

Big Data Challenges in Delivering Health Coaching Interventions to the Home



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&

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Monitoring->Care

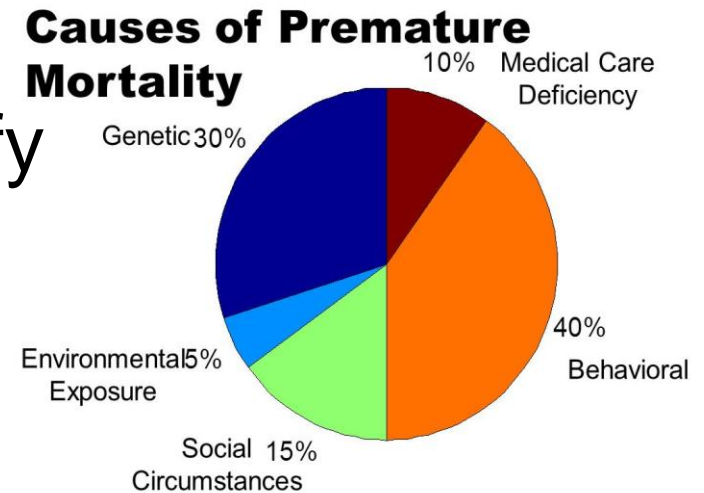


M Pavel, H Watclar, CISE, NSF



Technology for Health Coaching

- Importance of health behavior change
- How technology can amplify the scalability and effectiveness of health interventions
 - Tailoring of materials
 - Timeliness
 - Extend the reach of a coach



McGinnis JM, Russo PG, Knickman, JR. Health Affairs, April 2002.



Evidence-Based Principles

Theory-based coaching

- Develop shared goals with patient preferences
- Assess readiness to change, motivations, triggers, barriers, self-efficacy
- Tailor interactions (action plan, messages)
- Continuous monitoring with just-in-time intervention

Current practice

- ✓ Human - phone interaction at baseline
- ✓ Human - phone interaction at baseline
- ✓ Human phone interaction at baseline
- -- Predetermined set intervals for phone calls



What do coaches actually do?

Motivational Interviewing

- Collaborative (don't impose)
- Assess motivations to change
- Assess barriers to change
 - What are the triggers?
 - Develop problem solving plan for dealing with those situations
- Develop a tailored shared action plan
- Monitor & provide feedback / encouragement



Examples from Monitoring Older Adults

- Examples of New Behavioral Measures (used in remote coaching research)
 - Activity Monitoring in the Home
 - Cognitive Monitoring
 - Motor Speed
 - Sleep Monitoring
 - Socialization – Skype, phone, emails
 - Physical Exercise
 - Medication Management
 - Depression



