today
- Due next Wednesday
- Presentations tips…

Important advice!



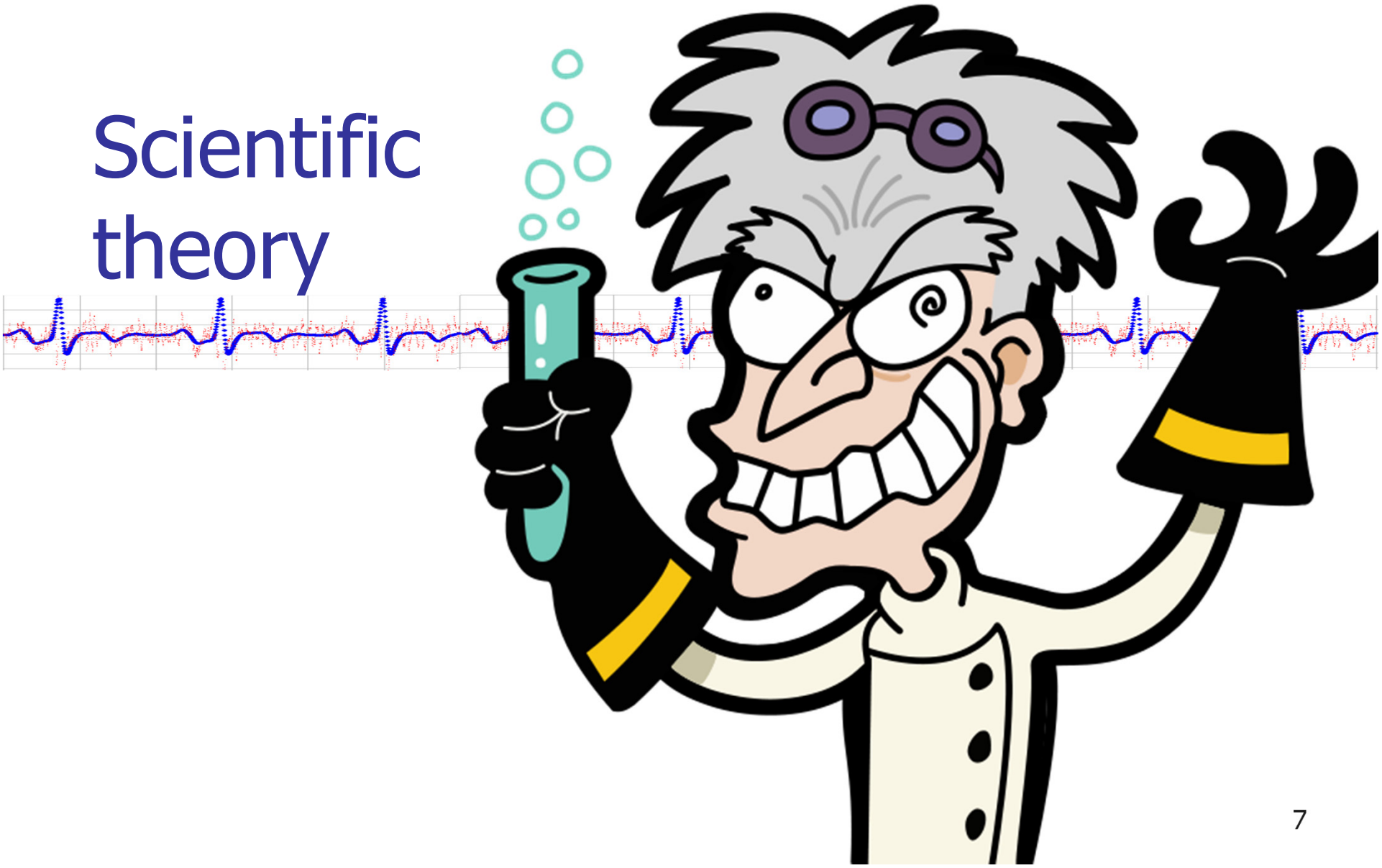
It's hard to be relaxed and be yourself when you're nervous. But time and again, the great presenters say that the most important thing is to connect with your audience, and the best way to do that is to let your passion for the subject shine through. Be honest with the audience about what is important to you and why it matters. Be enthusiastic and honest, and the audience will respond. Your presentation needs to be built around what your audience is going to get out of the presentation. As you prepare the presentation … are you reading this? It's pretty hard, isn't it? Raise your hand right now if you see this. You might not since I'm talking at the same time.

Presentation tips

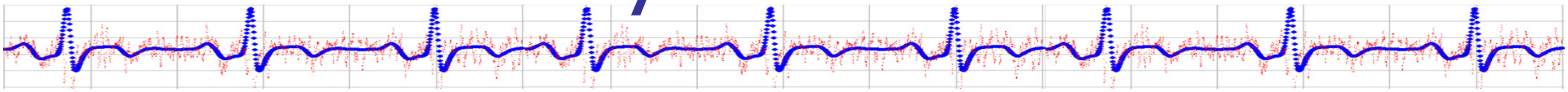


- Visuals where possible (but meaningful)
- Large fonts >> whitespace
- Break ideas into nuggets
- Compare to related work
- On graphs, help focus our attention
- Justify:
  - Choice of research design
  - Choice of descriptive/inferential stats

Scientific theory

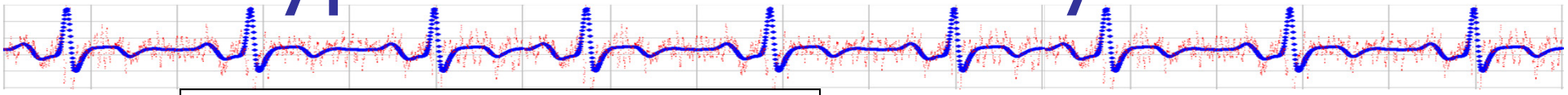


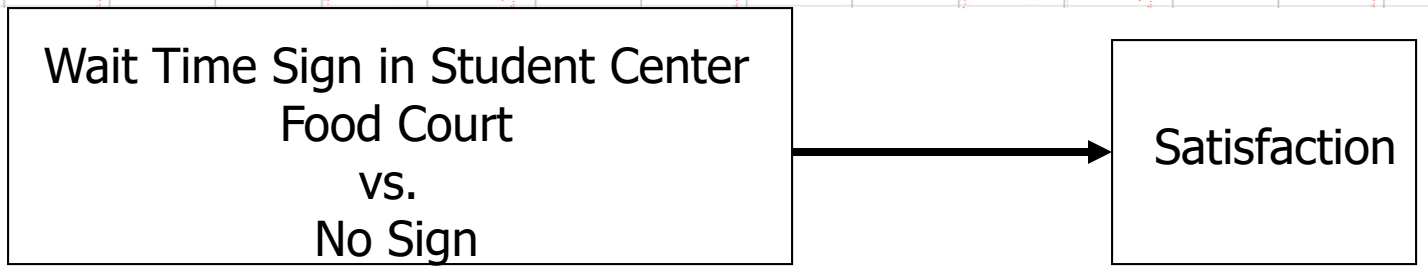
Take-aways



- What is a theory?
  - Difference between hypothesis and theory
- How theories are used
- Ideas for new research

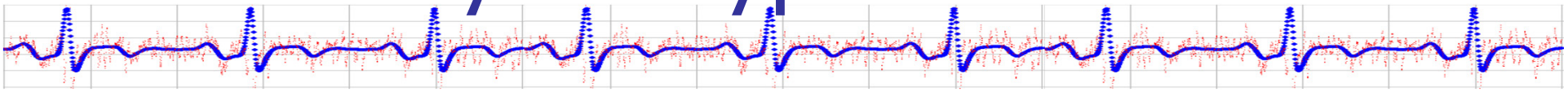
Example: Hypothesis -> theory





- Possible theories if prove hypothesis?
  - Decreasing uncertainty makes people happier
  - Saving people time makes people happier
  - Removing obstacles to food reduces anxiety
- New hypotheses?

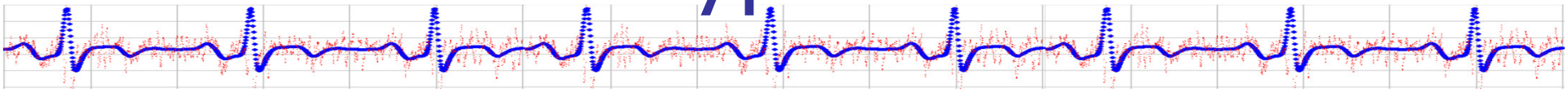
Example: Theory -> hypothesis



- Social Penetration Theory
  - People have layers of intimate information
  - As dyads build trust they disclose more, and vice versa
  - Self-disclosure creates a reciprocal obligation

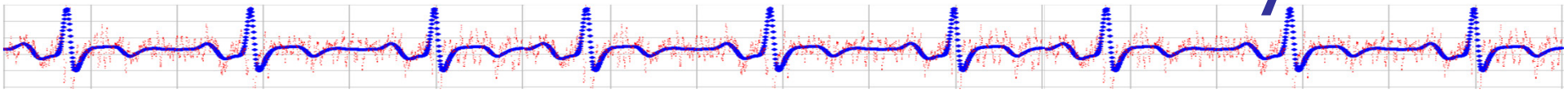
- You're building a marketing site and want users to disclose as much info as possible. Hypotheses?

What is a hypothesis?



