Course 2. Ecological Validity and Naturalistic Assessment: Research Update and Clinical Applications

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Workshop Agenda

9:00-10:20	Ecological Validity (Chaytor)
10:20-10:40	Break (20 mins)
10:40-12:00	Naturalistic Assessment (Robertson)

Learning Objectives

1. Describe the difference between ecological validity and other forms of test validity
2. Appreciate how ecological validity research findings can inform clinical neuropsychological practice
3. Understand the utility of naturalistic assessment, as well as the strengths and weaknesses of varying approaches.

Part 1. Ecological Validity

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Financial Disclosure

I have financial relationships to disclose:

Consultant for: Eli Lilly and Company

Clinical Problem

Clinical Referral:

- 67 year old with type 1 diabetes
- Cognitive complaints
- Is this patient safe to perform diabetes self-care?

Clinical Problem

- Start with cognition:
  - Make a diagnosis (MCI?, VCI?, Dementia?)
  - Understand how diabetes has impacted the brain
- Extrapolate to function:
  - If there is brain dysfunction, make inferences about the impact on diabetes care:
    - Memory impairment → Forget to bolus?
    - Executive Impairment → Can't estimate carbohydrate content?
    - Attention Impairment → Miscalculate insulin dose?

Clinical Problem

- Start with functioning:
  - Diabetes Self-Care: Dose insulin based on carbohydrate content of meal and current blood glucose
- Extrapolate to cognition:
  - What cognitive skills are needed for this task?

Clinical Problem

- But…?
  - Do all patients with a given pattern of brain dysfunction (or neurological disease) function the same way in everyday life?
    - Do people with memory impairment always forget?
  - Do people without brain dysfunction have trouble with everyday tasks?
    - Do people without memory impairment always remember?
  - What other things matter? What are we missing?

Ecological Validity: Nature of the Problem

- Traditional neuropsychological (NP) tests were not designed to answer these types of referral questions

Ecological Validity: Nature of the Problem

- Most NP tests were designed to detect brain dysfunction
- Most NP tests were validated for this purpose
- Assumption that we can make logical inferences about problems with everyday tasks.

Ecological Validity: Nature of the Problem

- Validity
  - A test measures what it claims to measure
- Internal Validity
  - The independent variable (brain) impacts the dependent variable (test performance)
  - Control extraneous variables
  - Use standardized procedures

Ecological Validity: Nature of the Problem

External validity:

- Do findings in the lab generalize to other populations, places and over time?

Ecological validity:

- Results generalize to typical settings in everyday life
- Specific type of external validity
- Also can be a type of criterion-related validity

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Ecological Validity: Cognitive Assessment Considerations

- The cognitive domains that are most sensitive to brain dysfunction may not be most sensitive to everyday function (and vice versa)
  - prospective memory vs. psychomotor processing speed
- The cognitive dysfunction associated with a given disease may not be important for everyday functioning
  - psychomotor processing speed is sensitive to vascular cognitive impairment, yet may not predict medication management in this population
  - Executive functioning and memory are important for most everyday functioning tasks

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Ecological Validity: Cognitive Assessment Considerations

- What about norms?
- 90 year old man with "average" RAVLT delayed recall (SS = 90)
  - Raw score = 3/15 (20% of information recalled)
- Which is more likely to predict medication taking?
- Criterion-based norms are needed

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Ecological Validity: General Approaches

- Veridicality (generalizability): take existing tests and empirically determine the degree of association with real world outcomes – construct led
  - Empirical association
- Verisimilitude (representativeness): develop new tests that more closely match everyday tasks (e.g., BADS, RBMT, TEA) – function led
  - May or may not also have veridicality
  - May or may not detect brain dysfunction
  - May improve with rehabilitation of function, even if brain dysfunction remains

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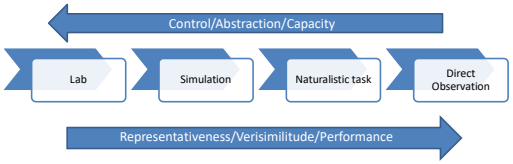
Ecological Validity: A Trade Off



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Ecological Validity: Real World Outcome Assessment

