Implementing Digital Technologies in Neuropsychological Evaluations: Challenges and Opportunities

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Disclosures

- Grant/Research Support: NIH; IBM, Corp., Johns Hopkins Artificial Intelligence and Technology Collaboratory (JH AITC)
- Venture Partner: Aphelion Capital
  - I have received salary from Aphelion Capital for employment, consulting, and investing activities
- Consultant: Teijin Pharmaceuticals

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Topics

- Neuropsychological Testing Today
- Defining Technology and Digital Technology
- Current Digital Technologies we use
- Ongoing Projects
- Looking Forward: What we're Building
- Lessons Learned

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Neuropsychological testing today

- Sensitive, not specific
- Problems establishing ecological validity
  - Controlled environment
  - "Snapshot"
- Tests have limitations
  - Normative Data
  - Culture
  - Age
- Noisy
  - Tests do not account for contextual factors that are readily quantifiable

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Assessment	Year	References
Wide Range Achievement Test	1941	Jastak & Bijou, 1941
Wechsler Adult Intelligence Scale (WAIS)	1955	Wechsler, 1955
WAIS-R	1981	Wechsler, 1981
WAIS-III	1997	Wechsler, 1997
WAIS-IV	2008	Wechsler, 2008
Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)	1998	Randolph, 1998
RBANS-Update	2012	Randolph, 2012
Trail Making Test	1944; 1985	Army Individual Test Battery, 1944; Reitan, 1958; Reitan & Wolfson, 1985
Boston Naming Test	1978	Kaplan et al., 1978
Boston Naming Test-2	2001	Kaplan et al., 2001
Controlled Oral Word Association Test (COWAT)	1989	Benton & Hamsher, 1989
Wechsler Memory Scale (WMS)	1945	Wechsler, 1945
WMS-R	1987	Wechsler, 1987
WMS-III	1997	Wechsler, 1997
WMS-IV	2009	Wechsler, 2009
Rey Auditory Verbal Learning Test	1988	Wiens, 1988
California Verbal Learning Test (CVLT)	1987	Delis et al., 1987
CVLT-II	2000	Delis et al., 2000
CVLT-3	2017	Delis et al., 2017
Delis-Kaplan Executive Function System	2001	Delis et al., 2001
Wisconsin Card Sorting Test (WCST)	1948	Berg, 1948; Grant & Berg, 1948; Heaton et al., 1981; Heaton et al., 1993
WCST - Computer Version 4	2008	Heaton, 2008
Token Test	1962	De Renzi & Vignolo, 1962
Rey-Osterrieth Complex Figure Test	1941	Rey, 1941
Benton Judgment of Line Orientation Test	1978	Benton et al., 1978
Grooved Pegboard	1964	Matthews & Klove, 1964
Minnesota Multiphasic Personality Inventory (MMPI)	1951	Hathaway & McKinley, 1951
MMPI-2	1990	Graham, 1990
MMPI-2 Restructured Form (MMPI-2-RF)	2008	Ben-Porath & Tellegen, 2008

Singh & Germine, 2020

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The "problem" with older tests

- Cannot be readily updated (e.g., using software updates)
- Must wait for a new version to include updated norms
- Heavily reliant on test-development companies (e.g., Pearson, PAR)
- Does not account for increasingly diverse population

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Poll

- What are some of the biggest challenges you've encountered when administering neuropsychological and/or psychological tests?

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My work in Digital Neuropsychology fills gaps in traditional testing by **leveraging digital technologies** towards *improving our ability to characterize cognitive and psychological functioning* in a way that is more ecologically valid.

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What is Technology?

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What are Digital Technologies?

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What are these digital tools?

Cognitive EMA	Cognitive fluctuations
Speech EMA	A proxy for cognition Data acquisition for digitized cognitive tests, like verbal fluency
Context	Environmental (noise) Psychological
Additional Tools	Face recognition Computer mouse clicks Pressure pads

EMA = Ecological Momentary Assessment

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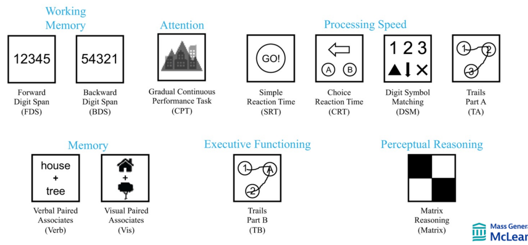
Cognitive EMA

Using TestMyBrain



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These methods are reliable and valid in clinical and community samples

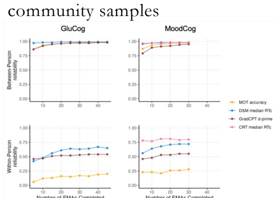

Figure 3. Within- and between-person reliabilities as functions of the number of ecological momentary assessments (EMAs) completed, separately for the GluCog and MoodCog groups. In the top-left panel, the line for Multiple Object Tracking (MOT) overlaps with the line for Gradual Onset Continuous Performance Test (GradCPT) such that only the GradCPT line is visible. CRT: Choice Reaction Time; d-prime: ability to discriminate targets from distractors; DSM; Digit Symbol Matching; RTc: reaction time responses.

Ecological Momentary Assessment of Cognition in Clinical and Community Samples: Reliability and Validity Study

Shifali Singh [1,2]; Roger Strong [1,2]; Irene Xu [1]; Luciana M Fonseca [3,4]; Zoe Hawks [1,2]; Elizabeth Grinspoon [1]; Lanee Jung [1]; Frances Li [1]; Ruth S Weinstock [5]; Martin J Sliwinski [6,7]; Naomi S Chaytor [3]; Laura T Germine [1,2]

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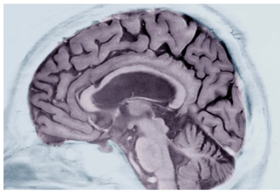
Alzheimer's Prediction May Be Found in Writing Tests

IBM researchers trained artificial intelligence to pick up hints of changes in language ahead of the onset of neurological diseases.

Give this article 307



An M.R.I. scan of a patient over the age of 60 with Alzheimer's disease. Zephyr/Science Source

The A.I. program predicted, with 75 percent accuracy, who would get Alzheimer's disease, according to results published recently in The Lancet journal EClinicalMedicine.

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Speech EMA

Please click the microphone button and then say:
"The quick brown fox jumps over the lazy dog."
You may press the Stop button if you finish before the timer runs out.