- A specific, testable statement
- Something you design an experiment to prove or disprove

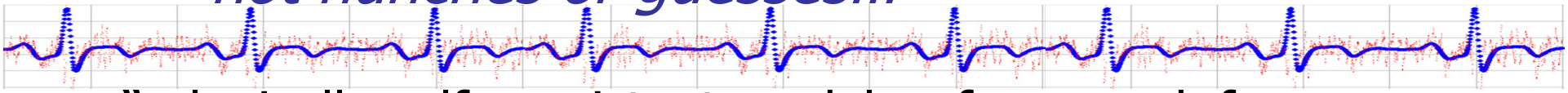
What is a scientific theory?



- "a comprehensive explanation of an important feature of nature that is supported by many facts gathered over time. Theories also allow scientists to make predictions about as yet unobserved phenomena."
  - *American Academy of Sciences*

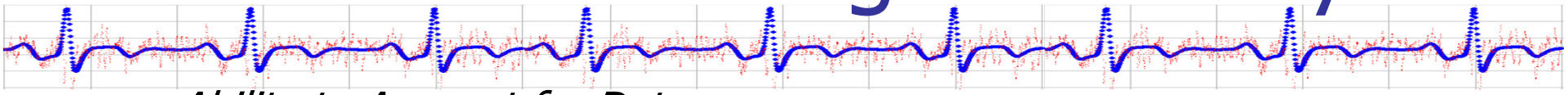
Scientific theory

not hunches or guesses…



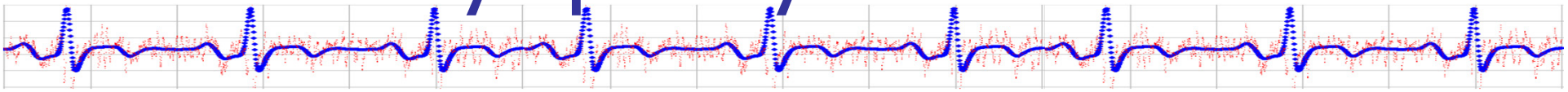
- "a logically self-consistent model or framework for describing the behavior of a related set of natural or social phenomena."
- More general than a hypothesis
  - e.g. involves multiple variables and/or more abstract variables
  - Can be used to generate hypotheses
- Must still be (potentially) testable (not necessarily true)
  - But, usually impossible to completely test
- Thus, often stated as a set of propositions
- Usually has some empirical basis
- Examples:
  - Media Equation – "People treat media as other people."
  - Exchange Theory – "People track costs vs. benefits in relationships."

What makes a good theory?



- *Ability to Account for Data*
  - Theory must account for existing data and well-established facts within its domain
- *Explanatory Relevance (~face validity)*
  - Theoretical explanation must offer good grounds for believing that the phenomenon would occur under specified conditions
- *Testability*
  - A theory must be testable.
    - It must be capable of failing some empirical test.
- *Prediction of Novel Events*
  - A theory should predict phenomena that the theory was not specifically designed to account for but that are within its domain
- *Parsimony*
  - A theory should explain phenomena within its domain with the fewest possible assumptions

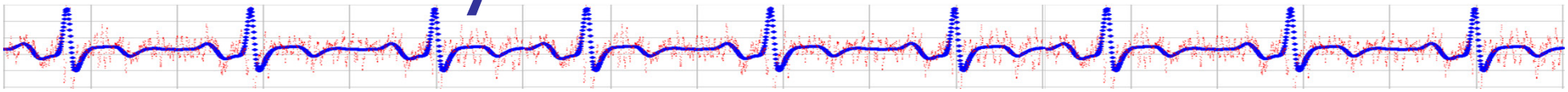
Theory quality



- A theory is a good theory if it satisfies two requirements:
  - It must accurately describe a large class of observations on the basis of a model that contains only a few arbitrary elements (assumptions), and
  - it must make definite predictions about the results of future observations

Stephen Hawking

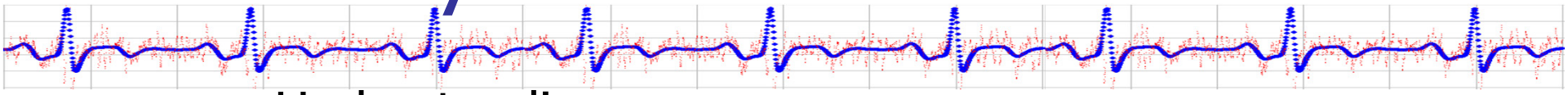
Theory vs. …



- Theory vs. hypothesis
  - Theory is more complex (e.g., multiple variables)
- Theory vs. law
  - A law is a theory that has be verified empirically
- Theory vs. model
  - A model may be a specific in general theory – casting a quantitative framework
  - E.g. exchange theory

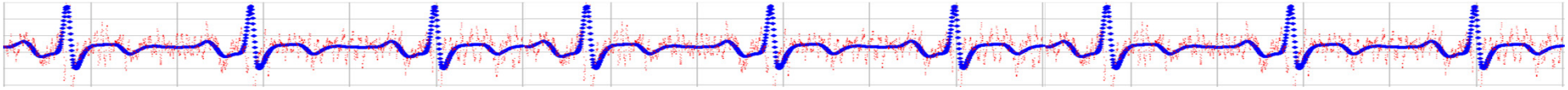
Social Exchange Theory says that if the costs of the relationship are higher than the rewards, such as a lot of effort or money put into a relationship and not reciprocated, this could lead to issues

What do you do with a theory?



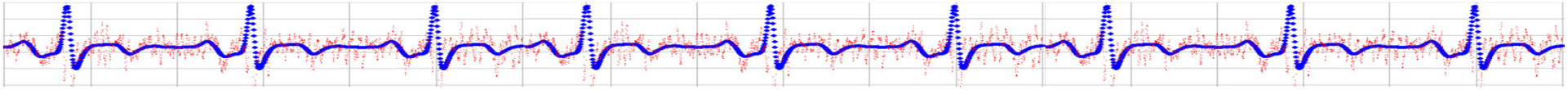
- Understanding
  - Highest role in science
  - Theory helps you understand phenomena better
- Prediction
  - Theory provides predictions about behavior under varying circumstances
  - Predictions are tested empirically
- Organizing and interpreting research results
  - A theory provides a framework for understanding research
  - Research results can be interpreted based on a theory
- Generating research
  - A theory is a source for new research ideas
    - Known as the *heuristic value* of a theory
  - A theory can be wrong, but still have heuristic value

Where do I get research ideas?



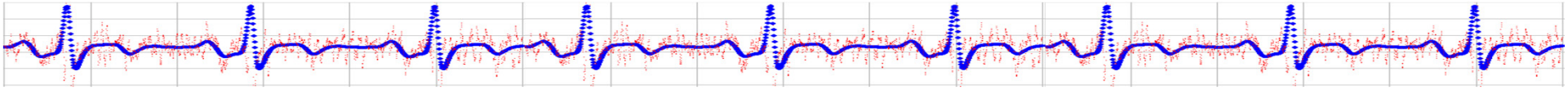
- Unless you become a researcher, your research questions will usually be given to you.
- But, if you're lucky…

Where do you get research ideas?



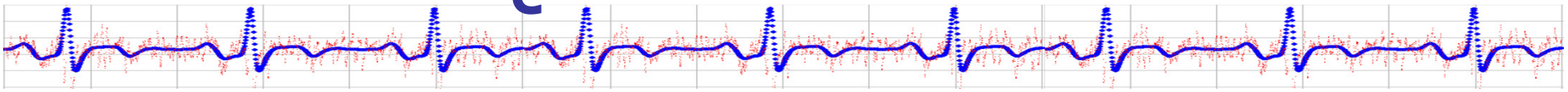
- Broad familiarity with theories (remotely) related to your area of investigation…
  - Can a theory be applied to a new domain?
    - Would the Media Equation theory (people treat media as other people) predict why MS Clippy was a failure?
  - Is there a phenomenon that would put two theories in conflict?
    - Maximization vs. consistency…
- The "future work" section of research papers
- Observation … *Ask Why!*

Where do you get research ideas?