ORCATECH
SUCCESSFUL AGING
WITH TECHNOLOGY

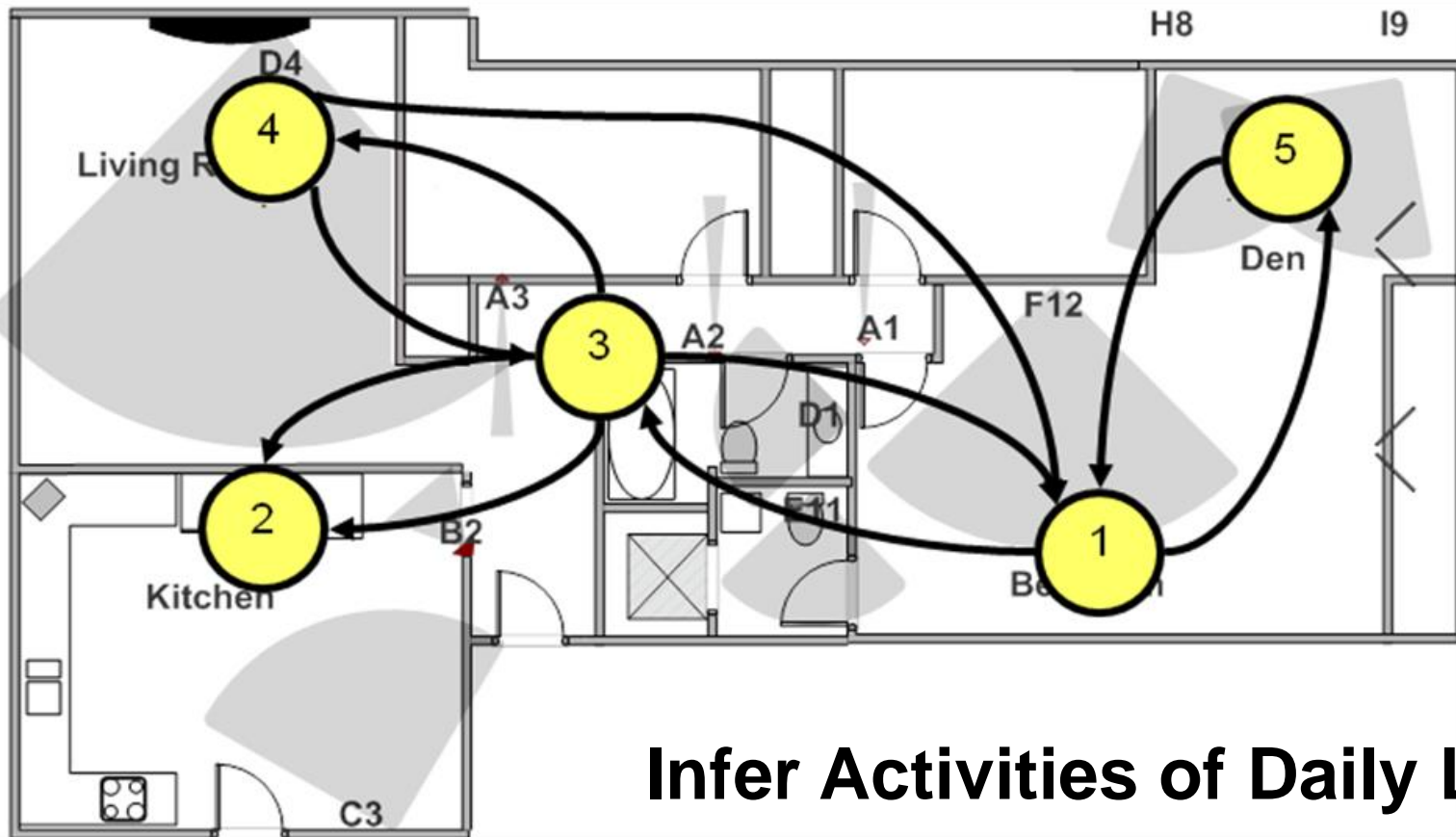


Northeastern University

Inference of Patient Activities Based on Sensor Data



Models to Infer Sensor Location & Legitimate Pathways

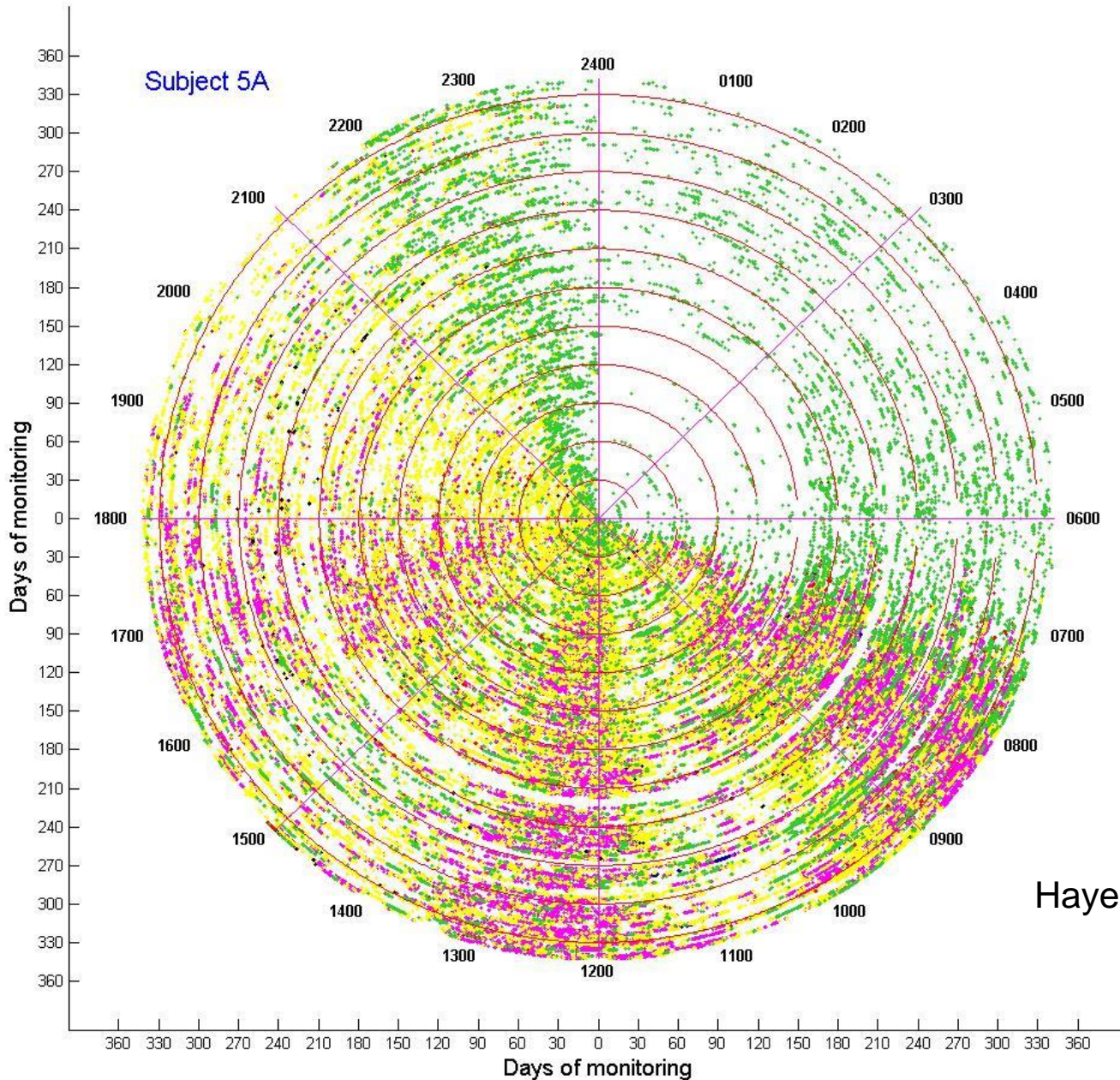


Infer Activities of Daily Living

Pavel et al., The role of technology and engineering models in transforming healthcare, IEEE Reviews in Biomedical Engineering, 6:156-177 (2013)

