

Streaming Sensor Data from the Home

What does it all mean? How can it help you?

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- National Institute on Aging
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- National Institute on Standards & Technology
- TEKES (Finland Government)

- **No conflicts of interest**

- **Collaborative work with**

- Oregon Health & Science University
- University of California at Berkeley



Scalable Approach to Delivering Health Interventions to the Home

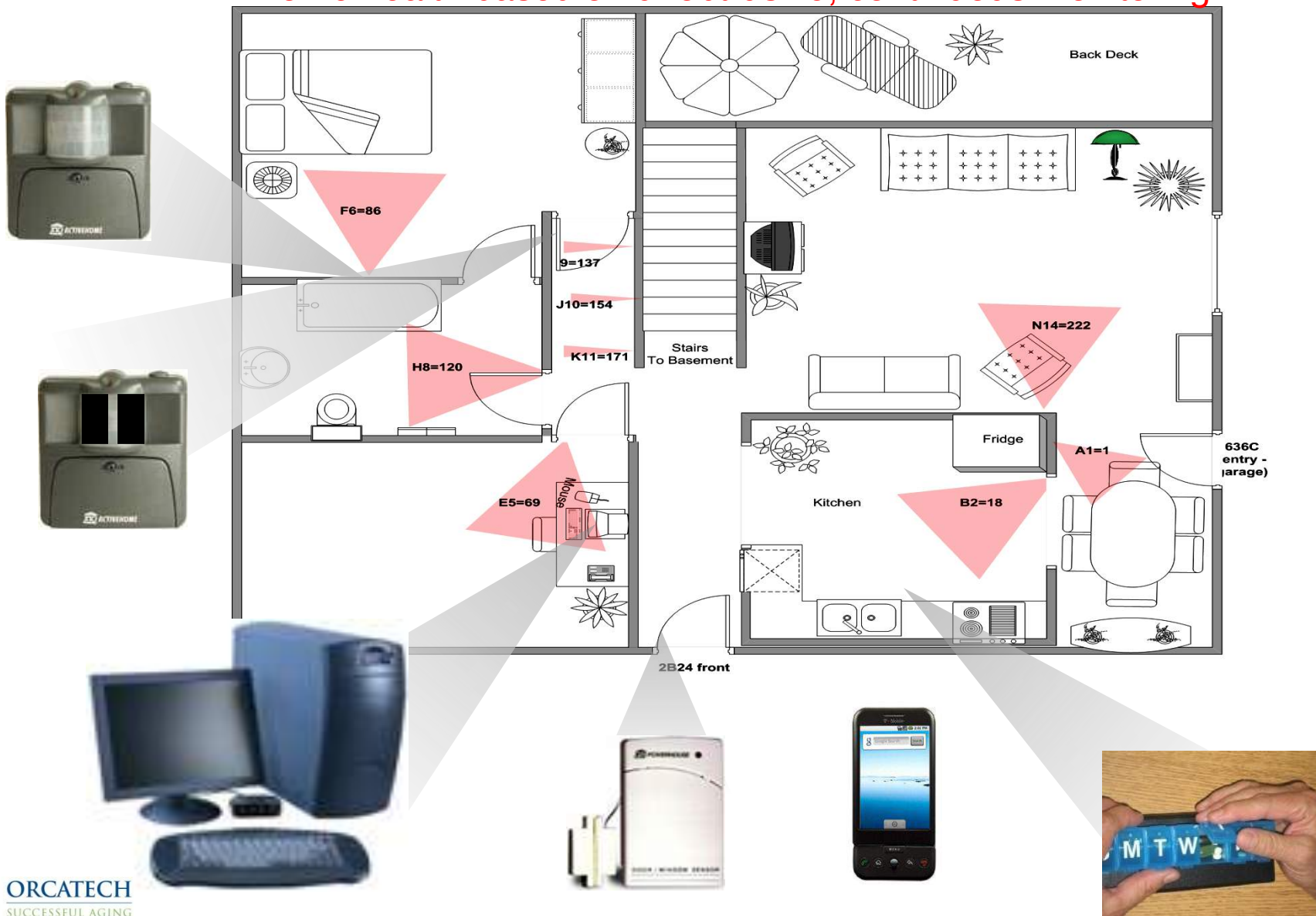
- Sensors, algorithms, mobile communications for lifestyle interventions
- Remote, just-in-time, continuous care
- Incorporate principles of health behavior change
- Optimal use of lower cost personnel
- Integrate family & informal caregivers into the health care team (untapped resource)
- Platform for testing sustained cognitive interventions

