Advances & Challenges in Measuring Dietary Intake and Physical Activity

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Innovative Tools for Assessing Diet & Physical Activity for Health Promotion
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Before I start: Thanks to

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**M2FED TEAM**
- Jack Stankovic, John Lach
  Kayla De La Haye

**Multiscale, Computational Modeling TEAMS**
- Misha Pavel, Steven Intille, Wendy Nilsen, Benjamin Marlin, Daniel Rivera, Eric Hekler, Pedja Klasnja, Matt Buman, Holly Jimison

**Repository for Algorithm Development in Ambulatory Research (RADAR) TEAM**

**mHealth Collaboratory, Institute for Creative Technology teams:**
- Bill Swartout, Skip Rizzo, Amo Harthold

**Imagine Health TEAM**
- Marc Weigensburg, Bas Weerman, Cheng Kun Wen, Stefan Schneider
Just In Time Adaptive Interventions

- Adaptive, Personalized
- Delivered via mobile devices
- Anytime, Anywhere,
- When the person is in need/ vulnerable & receptive (Spruijt-Metz et al 2015, Nahum-Shani, Hekler & Spruijt-Metz, 2015, Heron & Smyth, 2010)
- More effective than standard interventions or simple reminders (Smyth 2016)
Just In Time Adaptive Interventions

• Responsive to moment-by-moment context
Stuck in the Past?
The Case of Physical Activity

Repository for Algorithm Development in Ambulatory Research (RADAR) TEAM

James McClain, John Lach, Bor-rong Chen, Jim Morrow, Fahd Albinali, Bill Haskell, Sue Ann Sisto, David Bassett, Jon Moon, Stephen Intille, Edmund Seto, Kevin Patrick, Roozbeh Jafari, Julien Penders, Misha Pavel
RADAR Workgroup Mission:
- To develop preliminary recommendations for information and infrastructure resources needed to support and enhance health-related body sensor networks research to measure physical activity.

Primary Question:
- What type(s) of information and infrastructure resources are needed to support broader collaboration, methodological comparison or validation, direct data sharing, or data pooling within body sensor networks research.
Physical activity: What’s the question? What do we really want/need to know?

- Steps?
- Dynamic acceleration?
- Bouts? Intensity?
- Sedentary time?
- Sleep?
- Psychosocial data?
- Activity identification?
- Context?
  - Social (who are you with?)
  - Built Environment: temperature, humidity, altitude, light, noise, air quality, location in general, GPS in particular.
- Cardiovascular fitness?
- Energy Expenditure?
- Calorimetry?
- Strength?
- Balance?
- Posture?
- Physiological data?
  - Skin temperature
  - ECG (and heart rate)
  - Breathing rate,
  - GSR, EEG, EMG,
  - Fatigue

Berman, Weigensberg, Spruijt-Metz, 2012
False Dichotomy
Continua in digital data: A multilevel multidimensional problem
Mashing up and dynamically modelling digital data

- Machine Learning
- Networks analyses
- Deep Learning
- Bayesian
- Markov
- Control Systems

USC Dornsife
Center for Economic and Social Research

mHealth Collaboratory
What new questions can transdisciplinary teams ask this data?

- Semantically interesting patterns of behavior & health
- New variables/indices that can be discovered through a mash-up of measures
- Adjustable across dimensions, so that probability of a particular state is personalizable, as time-sensitive new data comes in.
- Computational models of behavior
What new questions can transdisciplinary teams ask this data?

• We don’t have temporally dense data at every level. Think across timescales, make use of temporal mismatch

• Enhance classic description of the past with prediction of the future – based on specific priors – in an ongoing fashion.

• Where is the signal in current noise that we can use?

• A new search for meaningful mechanisms.
The Case of Diet and Nutrition

Monitoring and Modeling Family Eating Dynamics: M2FED

Jack Stankovic, John Lach
Kayla De La Haye
Motivation

• The wicked problem in obesity research is accurate measurement of what and how much people eat outside of a laboratory situation.
  • Even new technologies fail here.

• What’s the question?
  • Mechanistic understanding of nutrient effects on health?
  • Interventions?

• Interventions aimed to modify specific nutrient and/or calorie intake behaviors have booked null or small effects, and these are not maintained (Waters et al 2012, Loveman et al 2015).