Activity Monitoring in the Home

Sensor Events Private Home

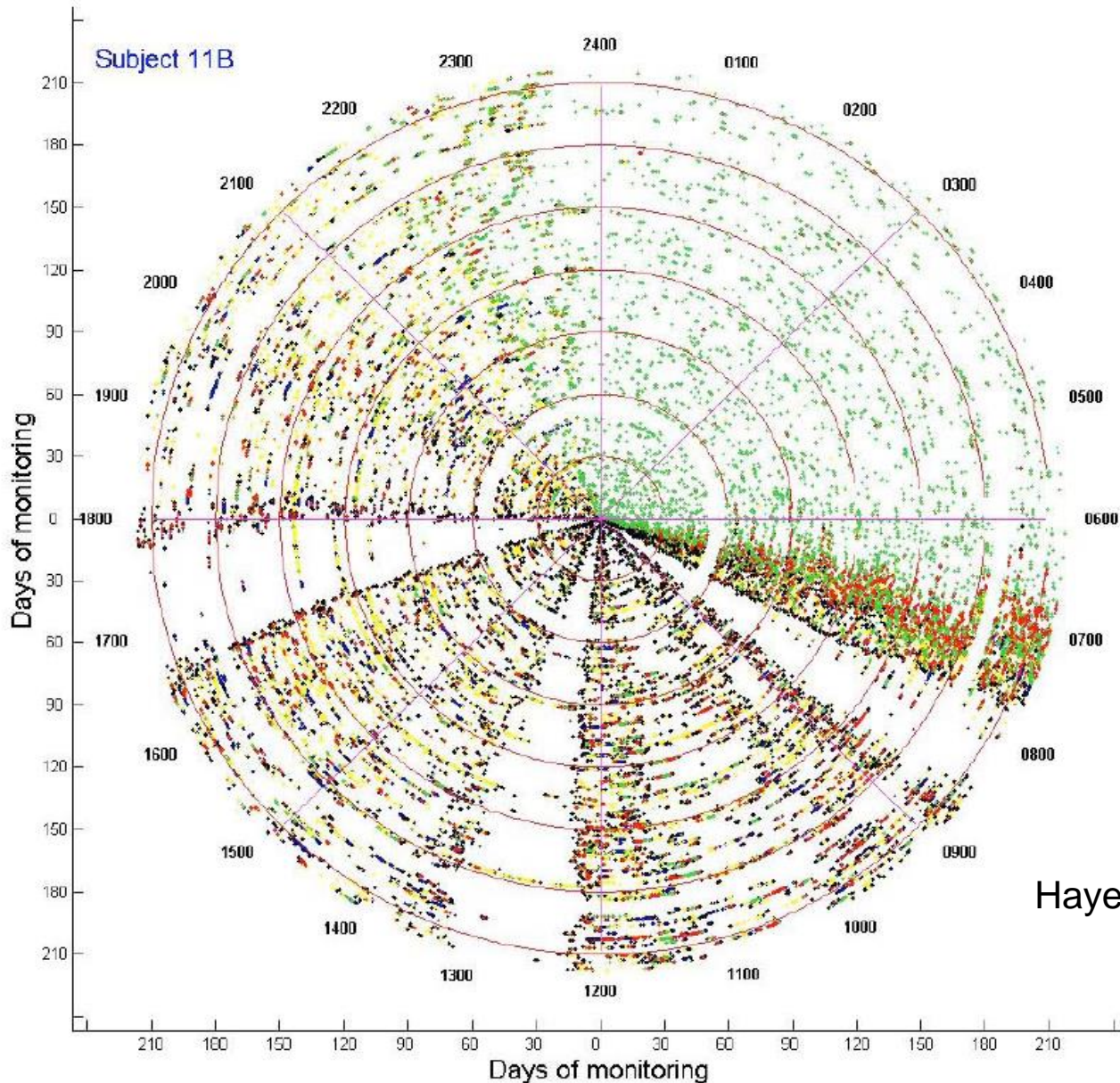


- Bedroom
- Bathroom
- Living Rm
- Front Door
- Kitchen

Hayes et al., www.orcatech.org

Activity Monitoring in the Home

Sensor Events Residential Facility

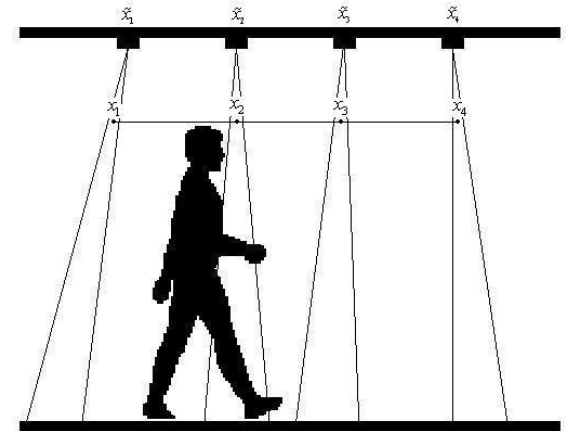


- Bedroom
- Bathroom
- Living Rm
- Front Door
- Kitchen

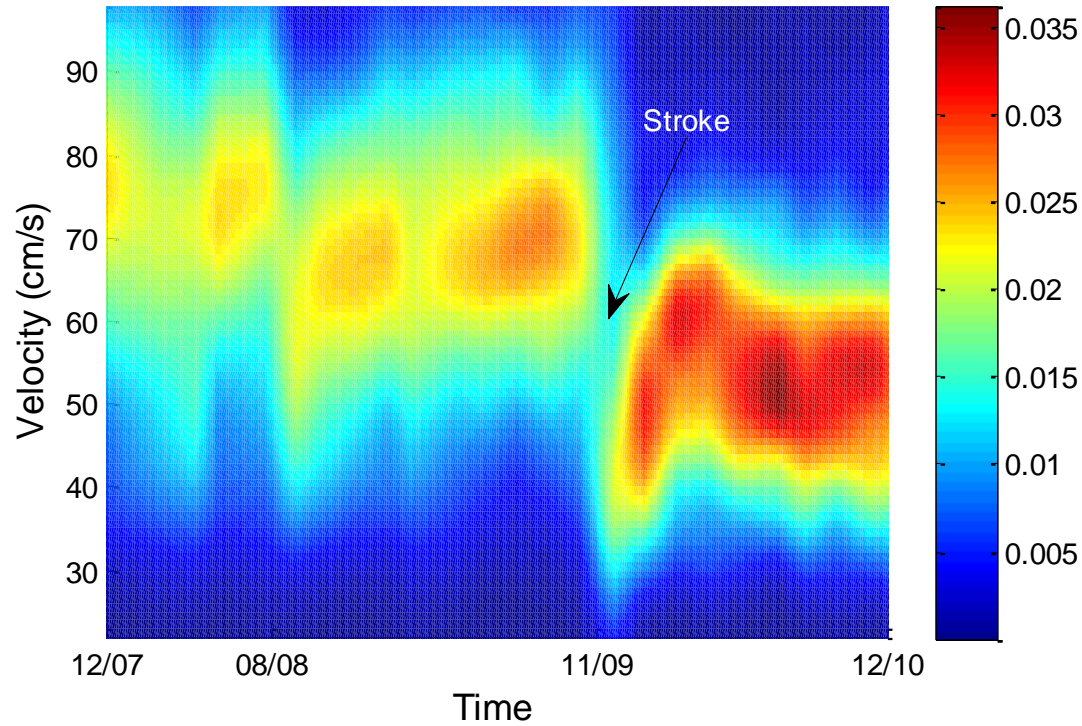
Hayes et al., www.orcatech.org

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 when subjects pass through the “sensor-line”
 - Deployed for the Intelligent Systems for Assessing Aging Changes (ISAAC) study
 - 200+ subjects monitored for > 4 years

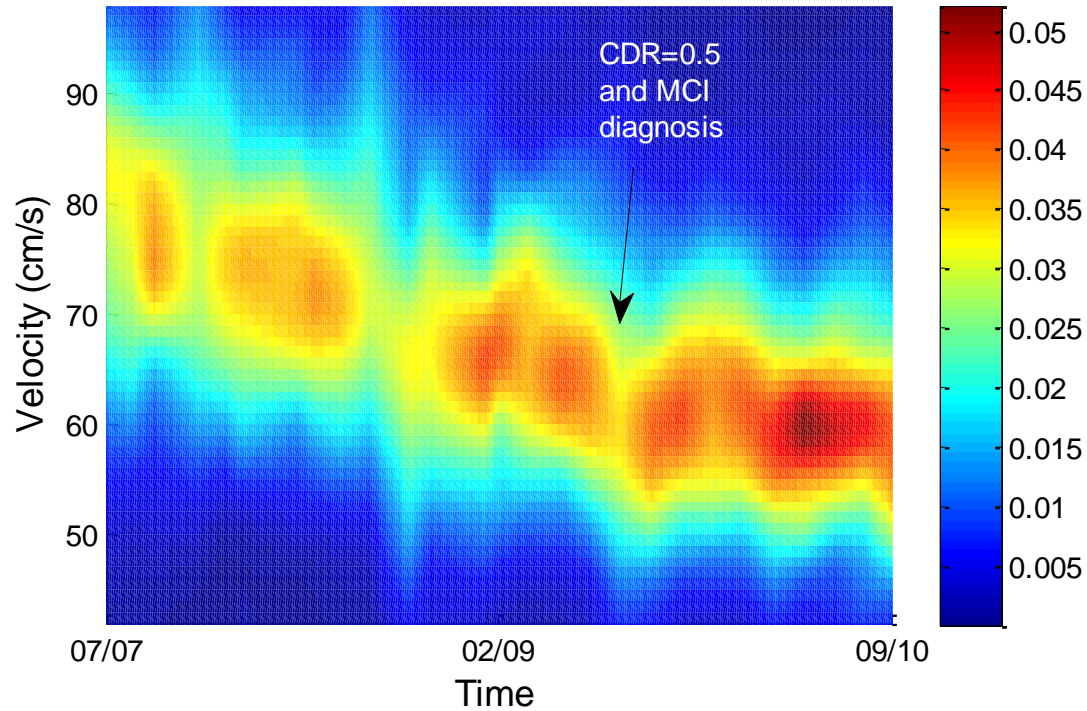


Subject 1



Austin et al, Sept 2011 - EMBC (Gait)