Modular Software for Multiple Protocols

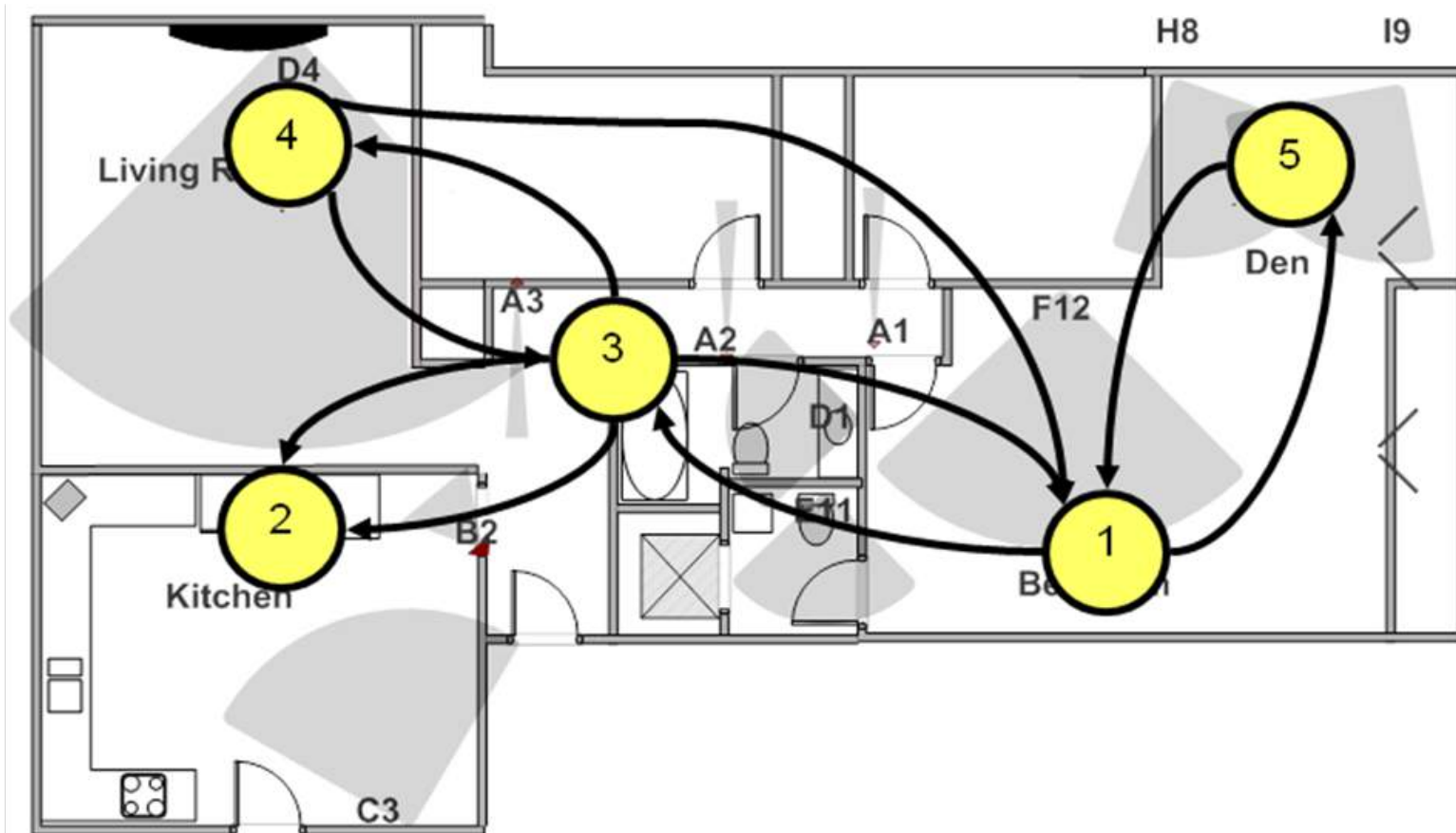
- Cognitive Exercise (computer game format)
- Novelty exercise
- Physical Exercise
- Sleep Management
- Socialization
- Medication Management
- *Mood Management (depression)*

Behavioral Markers = Continuous Monitoring & Computational Models

Home health based on unobtrusive, continuous monitoring



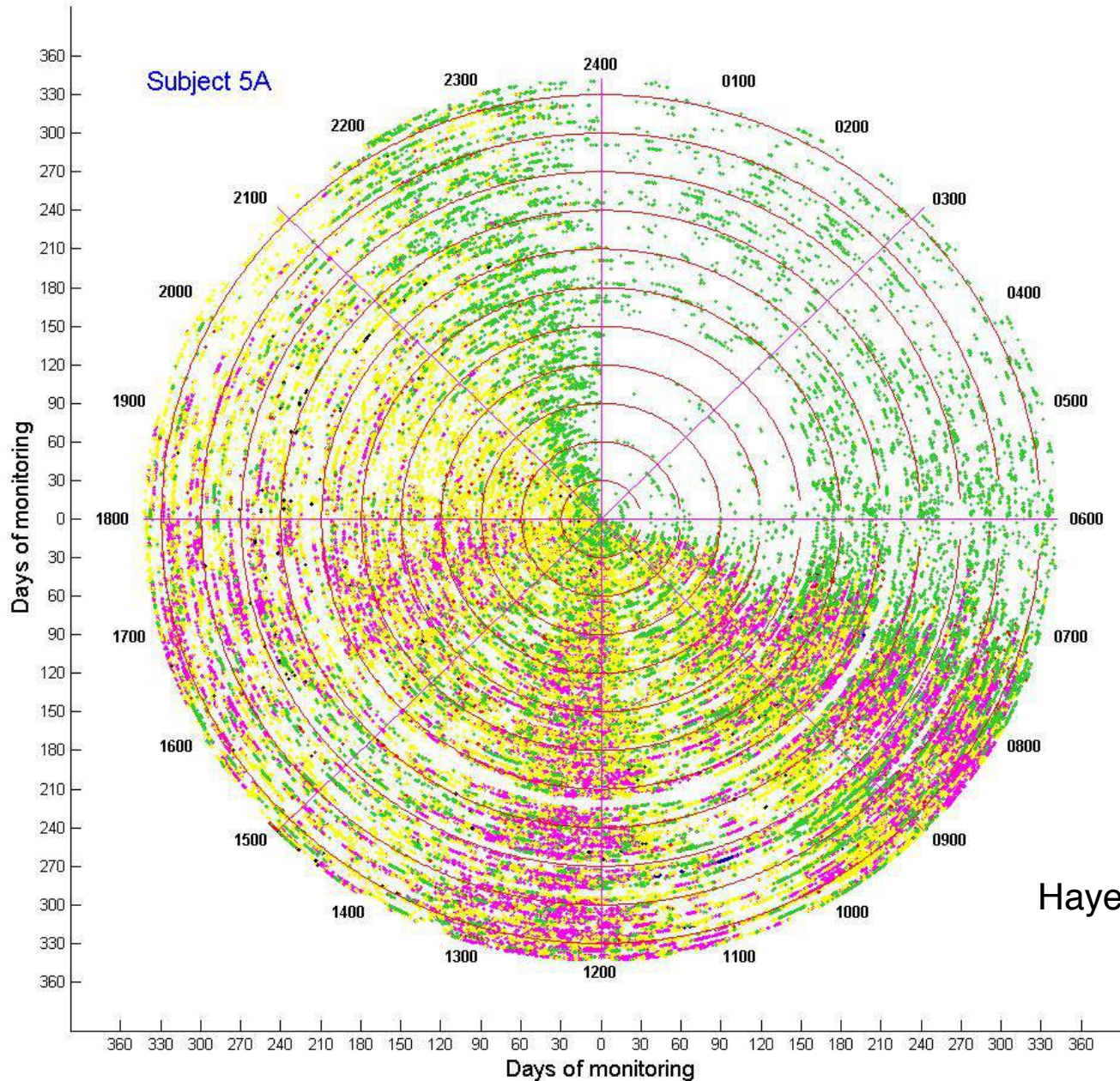
Models to Infer Activities of Daily Living



