

Jay Verkuilen
jverkuilen@gc.cuny.edu

Jennifer Case
jcase@gc.cuny.edu

CUNY Graduate Center

SIMULTANEOUS MEASUREMENTS

OVERVIEW

- What is the problem?
- Framework: Cattell's Data Box
- Example Analytic Technique: Functional Data Analysis
- Demo: In breakout session by Jen Case.

WHAT IS THE PROBLEM?

EXAMPLE STUDY

- Want to study interaction of person with a computer program.
 - Two randomized groups, treatment and control.
 - Want to compare whether T and C differ on frustration of use.
 - Measure frustration both at online and distally (with a survey question).

YOU ARE MEASURING SEVERAL SIMULTANEOUS PROCESSES:

- EEG
- EKG
- Skin conductance
- Body Temperature
- Eye Tracking
- Posture
- Mouse clicks
- Video
- ...

- You write a grant to pay for the gear to do this...
- You learn how to operate it...
- You design a study to use it...
- You get your study through the IRB...
- You run participants...

AND NOW YOU ARE “DROWNING IN DATA”



EASY SOLUTION: WASTE THE DATA

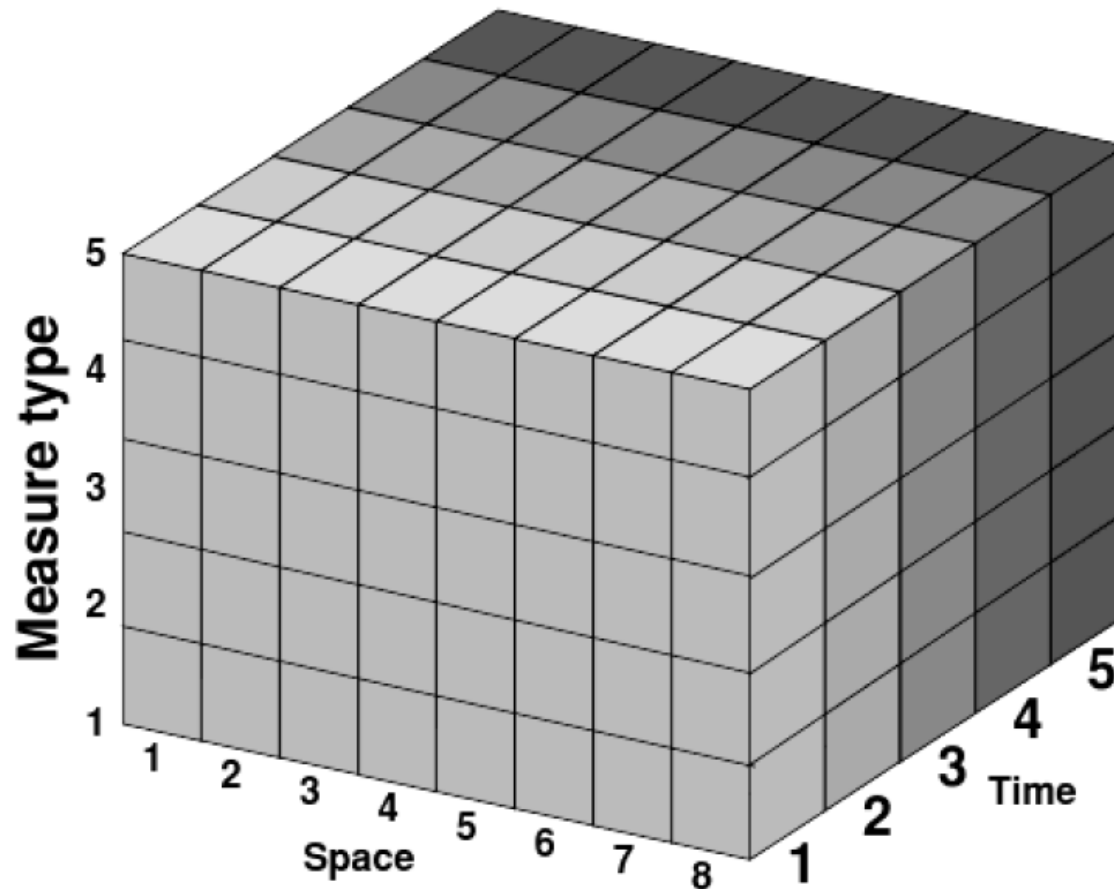
- **Blatantly:** Gather it but don't bother to look at it!
- **Subtly:** Use a highly inefficient method, e.g., turn eye tracking into a frequency table.