Subject 2



Austin et al, Sept 2011 - EMBC (Gait)

Creating Design Requirements

- Focus groups with elders and caregivers
- Expert interviews with stakeholders
- Technology assessment and interoperability standards review
- Resulting design recommendations
 - Tailored action plans for health interventions
 - Home monitoring
 - Decision support
 - Integration of nurse care managers and family caregivers into the health care team
- Development of use cases

Jimison, HB and Pavel, M. Integrating Computer-Based Health Coaching into Elder Home Care, Technology and Aging, eds. Mihailidis, A., Boger, J., Kautz, H., and Normie, L., IOS Press, Amsterdam, The Netherlands, 2008.

Participatory Design

- Living Lab –
 - Community dwelling seniors
 - Portland area; now Boston
 - Living independently
 - Used to test technologies to support independent living and provide scalable quality care in the home setting

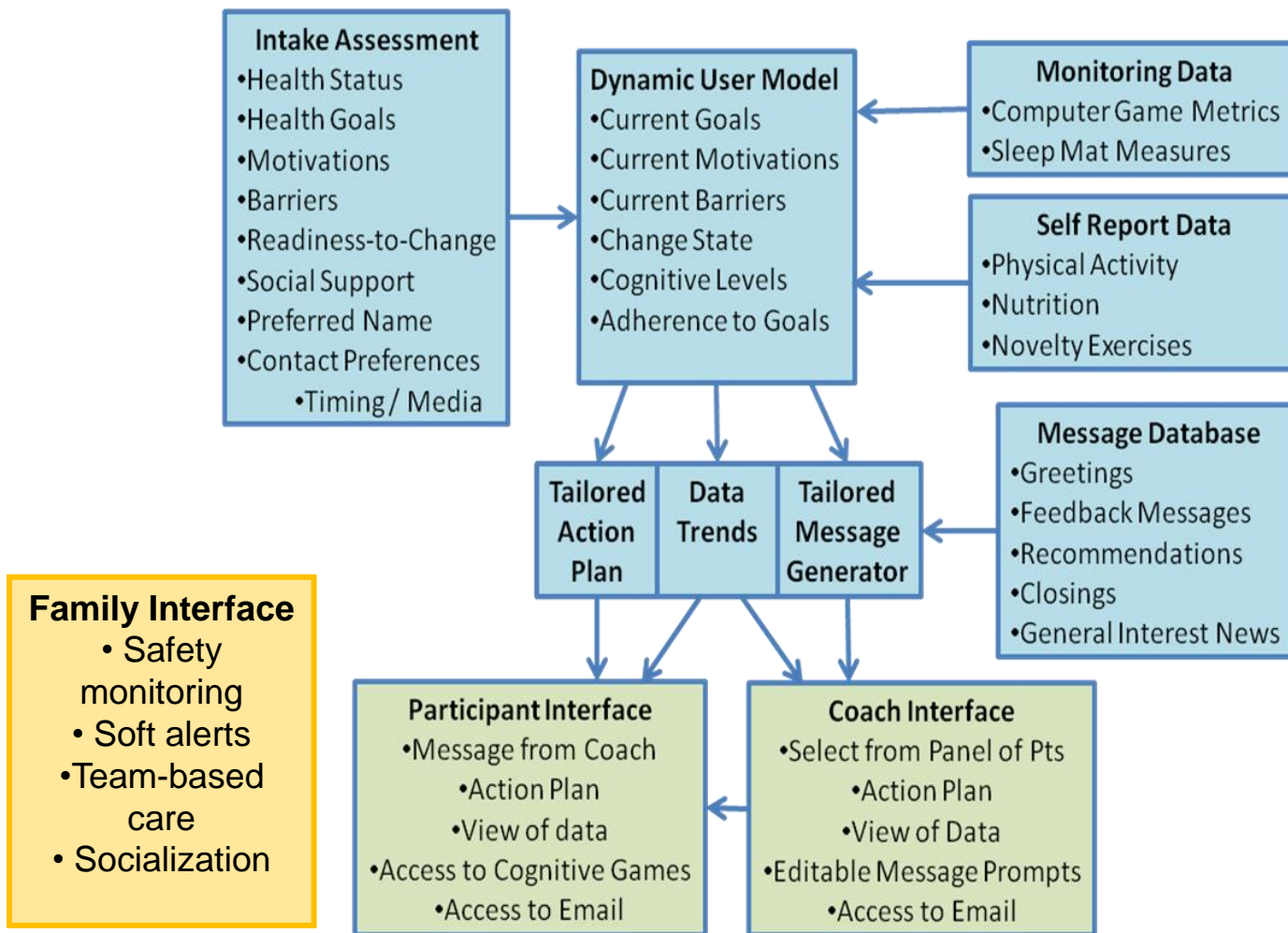


Technology Approaches to Facilitating Health Coaching

- Effective use of resources
 - Wise use of face-to-face, Skype, phone interactions (build rapport, careful assessment)
 - Supplemented by automated or semi-automated messages
- Dynamic user model
 - Behavior change variables
 - Activity / context / health state estimates from sensor data



Dynamic User Model to Support Tailored Messaging



Semi-Automated Messaging

Study of coaching efficiency with/without assisted messaging

- Coaches (n=6) completed 4 coaching sessions for a panel of 10 (simulated) patients, half using automated system, half using manual system. Coaches were crossed over to alternate system after each session.
- **Efficiency** improved with semi-automated system (mean time to clear patient manual 4:26 min vs 2:39 min ($p < .04$))
- **Quality** of message judged equivalent on average by both patients and other coaches.