Pavel et al., IEEE Special Issue, in press

Activity Monitoring in the Home

Sensor Events Private Home

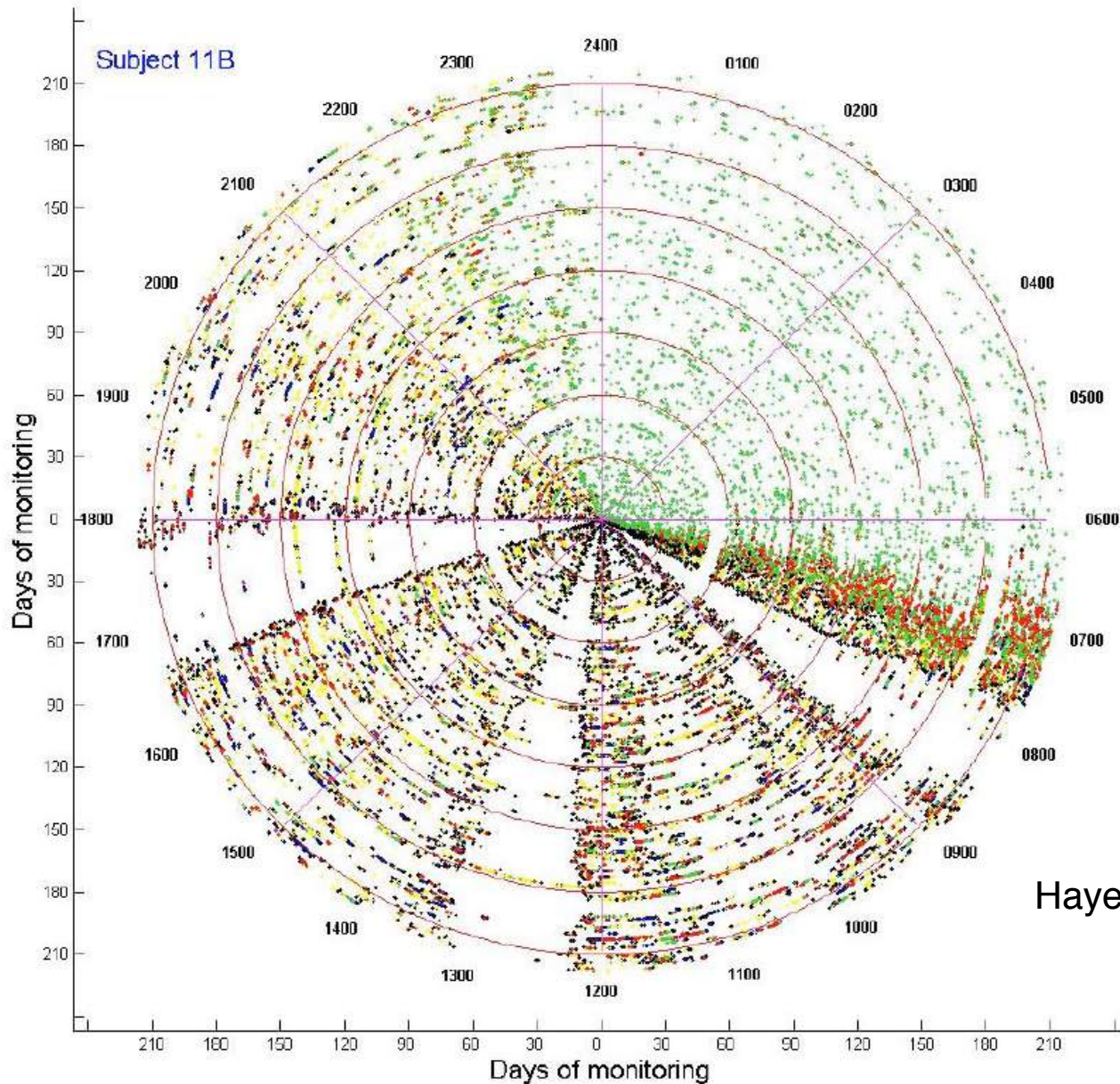


- Bedroom
- Bathroom
- Living Rm
- Front Door
- Kitchen

Hayes et al., www.orcatech.org

Activity Monitoring in the Home

Sensor Events Residential Facility

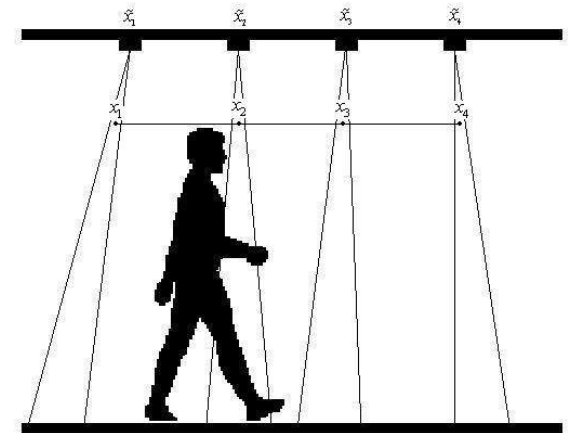


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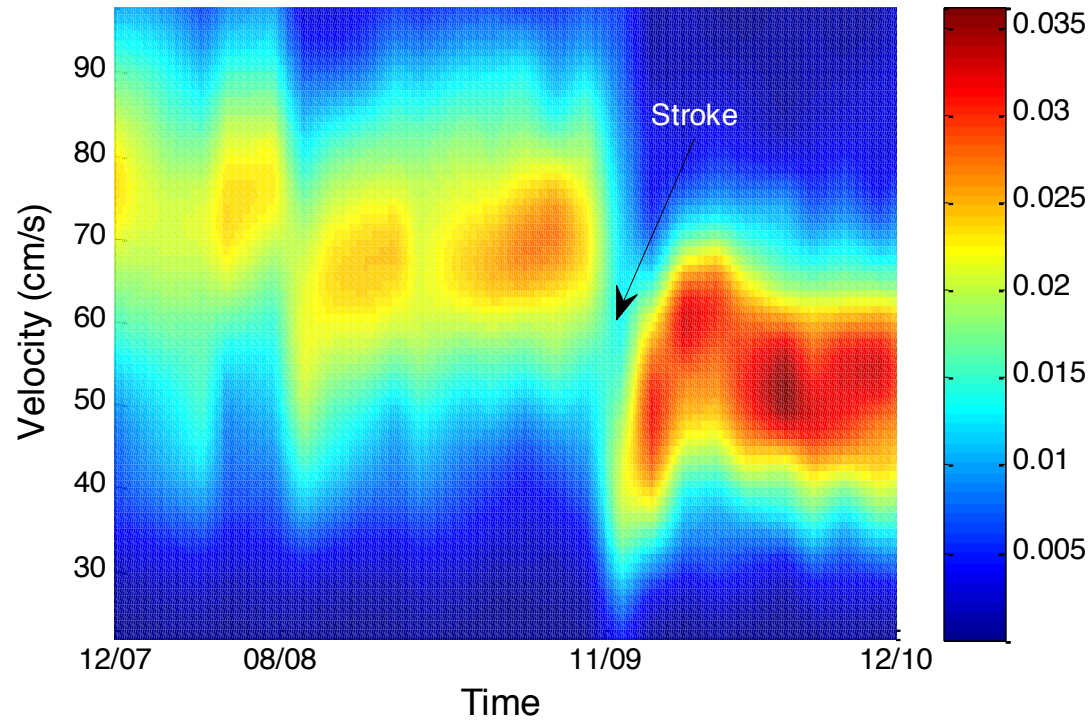
Hayes et al., www.orcatech.org