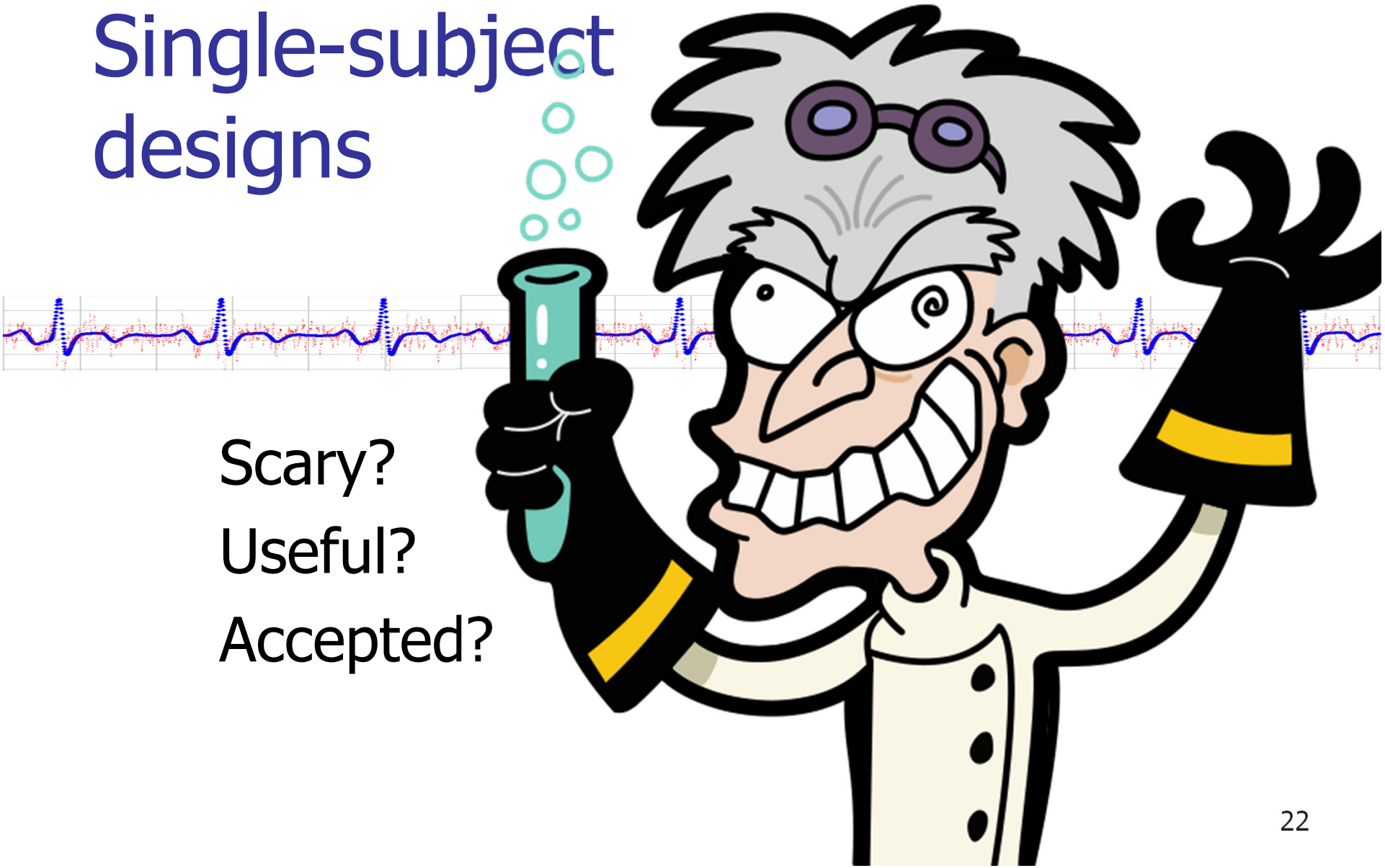
- Make sure…
  - It hasn't been done before
  - It's worth doing
  - You know how to conduct the study
  - Your study will answer the question

Some Questions



- Can you prove a theory true?
- Can you prove a theory false?
- Can a theory be false sometimes (inaccurate) but still useful?
- Why are theories tentative?
- What's wrong with letting theory exclusively drive research?
- What's wrong with letting data exclusively drive research?

Single-subject designs

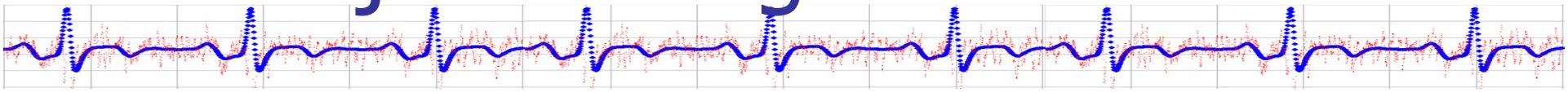


Scary?

Useful?

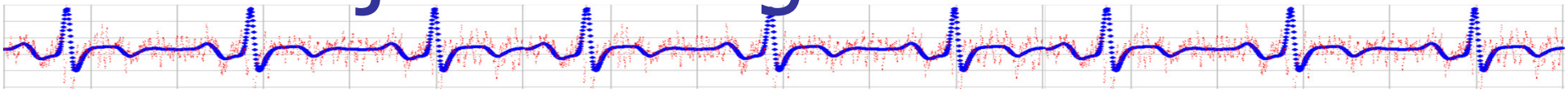
Accepted?

Single-subjects vs. within-subjects designs



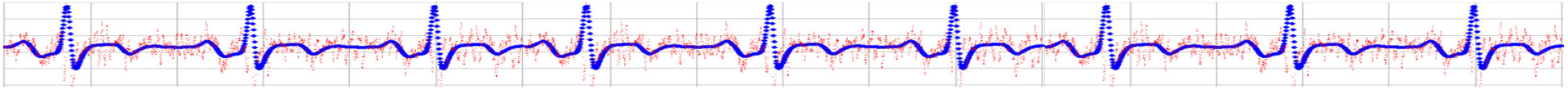
- Within-subjects:
  - Each subject exposed once to each level of the IV; measure change in DVs
  - Scores collected and averaged across people

Single-subjects vs. within-subjects designs



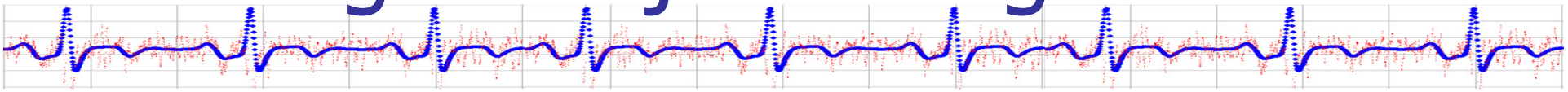
- Within-subjects
- Single-subject:
  - Expose a single subject, repeatedly, to each level of the IV, measure DVs; average across IV exposures to get a functional relationship
  - Compare functional relationships across participants; look for *intersubject replication*
  - Doesn't work if IV exposure produces irreversible changes or small effect

Generalize from an N of 1?



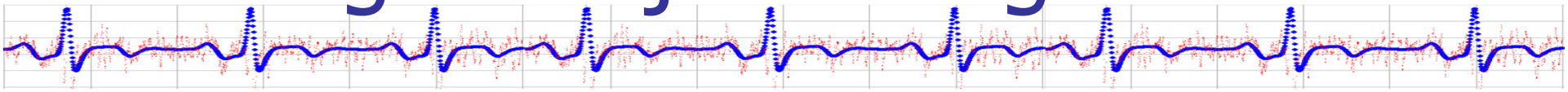
1. Large number of observations per subject, allowing random error to be characterized and factored out
2. Rigid control of extraneous factors
3. Study powerful variables whose influence is typically much greater than error variance
4. Solid measurement of variables (e.g., visible behavior)

Single-subject designs



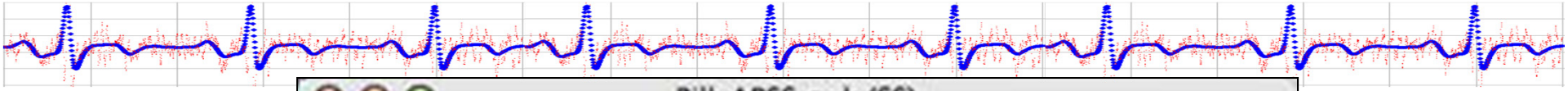
- Somewhat less common
  (but text says, "today the approach is widely accepted")
- Digital technologies for behavioral therapies could inspire a resurgence
  - May make more practical
  - Real-time tailoring
  - Intervention-like
- Can establish a non-general causal