Participant Home Page



Participant home page

- [Messages from coach](#)
- Featured story
- Weekly goals
 - Activities
 - [Surveys](#)
- Access modules
 - [Physical Activity](#)
 - [Sleep](#)
 - [Socialization](#)
 - [Novelty Mental Exercises](#)
 - [Cognitive Games](#)
- [Coaching Process](#)
- [Participant Materials](#)

OHSU Brain Health Coaching

Where Healing, Teaching & Discovery Come Together

Bill logged in: [Log out](#)

Next check in date: Sun August 7th
Week of Coaching: 69

Home | Coaching | Messages | Surveys | Status | Help

Latest News

Message from the Coach

M2 Your interest in the computer games seems to have fallen off. Would you like some help with Skype Call? When you encounter addition or subtraction in you life, do the calculation by hand. Do this one time. Count backwards from 100 by different increments Do this one time. Take a different route to your destination. Do this one time. Greet everyone you meet by name. Do this one time. When you encounter multiplication or division in you life, do the calculation by hand. Do this one time. A collection of relaxing music that will help you fall asleep Do this one time. A collection of soothing sounds that incorporate pianos and stringed instruments Do this one time. This is the first [More...](#)

Featured Story

[The Toll of Sleep Loss in America](#)

Sleep loss is taking a toll on our physical and emotional health, and on our nation's highways.

Goals

Currently viewing: this week

		August								
		3	4	5	6	7	8	9		
Activities		W	T	F	S	S	M	T	Total	Goal
Cognitive Games	Pyramid Builder	0	0	0	0	0	0	0	0	2
	Letter Lotto	0	0	0	0	0	0	0	0	2
	FreeCell	0	0	0	0	0	0	0	0	2
	Story Teller	0	0	0	0	0	0	0	0	1
Novelty Mental Exercises	Sound Replay	0	0	0	0	0	0	0	0	1
	Tell Us Apart	0	0	0	0	0	0	0	0	1
	Addition and Subtraction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0	1
Novelty Mental Exercises	Multiplication and Division	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0	1
	Take a different route	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0	1



Physical Activity Module



https://sprybox.bme.og.edu/console3_debug/coaching/view/Physical_Exercises.php

General Away From Home Activity List Videos Surveys Progress Spark People

Warm-ups Beginning

Beginning A great place to start with exercise

Stronger 04:41
A great way for Seniors to get the heart rate up and get

Stronger- 04:41
http://www.og.edu/

Talji On 04:41
Visit http://www.og.edu/

Talchi e 04:41
his is the designed t

talchi e 04:41
that is the back for n

Energy I 04:41
A sample i
Movies see

August 6 7 8 9 10 11 12

Activities	S	S	M	T	W	T	F	Total	Goal
Beginning	0	0	0	0	0	0	0	0	1

https://sprybox.bme.og.edu/console3_debug/coaching/view/Physical_Exercises.php

General Away From Home Activity List Videos Surveys Progress Spark People

Warm-ups Beginning

Warm-ups These are the warm-up exercises.

Smart Moves 05:27
Seated warm up and stretch
Chair exercise

B Seated Warm 02:26

August 6 7 8 9 10 11 12

Activities	S	S	M	T	W	T	F	Total	Goal
Warm-ups	0	0	0	0	0	0	0	0	1

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Where Healing, Teaching & Discovery Come Together

Jennifer logged in: Log out

Next check in date: Wed, August 10th
Week of Coaching: 8

Home • Coaching • Messages • Surveys • Status • Help

OHSU Brain Health Coaching

Physical Exercises

General Away From Home Activity List Videos Surveys Progress Spark People

Physical Exercises Chart This page charts your progress of physical exercises performed.

% Physical Activities Completed

100%
75%
50%
25%
0%

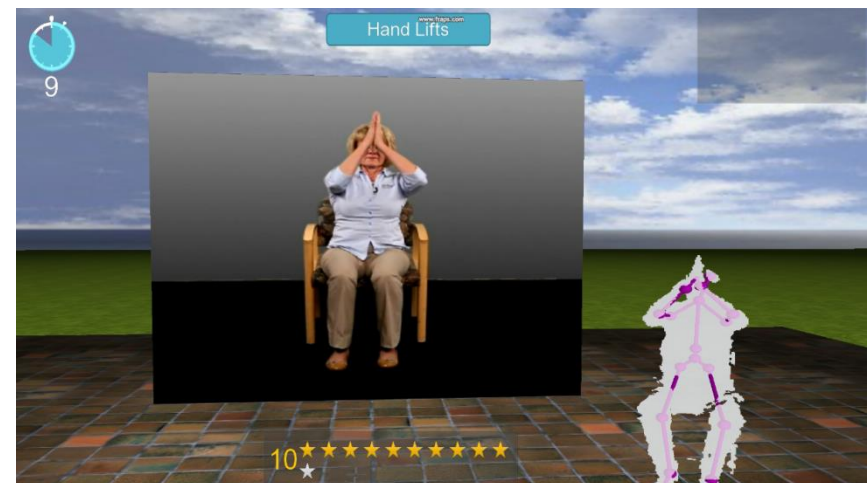
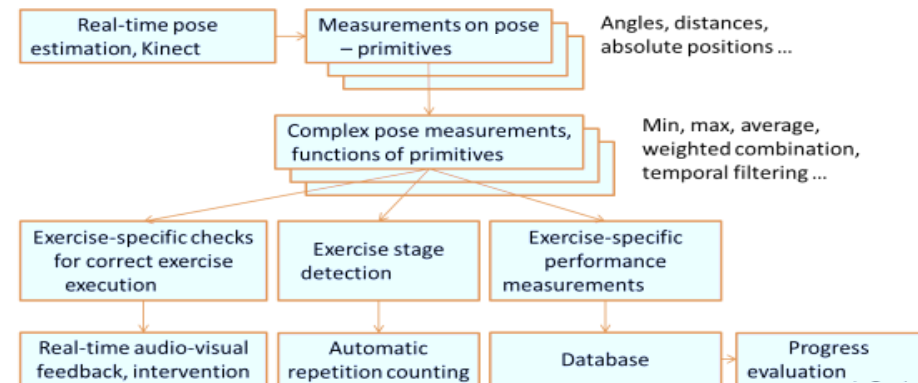
2011-08-06 2011-08-07 2011-08-08 2011-08-09 2011-08-10 2011-08-11 2011-08-12 2011-08-13

Date



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

Assessment

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

OHSU Brain Health: Home

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Next check in date: Mon. August 15th
Week of Coaching: 6

Home • Coaching Messages • Surveys Status • Help 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 shower. A relaxing soak in the tub might help.