Measuring Gait in the Home

- **Unobtrusive gait measurement in-home with passive infrared (PIR) sensors** - Hagler, et al., *IEEE Trans Biomed Eng*, 2010
 - Four restricted view PIR sensors
 - Measure gait velocity whenever a subject passes through the “sensor-line”
 - Deployed for the Intelligent Systems for Assessing Aging Changes (ISAAC) study
 - 200+ subjects monitored for > 4 years

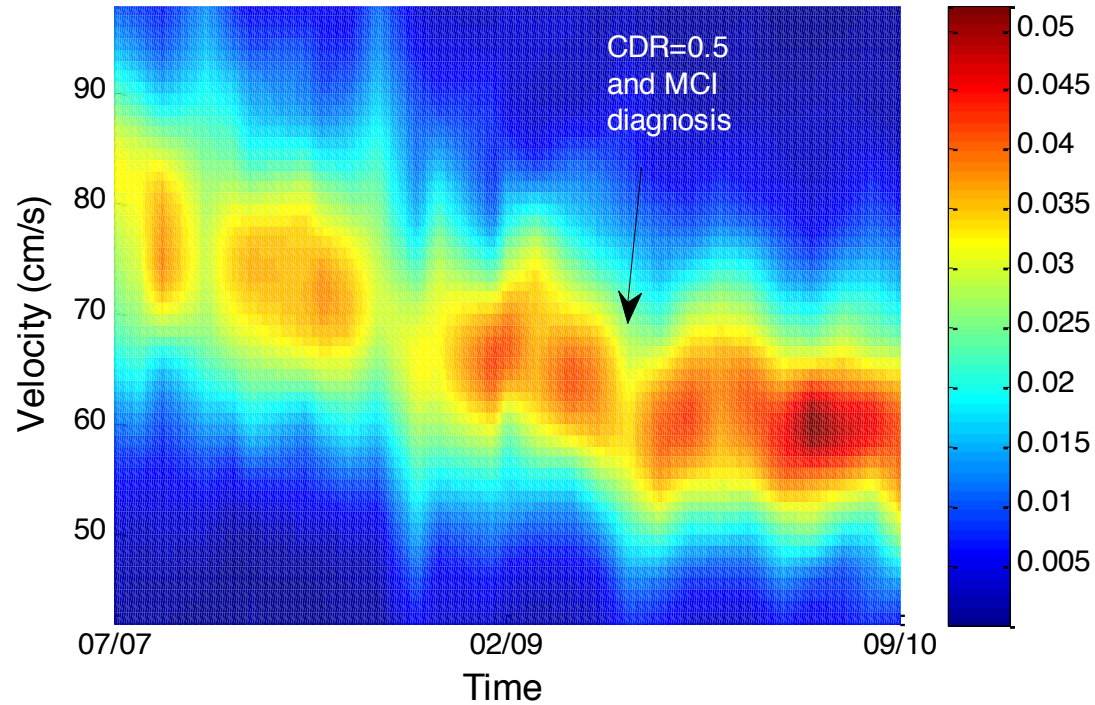


Subject 1



Austin et al, Sept 2011 - EMBC (Gait)