00:10

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Ongoing Projects

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Project 1: TestMyBrain Digital Neuropsychology Toolkit

- TMB Simple and Choice Reaction Time
- TMB Gradual Onset Continuous Performance Test
- TMB Matrix Reasoning
- TMB Trail Making Test (Parts A + B)
- TMB Forward Digit Span
- TMB Backward Digit Span
- TMB Verbal Paired Associates - Learn & Test (TMB Choice Reaction Time)
- TMB Visual Paired Associates - Learn & Test (TMB Choice Reaction Time)
- TMB Digit Symbol Matching

Gender: F

Age: 21-30

Years of Education: 7-11

Normative data are provided in z-score units, presenting the number of stanc
Where possible, all norms are coded such that higher (or more positive) z sc
See below table for description of test-specific column headings.

gender	age	education	Z	SRT	CRT.RT	CRT.ACC	BDS	FDS	DSM
F	21-30	7-11	-4	581	1208	0.6			
F	21-30	7-11	-3.75	564	1182	0.62			3
F	21-30	7-11	-3.5	548	1157	0.64			6
F	21-30	7-11	-3.25	532	1131	0.67			10
F	21-30	7-11	-3	515	1105	0.69			13
F	21-30	7-11	-2.75	499	1079	0.71			16

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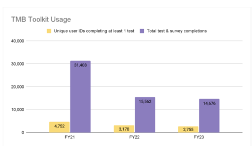
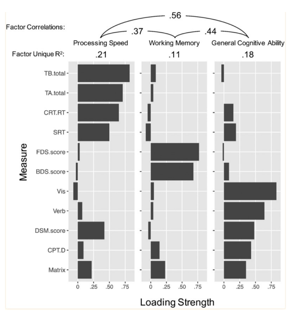


The TestMyBrain Digital Neuropsychology Toolkit: Development and Psychometric Characteristics

Shifali Singh,[a,b] Roger W. Strong,[a,b] Laneé Jung,[a,b] Frances Haofei Li,[a,b] Liz Grinspoon,[a,b] Luke S. Scheuer,[a,b] Eliza J. Passell,[a,b] Paolo Martini,[a,b] Naomi Chaytor,[c] Jason R. Soble,[d,e] and Laura Germine[a,b]



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Project 2: Digital Neuropsychology in Neuropsychology Dept

Technology meets tradition: a hybrid model for implementing digital tools in neuropsychology

Shifali Singh[a,b] and Laura Germine[a,b]

[a]Institute for Technology in Psychiatry, McLean Hospital, Belmont, MA, USA; [b]Department of Psychiatry, Harvard Medical School, Boston, MA, USA

- Implements a Hybrid Neuropsychology (Singh & Germine, 2022) approach, by validating digital cognitive and speech measures against traditional neuropsychological tests
- Develop a better understanding of the ways in which cognition, mood, patient-specific data (using EMR) relate to diagnoses and patient outcomes

Equivalence — Cross validate traditional and TMB cognitive tests

Diagnostic Clarity — Look for patterns captured through digital responses that translate to specific cognitive impairments

Performance Validity — Determine cutoffs for identifying inconsistent response patterns. Cross validate with standard performance validity measures to help identify poor effort

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Project 3: Cognitive Screening against blood-based biomarkers

- Cognitive EMA
- Speech EMA
- Mood Questionnaires
- Blood Phe levels
- 6 measurements over 1 month — Varying by time of day and day of week

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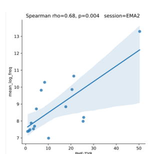
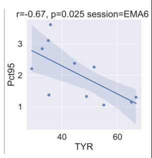
Speech Acquisition can Serve as a Proxy for Cognitive Functioning and Correlates with Blood-Based Biomarkers

Using speech acquisition software, we can collect patients' verbal responses to tests we give regularly, like semantic fluency

Response times between words and the frequency of words was directly related to blood levels of tyrosine and phenylalanine

This moves us towards a precision medicine model, where our tests can be integrated with biological and biometric markers





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Project 4: Characterizing and Stratifying Degrees of Cognitive Impairment: Cognitive and Speech EMA, Biometrics, and Traditional Measures

1

Provide traditional neuropsychological evaluations + cognitive EMA + speech EMA
- Goal: Better characterize and stratify degrees of cognitive impairment outside of traditional diagnostic criteria

2

Develop a conversational AI that can be used to "chat" with individuals >65
- Goal: To improve mood and predict prognosis of patients with mild neurocognitive disorder

3

Develop cognitive interventions using ChatGPT
- Goal: Develop methods for quickly assessing orientation and asking daily questions

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Moving Forward: What we're building in the lab

- Protocols to provide Fitbits/Apple Watches/actigraphy monitors to patients who have appointments within the next 6-12 months with a healthcare provider
- Understanding how fluctuations in speech might associate with clinical neuropsychology reports and H&Ps using ML/NLP/AI
- Developing a **Clinician Dashboard** with biometric, voice, and digital cognitive data that can be readily used by clinicians
- Feed data summary sheets from a wide variety of clinics in an ML/AI model to determine how we can streamline diagnosis and report writing

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Lessons Learned (so far)

- Establishing tools as **ecologically valid** is a uniquely complex challenge requiring
  - Large patient populations that are appropriately heterogeneous in gender, race/ethnicity, & diagnoses
  - Rigorous psychometric validation demonstrating sensitivity and specificity
- One of the largest barriers to entry is **clinical adoption** of these tools
  - Emphasizing and/or demonstrating that these tools are somehow "better" than traditional measures
- There are *a lot* of available digital tools, a challenge will be to determine ***which ones* are most relevant to disease**
  - Caveat: not all tools will be useful for the same disease types

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This is not using technology for the sake of using technology…

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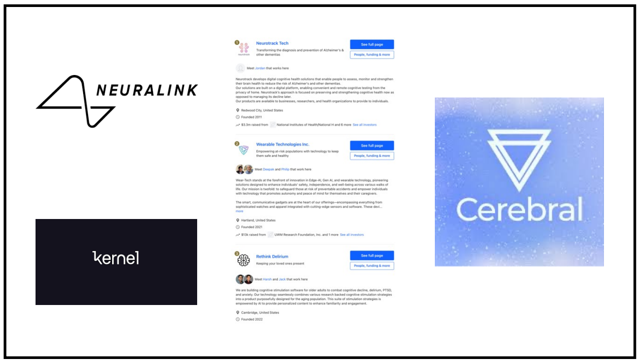

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Thank you!

- National Institutes of Health Rare Diseases
- PHEFREE Consortium & NPKUA
- Laura Germine, Ph.D., Kerry Ressler, MD, PhD, Katelin Curtis, BA, Irene Xu, BA
- Laboratory for Brain and Cognitive Health Technology
- McLean Institute for Technology in Psychiatry
- McLean Neuropsychology Department
- Harvard Medical School Department of Psychiatry

LABORATORY FOR DIGITAL COGNITIVE RESEARCH
MCLEAN HOSPITAL | HARVARD MEDICAL SCHOOL

laboratory for brain and cognitive health technology

National PKU Alliance

NIH National Institute on Aging

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Transforming Cognitive & Emotional Health Assessment with Digital Tools and Stepped Care

Sara L. Weisenbach, Ph.D., ABPP, Chief of Neuropsychology, McLean Hospital,
Associate Professor, Harvard Medical School
Director, Mood and Cognition in Aging Lab

June 2024 American Association of Clinical Neuropsychology

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Disclosures

ADHD Expert Advisory Board Member: Qbtech©

Member, Otsuka Apathy in Late Life Depression Advisory Board

Funding: NIH, Brain & Behavior Research Foundation

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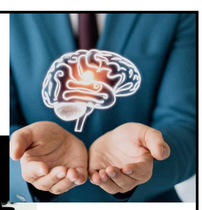
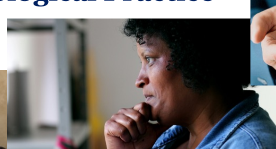
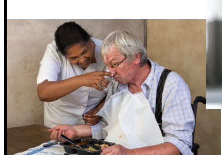
Expanding Precision Medicine in Neuropsychological Practice







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Objectives

- Describe the history of stepped-care models for managing mental health
- Depict examples of emotional and cognitive health assessment in stepped-care
- Illustrate examples of how emerging markers of cognitive and emotional health can be used as part of stepped care in neuropsychology
- Blueprint a roadmap forward

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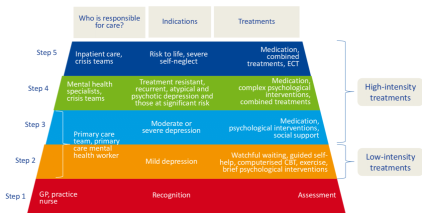
What is Stepped Mental Health Care?