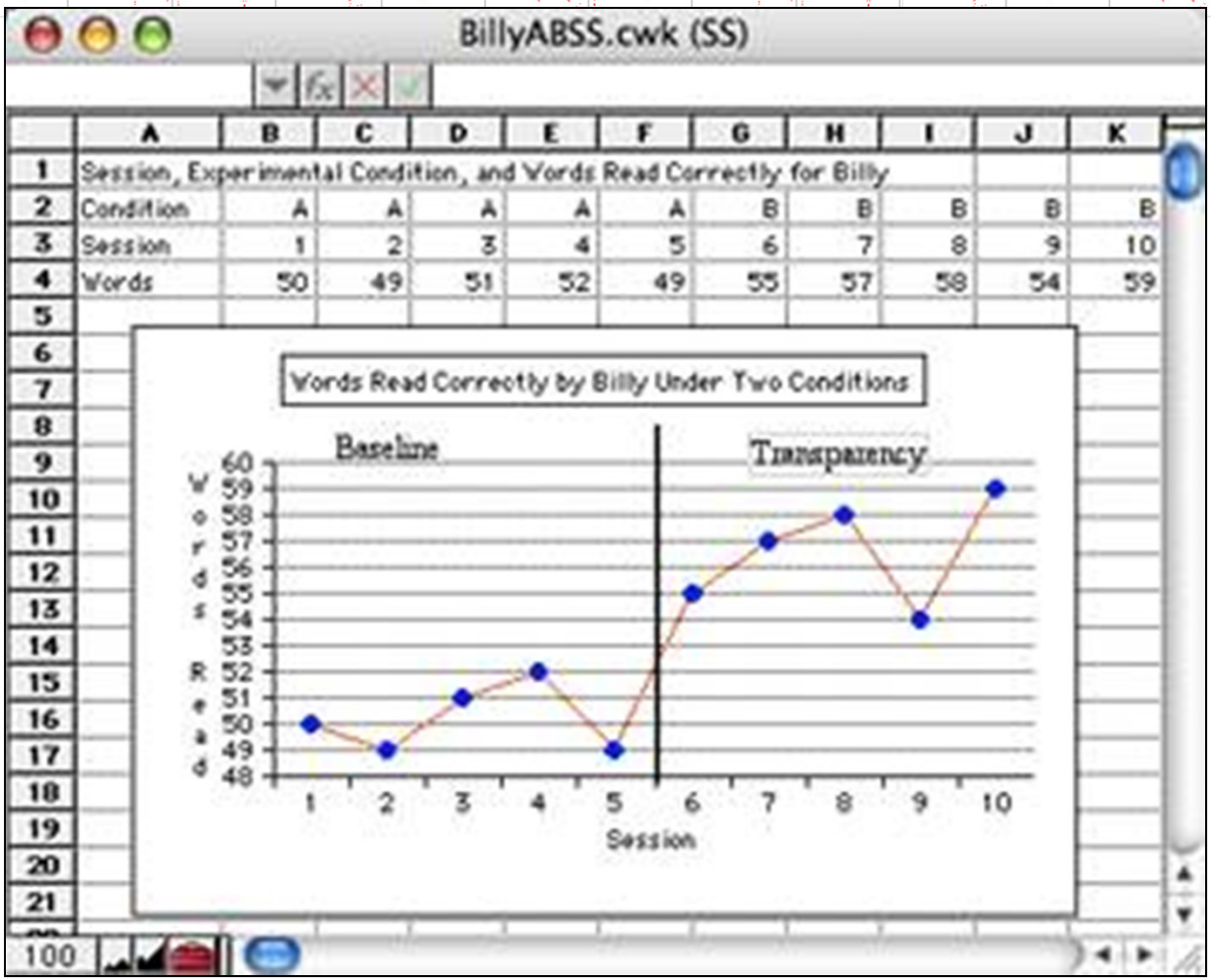
Single-subject designs



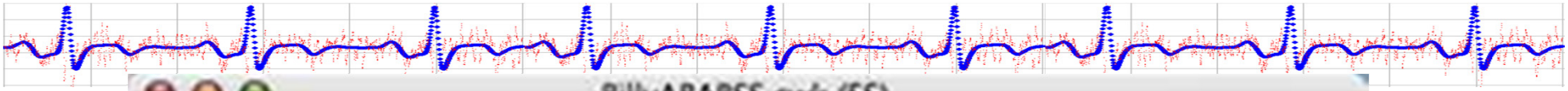
- Baseline Design
  - Repeat
    - Change IV
    - Sample DV until stable ("stability criterion")
- Dynamic Design
  - Continuously vary IV & measure DV response
- Discrete Trials Design
  - Repeat
    - Give randomly assigned IV
    - Measure DV

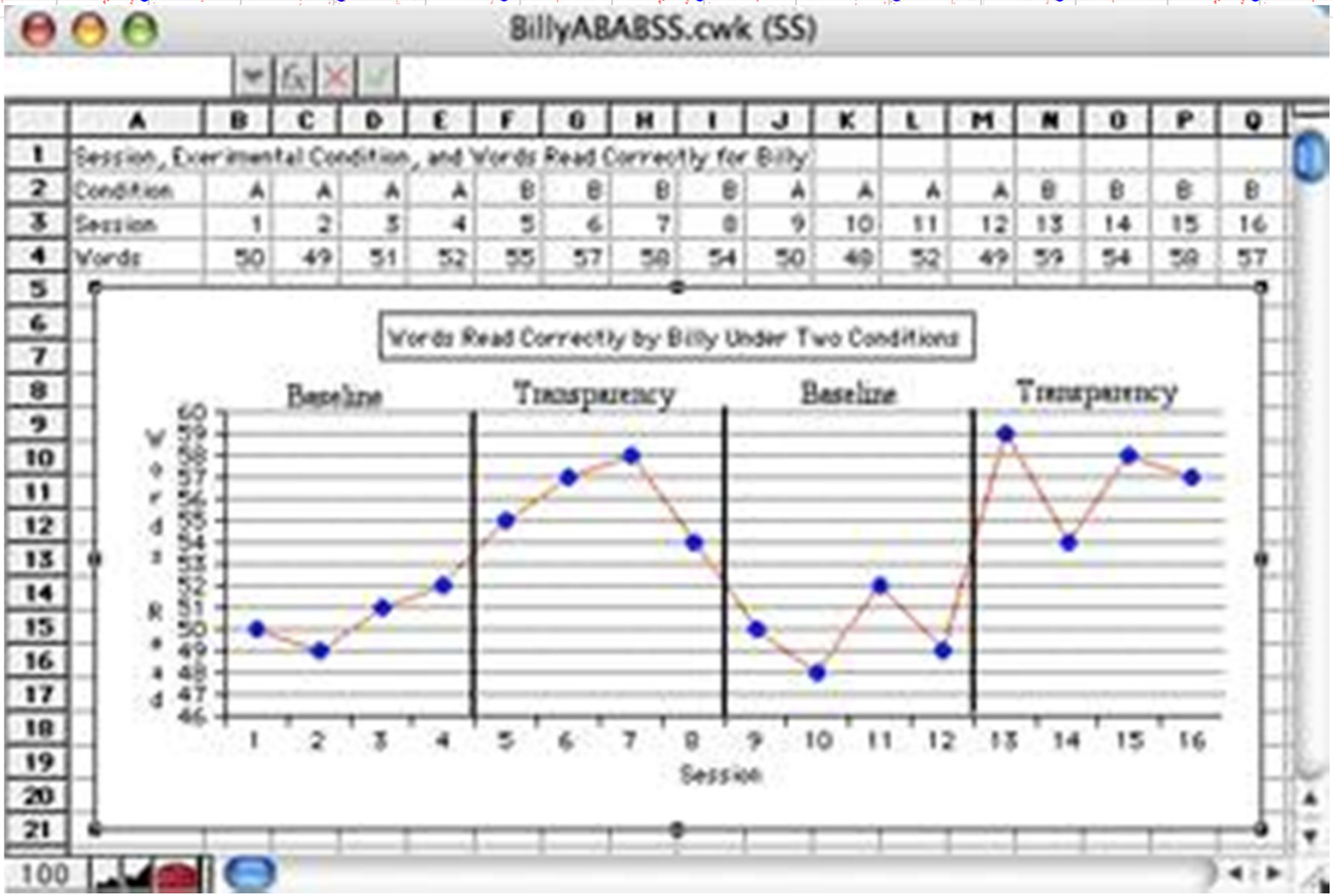
Single-subject baseline design A-B



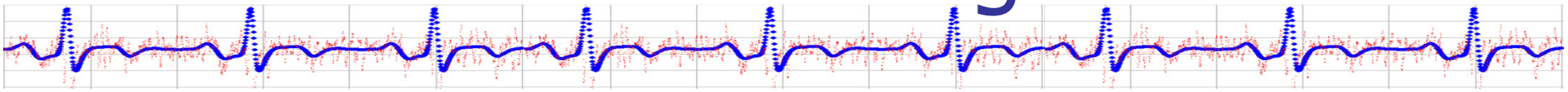


Single-subject baseline design A-B-A-B



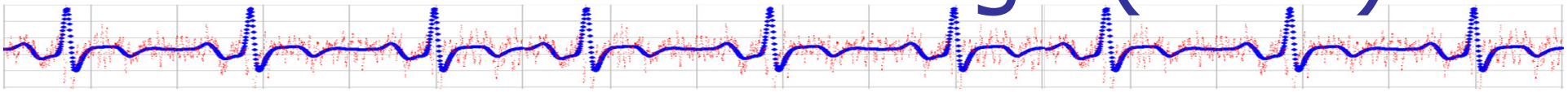


Characteristics: Single-subject discrete trials design



1. Individual subjects receive each treatment condition of the experiment dozens (perhaps hundreds) of times. Each exposure to a treatment or *trial,* produces one data point for each dependent variable measured.
2. Extraneous variables that might introduce unwanted variability in the dependent variable are tightly controlled

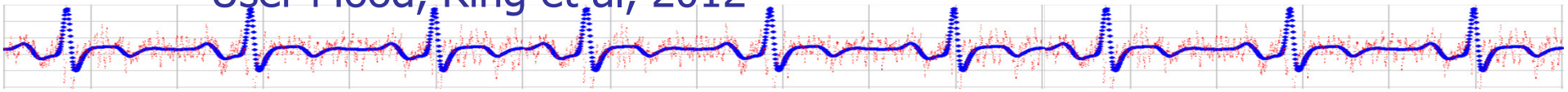
Characteristics: Single-subject discrete trials design (cont.)