This activity is self report:

August	3	4	5	6	7	8	9	Total	Goal
W	T	F	S	S	M	T		0	1
Take a bath before bed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>		0	1

OHSU Brain Health: Home

Guest logged in: [Log out](#)

Next check in date: Mon. August 15th
Week of Coaching: 6

Home • Coaching Messages • Surveys Status • Help OHSU Brain Health Coaching

Sleep Coaching

General Yoga Progress

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

Chair Yoga for 02:03 Mindfulness breathing is a yoga exercise that practices

Chair Yoga for 02:23 Yoga is a meditative practice that's great for releasing

Chair Yoga for 03:19 Wrist and feet yoga exercises are good ways for senior

Chair Yoga for 02:46 Performing a relaxing meditation is a great way for

August	3	4	5	6	7	8	9	Total	Goal
W	T	F	S	S	M	T		0	1
Beginner Level: 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>		0	1

OHSU Brain Health: Home

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Next check in date: Mon. August 15th
Week of Coaching: 6

Home • Coaching Messages • Surveys Status • Help OHSU Brain Health Coaching

Sleep Coaching

General Yoga Progress

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

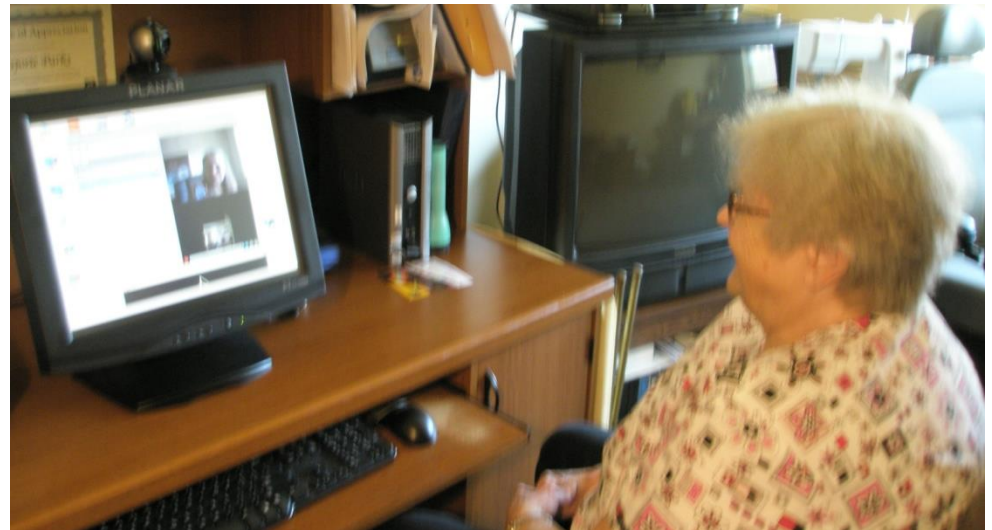
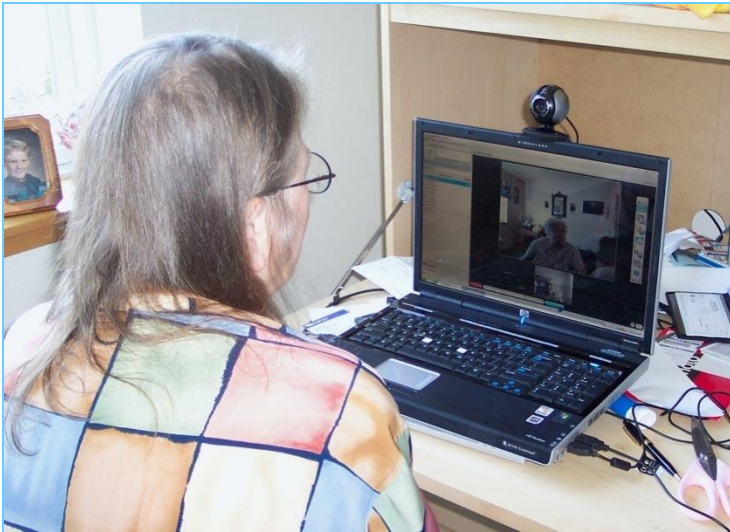
Legend: Hours of Sleep (blue), Quiet (red), Bed Count (orange)

Y-axis: Sleep (Hours of Sleep, Quiet, Bed Count) from -1.0 to 1.0

X-axis: Date (2011-07-18 to 2011-08-05)

Socialization Intervention

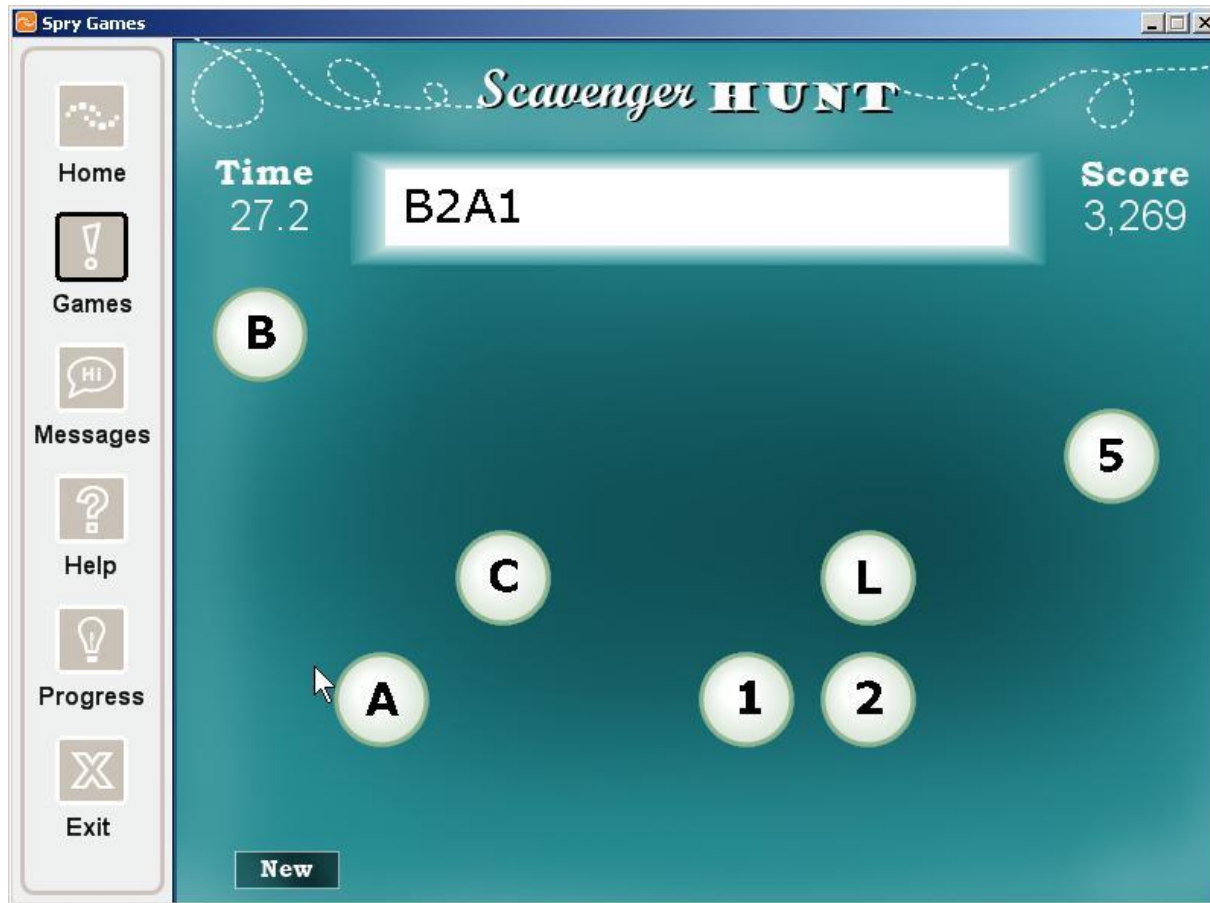
- Web cams and Skype software given to participants and their remote family partner
- Frequent spontaneous use among participants