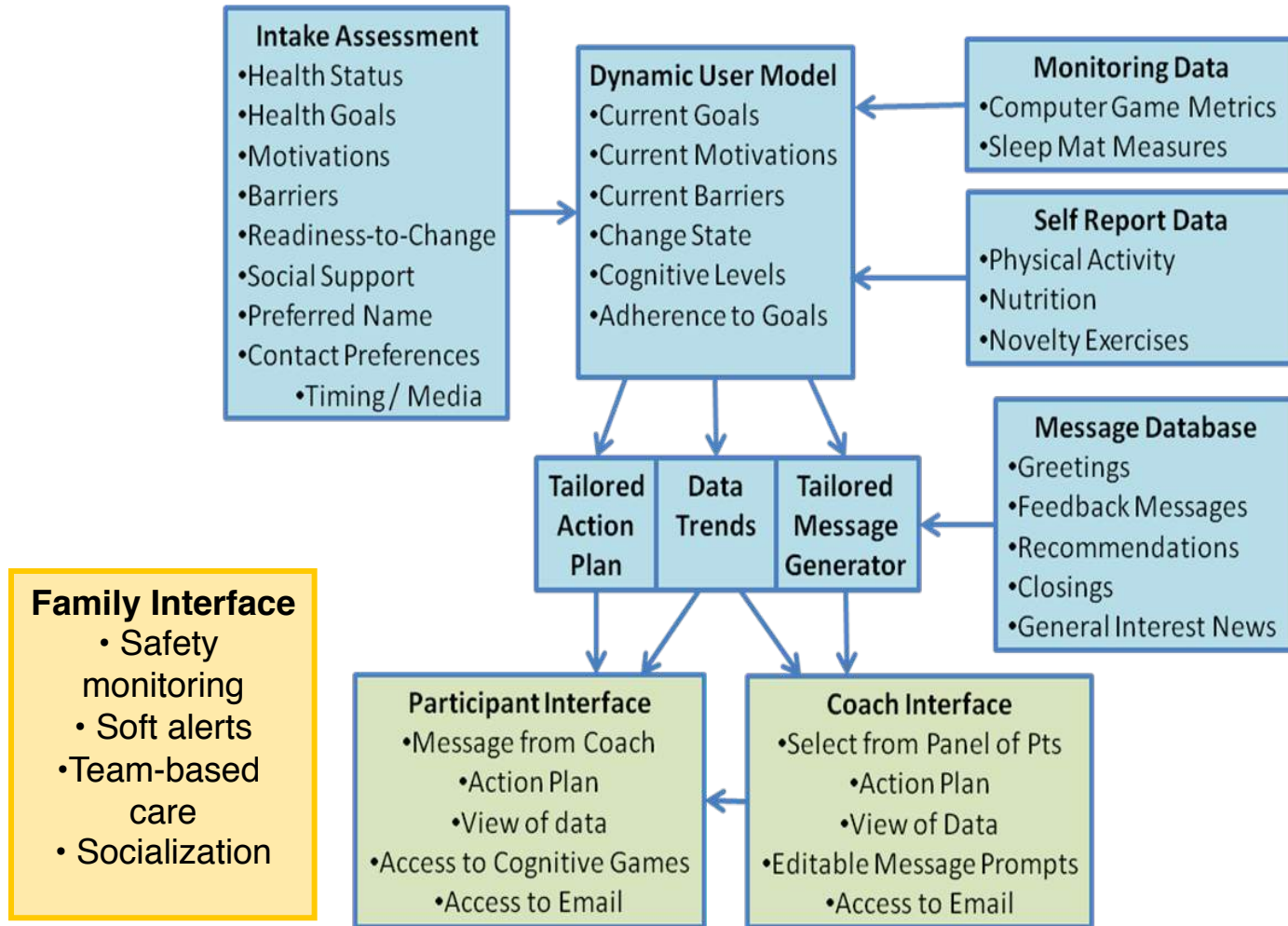
Subject 2



Austin et al, Sept 2011 - EMBC (Gait)

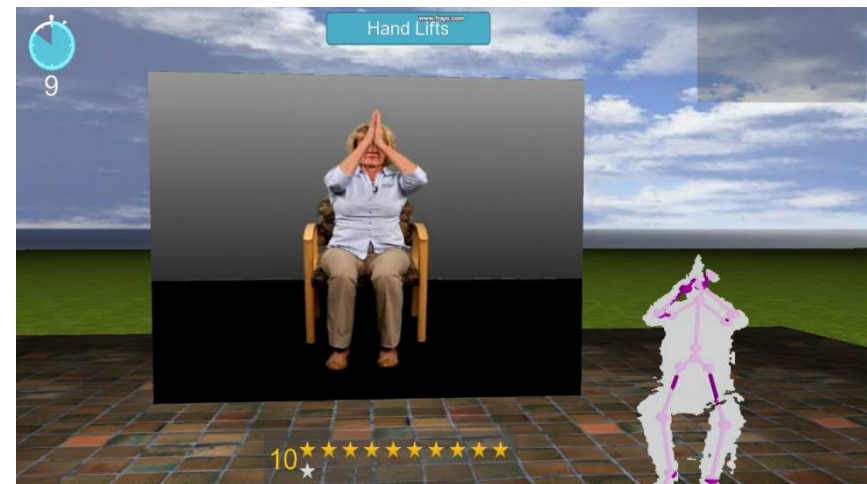
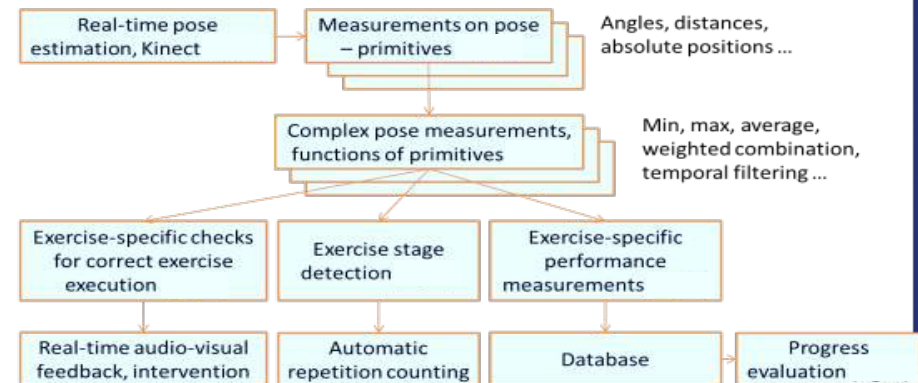


Health Coaching Platform



Automated Coaching for Physical Exercise

- **Collaboration with**
 - Oregon Health and Science University
 - University California Berkeley
- **Pre-recorded video clips for tailored exercise and Kinect Camera**
- **Real-time feedback based on image interpretation from Kinect skeleton representation**
- **Monitoring of balance, flexibility, strength, endurance**
- **Potential for remote interaction**



Sleep Module

Sleep Quality

Survey 0% complete: Page 1 of 1

[Reset](#) [Next](#)

INSTRUCTIONS:

The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, what time have you usually gone to bed at night?

Bedtime:

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

Minutes to fall asleep:

3. During the past month, what time have you usually gotten up in the morning?

Time you get up:

OHSU Brain Health Coaching - Sleep Coaching

General | Yoga | Progress

Take a bath before bed | **Keep a sleep schedule**

Take a bath before bed An hour or two before you go to bed try to take a bath or a shower. A relaxing soak in the tub might help you sleep better.

This activity is self report:

August

| Activities | W | T | F | S | S | S | S | S | S |
|------------------------|---|---|---|---|---|---|---|---|---|
| Take a bath before bed | | | | | | | | | |

OHSU Brain Health Coaching - Sleep Coaching

General | **Yoga** | Progress

Beginner Level 1 This is the first part of the yoga series:

Chair Yoga for 00:19
Muscles benefit from a good morning stretch.

Chair Yoga for 00:28
Yoga is a mind-body practice that's great for relaxing.

Chair Yoga for 00:38
Incorporating rest yoga practices are great when the joints are tired.

Chair Yoga for 00:40
Incorporating a good mobility is a great way to

August

| Activities | W | T | F | S | S | S | S | S | S |
|------------------|---|---|---|---|---|---|---|---|---|
| Beginner Level 1 | | | | | | | | | |

OHSU Brain Health Coaching - Sleep Coaching

General | Yoga | **Progress**

This is a chart of your recent sleep activity that was collected from the sensors in your phone.