3. If feasible, the order of presenting the treatments is randomized or counterbalanced to control order effects
4. The behavior of individual subjects undergoing the same treatment may be compared to provide intersubject replication

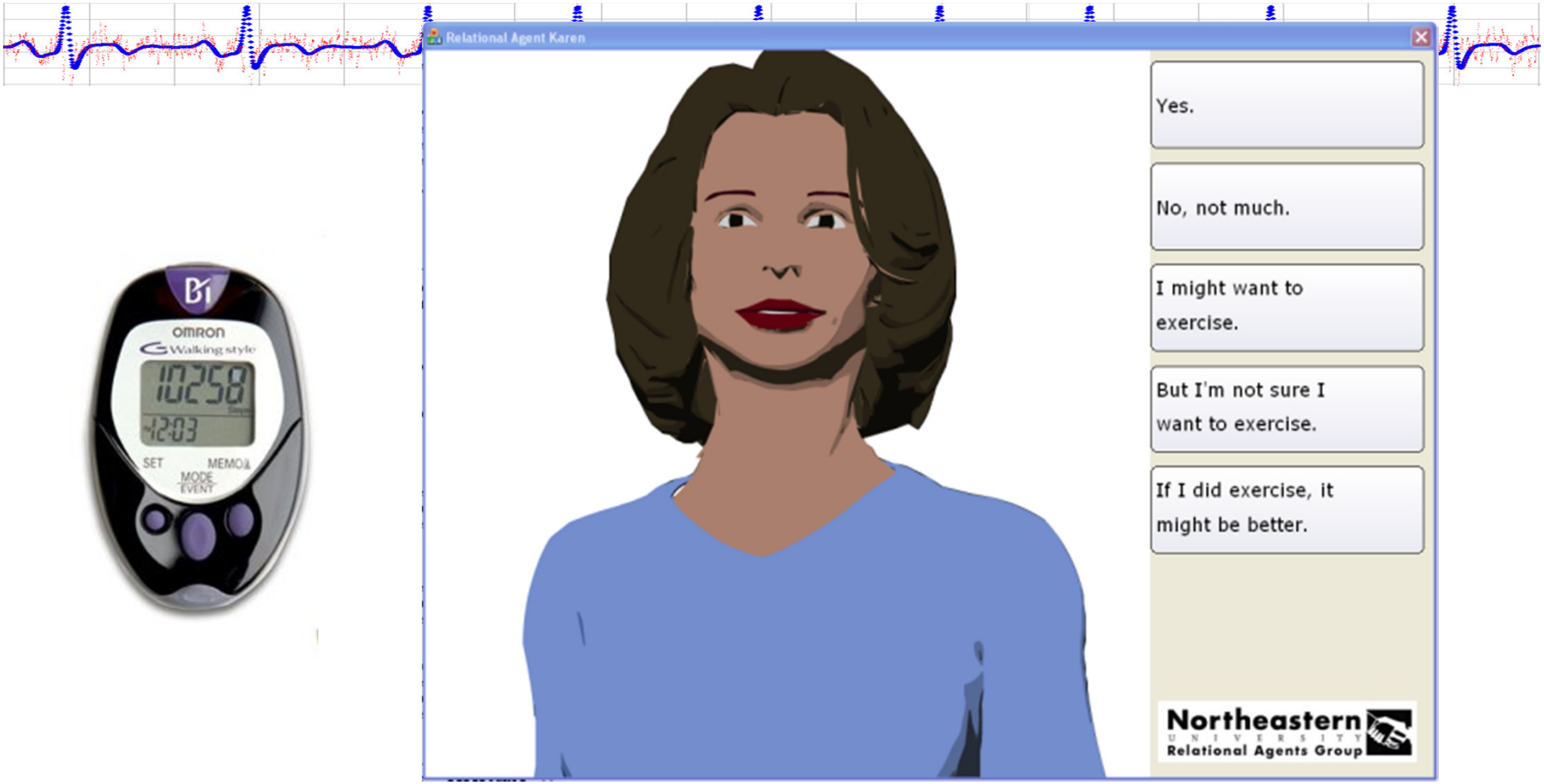
Example discrete trials design

Longitudinal Affective Computing - Virtual Agents that Respond to User Mood, Ring et al, 2012



- N=21 participants interacted with a virtual exercise coach for 2 months (696 samples)
- Each day, their mood was assessed via self-report.
- The coach would randomly say one of:
  - **Favor**: I was wondering if you'd mind doing me a favor and take a walk before our next session?
  - **Request**: Would you take a walk before our next session?
- Walking was assessed via pedometer

Virtual Coach



Example discrete trials design

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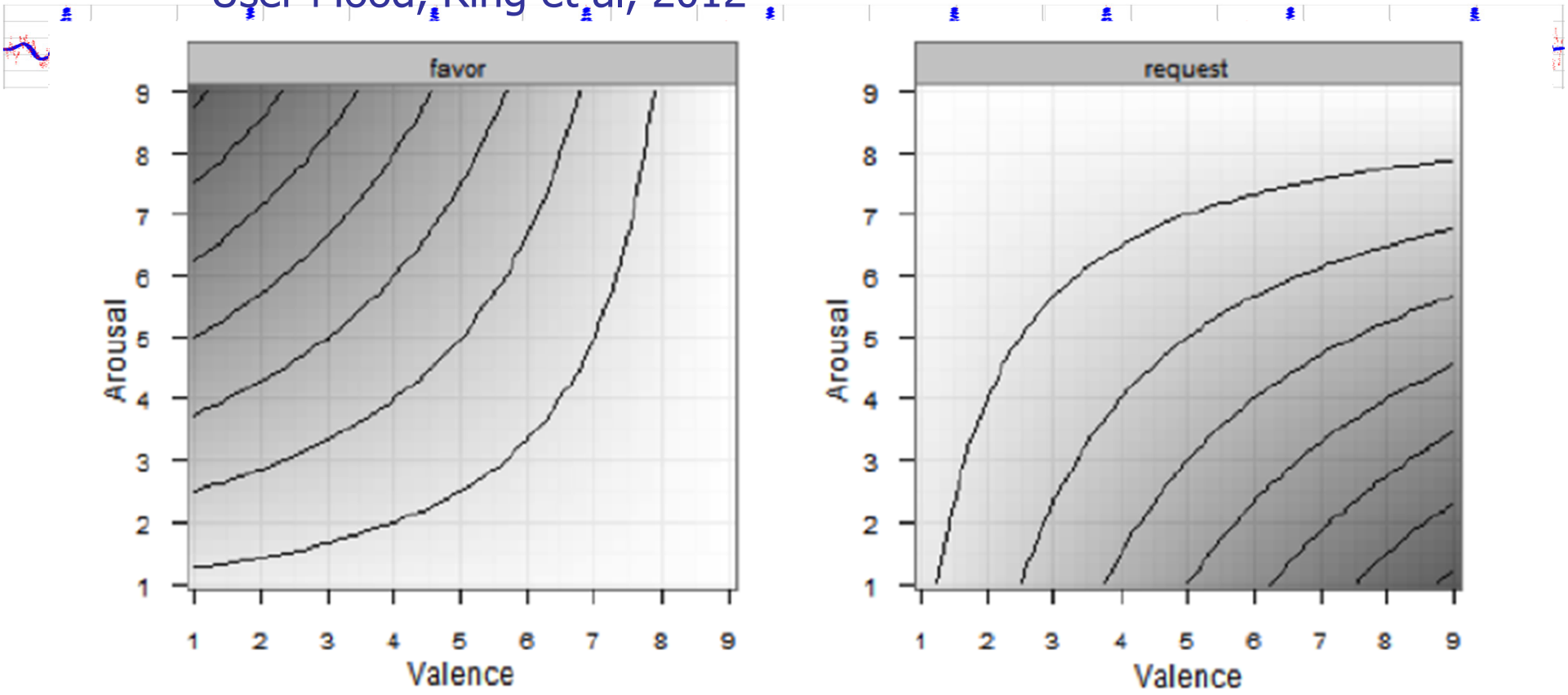
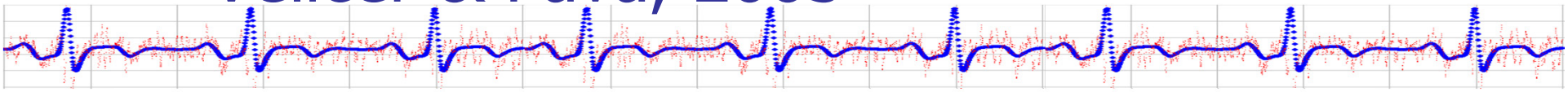
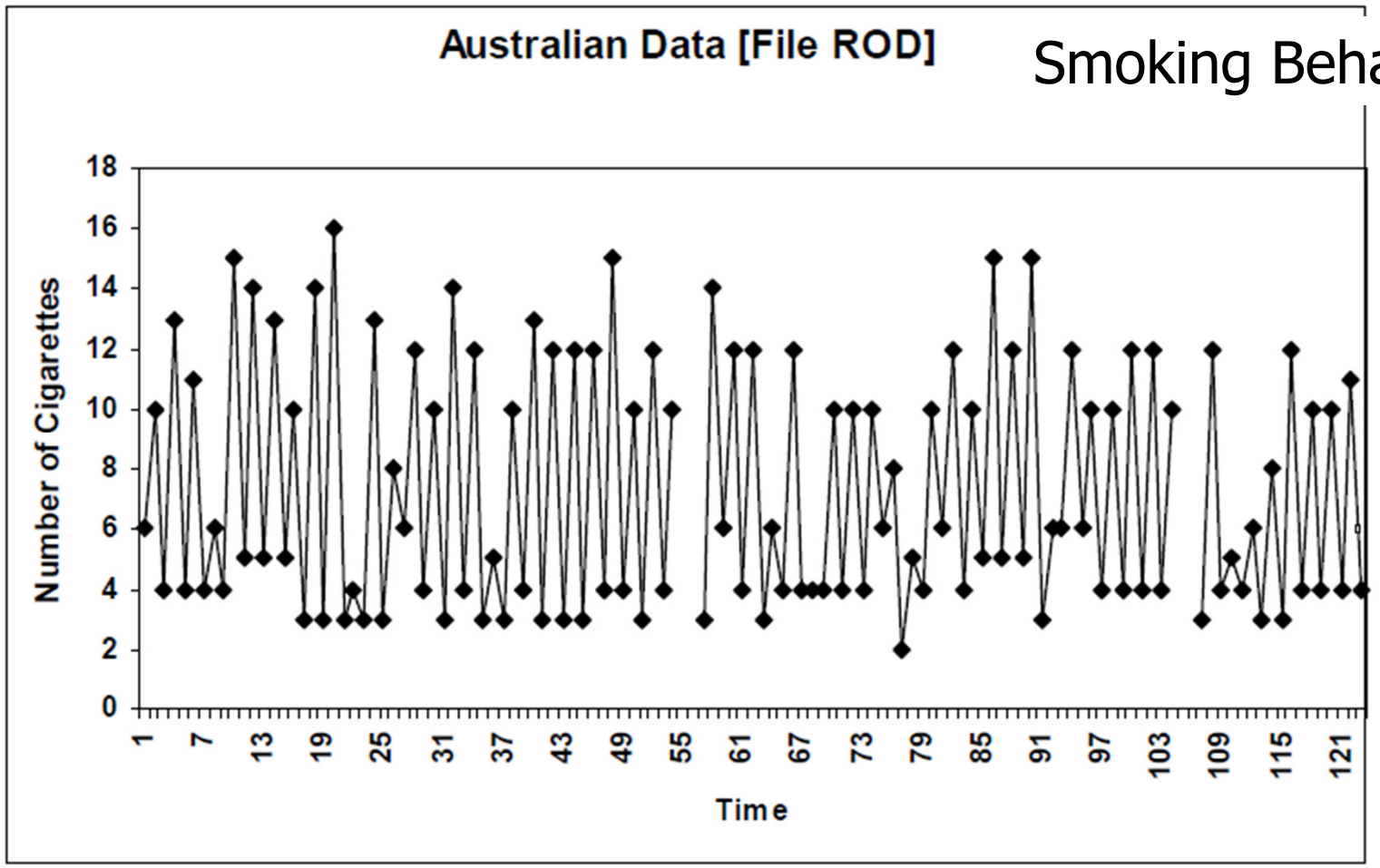