• Family eating dynamics have a major influence on eating behaviors and are modifiable (Boutelle et al 2001 & 2003, Lytle et al 2011, Volkow 2011).
**System Dynamics Models of FED**

**Approach:** Map and model the structure of the FED system as patterns of temporal relationships among key elements

- Key factors, directions of influence, flows, feedback loops, and resultant changes in states of the system

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**Table:**

<table>
<thead>
<tr>
<th>Family Member</th>
<th>Eating Event</th>
<th>Alone</th>
<th>Monday night</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child 1</td>
<td></td>
<td><img src="image" alt="Smiley face" /></td>
<td><img src="image" alt="Sad face" /></td>
</tr>
<tr>
<td>Child 2</td>
<td></td>
<td><img src="image" alt="Sad face" /></td>
<td><img src="image" alt="Sad face" /></td>
</tr>
<tr>
<td>Adult 1</td>
<td></td>
<td><img src="image" alt="Happy face" /></td>
<td><img src="image" alt="Sad face" /></td>
</tr>
<tr>
<td>Adult 2</td>
<td></td>
<td><img src="image" alt="Happy face" /></td>
<td><img src="image" alt="Sad face" /></td>
</tr>
</tbody>
</table>

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**Graph:**

- **Eating Rate over Time**

**Legend:**

- **Family Members**
  - C1 = Child 1
  - C2 = Child 2
  - A1 = Adult 1
  - A2 = Adult 2

- **Eating Event Categories**
  - Meal: EE-1, EE-2
  - Snack: EE-3, EE-4
  - Hunger: +
  - No Hunger: -
Transdisciplinary Challenge

- Family eating dynamics (FED) have yet to be measured unobtrusively and modeled dynamically, in real time, in people’s homes (i.e., in the wild).

- We are developing a system of systems to monitor, measure, and model FED in real time, in homes with overweight parents and children (Spruijt-Metz, de la Haye, Lach, Stankovic 2016).

- Change paradigm for intervening on childhood obesity using a dynamic family systems approach.

- Develop a cyberphysical ‘system of systems’ that can provide a framework to determine the most appropriate “nudges” for a given individual in a given situation.

- This system will be able to deliver Just-In-Time, Adaptive Interventions.
M2FED Cyberphysical System

- Eating, speed, time, length of incident via smartwatch
- Location (who is in the room, what room you are in), who opens the cabinet in the kitchen via watches + beacons
- Speaker ID, mood and stress via voice sound trace
- Sensed-event & time-frame triggered EMA for eating in the absence of hunger, mindfulness, mood.

Figure 1: System overview
In-lab protocols for algorithm development

Family discussion sessions: speaker recognition, mood detection

Eating protocol for eating and drinking detection

Mondol et al, 2016
M2FED
transdisciplinary
data dashboard
M2FED transdisciplinary data dashboard

Phone Usage During Meals
Oct 13 - Nov 11

Phone Usage During Meal

- Idle: 29.2%
- Messenger: 45.6%
- Call: 10%
- Sudoku: 5%
- Google Chrome: 4%

Duration of Meals

- Breakfast
- Lunch
- Dinner
- Snack

Duration (Minutes)

Room location / family presence during the day for Resident 1

- Outsider
- Resident 4
- Resident 3
- Resident 2

Stress Timseries
Oct 13 - Nov 11

Stress Level Throughout the Day

- D...
- R...

Time of Day

Rating (scale of 1-5)

8:00 AM 10:00 AM 12:00 PM 2:00 PM 4:00 PM 6:00 PM

Time of Day

0 1 2 3 4

7:30 AM 9:30 AM 11:30 AM 1:30 PM 3:30 PM 5:30 PM

0 1 2 3 4
Lessons from Digital Natives

**Born Digital:**
Digital blends seamlessly into experience – if it’s good *(Spruijt-Metz et al 2015)*

“**Its like having a doctor in your pocket!**” *(Spruijt, Nilsen, Pavel 2015)*
Lessons from Digital Natives

Trust: Accuracy

- Personal, engaging, but –
- Watch your language

OMG Do Not Say LOL: Obese Adolescents’ Perspectives on the Content of Text Messages to Enhance Weight Loss Efforts

Susan J. Woolford, Kathryn L.C. Barr, Holly A. Derry, Christina M. Jepson, Sarah J. Clark, Victor J. Strecher and Kenneth Resnicow
Lessons from Digital Natives

Willing to share your data and digital traces with researchers like me?

Willing to share that same data with friends/family?

Privacy and security concerns = different than ours:
They are the future. They have much to teach us.
Implications: Thinking outside the Tesseract

- New mind-sets:
  - What *can* we know?
  - What questions should we be asking?
  - What new variables are waiting for us to find them?
- Mash-ups of ‘great data’ and ‘less great’ data
  - At different frequency of collection
  - Ubiquitous and self-report
  - Changing at different rates
- New, computational, **learning** models of individual behavior
- Shared algorithms
- Transdisciplinary collaboration and access to analyses
- Data sharing
- Need for ontologies *(Larsen et al 2016)*
Thank you! Any questions? Please stay connected!

- Donna Spruijt-Metz
- dmetz@usc.edu
IoT: mHealth: 

- Monitoring,
- Modeling,
- Modifying and
- Maintaining health-related behaviors
in (near) Real-Time

Context