Process Tracing FOR DUMMIES®

Process Tracing for Dummies:
Solutions for design, analysis and presentation

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Process tracing

- What is process tracing?

  Process tracing is an experimental method used to capture process data during decision tasks

- Definition of process data:

  Any data collected between the presentation of the stimuli and the final response given

Old School process tracing

- Verbal reports, manual retrieval (information boards)
- early computerized information boards: Mouselab for DOS
- Analysis done on ad-hoc indices
  - Aggregation over attributes/alternatives
  - Difficult to comprehend the multivariate nature of the process data
- Addresses but does not model individual differences

New School Process tracing

- New technologies for capturing process
  - Clickstream data on the web
  - MouselabWEB
  - Eye movements (trackers)
  - fMRI
- New graphical representations (Icon Graphs)
- More sophisticated models (multilevel):
  - Allow for finer tests of theories
  - Allow for modeling of heterogeneity

Goal of this talk

- Important recent developments make process data more useful
- Process data should be used more to enhance our theories and predictions

- Solutions for:
  - Design of process tracing experiments
  - Representations of process data
  - Statistical methods for analysis of process data

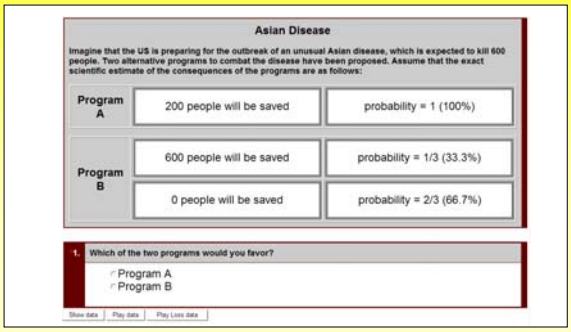
Design: MouselabWEB

- Goal: perform Mouselab-like process tracing experiments on the web (and in the lab)
- Approach: simple HTML/javascript available in recent browsers (works in 96%+ of browser usage)
  - Operating System Independent
  - No network delays: (Client-side, 1/60th second precision)
  - Fast and Easy: No plug-ins, small pages
  - No hassle server-side scripting (php/mySQL)
  - Easily extended: Open source (GNU license)

Features of MouselabWEB

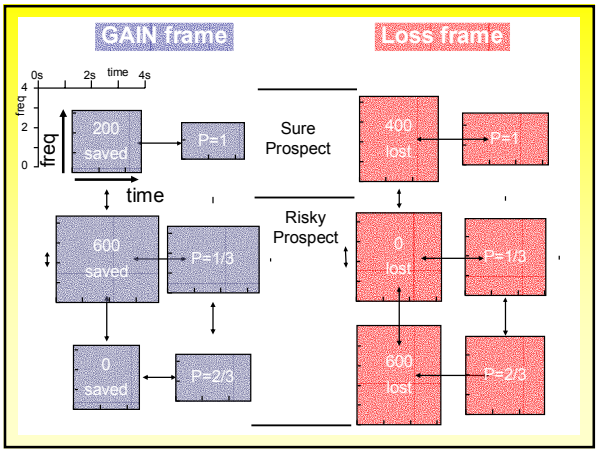
- **http://www.mouselabweb.org/**
- **Designer** program to design pages with mouselabWEB and other questions
- **Datalyser** program to retrieve and replay a movie of the process data
- Web-based means:
  - Large numbers of respondents
  - A lot of heterogeneity in participants (not quite the average 20 year old student lab participant)
  - Specificity of respondents: targeting specific groups

Asian Disease



Representation: Icon Graphs

- How to represent process data?
- Multivariate nature of process measures
  - **Attention:** acquisition frequency and looking time
  - **Search patterns:** direction and variability of search
  - **Time dynamics:** attention and search over time
- Icon Graphs can be used to display all this in one graph, using a 2D display.



Methods: Data structure

- Many repeated observations within a participant
- Data structures are rich:
  - Attributes/alternatives
  - Time per acquisition
  - Time dependencies between acquisitions
  - Transitions between acquisitions
- Data are clustered:
  - First level: individual observations
  - Second level: design and participant variables (including individual characteristics and individual-difference measures)

Multilevel models

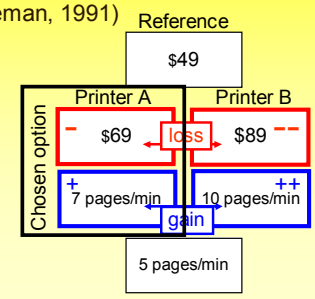
- Multilevel models allow investigating relations between lower-level predictors (e.g., attention to an option) and higher-level predictors (e.g., a measure of loss aversion on the participant level).
- Individual-level parameters (e.g., intercept, slopes, transition probabilities) become dependent variables:
  - β_{1i}= Linkfunction($\eta_0 + \eta_1 z_i$)

Advantages of Multilevel models

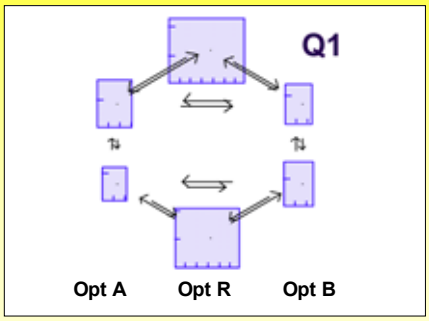
- Flexible decomposition of process measures
- Tests of random and fixed effects of individual-difference variables on decision process
- Incorporation of 'nuisance' effects (e.g., spatial dependencies in information display, reading order).
- Works with unbalanced data

Another example

- Reference dependence (Tversky and Kahneman, 1991)



Reference Dependence

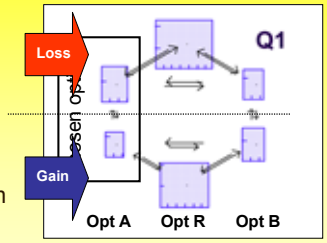


Example of Multilevel analysis

- Model for Reference dependence
  - Dependent variable: amount of attention to a box (frequency or time)
  - 48 observations (6 boxes x 4 quarters x 2 trials) per participant
  - Model some of the error variance by using random effects
  - Dynamics over time are modeled using a linear and quadratic terms
  - Choice is included in the model (to examine differences in process between A and B choosers)

Results

- Attention changes dynamically over time from the reference option towards to chosen option
- Losses do not loom larger than gains



Results

- Random factors (capture individual variance on these factors) are significant:
  - Intercept
  - trial
  - attention to loss
- Process data also predicts choice
- Multilevel model can be used to distinguish between different theoretical predictions about the process

Summary

- Synergy of new techniques, new representations, and new analysis methods
  - Sophisticated data collection on the internet increases diversity in samples
  - New graphical representations (e.g. Icon Graphs) help identifying what factors and differences are relevant
  - New multilevel analysis methods allow for actually modeling these effects, including individual differences

Summary

- Process data can tell why effects occur or do not occur and how individual differences might mediate this.
- Process data increases insight into cognitive processes underlying decision making
- Use process data yourself!

http://www.mouselabweb.org/