Linear Mixed-Effect Regression Model: Favors are more persuasive than direct requests when users are in negative moods, while direct requests are more persuasive for users in positive moods

Time series analysis

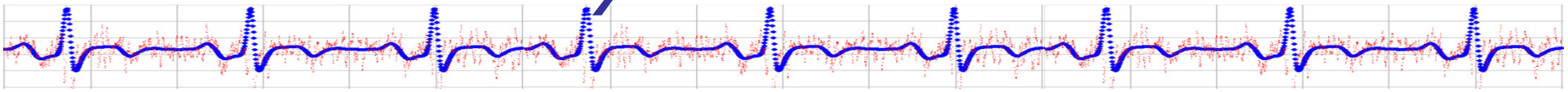
Velicer & Fava, 2003





Smoking Behavior

Why is this science?
Generality?



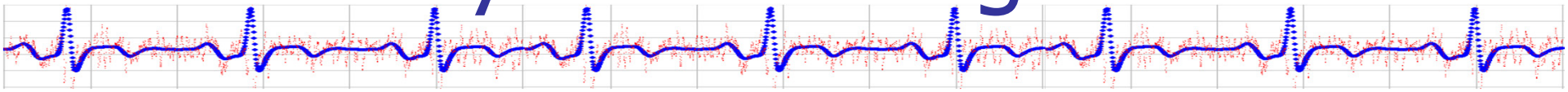
1. Large number of observations

   Average out small error variations
2. Rigid control of extraneous variables
3. Focus on powerful effects

4. Still show inter-subject generality

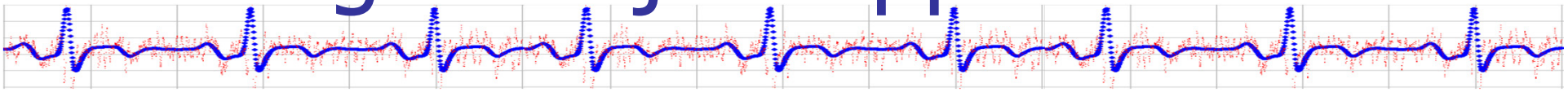
   But usually small N (3-6)

The Dynamic Design



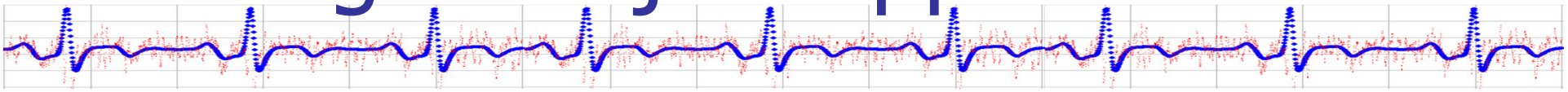
- A constantly changing independent variable
- Similar to the baseline design
- The design was used infrequently, but technology makes it more viable

Advantages of the single-subject approach



- Focus on tightly controlling error variance
- Focus on individual behavior makes identifying and controlling sources of error variance relatively easy
- Focus on individual behavior may reveal subtle effects of an independent variable lost with a group approach
- Causal relationships can be established with very few subjects

Disadvantages of the single-subject approach



- Making multiple observations is time-consuming and can be tedious
- The single-subject approach is not appropriate for all research questions (e.g., jury decision making)
- Results may be of limited generality
- All variables that can cause error variance cannot be identified and controlled
- Not widely accepted by the research community

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Micro-Randomized Trials: An Experimental Design for Developing Just-in-Time Adaptive Interventions

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Abstract

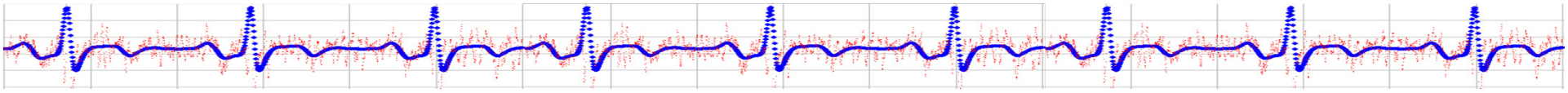
Objective—This paper presents an experimental design, the micro-randomized trial, developed to support optimization of just-in-time adaptive interventions (JITAIs). JITAIs are mHealth technologies that aim to deliver the right intervention components at the right times and locations to optimally support individuals' health behaviors. Micro-randomized trials offer a way to optimize such interventions by enabling modeling of causal effects and time-varying effect moderation for individual intervention components within a JITAI.

Methods—The paper describes the micro-randomized trial design, enumerates research questions that this experimental design can help answer, and provides an overview of the data analyses that can be used to assess the causal effects of studied intervention components and investigate time-varying moderation of those effects.

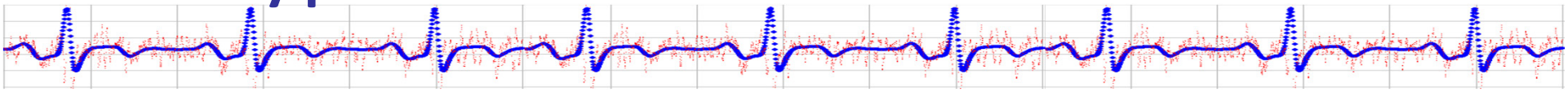
Results—Micro-randomized trials enable causal modeling of proximal effects of the randomized intervention components and assessment of time-varying moderation of those effects.

Conclusions—Micro-randomized trials can help researchers understand whether their interventions are having intended effects, when and for whom they are effective, and what factors moderate the interventions' effects, enabling creation of more effective JITAIs.

Within-subjects designs

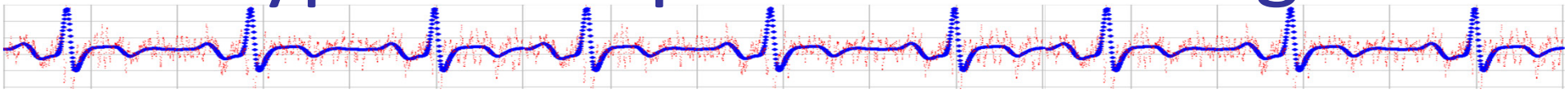


Types of studies discussed



- Descriptive
- Correlational
- Demonstration
- Experimental
  - One-factor, two-level, between-subjects (i.e., one IV with two variations)
  - Matched pairs
  - One-factor, two-level, within-subjects
    - Aka “repeated measures” or “crossover”