- Two Core Features:
  - Least-restrictive
  - Self-correcting
- Mixed evidence for success (typically compared to CAU), depending on trial
- More cost-effective than CAU
- Simpler in conception than application

Image adopted from Kohn L, Obyn C, Adriaenssens (J), Christiaens W. (2016). Model for the organization and reimbursement of psychological and ortho pedagogical care in Belgium. KCE *Report 265*, p. 55.

See Ho, Yeung, Ng, & Chan (2016). The efficacy and cost-effectiveness of stepped care prevention and treatment for depressive and/or anxiety disorders: A systematic review and meta-analysis. *Scientific Reports, 6*(29281) for review.

Richards, DA (2012). Stepped care: A method to deliver increased access to psychological therapies. *Can J Psychiatry, 57*(4), 210-215.

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OXFORD UNIVERSITY PRESS

Archives of Clinical Neuropsychology 33 (2018) 269–279

Archives of CLINICAL NEUROPSYCHOLOGY

Integration of Neuropsychology in Primary Care

Margaret Lanca*

Department of Psychiatry, Harvard Medical School, Boston, MA, USA

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Editorial Decision 1 November 2017; Accepted 22 December 2017

- Steps can be recursive
- Case examples for ADHD and dementia

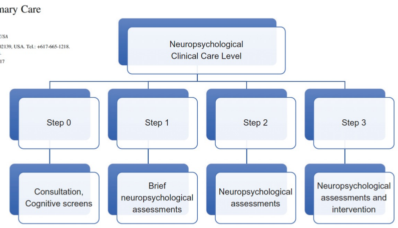

Figure 1. Description of neuropsychological care at each stepped level.

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Figure from Lanca M. (2018). Integration of neuropsychology in primary care. *Archives of Clinical Neuropsychology, 33*, 269-279, p. 270.

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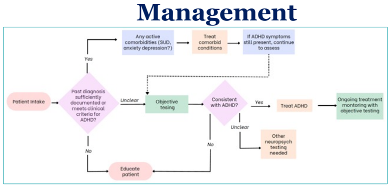
Stepped Care for ADHD Evaluation and Management



- No official guidelines exist for assessing adult ADHD; consistent with guidelines for adult ADHD diagnosis proposed by Sibley (2021)
- Objective testing enhances accuracy of diagnosis and is billable
- Neuropsychology only needs to be involved in the most complex cases
- Does not yet account for symptom validity

National Academies of Sciences, Engineering, and Medicine. 2024. Adult Attention-Deficit/Hyperactivity Disorder: Drug Development, Diagnosis, and Treatment: Proceedings of a Workshop. Washington, DC: The National Academies Press. https://doi.org/10.17226/27770.

Sibley, MH (2021). Empirically-informed guidelines for first-time adult ADHD diagnosis. Journal of Clinical and Experimental Neuropsychology, 43(4), 340-351.

Weisenbach (In Press). Empowering Minds: revolutionizing cognitive and emotional health assessment with stepped care and digital tools. *Journal of Clinical and Experimental Neuropsychology*.

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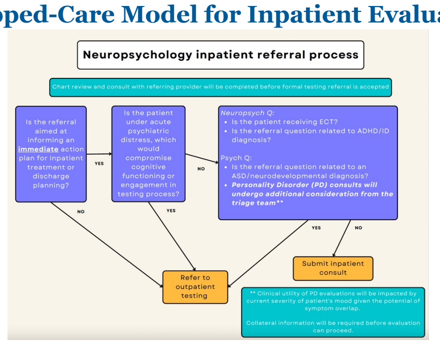
Stepped-Care Model for Inpatient Evaluations



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Current Uses of Digital Health Tools in Neuropsychology

- Digitized existing paper-and-pencil measures
- Automated scoring software
- Computerized continuous performance tests
- Digital cognitive screening measures and batteries (e.g., TabCAT, CNS Vital Signs, ImPACT, CANTAB, ANAM), some of which are web-based
- Use of REDCap or similar software to collect intake and survey data
- Entry of cognitive test scores into a clinic database
- Tele/virtual neuropsychology

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Exploratory Tools for Measuring Psychological and Cognitive Health

- Mobile platforms
- Wearables
- SMART homes

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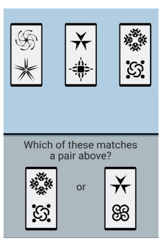

Symbol-Match
(Attention and Processing Speed)

Instructions

You will see pictures of mountains and cities - one at a time.

Press **Next** to continue.

Images of Cities and Mountains (Cognitive Control)

When you see a **CITY** picture, **press the button as quickly as you can**

Press **Next** to continue.

When you see a **MOUNTAIN** picture, **DO NOT PRESS the button**

Press **Next** to continue.

Zhaoyang R, Scott SB, Martire LM, & Sliwinski MJ (2021). Daily social interactions relate to daily performance on mobile cognitive tests among older adults. PLOS ONE. https://doi.org/10.1371/journal.pone.0256583

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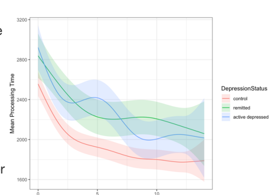
Symbol Match

- processing speed at noon and in the afternoon (4 pm) tends to be faster than in the morning
- actively depressed and remitted patients tend to have lower response speed than controls



	symbol_search.median_response_time_all_trials		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	-587.06	-969.54 – -204.59	**0.003**
timeofday [Noon]	-87.85	-169.35 – -6.35	**0.035**
timeofday [Afternoon]	-93.42	-173.99 – -12.86	**0.023**
DepressionStatusremitted	262.70	127.44 – 397.97	**<0.001**
DepressionStatusactive depressed	382.21	226.98 – 537.45	**<0.001**
Age	35.19	30.96 – 39.43	**<0.001**
Sex [Male]	-109.34	-164.66 – -54.02	**<0.001**
Education	11.60	4.83 – 18.37	**0.001**
MADRS	-13.99	-23.89 – -4.09	**0.006**
timeofday [Noon] × DepressionStatusremitted	94.08	-89.21 – 277.37	0.314
timeofday [Afternoon] × DepressionStatusremitted	187.76	7.26 – 368.27	**0.041**
timeofday [Noon] × DepressionStatusactive depressed	-58.26	-223.05 – 106.52	0.488
timeofday [Afternoon] × DepressionStatusactive depressed	89.72	-70.49 – 249.93	0.272
Smooth term (days) × DepressionStatuscontrol			**<0.001**
Smooth term (days) × DepressionStatusremitted			**<0.001**
Smooth term (days) × DepressionStatusactive depressed			**<0.001**
Smooth term (participant id)			**0.027**
Observations	2269		
R^2	0.233		

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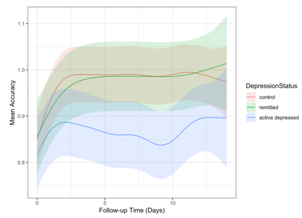
Cities Mountains

- increasing trend of accuracy over time
- actively depressed are less accurate than other groups.