BECAUSE WE PREFER NOT TO WASTE

- We need a framework to avoid having a “dataset in search of a question.”

CATTELL'S DATA BOX AS A FRAMEWORK

Multivariate nature of psychophysiological data



WHAT ARE THESE VARIABLES?

- Character of variable:
 - Absolute quantity (stock)
 - Rate (flow)
 - Discrete events (point process)
 - Discrete events with strength or quality (marked point process)
- Time scales of observation
 - Sampling rate of equipment/observer
 - Slow vs. fast response of physiological process

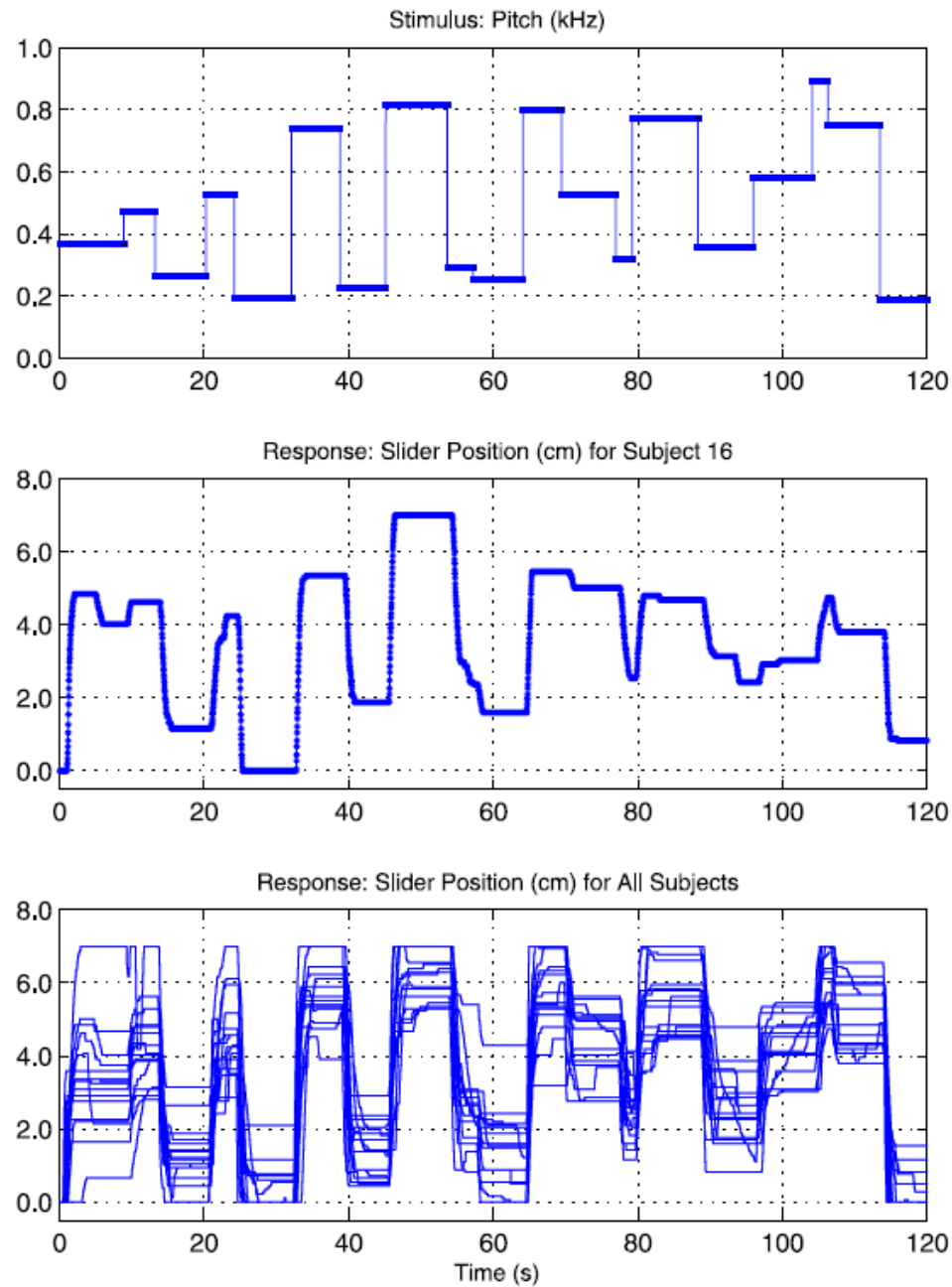
ANALYTIC TASKS INCLUDE

- Data cleaning and preprocessing
- “Proper” analysis of substantive variation

These are logically distinct but not separable....