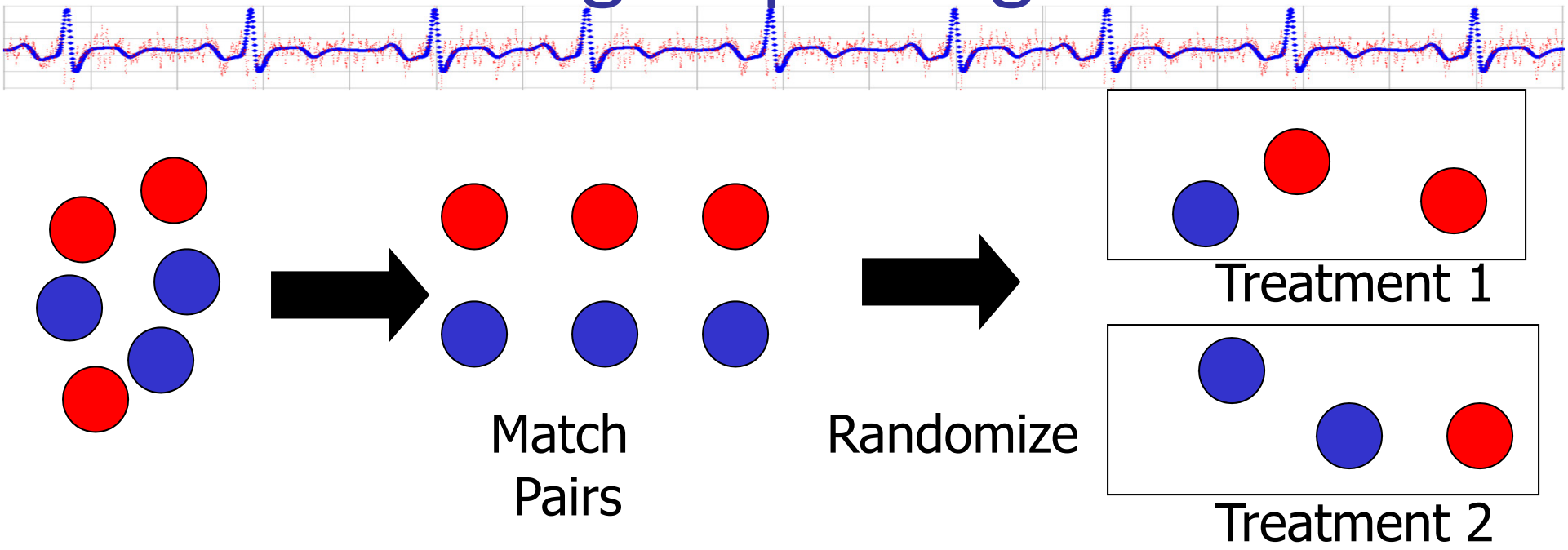
Types of experimental designs



- *Between-Subjects Design*
  - Different groups of subjects are randomly assigned to the levels (2) of your independent variable (1 factor)
  - Data are averaged for analysis
  - Use t-test for independent means

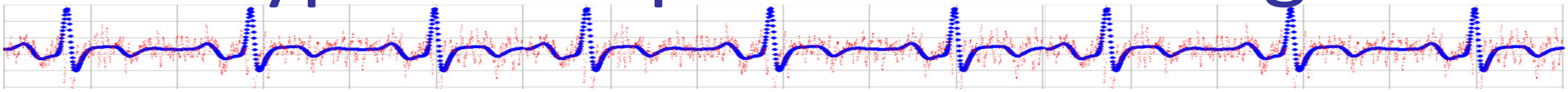
  - We have discussed “single factor, two-level, between subjects” designs

Matched group design



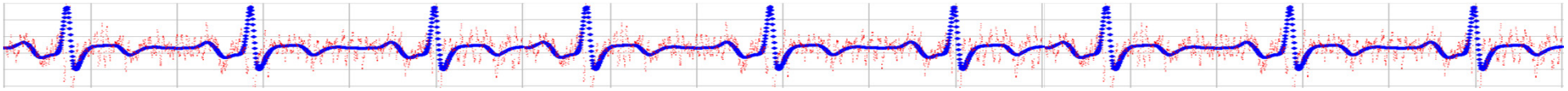
- Use when you know some extraneous inter-subject variable has significant correlation with DV
- A between-subjects design

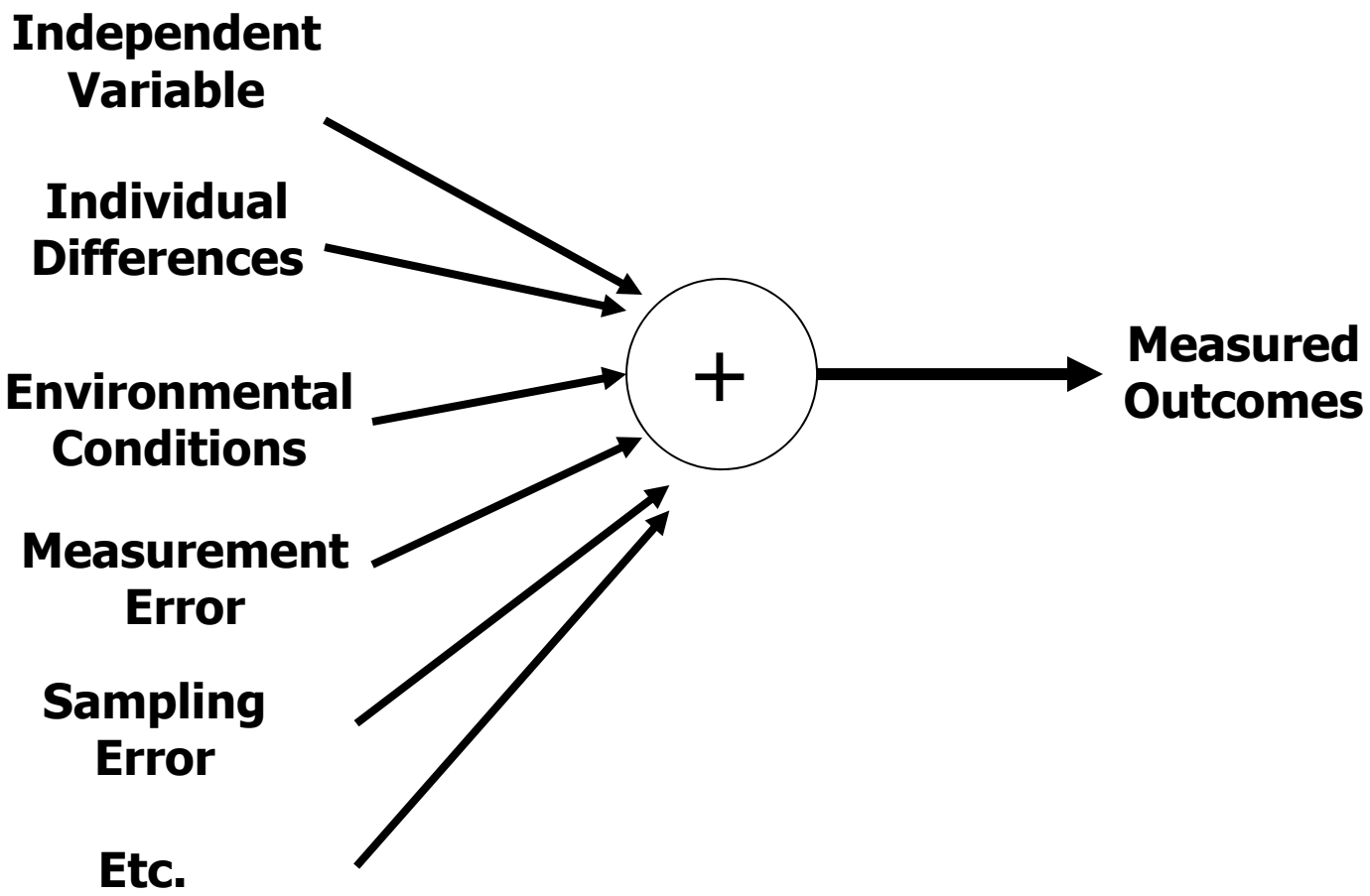
Types of Experimental Designs



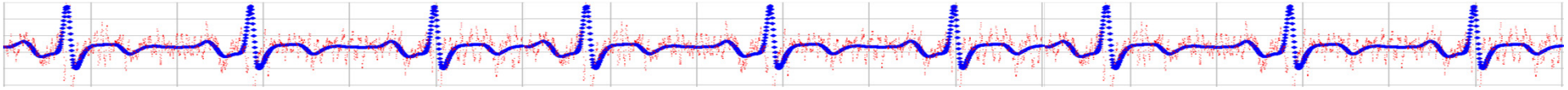
- *Within-Subjects Design*
  - A single group of subjects is exposed to all levels of the independent variable
  - Data are averaged for analysis
  - Aka “repeated measures design”, “crossover design”
  - Use t-test for dependent means aka “paired samples t-test”
  - We will discuss “single factor, two-level, within subjects” designs

Error variance



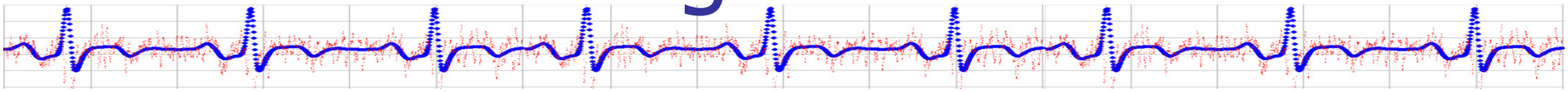


Within-subjects designs: Benefits



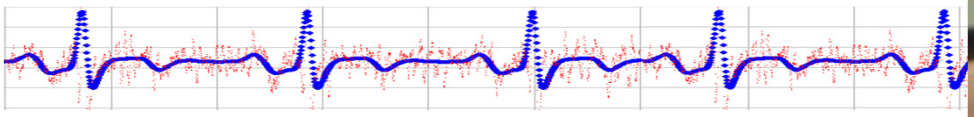
- More Power! *Why?*
  - Controls for <u>all</u> inter-subject variability (identified or not)
  - Randomized between-subjects design just balances the effects between groups
  - (Matched-pair controls for identified and matched extraneous variables)
- Subjects can be asked to directly compare treatments