Smartphone-Based Cognitive Assessment

	accuracy		
Predictors	Estimates	CI	p
(Intercept)	1.09	1.01 – 1.17	**<0.001**
timeofday [Noon]	0.01	-0.01 – 0.03	0.203
timeofday [Afternoon]	0.02	0.00 – 0.03	**0.042**
DepressionStatusremitted	-0.00	-0.03 – 0.03	0.943
DepressionStatusactive depressed	-0.08	-0.10 – -0.05	**<0.001**
Age	-0.00	-0.00 – -0.00	**<0.001**
Sex [Male]	0.02	0.01 – 0.03	**0.002**
Education	-0.00	-0.00 – -0.00	**0.036**
timeofday [Noon] × DepressionStatusremitted	-0.00	-0.04 – 0.03	0.851
timeofday [Afternoon] × DepressionStatusremitted	-0.04	-0.07 – 0.00	0.059
timeofday [Noon] × DepressionStatusactive depressed	-0.03	-0.07 – 0.00	0.076
timeofday [Afternoon] × DepressionStatusactive depressed	-0.02	-0.05 – 0.01	0.254
Smooth term (days) × DepressionStatuscontrol			**<0.001**
Smooth term (days) × DepressionStatusremitted			**<0.001**
Smooth term (days) × DepressionStatusactive depressed			0.062
Smooth term (participant id)			0.137
Observations	2268		
R^2	0.139		

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Digital Phenotyping in MS

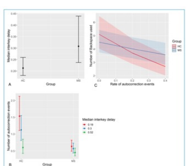

Figure 2. Group differences in keystroke dynamics. Panel A displays differences between MS and HC groups in median interkey delay (typing speed); the MS group typed significantly slower. Panel B displays moderating effect of median interkey delay on number of autocorrection events (offset with number of characters per session); interkey delay is split into lower, median, and upper quartiles for visualization. The HC group had more autocorrection events than the MS group, but only among those who typed faster. Panel C displays the moderating effect of diagnostic group on the relationship between backspace and autocorrection rates; the relationship was steeper among HC than MS. Plots represent predicted values from multilevel models, and error bars/bands represent 95% confidence intervals. MS: multiple sclerosis; HC: healthy control.

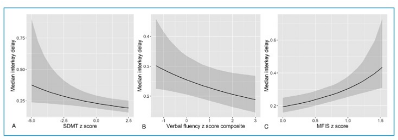

Figure 3. Associations between median interkey delay and neuropsychological performance/symptom rating. Plots represent predicted values from multilevel models, and error bands represent 95% confidence intervals. Faster typing speed was associated with better performance on neuropsychological tests (e.g., SDMT and verbal fluency in Panels A and B and less severe symptom ratings (e.g., MFIS in Panel C). SDMT: Symbol Digit Modalities Test; MFIS: Modified Fatigue Impact Scale.

Chen MH et al. (2022). Associations between smartphone keystroke dynamics and cognition in MS. *Digital Health*, *8*, 1-12

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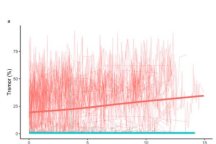
Tracking Motor and Non-Motor Features of Parkinson's Disease Using Wearable Sensors, Smartwatch, and Smartphone Technology

Table 4 | Summary of findings to date from the Watch-PD study

Domain	Findings	Device	Assessment	Comment
Gait • Arm swing • Gait speed	• Reduced at baseline compared to controls • Decreases significantly over 12 months	Smartwatch and smartphone	Active	Promising measure for assessment in future clinical trials in PD population
Tremor • Proportion of day with tremor	• Increased at baseline compared to controls • Increased significantly over 12 months	Smartwatch	Passive	Promising measure for assessing the efficacy of therapies aimed at reducing tremor
Neuropsychology • Finger tapping	• Reduced at baseline compared to controls but no significant progression over 12 months	Smartphone	Active	Results may have been complicated by learning effects
Cognitive • Trails tests	• Reduced at baseline compared to controls but no significant progression	Smartphone	Active	Other measures of cognition may be more sensitive to change
Speech • Composite score	• Reduced at baseline compared to controls and shows modest progression	Smartphone	Active	Beneficial for differentiating PD from controls
Activity • Steps taken daily	• Reduced at baseline compared to controls and may decrease with time	Smartwatch	Passive	Promising measure but larger datasets required



Adams et al. (2024). Using a smartwatch and smartphone to assess early Parkinson's disease in the WATCH-PD study over 12 months. *Npj Parkinson's Disease, 10*:112.

15

15

THE CLINICAL NEUROPSYCHOLOGIST
https://doi.org/10.1080/13854046.2024.2330143

Routledge
Taylor & Francis Group

Check for updates

Predicting daily cognition and lifestyle behaviors for older adults using smart home data and ecological momentary assessment

Maureen Schmitter-Edgecombe[a], Catherine Luna[a], Shenghai Dai[b] and Diane J. Cook[c]

[a]Department of Psychology, Washington State University, Pullman, WA, USA; [b]College of Education, Washington State University, Pullman, WA, USA; [c]School of Electrical Engineering and Computer Science, Washington State University, Pullman, WA, USA

Table 4. Rank ordering of features for ecological momentary assessment (EMA) survey questions and *n*-back task.

Feature	EMA survey question and *n*-back							
Order	Sharp	Social	Physical	Cognitive	Fatigue	Mood	Limited	*n*-back
1	Bedroom	Outside	Outside	Count	Hour	Count	Bedroom	Count
2	Count	Count	Count	Outside	Outside	Kitchen	Bathroom	Current
3	Bathroom	Hour	Kitchen	Kitchen	Bedroom	Outside	Count	Bedroom
4	Outside	Bathroom	Bedroom	Bedroom	Count	Bathroom	Outside	Outside
5	Hour	Bedroom	Bathroom	Bathroom	Kitchen	Bedroom	Kitchen	Kitchen
6	Kitchen	Kitchen	Hour	Hour	Bathroom	Hour	Hour	Bathroom
7	Day	Day	Current	Current	Day	Current	Current	Hour
8	Current	Current	Day	Day	Current	Day	Day	Day

Note: All survey questions started with "In the past two hours …" See Table 1 for exact wording of EMA questions and Table 2 for definitions of smart home digital marker features. Sample size = 44; valid EMA responses = 2,016.

- For every 30 minutes spent outside the home, there was an increase in self-reported social, physical, and cognitive engagement
- For every 1000 sensor counts (i.e., movement), self-reported mental sharpness, social, physical and cognitive levels increased.