DATA CLEANING/PREPROCESSING

- Synchronize the clock
- Error filtering
- Interpolation of irregular series
- Assessment and management of individual differences (may be part of “proper” analysis)



HOW DO WE ANALYZE THEM?

- A number of promising new methods:
 - Multiway Data Analysis (Kroonenberg, 2008)
 - Functional Data Analysis (FDA) (Ramsay & Silverman, 2005)
 - Generalized Additive Models (GAM) (Wood, 2006)
- These are not “weekend” analyses. Plan and budget accordingly.

FUNCTIONAL DATA ANALYSIS

FUNCTIONAL DATA ANALYSIS

- FDA fits a smooth curve (i.e., a function) to data:
 - Allows for irregularly observed series (crucial for simultaneous observations).
 - Smoothing remove errors in a principled way.
 - Solves the “time warping” problem. Qualitative processes are what we are interested in, not clock time.
 - Functional versions of nearly all standard analytic techniques (regression, cancor, PCA, etc.)
 - Dynamic models.

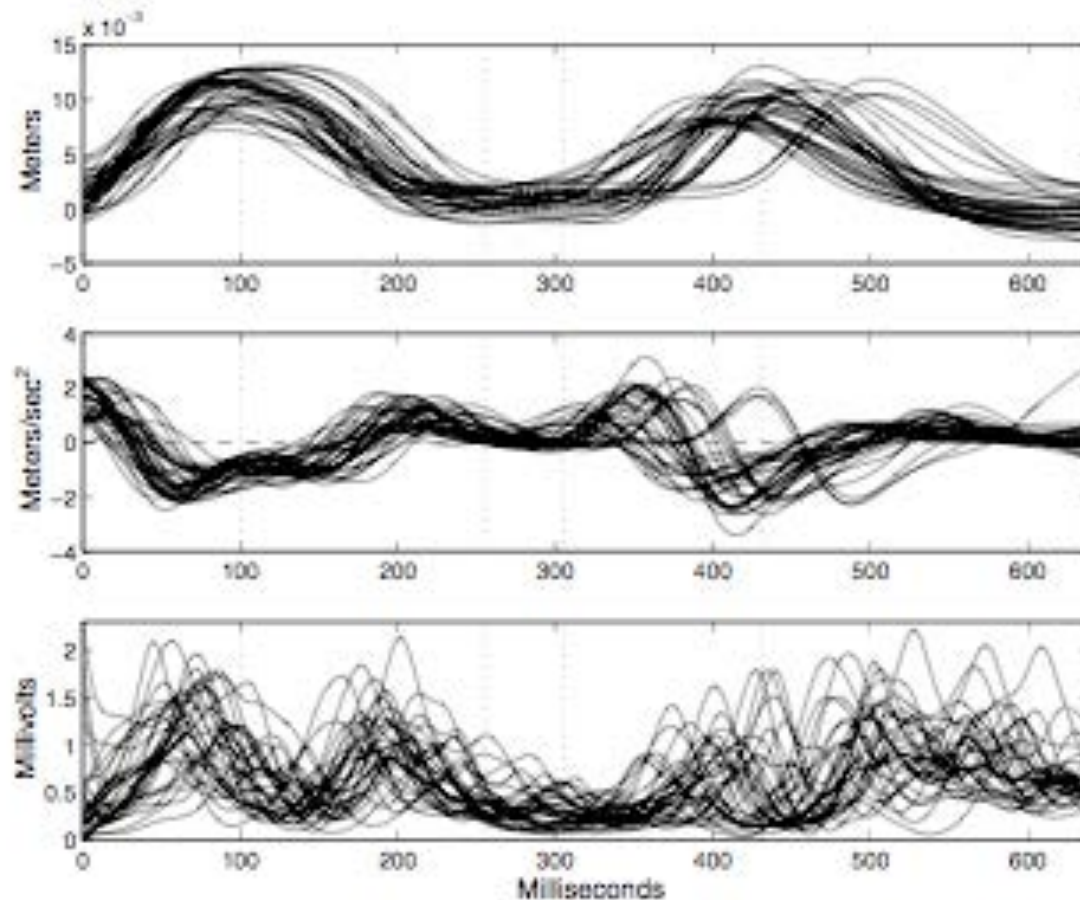


Figure 10.1. The top panel displays the position of the center of the lower lip of a speaker pronouncing the syllable “bob” for 32 replications. The middle panel displays the corresponding accelerations. The bottom panel contains electromyogram (EMG) recordings from a facial muscle that depresses the lower lip, the depressor labii inferior. The dotted lines indicate distinct phases in the articulation of the syllable. The EMG recordings are shifted to the right by 50 milliseconds, the time lag of the direct effect of a neural excitation as a muscle contraction.