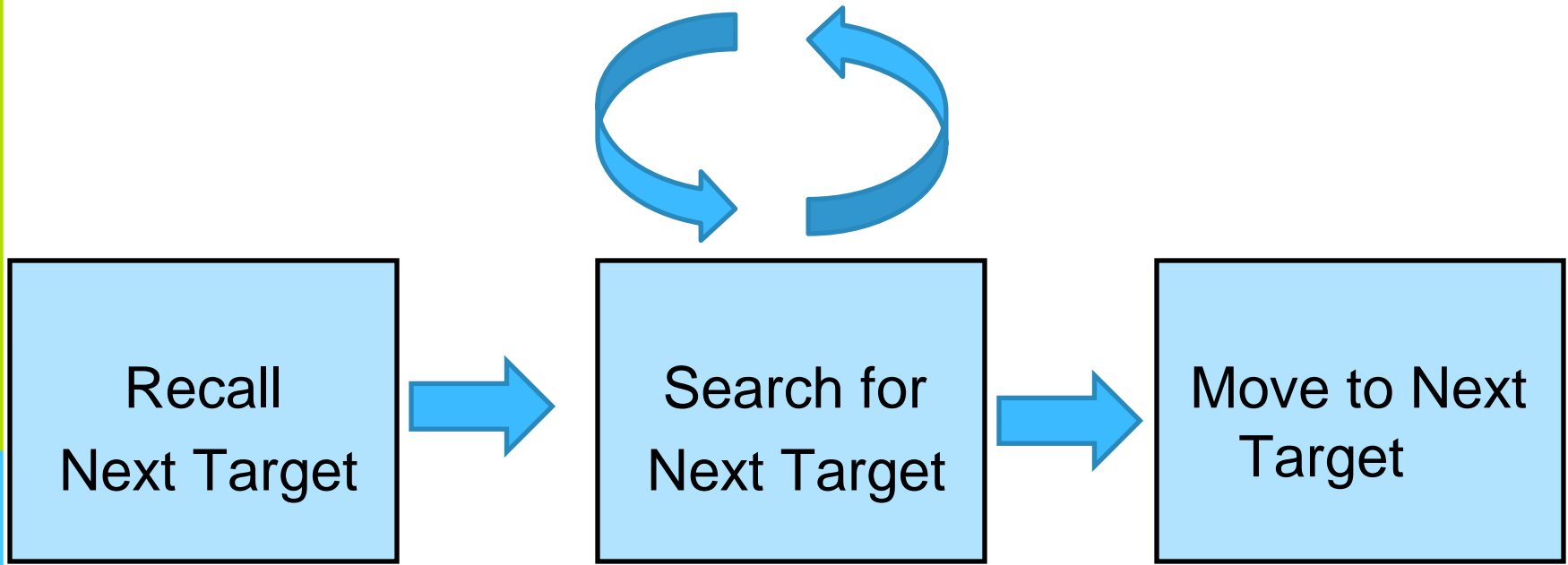
Cognitive Computer Games (embedded cognitive metrics)