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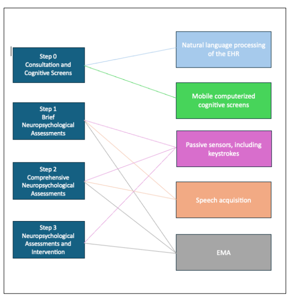

Weisenbach (In Press). Empowering Minds: revolutionizing cognitive and emotional health assessment with stepped care and digital tools. *Journal of Clinical and Experimental Neuropsychology.*

17

17

Challenges and Ethical Issues Related to DHTs and AI

- Digital security
- Informed consent
- Adaptations to test administration and testing the limits
- Availability of high-quality normative data in diverse patient and non-patient samples
- Construct validity of newer methods and tests with current practices
- Verification of the identity of the test taker
- Test security
- Assessment of validity of data gathered
- Sharing of devices
- Hardware and software limitations

Bilder & Reise, 2019; Miller & Barr, 2017; Parsons, McMahan, & Kane, 2018

McLean Hospital | Confidential—do not copy or distribute

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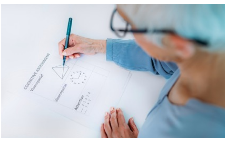
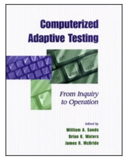
How Do We Get from

HERE **to** **THERE?**





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Roadmap Blueprint

- Aggregation of data in diverse samples against which novel assessment methods can be validated
- Knowledge dissemination beginning at the undergraduate level
  - Modern psychometrics
  - Health informatics
- Strategic partnerships between academic research groups, federal funding agencies, and industry/start-ups
- Continued advocacy for adequate reimbursement at every step of care
- Consideration and decision-making around emerging ethical issues
- Implementation that promotes health equity and avoidance of bias

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Some Current Efforts

- SCN
  - Neurotechnology Working Group
  - ANST Neurotechnology Focus Group
- AACN Disruptive Technology Initiative
- National Neuropsychology Network
- 2022 Minnesota Conference Guidelines (in progress)

THE SOCIETY FOR CLINICAL NEUROPSYCHOLOGY

AACN American Academy of Clinical Neuropsychology

National Neuropsychology Network (NNN)

Minnesota Update Conference 2022

21

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Acknowledgements

SCN Neurotechnology Working Group
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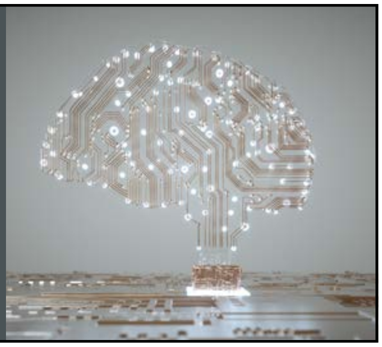
23

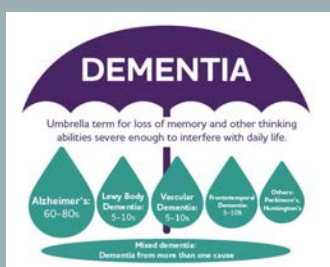
REMOTE TOOLS FOR IDENTIFYING COGNITIVE IMPAIRMENT ACROSS CULTURES



Yakeel T. Quiroz, PhD
Associate Professor
Harvard Medical School
Massachusetts General Hospital

April 2025

1



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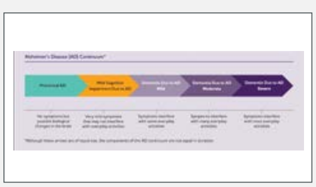
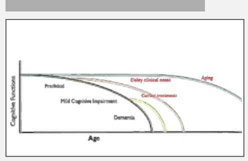




3

ALZHEIMER'S DISEASE

Sporadic AD: 90-95% of cases

*Generally diagnosed in individuals over the age of 65.

*The most important risk factors—age, family history and heredity (APOE4, the major genetic risk factor).

Familial AD: <2% of cases

*Autosomal-dominant mutations: Presenilin 1 and 2, Amyloid precursor protein (APP) genes

*Before the age of 65

*Nearly 100% penetrance

*Specific age of onset

4

A 30+YEAR JOURNEY…

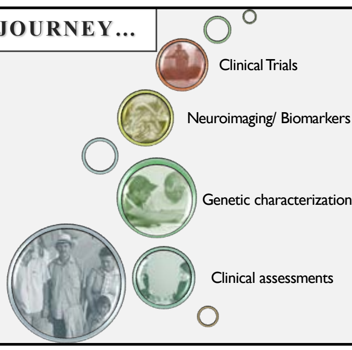
Alzheimer's disease

Frontotemporal

Huntington

CADASIL

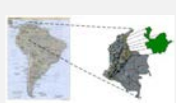
Families from Antioquia



5

A LARGE EXTENDED FAMILY WITH EARLY-ONSET ALZHEIMER'S DISEASE (AD) IN ANTIOQUIA, COLOMBIA

- Autosomal dominant AD (ADAD): A unique opportunity to examine early AD-related changes in cognitively-normal individuals.
- Presenilin-1 (*PSEN-1*) mutation carriers develop early-onset AD with near 100% certainty.
- The Colombian kindred (E280A mutation) has a median age of mild cognitive impairment (MCI) at 44 years (95% CI +/- 2 years), and dementia at 49 years (95% CI +/- 2 years).
- Clinical, cognitive and biomarker similarities between ADAD and late-onset Sporadic AD.



Lopera et al, 1997; Acosta-Baena et al, 2011; Fuller et al., 2019

6

What are the earliest changes associated with the predisposition to Alzheimer's disease?

7

Colombia-Boston (COLBOS)

Longitudinal study of autosomal dominant Alzheimer's disease

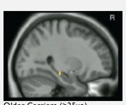
2014

NIH DP5; NIA R01; MGH

8

Evidence for brain changes in cognitively presymptomatic individuals, many years before clinical onset

Hippocampal hyperactivation, and less deactivation of parietal regions



Older Carriers (>25yo)

Quiroz et al. (2010) Annals of Neurology

Younger Carriers (18-25yo)

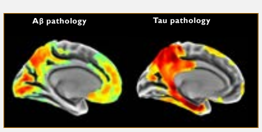
Reiman*, Quiroz* et al. (2012) Lancet Neurology

Children/Adolescents (9-18yo)

Quiroz et al., (2015) JAMA Neurology

PSEN1-E280A mutation carriers had elevated amyloid pathology as early as 28 years old.

PSEN1-E280A mutation carriers showed increased tau pathology in their late-30s, a few years before their clinical onset.

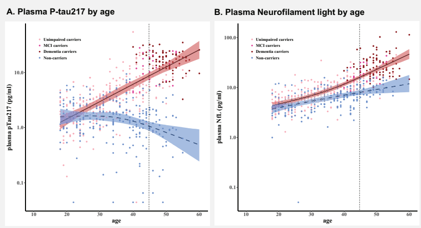


Older Carriers (>28yo)

Quiroz et al. (2018) JAMA Neurology

9

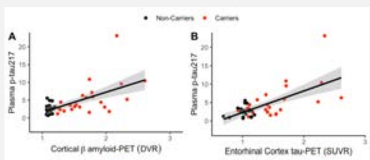
PLASMA BIOMARKERS



Quiroz et al., *The Lancet Neurology* 2020 (NfL); Palmqvist et al., *JAMA* 2020 (p-tau217)

10

P-TAU217 AND PET PATHOLOGY



Baseline plasma p-tau217 is associated with greater PET pathology burden ~7.5 years later.