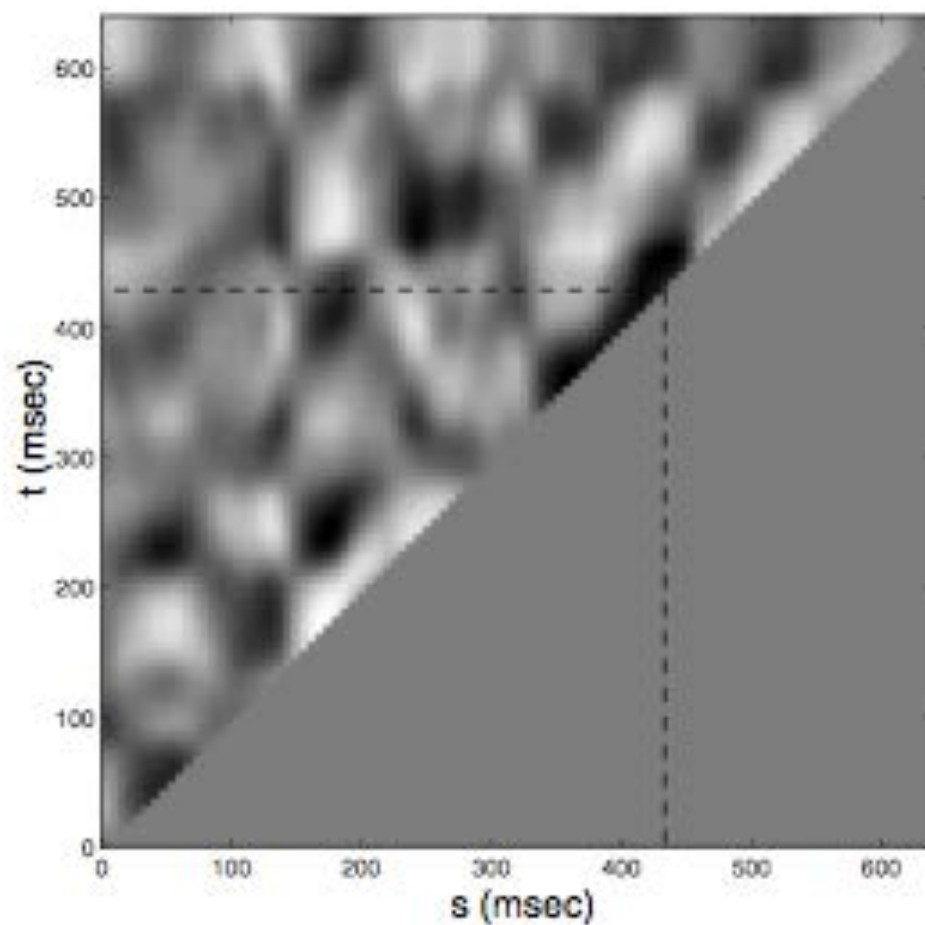


Figure 10.2. The correlations between the accelerations, functions of t , and the electromyogram recordings, functions of s , for all pairs of time values $s \leq t$. White regions correspond to positive correlations and dark regions to negative correlations. The gray level below the diagonal corresponds to a value of zero.

YOU WILL NEED TO LEARN A LOT OF MATH

- These data are inherently multivariate
- Intensively longitudinal
- Theory will probably need to be cast in terms of change processes
- Math includes:
 - Probability theory
 - Signals processing
 - Dynamical systems

CONNECTING DISCIPLINES

- ❑ Psychophysiology
- ❑ Social and personality psychology
- ❑ Health psychology
- ❑ Chemometrics/sensory science
- ❑ Human factors research

SOME REFERENCES

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- Walls, T. A. & Schafer, J. L. (2006). *Models for Intensive Longitudinal Data*. Oxford.
- Wood. S. (2006). *Generalized Additive Models*.