Sleep Chart

Legend: Sleep (blue), W (red), Bed (orange), Awake (green)

Y-axis: Sleep (0.0 to 1.0)

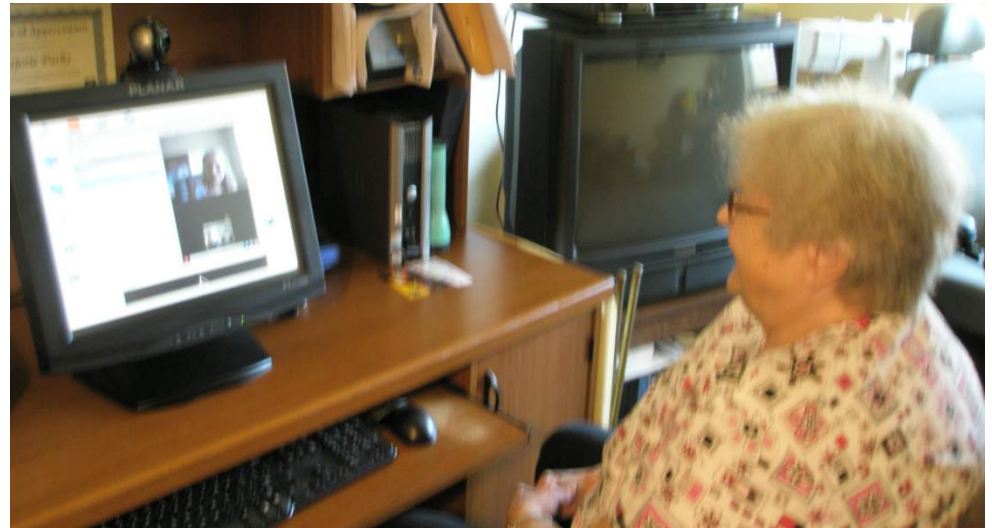
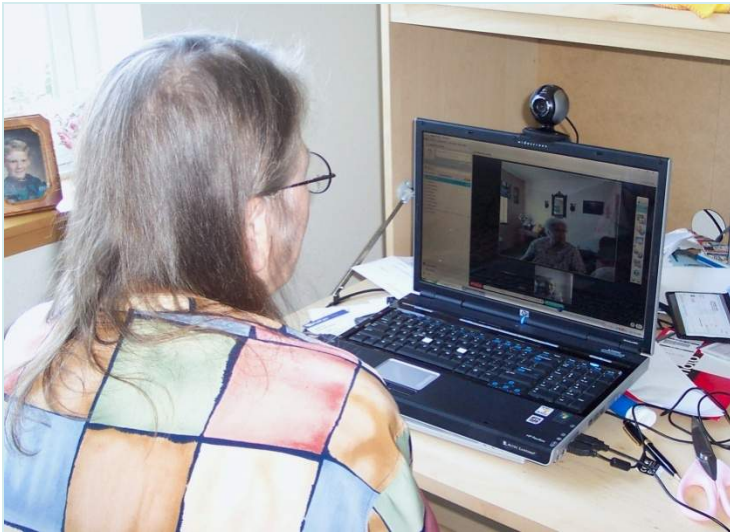
X-axis: Time (2018-08-20 00:00 to 2018-08-20 06:00)

Assessment

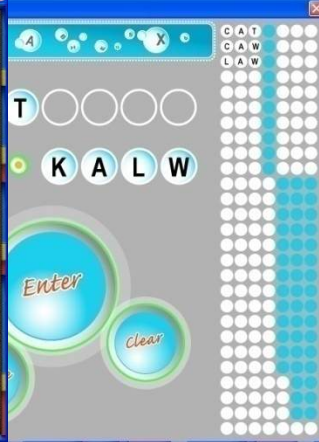
- Sleep Hygiene
 - Anxiety
 - Circadian Rhythm
- ## Tailored Intervention

Socialization Protocols for Cognitive Health

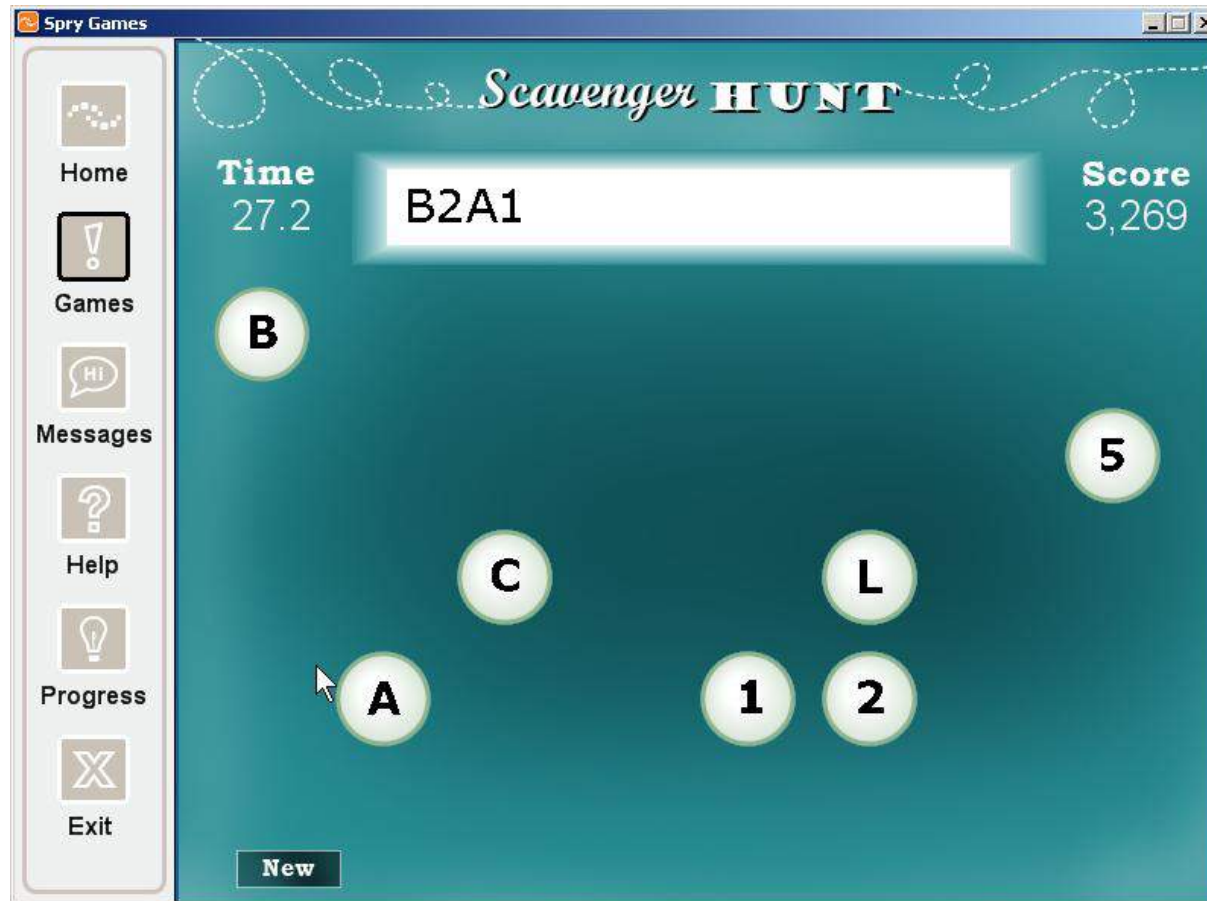
- Web cams and Skype software given to participants and their remote family partner
- Frequent spontaneous use among participants