	Non-Carriers		All Carriers		Unimpaired C	
	R	*p*	R	*p*	R	*p*
Cortical Aβ	0.16	.495	0.55	.005	0.66	.003
Inferior Temporal Cortex Tau SUVR	0.08	.738	0.71	< .001	0.79	< .001
Entorhinal Cortex Tau SUVR	0.15	.517	0.61	.002	0.49	.037
Precuneus Tau SUVR	0.39	.089	0.72	< .001	0.58	.012

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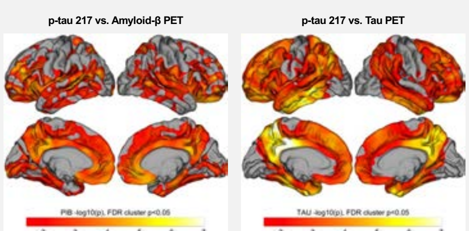
WHOLE-BRAIN ANALYSES (ALL CARRIERS)



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EARLY DIAGNOSIS OF COGNITIVE DECLINE AND DEMENTIA

13

REMOTE AND UNSUPERVISED ASSESSMENTS FOR DETECTION OF COGNITIVE IMPAIRMENT

14

REMOTE COGNITIVE BATTERIES

- Remote cognitive testing has expanded over the past two decades, especially during the COVID-19 pandemic.
- Many traditional tests have been adapted for telehealth, with studies linking remote performance to neurodegenerative biomarkers.
- Most tools lack cultural and linguistic adaptability.
- There's limited validation of remote assessments in diverse populations.
- Our research addresses these gaps by focusing on non-English speaking communities.

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MAPP REMOTE COGNITIVE BATTERY

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Validation of the Latin American Spanish version of the face-name associative memory exam in a Colombian Sample


The Latin American Spanish version of the Face-Name Associative Memory Exam is sensitive to cognitive and pathological changes in preclinical autosomal dominant Alzheimer's disease

LATIN AMERICAN SPANISH FACE-NAME ASSOCIATIVE MEMORY EXAM (LAS-FNAME)

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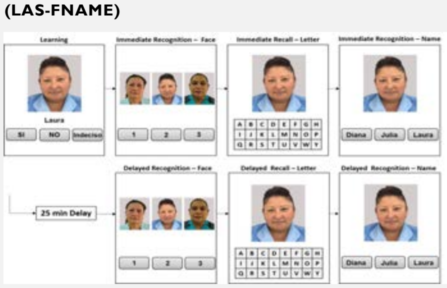
Latin American Spanish Face-Name Associative Memory Exam (LAS-FNAME)



Vila-Castelar, et al. (2019)

18

RESULTS: LAS-FNAME

LAS-FNAME	Noncarriers n=48	Cognitively-intact Carriers n=35		Symptomatic Carriers n = 19	
	M (SD)	*M (SD)*	p^a	*M (SD)*	p^b
IM Total	26.42 (4.19)	24.34 (4.66)	.037*	20.68 (4.40)	.001*
DM Total	27.14 (4.88)	25.06 (4.93)	.059	20.79 (4.43)	.003*
LAS-FNAME Total	53.56 (8.76)	49.40 (9.26)	.040*	41.47 (8.32)	.001*

Vila-Castelar & Muñoz et al., 2020

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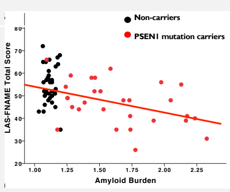
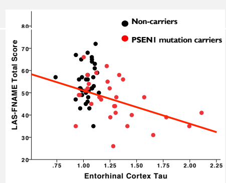
LAS-FNAME & AMYLOID



All carriers:

r_s = -.436, p = .018

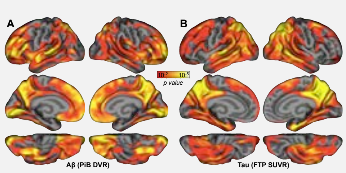
LAS-FNAME & TAU



All carriers:

r_s = -.394, p = .031

20



WHOLE-BRAIN ANALYSES

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LATIN AMERICAN SPANISH FACE-NAME ASSOCIATIVE MEMORY EXAM (LAS-FNAME)

- The LAS-FNAME was tested on both carriers (impaired and unimpaired) and non-carrier controls to assess sensitivity to early ADAD changes.
- Cognitively unimpaired carriers without reported concerns scored lower than non-carriers, indicating early memory decline.
- Higher Aβ and tau levels (entorhinal and inferior temporal regions) were linked to lower LAS-FNAME scores across all carriers.

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MEMORY FOR SEMANTICALLY RELATED OBJECTS (MESERO):

VISUAL WORKING MEMORY AND SEMANTIC PROCESSING TASK

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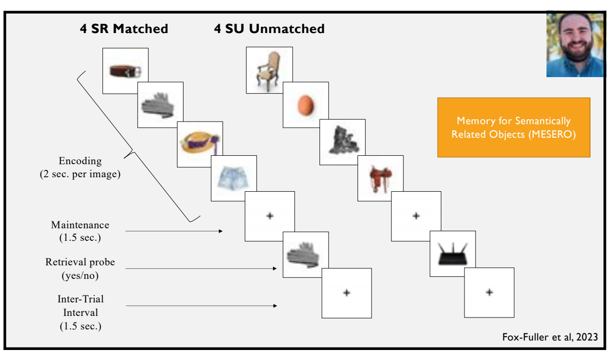

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	Non-Carrier (n=26)	Cognitively Unimpaired *PSEN1* E280A Carrier (n=35)	*PSEN1* E280A Carrier with MCI due to ADAD (n=5)	P-values
MESERO Total Score (out of 80)	**73.46 (5.67)**	**70.77 (6.51)**	64.60 (8.68)	***p*=.04**
MESERO Related Trials Sub-Score (out of 40)	**35.77 (2.89)**	**33.91 (4.15)**	31.60 (5.27)	***p*=.04**
MESERO Unrelated Trials Sub-Score (out of 40)	37.69 (3.31)	36.85 (3.48)	33.00 (3.53)	*p*=.15
4-Item Object Load Score (out of 40)	**37.31 (3.18)**	**35.54 (4.19)**	32.40 (5.32)	***p*=.02**
6-Item Object Load Score (out of 40)	36.15 (2.69)	35.23 (3.04)	32.20 (3.42)	*p*=.19

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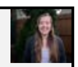
THE MAPP ROOM MEMORY TEST




Brief Communication

The MAPP Room Memory Test: Examining Contextual Memory Using a Novel Computerized Test in Cognitively-Unimpaired Individuals with Autosomal Dominant Alzheimer's Disease

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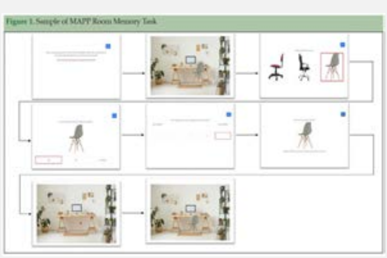
The MAPP Room Memory Test



Giudicessi, et al. (2024)