- How do we measure "everyday functioning"?
  - Is my "everyday" the same as yours?
- Traditional approaches:
  - Self/Significant other/Clinician/Teacher report
  - Actuarial data (accident reports, employment status, school grades)

Ecological Validity: Rating Scales

- Pros
  - Easy/quick
  - Comprehensive (multiple behaviors over time)
- Cons
  - Subjective (recall bias, negative or positive bias, secondary gain)
  - Does not account for variable environmental demands
    - Gender roles (e.g., never cooked)
    - Changing lifestyles (e.g., recalls phone numbers)
  - How do you validate? What is the gold standard?

Ecological Validity: Rating Scales

- The person rating the behavior matters
  - Self-report
    - Mood, cognitive impairment, insight, desirability, cry for help
  - Significant other
    - Education, relationship quality, time spent with patient, opportunities to observe
  - Clinician
    - Opportunities to observe, base rates/"normal" reference criteria
  - Teacher
    - Environment, social factors, expectancies, interpretations of behavior

Ecological Validity: Rating Scales

- The specificity of the assessment matters
  - Everyday cognitive problems
    - Specific cognitive domains (e.g., FrsBe, DEX)
    - General Cognition (e.g., Neuro-QoL)
  - Instrumental ADLs (vs. ADLs)
    - Specific domains (e.g., finances, cooking, driving)
    - Comprehensive surveys (e.g., FAQ, Lawton-Brody)
    - Variation in amount of cognition needed for the behavior

Ecological Validity: Actuarial Data

- Pros
  - What we are really interested in
  - Reduced observer effects
- Cons
  - Not available for all outcomes of interest
  - Low base rate events (e.g., driving; doesn't include near misses)
  - Binary outcome (accident vs no accident)
  - Often multi-determined complex data (e.g., employment)

Ecological Validity: Summary of the Literature

- *Ecological Validity of Neuropsychological Testing* (Sbordone & Long, 1996)
  - Overview of research to date and call for action
  - Construct-driven approach
  - Results differ by population

Ecological Validity: Summary of the Literature

- Chaytor & Schmitter-Edgecombe, 2003 review
  - Moderate ecological validity (~20% of variance in real world outcomes)
  - A bit better for representative tests
  - Better when domain specificity (e.g., memory tests and high memory demand real world tasks)
  - Better with objective everyday function measures
- Kalechstein et al, 2003 meta-analysis
  - NP tests have small to medium effect sizes in predicting work status (EF, Memory and IQ)

Ecological Validity: Summary of the Literature

- Royall et al., 2007
  - the variance in functional status that can be specifically attributed to cognition is surprisingly modest (20% of variance)
  - some cognitive domains are more relevant to functional capacity than others
  - some measures of executive control function are relatively strong correlates of medical or financial decision-making
  - "general" cognitive screening tests are surprisingly strong correlates of functional status.

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Ecological Validity: Summary of the Literature

- Gross et al., 2011
  - Inductive reasoning largest predictor (R^2 = .18) of concurrent older adult everyday functioning
    - Speed poorer predictor
  - Memory at baseline predicted (R^2 = .06) decline in everyday functioning

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Ecological Validity: Summary of the Literature

- *Neuropsychology of Everyday Functioning* (Marcotte & Grant, 2010)
  - Another call to action
  - Function-led approach
  - Separated by population (i.e., siloed research)

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Ecological Validity: Summary of the Literature

- Special issue on Ecological Validity in Neuropsychological Rehabilitation, vol 27, No. 5, 2017
  - Representative tests have become more practical
  - Function-led vs construct-led assessment

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Ecological Validity: What is the upper limit?