Computer Game to Measure Executive Function



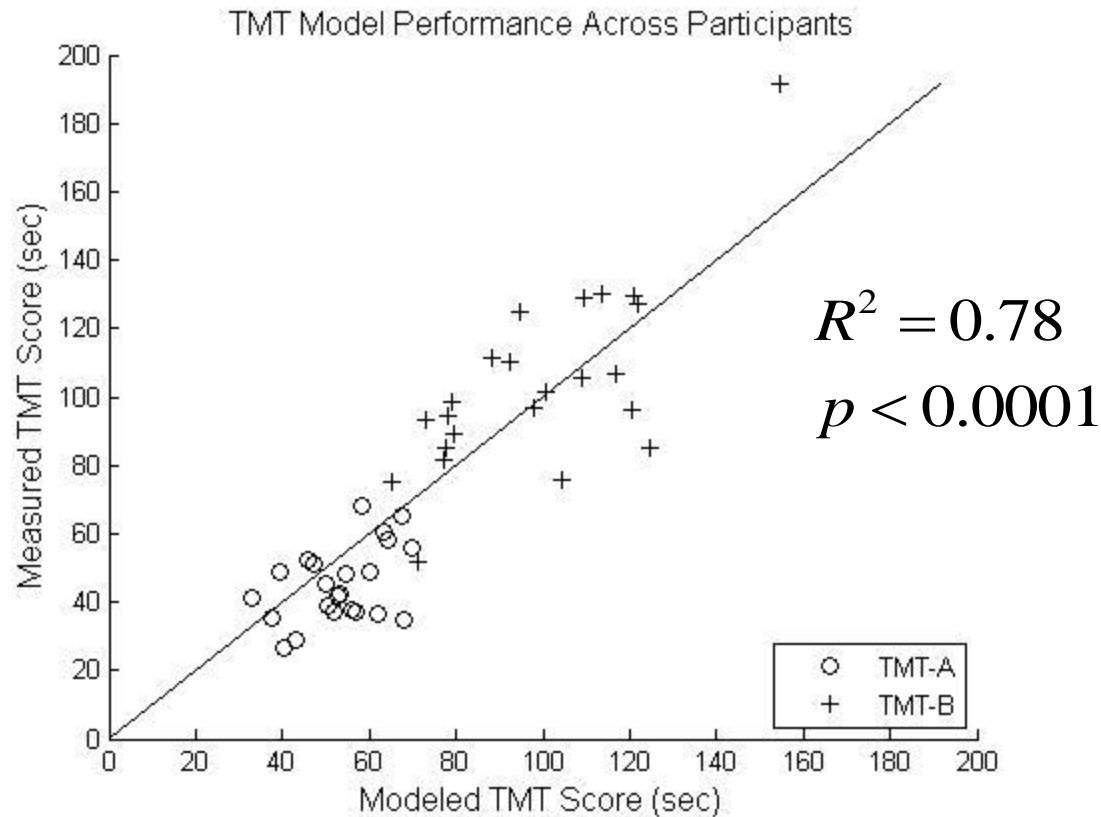
Model Recall, Search, Motor Speed



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

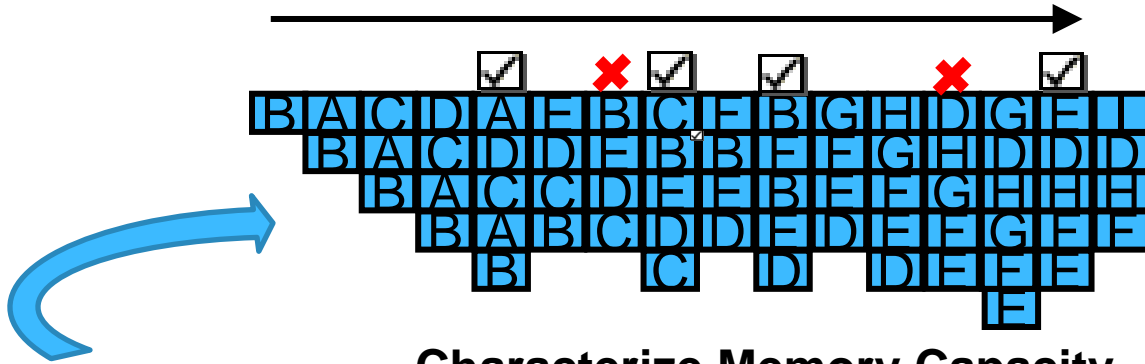
S. Hagler, H. Jimison, M. Pavel, Modeling Cognitive Processes from Computer Interactions, IEEE Journal of Biomedical and Health Informatics, Vol 18, No, 4, 2014.

Predicting Neuropsych Test Scores



S. Hagler, H. Jimison, M. Pavel, Modeling Cognitive Processes from Computer Interactions, IEEE Journal of Biomedical and Health Informatics, Vol 18, No, 4, 2014.

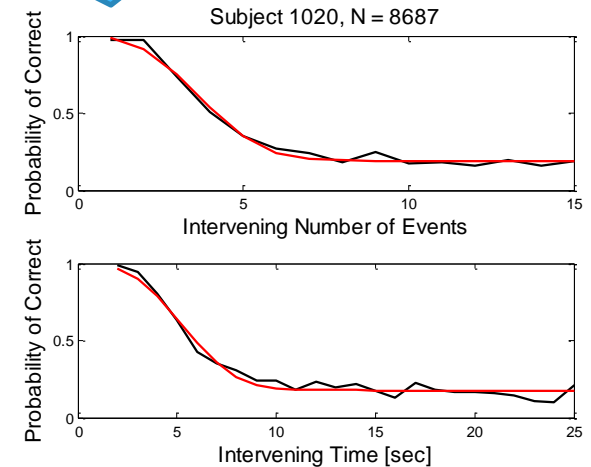
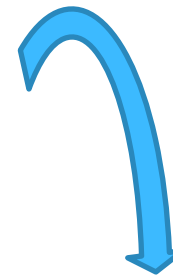
Cognitive Modeling Example: Memory



Characterize Memory Capacity

- Intervening number of events
- Intervening time
- Memory load

Simple Memory Model: Discrete Buffer



Characterize Memory Capacity with a Single Parameter

Interface options for:

- Older adult
- Remote family member
- Community health worker
- Health coach



Steven Williamson, PhD Dissertation,
Oregon Health & Science University



Caregiver Information for Jack Savin



Medication



Home Activities



Social Activities



Brain Health



Action Plan



Calendar

Brain Health

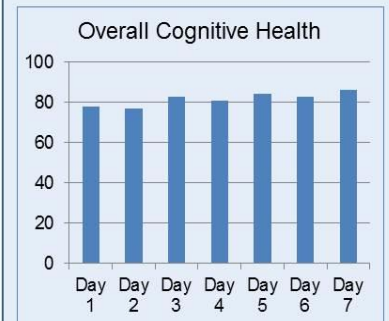
Cognitive Health Components



Jack's Weekly Tasks

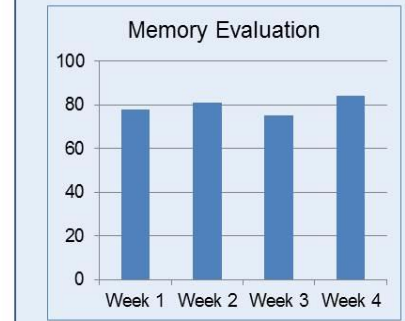
- Brush teeth with opposite hand. ✔
- Take a different route at the grocery store. ✘
- Play a game of cards. ✔
- Walk the opposite route on your morning walk. ✔

Overall Cognitive Health



[Daily](#)
 [Weekly](#)
 [Monthly](#)
 [Yearly](#)

Memory Evaluation



[Daily](#)
 [Weekly](#)
 [Monthly](#)
 [Yearly](#)

User reactions to tracking

- there is great variability in what factors about their life people would want to track
- what people wish to track will change over time, based upon their age, life circumstances, interactions with friends and family, health status, and general curiosity
- ubiquitous “monitoring” systems may be more readily adopted by end users if they are developed as tools for personalized, longitudinal self-investigation that primarily help end users, instead of or in addition to medical professionals, learn about the conditions and variables that impact their social, cognitive, and physical health.

Beaudin JS, Intille SS, Morris ME

To Track or Not to Track: User Reactions to Concepts in Longitudinal Health Monitoring

J Med Internet Res 2006;8(4):e29

<URL: <http://www.jmir.org/2006/4/e29/>>

Monitoring Attitudes from Older Adults

- Older adults are willing to trade privacy for increased independence and ability to age in place.
 - Adult children had more concern.
- Cognitive health was most important health concern (quality of life & independence).
- Jimison, HB and Pavel, M. Integrating Computer-Based Health Coaching into Elder Home Care, Technology and Aging, eds. Mihailidis, A., Boger, J., Kautz, H., and Normie, L., IOS Press, Amsterdam, The Netherlands, 2008.



Lessons Learned

- Algorithm Issues
 - New analytic models for developing behavioral markers derived from sensor data
 - Dynamic user models
 - Tailored message generation
 - Privacy / Security – tailored data sharing
 - User centered design – ease of use
- Protocol Issues
 - Need to have a variety of activities for novelty and sustained engagement
 - Coaching (automated and in-person) important

Opportunities for Nursing

- Home Health and Self-Management are domains of Nursing
- New job opportunities
 - Coordination of care to the home
 - Multidisciplinary teams
 - Community health workers
- New research opportunities
 - Need to use technology to make the clinical interventions more tailored & timely



Summary:

Considerations when Designing mHealth Behavior Change Interventions

- Make use of sensors and data analytic models
- Remote, just-in-time, continuous care
- Integrate principles of health behavior change
- Usability
- Access issues, culture, literacy, etc.
- Integrate family & informal caregivers into the health care team (untapped resource)
- Security & privacy issues
- Business model



Acknowledgements

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- Oregon Health & Science University: Paul Gorman, Jenniver Marcoe, Nicole Larimer, Jon Yeagers, Steve Williamson, Don Young
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- Alzheimer's Association / Intel Company
- National Institute on Standards & Technology
- TEKES (Finland Government)



Questions?

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Northeastern University**