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RESULTS: ROOM TASK

	Non-Carriers, n = 31[1]	PSEN1 E280A Carriers, n = 15[1]	Test Statistic	p-value	Effect Size (r)
Age	38.97 (6.11)	35.67 (5.50)	1.84	0.08	0.24
Education	11.45 (4.34)	10.60 (3.83)	0.68	0.5	0.09
Sex			1.58	0.21	–
Female / Male	20/11	6/9			
MMSE	29.06 (1.03)	28.47 (0.92)	1.99	0.06	0.32
CERAD List Recall	7.68 (1.42)	7.00 (1.65)	1.36	0.2	0.19
Total Placement Score	0.54 (0.19)	0.54 (0.20)	241.5	0.81	0.03
Immediate Object Placement Accuracy	0.52 (0.20)	0.54 (0.20)	294.5	0.60	0.08
Immediate Object Recognition	0.68 (0.14)	0.61 (0.13)	161.0	0.09	0.25
Immediate Metamemory Score	0.37 (0.16)	0.42 (0.13)	205.5	0.43	0.12
Delayed Object Placement Accuracy	0.37 (0.24)	0.55 (0.28)	225.5	0.87	0.03
Delayed Room Recognition Accuracy	0.99 (0.05)	0.89 (0.18)	168.0	0.02*	0.36
Delayed Metamemory Score	0.67 (0.20)	0.61 (0.21)	197.0	0.38	-0.13
Object Recognition + Object Placement Pair Binding	0.36 (0.23)	0.38 (0.17)	248.5	0.70	0.06

1. Mean (SD); n, MMSE: Mini Mental State Examination CERAD: Consortium to Establish a Registry for Alzheimer's Disease, χ^2, Mann-Whitney U Test, all other test statistics=t, *=p<0.05

Giudicessi et al., 2024

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CONCLUSION

Findings across studies consistently demonstrate that the LAS-FNAME, along with the newly developed MESERO and MAPP Room Memory Test, effectively distinguish cognitively unimpaired carriers from non-carriers.

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REMOTE ASSESSMENT FOR SPANISH SPEAKERS

- Health care inequalities are both an ethical concern and a barrier to true equity.
- Neuropsychology research and clinical practices often overlook minoritized groups.
- This neglect limits access to accurate diagnoses and appropriate treatments.
- Advancing technology offers opportunities to reduce these disparities.
- Digital tools can promote equity in neuropsychological research and care.

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INCREASED INCIDENCE OF DEMENTIA IN LATINO POPULATION

- Rise in Latino elderly population:
  By 2028, Latino elders will become the largest elderly minority population in the U.S. (US Census Bureau).
- Prevalence of dementia in Latinos 1.5 times higher than in non-Latinos
- Age of onset tends to be earlier
- Number of Latinos affected by AD expected to rise from 481,000 currently to 3.5 million in 2060

In spite of this, evidence suggests they are not receiving adequate services to reduce their risk or manage their dementia.

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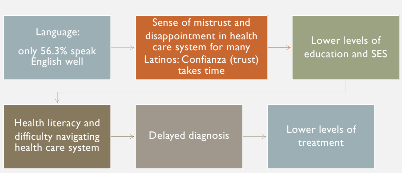
Older Latinos suffering from dementia: Barriers to health



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BOSTON LATINO AGING STUDY

- Cultural factors — together with socioenvironmental factors — should be integrated into dementia research (from recruitment/retention strategies to design and implementation of clinical studies).
- The goal of BLAST is to investigate the impact of various AD risk factors on cognition, brain function and molecular markers of AD pathology in individuals older than 55yo.

BLAST
Boston Latino Aging Study
Estudio del Envejecimiento en Latinos
Estudo sobre o Envelhecimento em Latinos
MASSACHUSETTS GENERAL HOSPITAL

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MULTICULTURAL RESILIENT BRAIN

- Memory declines as people age, but this is not inevitable.
- Individuals who maintain cognitive function despite high levels of AD-related pathology are said to be 'resilient' to dementia.
- Several factors have been associated with protection and resilience, but our understanding of which factors are causal or simply correlated with resilience is still limited. *Our knowledge of resilience in diverse samples is very limited.*
- **The goal Identifying mechanisms underlying resilience represents an exciting opportunity for prevention and treatments!**

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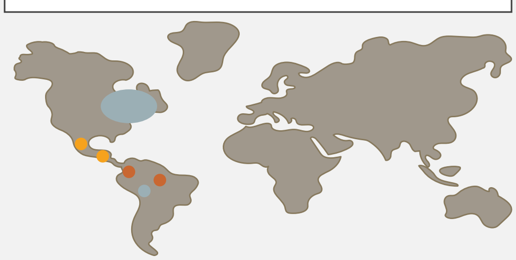
MAPP REMOTE PARTICIPANTS



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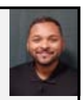
PARTICIPANTS

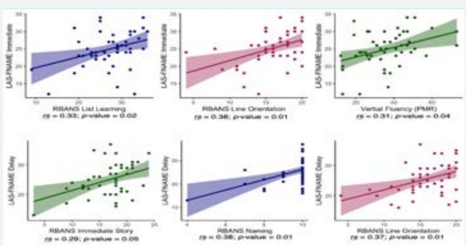
	Total (N = 54)	Female (n = 35)	Male (n = 19)
	M (SD)	M (SD)	M (SD)
AGE	64.57 (8.05)	65.40 (7.72)	63.05 (8.62)
EDUCATION	15.41 (3.59)	14.77 (3.40)	16.58 (3.72)
LAS FNAME IM TOTAL	24.94 (4.90)	24.83 (4.48)	25.16 (5.72)
LAS-FNAME DM TOTAL	25.39 (5.16)	25.49 (5.14)	25.21 (5.34)
LAS FNAME Total	50.33 (9.54)	50.31 (9.06)	50.37 (10.64)

37

Examining associative memory with the web-based Latin American version of the Face-Name Associative Memory Exam (LAS-FNAME) in community dwelling older Latino adults

Christopher Gonzalez Corona, MS[1,2], Perla Ortiz, MA, MS[3], Meredith Rowe, MA[1,4], Clara Vila-Castelar, PhD[1], Averi Giudicessi, MA[1,4], Marta Gonzalez Catalan, PhD[1], Daniel Saldana, PhD[1], Yakeel T Quiroz, PhD[1,4],





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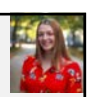
Investigating Memory for Semantically-Related Objects in Older Latino Adults Through a Web-Based Measure

Meredith Rowe, MA; Perla Ortiz, MA; Averi Giudicessi, MA; Christopher Gonzalez, MS; Joshua Fox-fuller, PhD; Alice Cronin-Golomb, PhD; Yakeel T. Quiroz, PhD



MESERO Related Avg Score (out of 40)	33.27 (4.95)
MESERO Unrelated Avg Score (out of 40)	34.76 (5.53)
MESERO Total Avg Score	68.039 (10.21)
MESERO Related Avg Median Reaction Time	2783.42 ms
MESERO Unrelated Avg Median Reaction Time	2904.631 ms

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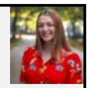
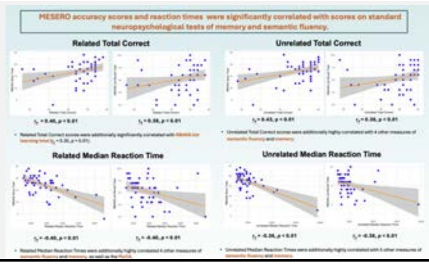
Investigating Memory for Semantically-Related Objects in Older Latino Adults Through a Web-Based Measure