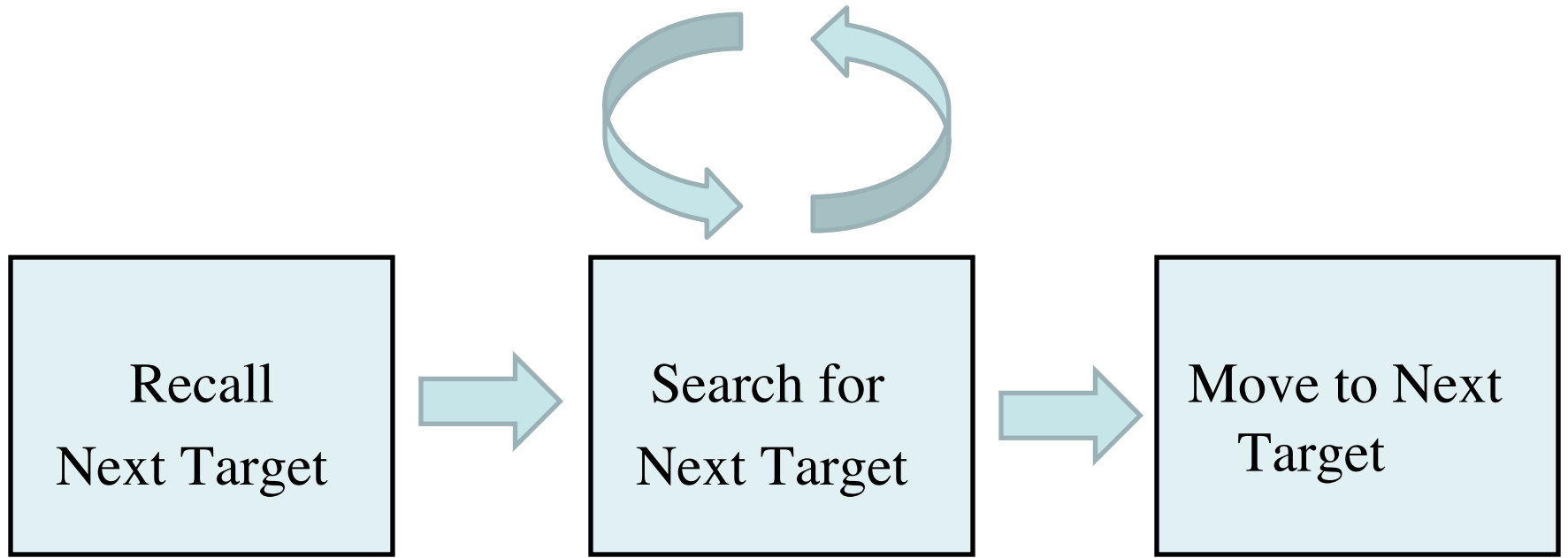
Cognition - Monitoring & Intervention



Computer Game to Measure Executive Function

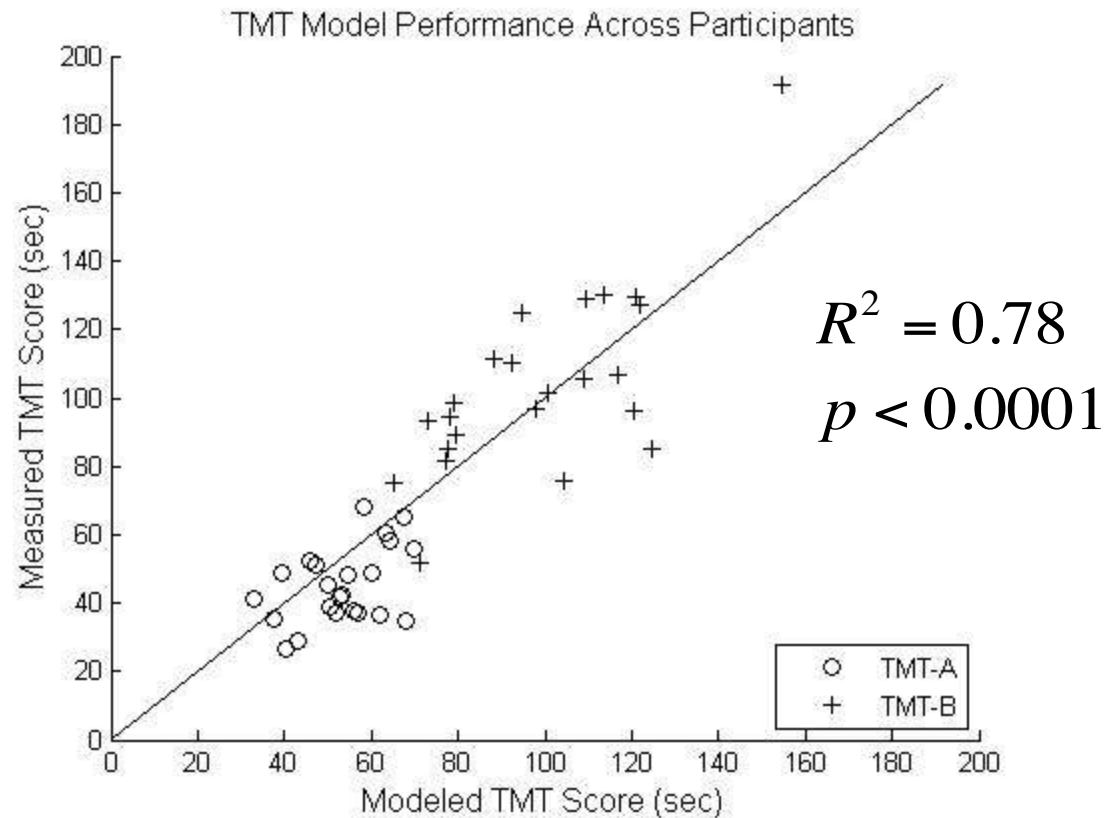


Model the timing of the mouse clicks

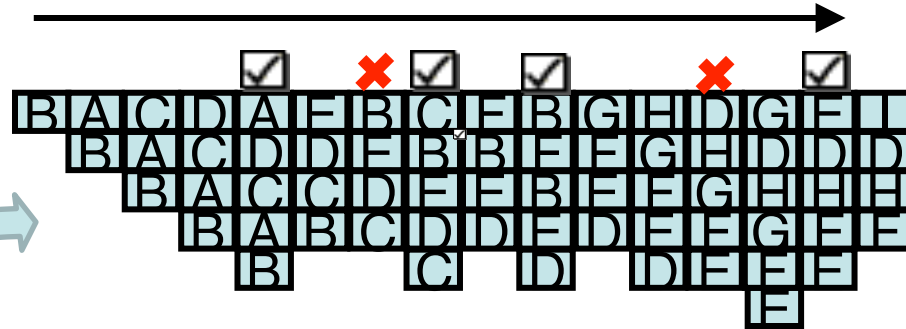


$$t_R + t_S(n, d) + t_M$$

Estimates from Game Predict TMT Scores



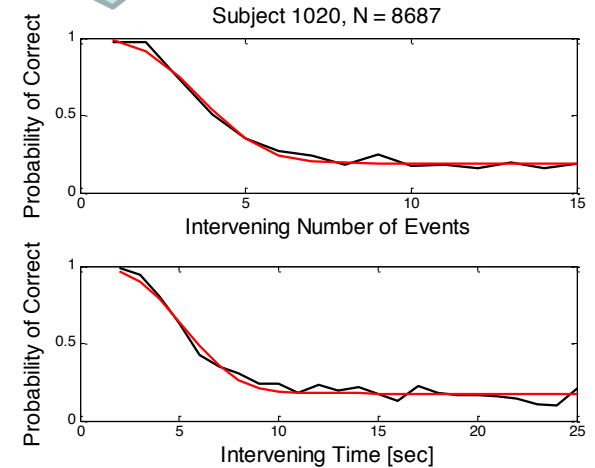
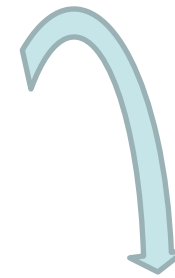
Cognitive Modeling Example: Memory



Characterize Memory Capacity

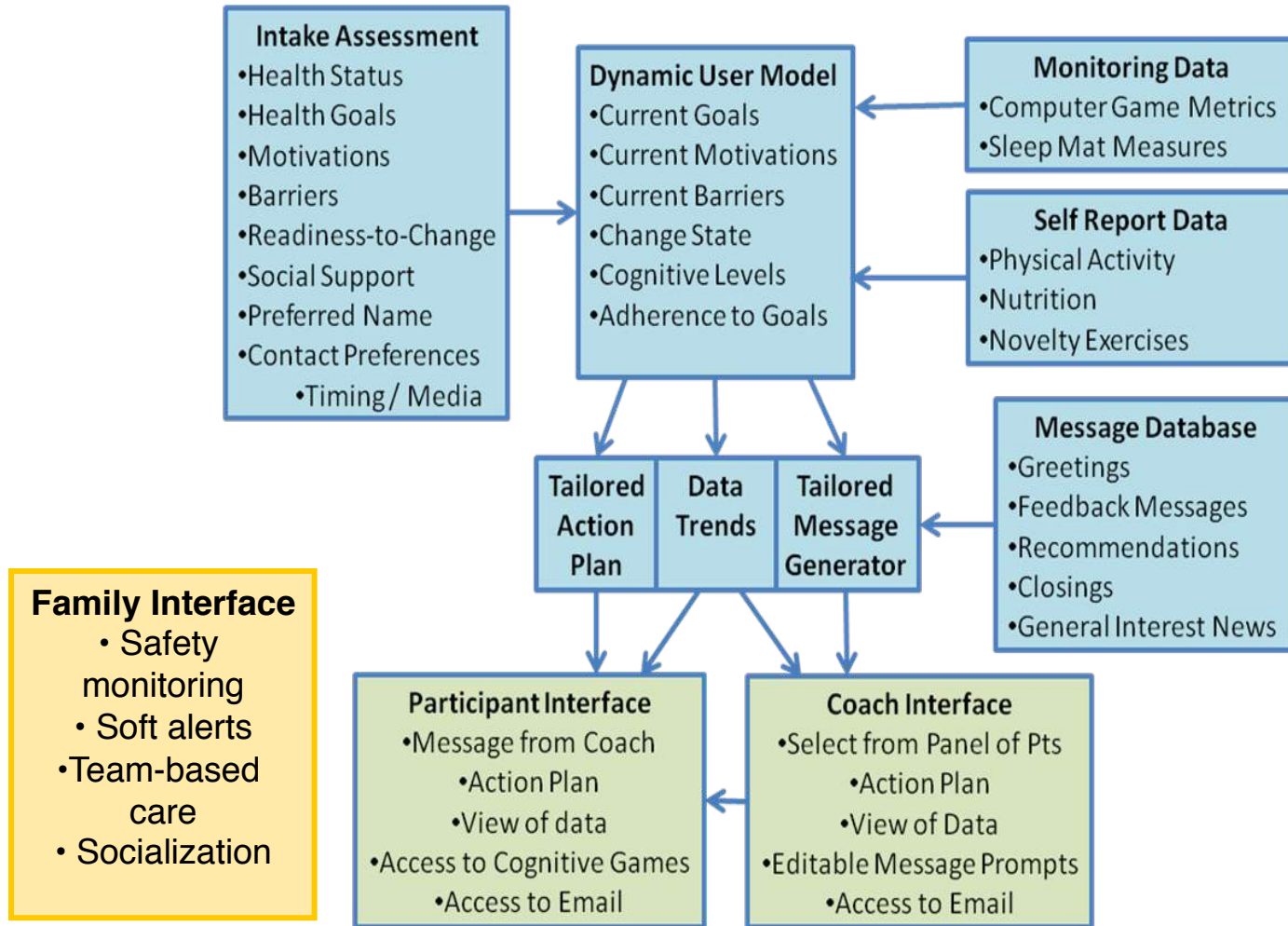
- Intervening number of events
- Intervening time
- Memory load

Simple Memory Model: Discrete Buffer



Characterize Memory Capacity with a Single Parameter

Dynamic User Model to Support Tailored Messaging



Family Caregiver Interface

[Link to Demo](#)



Monitoring -> Intervention

- **Activity Monitoring in the Home**
- **Cognitive Monitoring**
 - Adaptive Computer Games – Divided Attention, Planning, Memory, Verbal Fluency, +++
 - Linguistic Complexity – Emails, phone
- **Motor Speed**
 - Speed of Walking, Computer Typing, Mouse Movements
- **Sleep Monitoring**
- **Depression – affect on phone, linguistic analysis**
- **Medication Management – Context aware reminding**
- **Socialization – Skype, phone, emails**
- **Physical Exercise – Interactive video**