- Is 20% of the variance enough? What should it be?
- Cognition isn't the only thing that matters
  - Depression, anxiety, apathy, personality
  - Medical problems/physical disabilities
  - Environmental supports and demands
  - Compensatory strategies
  - Expertise/routine
  - Time varying influences (affect, fatigue, sleep, pain)
  - Effort, grit, perseverance, conscientiousness

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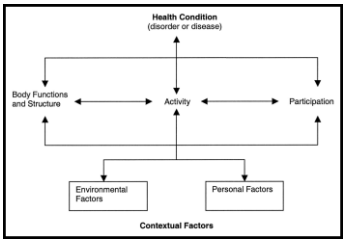

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Ecological Validity: Role of the Environment

- The physical, social and attitudinal environment
  - Can facilitate or hinder functioning
- Burns et al, 2018:
  - The environment is a powerful determinant of whether cognitive impairment will impact everyday functioning or not (e.g., professor being late vs., hourly employee being late)
  - naturalistically emerging supports and barriers

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Ecological Validity: Personal Factors

- IQ/general cognitive ability (Strategy use? Task is just too hard?)
- Prior level of functioning
  - May have never worked, learned to cook, take medications, manage finances
- Tasks that were highly routine/overlearned (e.g., habits, expertise)
- Longstanding use of compensatory strategies (e.g., calendars, reminders, social supports)

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Ecological Validity: Personal Factors

- Personality characteristics
  - Perseverance
  - Conscientiousness
  - Frustration tolerance
  - Self-efficacy
- Socioeconomic status (e.g., ability to hire support, complexity of the environment)

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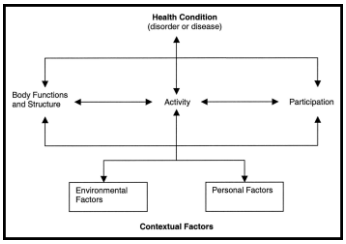

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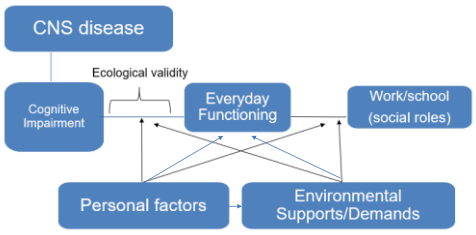

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Compensatory Strategies: Interaction of Environmental and Personal Factors

- Compensatory strategy use can influence whether cognitive impairment will impact everyday functioning or not (e.g., use a calendar to recall appointments)
  - Accounts for unique variance above cognitive assessment
- Wide variation in spontaneous use of strategies
  - Executive functioning? Learned skill?
- Environment as strategy (e.g., visual cues, few distractions)
- Formal assessment is ideal (e.g., compensatory cognitive strategies scale, Becker et al. 2017)

Clinical Problem

- Is this patient safe to manage diabetes self-care?
  - Environmental supports/demands?
  - Personal Factors?
  - Compensatory Strategies?

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Clinical Problem

Cognition matters for diabetes self-care:

- Executive functioning, memory, attention and visual construction skills predict T2D self-management behaviors (Primozic et al, 2012)
- Cognitive performance at baseline predicted hypoglycemic episodes at 20 month follow-up in those with T2D and no baseline hypoglycemia (Punthakee et al., 2012).
- Executive functioning is associated with treatment adherence and self-management in children with T1D (McNally et al, 2010)

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Clinical Problem

Environmental demand/supports:

- How much variability in their routine/meals? How much do they eat out in restaurants? Does their treatment change often? Does someone else help them?

Personal factors:

- How long have they had diabetes? How much diabetes education have they had?
- Comorbid medical and psychiatric disorders? Diabetes distress? Hypoglycemia fear?

Compensatory strategy Use:

- Do they have an insulin pump that calculates carb to insulin ratio?
- Continuous glucose monitor that will alert if blood glucose is low/high?
- Do they use carbohydrate counting apps (e.g., My Fitness Pal)?

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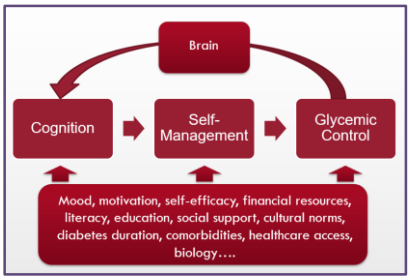

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Clinical Problem

Recommendations:

- **↓Environmental demands**
  - Prepared meals with carbohydrate content
  - Simplified insulin regimen
- **↑ Environmental supports**
  - Limit distractions
  - Share data with family or providers
- **↑ Compensatory strategies**
  - Continuous glucose monitor alarms
  - Pump alarms/alerts/bolus calculator
  - Artificial pancreas technology – automated insulin delivery