Within-subjects designs: Disadvantages

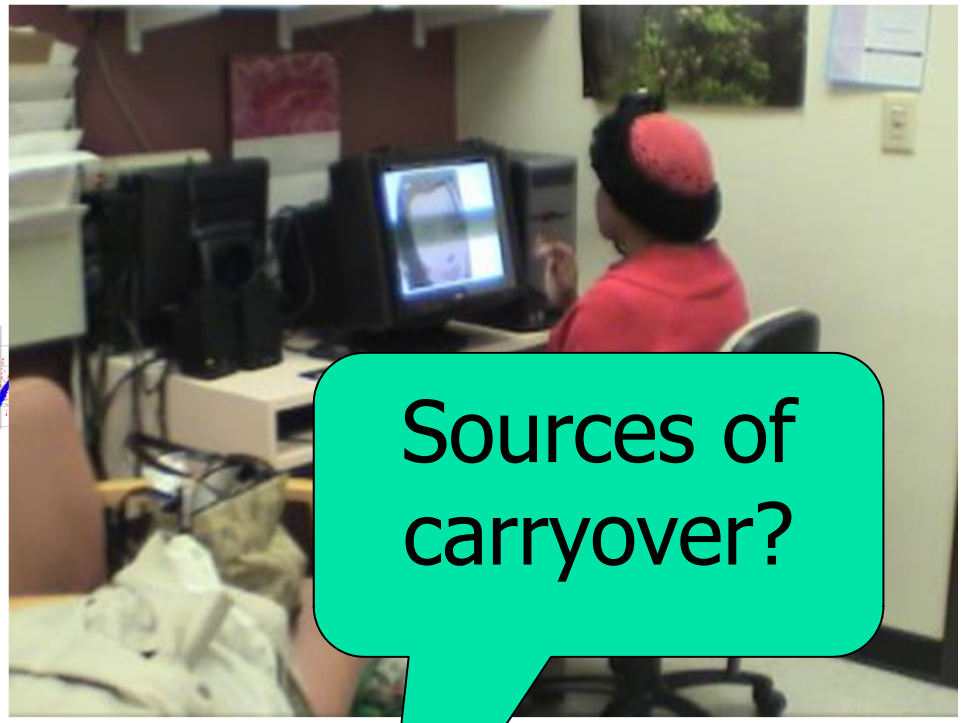


- More demanding on subjects, especially in complex designs
- Subject attrition is a problem
- *Carryover effects:* Exposure to a previous treatment affects performance in a subsequent treatment

Carryover Example



- Embodied Conversational Agents to Promote Health Literacy for Older Adults



Brochure

Computer

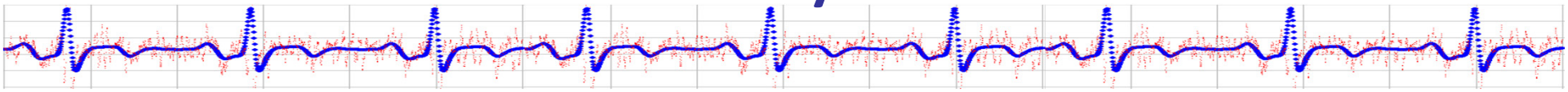
T0 → T1 → T2

Diabetes Knowledge Assessment

Diabetes Knowledge Assessment

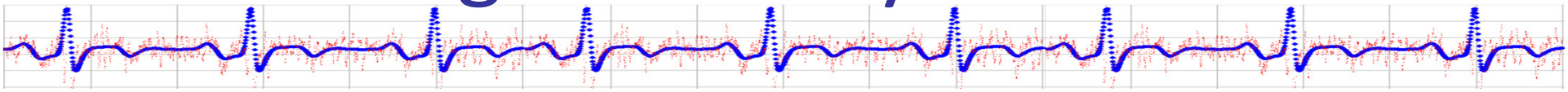
Diabetes Knowledge Assessment

Sources of Carryover



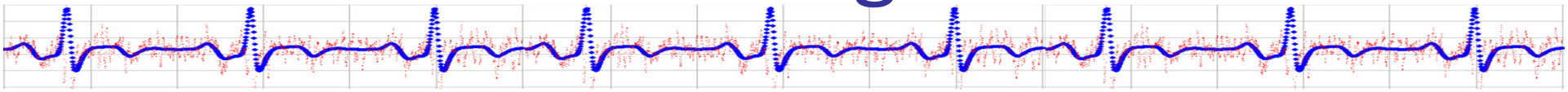
- *Learning*
  - Learning a task in the first treatment may affect performance in the second
- *Fatigue*
  - Fatigue from earlier treatments may affect performance in later treatments
- *Habituation*
  - Repeated exposure to a stimulus may lead to unresponsiveness to that stimulus
- *Sensitization*
  - Exposure to a stimulus may make a subject respond more strongly to another
- *Contrast*
  - Subjects may compare treatments, which may affect behavior
- *Adaptation*
  - If a subject undergoes adaptation (e.g., dark adaptation), then earlier results may differ from later ones

Dealing with carryover effects



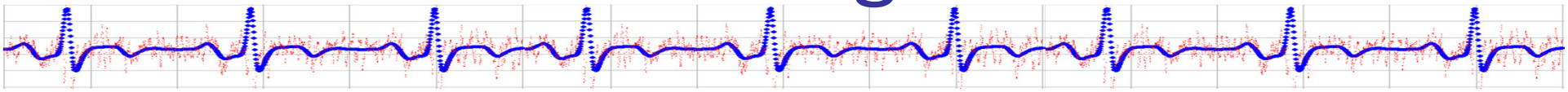
- *Counterbalancing!*
  - The various treatments are presented in a different order for different subjects
  - May be complete or partial
  - Balances the effects of carryover on each treatment
  - **Assumes** carryover effect is independent of the order

Counterbalancing



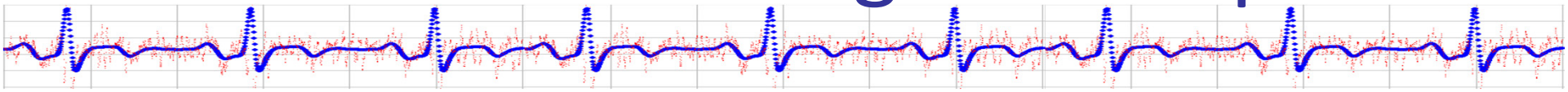
- By randomizing treatment order you balance the influence of all time-related extraneous variables across conditions
- E.g., Use to balance effect of minor fatigue

Counterbalancing



- Full counterbalancing
  - N! treatment orderings
- Partial
  - Randomly select <N! treatment orderings
- Other partial counterbalancing strategies
  - Latin Square – each treatment in each position the same number of times

Counterbalancing: Latin Square

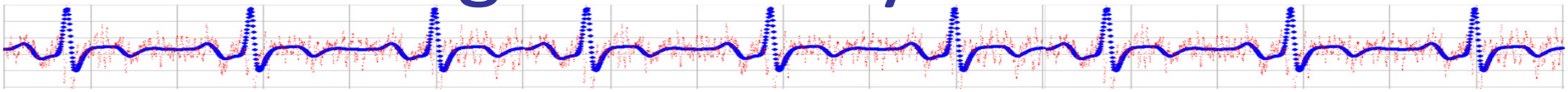


- A partial counterbalancing approach
- Make number of treatment orders = treatments (each treatment occurs once in every row and column)
- Example: want to evaluate 4 different word processors in an IT company using 4 subjects. A completely counterbalanced design would require 4x3x2=24 trials.
- Latin square attempts to eliminate systematic bias in assignment of treatment to departments & subjects.

Subject	1	2	3	4
1	C	B	A	D
2	B	A	D	C
3	D	C	B	A
4	A	D	C	B

Treatments A-D

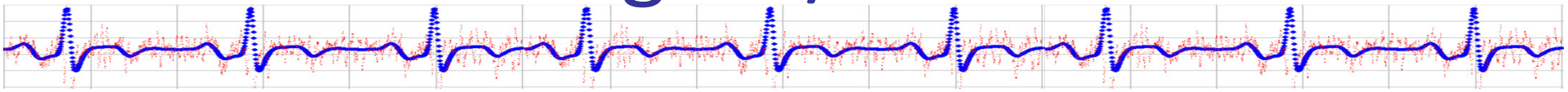
Dealing with carryover effects



1. Taking steps to minimize carryover
   - Techniques such as pre-training, practice sessions, or rest periods between treatments can reduce some forms of carryover

2. Make treatment order an IV
   - Allows you to measure the size of carryover effects, which can be taken into account in future experiments

E.g.: Counterbalanced single-factor design w/ two treatments

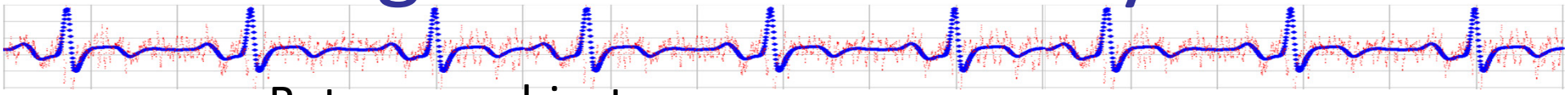


Order	Treatment Sequence
1	A B
2	B A

Subject	Order	Treatment A	Treatment B
1	2	23.5	14.2
2	1	14.6	11.5
…	…	…	…

How do you test for "order effects"?
Use Order as covariate in a repeated measures ANOVA (later)

Design criteria summary



- Between-subjects
  - Default
  - No carryover issues, but may require many subjects
- Within-subjects
  - More power, fewer subjects
  - Sensitive to carryover effects, requires more subject time
  - Allows direct comparison of treatments by subjects
- Matched-pairs
  - Suspect extraneous inter-subject variable highly correlated with DV
  - And, anticipate large carryover effect or other constraint (else within-S)
- Other issues (e.g., recruiting) may be determining factor