The Creative Destruction of Health Behavior Research

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Research Methods in a Data Poor Environment

- Priority is prospective design and data collection
- Limited data collection opportunities
- Predominately cross-sectional or minimally longitudinal designs
- Unable to assess or control myriad confounds
- Randomize to control
Research Methods in a Data Rich Environment

- Temporally Dense
- Noisy But Precise
- Computational
- Predictive

"Nearly all the grandest discoveries of science have been but the rewards of accurate measurement." Lord Kelvin, 1872
Previous State of Behavioral Measurement

Technological Advances in Behavioral Measurement

- Item Response Theory (IRT) and Computer Adaptive Testing (CAT)
- Ecological Momentary Assessment (EMA)
- Passive Sensor Technologies
Computerized Adaptive Tests

- **Question #1**
  - High physical function

- **Question #2**
  - Wide Range
  - High Precision
  - Minimal Burden

- **Question #3**
  - Low physical function
Ecological Momentary Assessment


Sensor Technologies

Growth Mixture Models: Elkhart Group Ltd

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Population Scale Activity Measures

- Population-scale measurement of physical activity
- Miniature, low-cost devices that measure human motion using redesigned accelerometers in a user-friendly format

Stephen Intille, PhD, Northeastern University
NHLBI, U01HL091737

Emerging Technologies and Assays for Adherence Monitoring

Xhale SMART “breathalyzer” for GRAS drug taggants

Drug (metabolite) concentrations via hair samples or dried blood spots

Proteus pill microchips and sensor

GlowCaps
Psychophysiology

Autosense
Santosh Kumar
University of Memphis

Wearable Chemical Sensor System

- Chemical exposure varies by context, need personal exposure
- Selective detection of VOCs (hydrocarbon and acid vapors)
  - Sensitive: ppb – ppm
  - Real-time: sec. – min.
  - Spatially resolved
  - Wearable: cell phone size
  - Cell phone based interface

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http://www.airnow.gov
Implantable Biosensors

- Measurement of analytes (glucose, lactate O2 and CO2) that indicate metabolic abnormalities
- Miniaturized wireless implantable biosensor that continuously monitors metabolism
  - Inserted by needle subcutaneously
  - Operated remotely using a PDA
  - Multi-analyte sensor
  - One month continuous monitoring

Diane J. Burgess, University of Connecticut NHLBI, R21HL090458

New Modalities for Prospective Data Collection

- Citizen Science and Crowdsourcing Efforts
  - Mechanical Turk for:
    - Volunteer Data Collection and Sharing (Quantified Self)
    - Cognitive Testing of Survey Items
    - Environmental Field Assessments
- Opt-In Internet Panels
  - See Summary Report of the AAPOR Task Force on Nonprobability Sampling
  - See Roshwalb et al. (2012) Towards the use of Bayesian credibility intervals in online survey results. NY: Ipsos Public Affairs
Archival Big Data Sources in the Behavioral Sciences

“Digital Breadcrumbs” (Pentland, MIT)

• Behavioral Data Traces gleaned from consumer-based data sources
  – Social Media (Twitter, Facebook)
    • Twitter opens up its 200 million users with 500 million tweets per day to researchers (2/10/2014)
  – Internet Searches (Google)
  – Cell phone Use (# calls and texts)
  – Cable Box Data (hours of TV)
  – Auto Black Box data
    (miles driven, seat belt use)
BD2K: Programmatic Areas

1) Facilitating Broad Use of Biomedical Big Data
2) Developing and Disseminating Analysis Methods and Software for Biomedical Big Data
3) Enhancing Training for Biomedical Big Data
4) Establishing Centers of Excellence for Biomedical Big Data

Big Data Analytics – Pattern Recognition

The fluid analogy depicts accumulation-depletion of the output (MVPA) as a result of changes in the input (self-efficacy). A controller / self-regulator relying on a sensed value of the output attempts to compensate for the input change, resulting in potentially significant variability.

What We Mean by “Model”? Conceptual Model
What Do We Mean by “Model”?

Statistical Model

-- Anderson-Bill et al., J Med Internet Res 2011;13(1):e28

Concept of Computational Dynamic Modeling of Social and Behavioral Phenomena is Not New


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Social Cognitive Theory (SCT)

- Dominant, influential theory of health behavior (Bandura, 1986)
- Lineage from Social Learning Theory
- Core Concepts:
  - Triadic reciprocity (reciprocal determinism)
  - Self-efficacy - Perceived ability to succeed in specific situations
  - Outcomes expectancy - Perceived likelihood that performing the behavior will result in expected outcomes
  - Cue to Action – stimulus that prompts behavior
Advantages of Computational Models

- Requires explicit and detailed system identification (even if only as hypothesis) and provides simulation capabilities
- Model is testable via precise and temporally dense data collection
- Ability to test “controllers” and their impact on the model to build JITAI's
- Utilize a series of N-of-1 trials to optimize the intervention
- Ability to be pre-emptive, not just reactive