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Clinical Problem

Recommendations:

- **↑ Personal Factors**
  - Treat mood/anxiety
  - Reduce stress
  - Improve Sleep
  - Diabetes education
  - Motivational interviewing
  - Patient financial assistance programs/social work

Ecological Validity: Future Directions

- Using passive sensor data to assess everyday functioning
  - Smart home technology, activity trackers, GPS, continuous glucose monitoring
- Mobile cognitive assessment (cognitive ecological momentary assessment)
  - Assessment in real-world environments and simultaneous assessment of the environment (e.g., noise, location, other people)
  - Repeated short cognitive assessments over days/weeks (↑representativeness)
  - Assess variability in performance – risk for low base-rate events
  - Impact of fluctuating state factors (mood, stress, fatigue)

Ecological Validity: Future Directions

- Focus on assessing and incorporating non-cognitive predictors of everyday functioning into our clinical work:
  - Environmental demands and supports
  - Personal factors
  - Compensatory strategy use
- What is the relative importance of each?
- Evidence based clinical algorithms? Precision medicine?

- 20 minute Break
- Up next: Naturalistic Assessment

Part 2. Naturalistic Assessment

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Financial Disclosure

I have no financial relationships to disclose

Overview Part II: Naturalistic Assessment

- Different approaches to naturalistic assessment
  - Simulated Environments
  - Virtual Reality
  - Real World Environments
    - Structured tasks and real world monitoring
- Key Research Findings
- Clinical Applications

Simulated Environments | Virtual Reality | Real World: Structured | Real World: Monitoring

Lab-Based Tasks

Tasks that simulate real world activities within a lab/office setting

- Executive Function Performance Test (EFPT; Baum, Morrison, Hahn, & Edwards, 2003)
- Naturalistic Action Test (NAT; Schwartz et al., 2003)
- Medication Management Ability Assessment (MMAA; Patterson et al., 2002)
- Rivermead Behavioral Memory Test (RBMT; Wilson et al., 2008)
- Texas Functional Living Scale (TFLS; Cullum, Saine, & Weiner)
- Prospective memory tasks
  - Telephone Task (Delprado, Kinsella, Ong, & Pike, 2013)

Research Findings from Lab-Based Tasks

- Mostly good discriminant validity
  - Effect sizes: 0.08-0.63
    - Populations: MCI, Dementia, Schizophrenia, Bipolar Disorder, Stroke, MS
- Strongest cognitive associations usually found in executive functioning and memory
- Some research suggests that these tasks are better at predicting everyday functioning
  - But other research says that they do not always translate to everyday functioning

Considerations/Limitations

- More contextually realistic stimuli
- Convenient and accessible
- Limited ecological and face validity
- Little research on how these lab-based tasks relate to everyday functioning

Community Simulated Environments

- Easy Street Environments
- "The Community" Environment
  - The Community Shopping Task (CST): Semi-structured grocery shopping task (Robertson et al., 2017)


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CST Task Components

Recipe Section (Preparation)	
• Begins task • Looks up recipe • Refers to items that they have at home • Begins writing down items • Writes down paprika • Writes down pepper • Writes down onions • Writes down garlic	• Writes down 1 can whole tomatoes • Writes down noodles • Writes down items not needed • Writes down chocolate dessert • Writes down stamp book • Indicates they are ready to move to shopping area • Takes Wallet and list with them

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CST Task Components

Shopping Section (Execution)	
• Begins task • Chooses a shopping instrument • Consults grocery list • Begins to gather items on the list • Gets paprika • Gets pepper • Gets 3 onions • Gets garlic • Gets 1 can whole tomatoes • Gets noodles • Chooses a chocolate dessert • Gets children's ibuprofen	• Gets items not needed • Brings items to cashier • Sets items on counter • Asks cashier for stamps • Retrieves cash from wallet • Counts out cash • Pays cashier • Picks up grocery bag and has wallet • Moves towards the bus; leaves cart • Uses stop light to cross street • Gives the bus driver the bus pass

