Incorporating Sensor, App, and Neurocognitive Assessment Data in a Health Study, Solutions, and Future Implications for Research

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<<Topics

- Study Overview
- Enrollment Architecture
- Protocol Design as Big Data Elements
- Screening and Response Rates
- Future Considerations>>
The AURORA Study (Overview)

- Funded as the Longitudinal Assessment of Post-Traumatic Syndromes Cooperative Agreement
- Understand, prevent, and predict post-traumatic neuropsychiatric conditions
- 5-year study funded by NIH and foundations
  - University of North Carolina at Chapel Hill
  - Harvard University
- Recruitment from Emergency Departments
- Goal is to enroll 5,000 participants
Protocol: Variety of Data

I. PID Created @ Screener
   - ED Surveys (n = 3)
   - 2 Week Follow-up
   - 8 Week Follow-up
   - 3 Month Follow-up
   - 6 Month Follow-up
   - 12 Month Follow-up

   IMS Passes PID-PIN directly to CAI
   - IMS Utilizes PID-PIN linkage in these communications

II. Phenotypic Data
   - ED Surveys (n = 3)
   - 2 Week Follow-up
   - 8 Week Follow-up
   - 3 Month Follow-up
   - 6 Month Follow-up
   - 12 Month Follow-up
   - IMS Passes PID-PIN to CAI (1-time linkage required)

   IMS Links PID to Sample ID (at the Site ID & PID levels)

III. External Data Events
   - PID-PIN Linkage Needed
     - Verily
       - IMS Links PIN to Serial ID (One-to-Many issue though)
     - TestMyBrain
       - IMS Links PIN (with rotational Group # Assignment [1-4])
     - Mindstrong Health
       - IMS Links PIN to Username & Password

IV. Genotypic Data
   - All use Sample ID (SID)

   - Deep Phenotyping In-person

   - Reminders Emails and Texts

   - MRI
     - Blood
     - Acoustic Startle
     - Pain & Anxiety
     - Cold Pressor
     - Cuff Algometry
     - Temporal Summation
     - Pressure/Pain Threshold
     - Conditioned Pain Modulation
     - Anxiety/Catastrophizing

   - Blood Draws
     - [Non-DP & DP]
     - Use SID

   - Saliva
     - Use SID (on hold)
Protocol: Variety of Data Sources

Source: UNC School of Medicine, Dr. McLean
External Data Source: Study Watch

Verily Device

GIVE:
$1 Day Incentive

ASK:
Wear 21 Hours/Day
N=154 events
(now 365)

BIOSENSING:
• Biometric
• Environmental
• Movement

FDA 510(k):
Class II Med Device
On-demand, single-lead ECG

1-to-Many Assign
CoC Sync
External Data Source: Neurocognitive Assessments

TestMyBrain

GIVE: $5 Unit Incentive

Not-for-profit:
- Open source
- Web-based
- Various experiments

Experiments:
Research specified
Citizen-science

Group Assign. Randomization
Device Agnostic

Rotational Batteries (e.g., reaction time, learning, concentration, personality, memory)

ASK:
13 Assessments
10-15 mins/ per
External Data Source: Digital Phenotyping via Smartphone

**Mindstrong Discovery App**

**Installation:**
- Detailed Consent
- In ED
- Account

**Device/OS Specific Install App Keyboard**

**Passive Data Collections:**
- time & duration phone calls
- time & duration emails
- keystroke information
- swipes & taps
- wifi access
- location
- word cloud

**Rotational Batteries**
- reaction time
- learning
- concentration
- personality
- memory

**GIVE:**
- $0.75 Unit Incentive

**ASK:**
- 85 Flash Surveys
- ~5 mins/per

**Conducts:**
- (e.g., acute loss;
  depression;
  disorganization;
  self-regulation;
  panic attack;
  sleep issues)

**Measures of Cognition & Emotion**
Protocol: Velocity of Data Capture

Intensive ambulatory biobehavioral assessment of onset trajectory of RDoC constructs.

Deep phenotyping of high risk group during critical early developmental period (n=800)

Data collected through twelve week follow-up used to select probability samples of the 7 most common multidimensional outcome groups (including a recovery group)

Deep phenotyping of high risk group (n=800)
Additional follow-up blood draw group (n=2,200)

Saliva collection n=2000: weeks 1 - 4
Flash surveys daily: week 1
Flash surveys 3 times per week: weeks 2 - 12
Wrist wearable worn continuously: weeks 1 - 12

Wrist wearable worn for 1 week per month: months 4 - 11
Flash surveys once per week: weeks 13 - 52

Figure X. Study design overview (n=5,000). 🔄 = web-based neurocognitive assessment; ⏰ = flash surveys of cognition and symptoms; ⚠️ = wrist device evaluating circadian and physiologic characteristics; 🥤 = saliva collection; ⛑️ = blood product collection; • • = passive digital phenotyping 📲 = telephone/internet survey; deep phenotyping includes blood draw, fMRI, and psychophysical assessment.

Source: UNC School of Medicine, Dr. McLean
Protocol: Velocity of Contacts

- Protocol events for weekly neurocognitive assessment

**Weekly neurocognitive assessment contact protocol for all participants (week 2 – week 9)**

- **Day 7** (repeated on days 13, 20, 27, 34, 41, 48, 55; text and email), 2 hours after their daily blackout period ends: IMS sends initial automated neurocognitive assessment completion request to participants. No link in text.

- **Day 9** (repeated on days 15, 22, 29, 36, 43, 50, 57), 2 hours after their daily blackout period ends: IMS automated reminder to complete initial neurocognitive assessment. No link in text.