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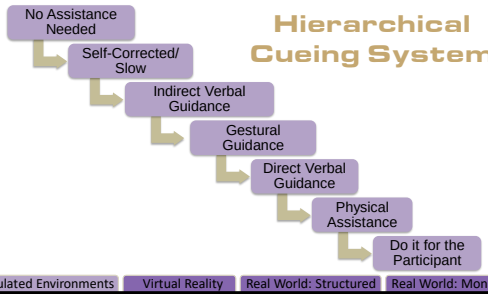
Hierarchical Cueing System



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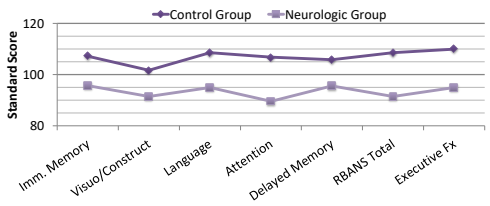
Performance on Cognitive Measures



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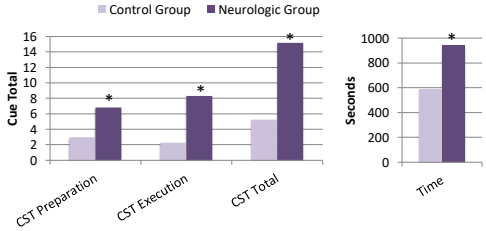
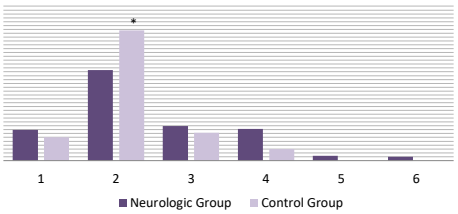
Performance on CST



Characteristics of CST Performance

- Significantly more cues on task components that involved:
  - Initiation
  - Problem solving
  - Decision making

Results: CST Cue Levels



CST, Cognitive Measures, & Functional Status

- All CST scores were related to:
  - Immediate Memory → most predictive of CST cues
  - Attention/PS → most predictive of CST time
  - Language
- CST execution score → executive functioning

Limitations/Considerations

- High face validity and good ecological validity
  - Automaticity
  - Patient buy-in
- Replication & Standardization
- High cost/Accessibility
- Little research

Types of Virtual Reality

Tasks performed in virtually created environments, typically designed to mimic the real world

- Two types of VR platforms
  - HMDs- Provides a 360° first person view of the environment
  - Projected video-capture- Video camera that captures and converts the persons movement in a 2D world on a monitor

Virtual Reality

- Wide Variety of VR tasks
  - Classroom, office, home
  - Route finding/way-finding tasks
  - Shopping Tasks
  - Cooking Tasks
  - Maze and other computerized "games"
    - Some designed to mimic popular cognitive tests (e.g., WCST)

Task from Kit et al., 2014

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VR and Cognitive Assessment

- Office/Room VR tasks with a memory component
  - Allows for assessment of different aspects of memory (distractors, prospective memory)
    - AND assesses relatively preserved aspects of memory
  - Used for diagnosis: Classroom task for ADHD assessment
- Route Findings Tasks
  - Associated with spatial abilities, visual search, & neglect
- Shopping and Cooking Tasks
  - Associated with executive functioning

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Meta-Analysis on Virtual Reality Tasks

- Negut et al., 2016
  - 18 studies included in final analyses
    - n = 668
    - Clinical groups: ADHD, brain injury, neurofibromatosis, and schizophrenia
    - Environments: Maze, mall, classroom, office
  - Findings:
    - Large mean effect (g = .95)
      - For Visuospatial: g = 1.70
      - For Memory: g = .96
      - For EF: g = .77
    - Significant moderators: Age, type of clinical group, presence of distractors, type of exploration

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VR and Real World Performance

- Conflicting information on how VR tasks relate to analogous real world tasks
  - VR MET and real world MET: High concordance
  - Analogous WCST tasks: Modest to strong correlations
  - VR cooking task and real cooking tasks: Not significantly correlated

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Considerations/Limitations

- Ability to generate any type of environment/task
  - Standardization
- Accessibility
- Feasibility
- No clear standardized, clinically marketed VR task
- Certain populations might not tolerate VR
  - Vision limitations
  - Motion sickness

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Structured Tasks in Real World Environments

Everyday tasks performed in the real world

- Cooking
  - Rabideau Kitchen Evaluation (RKE; Yantz et al., 2010)
  - Kitchen Task Assessment (KTA; Baum & Edwards, 1993)
  - Kettle Test (Hartman-Maeir, Harel, & Katz, 2009)
- Shopping/Errands
  - Test of Grocery Shopping Skills (TOGSS; Hamera & Brown, 2000)
  - Multiple Errands Test (MET; Shallice & Burgess, 1991)

Simulated Environments | Virtual Reality | Real World: Structured | Real World: Monitoring

Structured Tasks in Real World Environments

- Vocational
  - Complex Task Performance Assessment (CPTA; Wolf, Morrison, & Matheson, 2008)
  - Executive Secretarial Task (EST; Lamberts, Evans, & Spikman, 2010)
- Home
  - Map Task (Amap; Sanders, Low, & Schmitter-Edgecombe, 2014)
  - Day Out Task (DOT; Schmitter-Edgecombe, McAlister, & Weakley, 2012)
  - Eight Instrumental Activities of Daily Living (8IADL; Schmitter-Edgecombe & Parsey, 2014)
  - Assessment of Motor and Process Skills (AMPS; Fisher, 2003)

Smart Apartment Testbed Experiments

Watering Plant Steps
P retrieves watering can from supply closet
P fills watering can
P water plants (windowsill)
P water plants (coffee table)
P empties extra water into sink
P returns watering can to supply closet

Research Findings: Real World Environments

- Cooking tasks associated with:
  - Executive functioning
  - Delayed verbal memory and prospective memory
  - Simple auditory attention
  - Visuospatial skills
- None of the cooking tasks reviewed examined connection with everyday functioning

Research Findings: Real World Environments

- Shopping/Errand tasks associated with:
  - Executive functioning
  - Aspects of everyday functioning:
    - Analogous real world task
    - Independent living skill of grocery shopping
    - DEX
    - IADLs
    - Everyday life executive problems
- Work related tasks associated with:
  - Executive Functioning

Research Findings: Real World Environments

Home environments:

- Smart Apartment Tasks:
  - High discriminate validity
  - Associations with:
    - Learning
    - Retrospective and prospective memory
    - Executive Functioning
    - Variety of measures of everyday functioning (OTDL-R, IADL report)
- AMPS: High discriminant validity, mixed ecological validity

Limitations/Considerations

- Benefit of being as naturalistic as possible
  - Ecological and face validity
- Limited Research
- Accessibility/Cost/Feasibility
- Measurement & Standardization

Approach: Real World Environment

In-Home Monitoring

- Unobtrusive assessment of everyday activities within the home via sensor systems
  - Infrared and motion sensors for movement
  - Magnetic door sensors
  - Vibration and pressure sensors for objects
  - Light sensors
  - Temperature and humidity sensors
  - Whole-home electricity consumption sensors

In-Home Monitoring

- Online and offline activity monitoring/recognition techniques
  - Machine learning, template matching, and discriminative approaches
  - Unsupervised activity discovery algorithms

In-home Longitudinal studies

- Use smart home data
  - •Predict clinical scores
  - •Model daily behavior
- **People Living in Own Smart Homes:** tracked for > 2 years; clinical data collected every 6 months

Longitudinal Data

Detecting Long Term Functional Change

•Compare activity curves for possible changes in cognitive or physical health
(Dawadi, Cook, & Schmitter-Edgecombe, 2016)

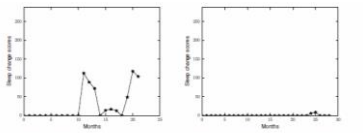
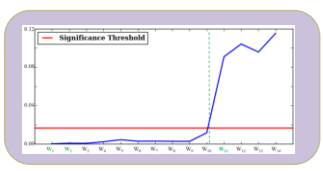
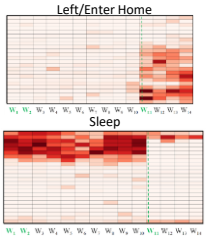


Figure 11: The continuous sleep change scores of two residents calculated by running PCAR algorithm on a sliding window of 6 months with an aggregation window size of $\varepsilon = 30$ days.