- **Day 10** (repeated on days 17, 24, 31, 38, 45, 52, 59), 2 hours after their daily blackout period ends: IMS automated reminder to complete initial neurocognitive assessment. UNC team begins phone calls to touch base and ask.

- **Midnight of study day 12** (repeated on days 19, 26, 33, 40, 47, 54, 61): IMS closes weekly neurocognitive assessment window.

**CHALLENGES:**
- Tied to participant’s preferences
- Opening and closing dates
- Multi-communication channels
- Black out period
- Status codes
- Active vs. Inactive vs. Cancellation
- Incentives
- 5,000 individual schedules
- Protocol changes
Protocol: Velocity of Contacts (Solution)

- RTI developed a sophisticated control system to support data collection projects. This system:
  - Defines events and related status codes
  - Houses participant information
  - Can send emails and SMS messages

- This system was leveraged, tailored, and enhanced for AURORA SOLUTIONS:
  - System data driven schedule generation
  - Event Table holds the “master shell” schedule
    - Event code
    - Day “offset” from Day 0 Enrollment
    - Hours from Blackout
    - Communication mode(s)
    - Incentive points for completion
    - Batch processing (hourly, daily)

<table>
<thead>
<tr>
<th>Event</th>
<th>Day Offset</th>
<th>Last Day</th>
<th>Hours After Offset</th>
<th>Event Type ID</th>
<th>Via Text</th>
<th>Via Email</th>
<th>Via Phone</th>
<th>Active</th>
<th>Incentive Points</th>
<th>Stage</th>
<th>Complete Status</th>
<th>Assessment ID</th>
<th>Survey ID</th>
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<tbody>
<tr>
<td>NCA1</td>
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<td>6</td>
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<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>400</td>
<td>412</td>
<td>2690</td>
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<tr>
<td>NCA1 Invite (email)</td>
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<td>1</td>
<td>2</td>
<td>2</td>
<td>-</td>
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<td>-</td>
<td>1</td>
<td>0</td>
<td>700</td>
<td>1052</td>
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<tr>
<td>NCA1 Invite (text)</td>
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<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
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<td>0</td>
<td>701</td>
<td>1052</td>
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</table>
Screening Rates (as of 12/31/2019)

% Enrollment By Age Group

- 18-19: 6%
- 20-29: 35%
- 30-39: 25%
- 40-49: 16%
- 50-59: 12%
- 60-69: 5%
- 70-75: 1%
- 80-85: 6%

% Enrollment By Race

- White: 35.8%
- Black or African American: 55.5%
- Asian: 0.4%
- Native Hawaiian or Pacific Islander: 8.4%
- American Indian or Alaska Native: 2.1%
## Follow-Up Rates (as of 12/31/2019)

<table>
<thead>
<tr>
<th>Follow-Up Surveys</th>
<th>Complete</th>
<th>Pending</th>
<th>Expired</th>
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</thead>
<tbody>
<tr>
<td>2 Week Follow-Up</td>
<td>71.50%</td>
<td>0.07%</td>
<td>28.43%</td>
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<tr>
<td>8 Week Follow-Up</td>
<td>76.48%</td>
<td>0.46%</td>
<td>23.06%</td>
</tr>
<tr>
<td>3 Month Follow-Up</td>
<td>81.39%</td>
<td>0.05%</td>
<td>18.56%</td>
</tr>
<tr>
<td>6 Month Follow-Up</td>
<td>67.29%</td>
<td>2.36%</td>
<td>30.35%</td>
</tr>
<tr>
<td>12 Month Follow-Up</td>
<td>55.53%</td>
<td>1.20%</td>
<td>43.27%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>72.40%</td>
<td>0.64%</td>
<td>26.96%</td>
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</table>

<table>
<thead>
<tr>
<th>NCAs</th>
<th>Complete</th>
<th>Pending</th>
<th>Expired</th>
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</thead>
<tbody>
<tr>
<td>(n = 10)</td>
<td>54.44%</td>
<td>4.96%</td>
<td>40.60%</td>
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</table>

<table>
<thead>
<tr>
<th>Flash Surveys</th>
<th>Complete</th>
<th>Pending</th>
<th>Expired</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n = 85)</td>
<td>54.51%</td>
<td>4.75%</td>
<td>40.74%</td>
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<table>
<thead>
<tr>
<th>Verily Watch</th>
<th>Complete</th>
<th>Pending</th>
<th>Expired</th>
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</thead>
<tbody>
<tr>
<td>(n = 365)</td>
<td>54.24%</td>
<td>5.41%</td>
<td>40.35%</td>
</tr>
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Future Implications

- Given the complexity of the study protocol, the intensity of data collections, and the total burden, it is critical to maximize participation of those potentially interested and willing to participate.

- Given the multiple technology partners and/or platforms, one needs to plan for differential data use agreements and accompanying limitations and understand the implications for the protocol and architecture.

- Given the likely software and platform specific requirements, may need to develop a methodology that utilizes multiple unique participant identifiers for linkages to the study’s Participant ID over the course of a longitudinal study.
Future Implications (cont.)

- Given budget constraints, one must account for software, platform, and technological enhancements (e.g., new versions, downtimes, security changes) and how e-linkages between systems are affected (scalability and flexibility are key constructs).

- If incorporating specific hardware/sensors, ensure manufacturing and production schedules can meet main protocol recruitment timelines, sharing/distribution of sensors, and implications on chain-of-custody and analysis.
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