Detecting Acute Behavior Change

86 year old female started radiation treatment during week 10





Wearable Sensors

- Accelerometers
  - Postural sway, fall risk, functional movement abilities, and overall physical exertion
- Actigraphs
  - Sleep quality and quantity
  - High agreement with polysomnography
- Gyroscopes
  - Angular velocity when combined with accelerometers
    - Useful in movement disorders, such as PD
- Piezoelectrodes and textile pressure sensors
  - Gait assessment
- Heart rate monitors
  - Activity, stress

Ecological Momentary Assessment (EMA)

- EMA administers questionnaires through a device across various time points throughout a person's day
  - Reduces response bias, such as recency effects, and increases ecological validity
- EMA has been used to assess:
  - Mood
  - Drug craving and/or use
  - Medication adherence
  - Everyday Functioning
- Video Ethnography (Bromley et al., 2002)

Considerations/Limitations

- Truly "real world"
- Continuous, unobtrusive monitoring
- Able to measure a variety of health variables
- Privacy Issues
- Scaling
- Large Data Sets
- Adherence
- Technology factors
  - Reliability
  - Battery life
  - Cost

What About Compensatory Strategies?

- How do compensatory strategies impact performance?
  - Account for high level of independence even after controlling for cognition (Tomaszewski Farias et al., 2018)
- Difficulty accounting for this in many of the structured naturalistic tasks
- Monitoring and observation via naturalistic assessment

WHO CURRENTLY USES ANY OF THE TASKS REVIEWED IN CLINICAL PRACTICE?

Current Clinical Use

- Survey of 750 Neuropsychologists: 10% use ecologically valid measures
- Why?
  - Assumption that traditional tests are ecologically valid (despite limited evidence)
  - Tendency to stick with tests on which a person was trained
  - View that verisimilitude is synonymous with face validity, suggesting a less rigorous or "unscientific" evaluation of the ecological validity of a measure, even if they have research behind them
  - Belief that tests based on verisimilitude overlap with OT
  - Belief that traditional tests measure specific constructs (although the application of labels to cognitive domains has been somewhat ambiguous)

Spooner & Pachana, 2006

Demographics:
- 22 years old
- Male
- 12 years of education
- Severe TBI
  - Coma 4 weeks
  - 5 years post-injury

Test	%ile	Descriptor
WTAR	95th	Superior
RBANS Indexes		
Immediate Memory	7th	Borderline
Visuospatial/Constructional	2nd	Impaired
Language	7th	Borderline
Attention	5th	Borderline
Delayed Memory	<1st	Impaired
Total Score	3rd	Borderline
D-KEFS subtests		
Design Fluency	1st	Impaired
Letter Fluency	9th	Low Average
Digit Cancellation	<1st	Impaired
Grip Strength	N/A	Dominant hand=BNL Non-Dominant Hand= WNL

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Case Example 2

Demographics:
- 40 years old
- Female
- 16 years of education
- MS
  - Diagnosed over 10 years ago

Test	%ile	Descriptor
WTAR	93rd	Superior
RBANS Indexes		
Immediate Memory	5th	Borderline
Visuospatial/Constructional	1st	Impaired
Language	45th	Average
Attention	34th	Average
Delayed Memory	18th	Low Average
Total Score	8th	Borderline
D-KEFS subtests		
Design Fluency	63rd	Average
Letter Fluency	1st	Impaired
Digit Cancellation	35th	Average
Grip Strength	N/A	Dominant hand=BNL Non-Dominant Hand= BNL

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Conclusions

- Naturalistic assessment can improve standard of care
  - Current standard of care has limitations and naturalistic tasks can help to fill these limitations
  - Assessment of functioning can help with both diagnosis and recommendations in those with a variety of neurological and medical conditions
    - Implementation of effective interventions
- Call for more research

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Questions?