Meredith Rowe, MA; Perla Ortiz, MA; Averi Giudicessi, MA; Christopher Gonzalez, MS; Joshua Fox-fuller, PhD; Alice Cronin-Golomb, PhD; Yakeel T. Quiroz, PhD





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	Total (N = 60)	Female (n = 41)	Male (n = 19)
	M (SD)	M (SD)	M (SD)
AGE	62.80 (8.67)	63.15 (8.65)	62.05 (8.91)
EDUCATION	15.02 (3.66)	14.39 (3.43)	16.37 (3.87)
Immediate Object Placement	0.43 (0.17)	0.42 (0.17)	0.46 (0.18)
Immediate Object Recognition	0.59 (0.12)	0.60 (0.12)	0.57 (0.11)
Immediate Meta Memory	0.51 (0.17)	0.52 (0.16)	0.48 (0.18)
Delay Object Placement	0.54 (0.26)	0.56 (0.22)	0.49 (0.33)
Delay Room Recognition	0.94 (0.15)	0.98 (0.11)	0.88 (0.21)
Delay Meta Memory	0.61 (0.20)	0.61 (0.19)	0.61 (0.23)
Total Raw Placement Score	7.05 (2.62)	7 (2.44)	7.16 (3.04)

ROOM MEMORY TEST

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CONCLUSIONS

- We adapted the Face-Name Associative Memory Exam (FNAME) to Latin American Spanish (LAS-FNAME).
- LAS-FNAME, MESERO & THE ROOM TEST detect cognitive decline in individuals at risk for autosomal dominant Alzheimer's disease.
- Performance on LAS-FNAME is linked to elevated amyloid and tau levels in asymptomatic individuals.
- Recently shown to differentiate individuals with MCI from controls in Argentina (Keller et al., 2024).
- Preliminary findings suggest that LAS-FNAME, MESERO & THE ROOM TEST may be sensitive memory measures across heterogenous Hispanic/Latino older adults residing in the U.S.

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OVERALL CONCLUSIONS

- Clinical tools should evolve to include more precise measures like our computerized tasks (e.g., MAPP Room Memory Test, MESERO).
- These tools support earlier and more nuanced detection of disease, including preclinical stages of AD.
- Digital tools can enhance monitoring and intervention, but access and usability remain barriers for some communities.
- It's essential to address digital inequities to ensure inclusive research and clinical practice.

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Tele-Neuropsychological Testing: Science, Practice, & Policy

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Center for Neurological Restoration
Neurological Institute
Cleveland Clinic

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1

Disclosures

- Health Care Delivery and Implementation Science Center
- American Academy of Clinical Neuropsychology Foundation
- American Psychological Association Advisor to the American Medical Association/Specialty Society RVS Update Committee

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2

Objectives

1) Develop new knowledge of the feasibility and reliability, of tele-neuropsychological testing in different clinical populations
2) Develop knowledge of the feasibility, reliability, and diagnostic validity of in-home tele-neuropsychological testing in Parkinson's disease
3) Develop knowledge of healthcare policy and advocacy efforts related to tele-neuropsychology

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3

Tele-Neuropsychology:
Context & Policy

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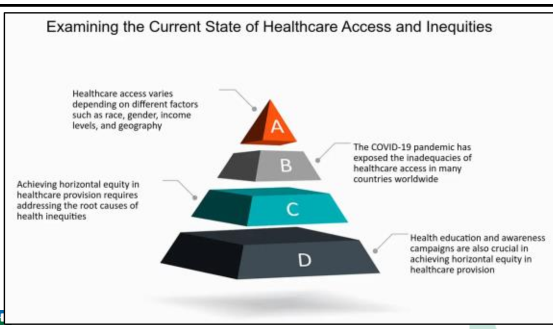

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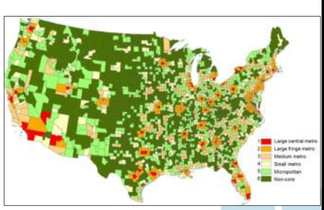
- 7% of neuropsychologists practice in rural environments
- Over half of all neuropsychologists practice in 9 states
- Declining number of lifespan neuropsychologists
- 20% pediatric neuropsychologists



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Sweet et al., 2021

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Indirect Healthcare Costs

- Transportation costs
- Losses in income
- Losses in work and personal leave time
- Child and/or elder care costs
- Costs are extended to care partners

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Healthcare Policies & Programs

- Designed to address the specific needs of the population they serve
- Evidence-based
- Evaluated regularly to ensure effectiveness
- Implemented in a culturally sensitive and respectful manner

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Tele-Neuropsychology: The Science

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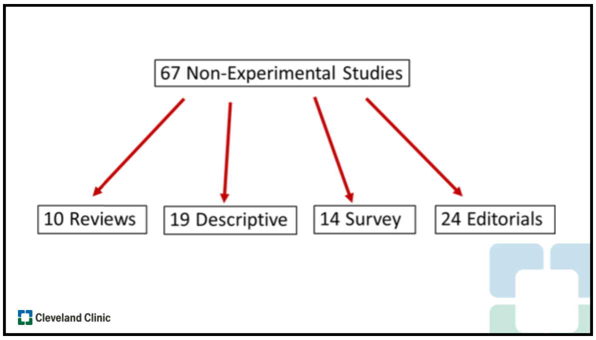
67 Non-Experimental Studies
10 Reviews
19 Descriptive
14 Survey
24 Editorials
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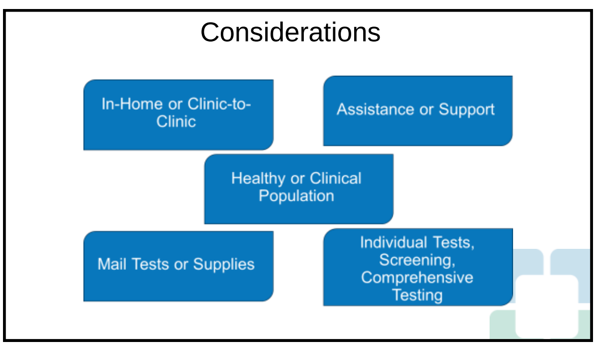
Considerations
In-Home or Clinic-to-Clinic
Assistance or Support
Healthy or Clinical Population
Mail Tests or Supplies
Individual Tests, Screening, Comprehensive Testing

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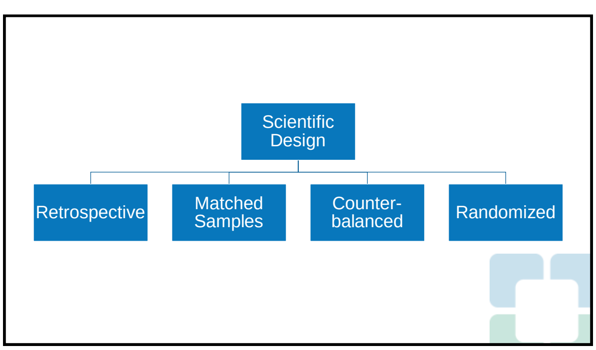
Scientific Design
Retrospective
Matched Samples
Counter-balanced
Randomized

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- Outcomes
  - Feasibility
    - Acceptability
    - Satisfaction
  - Concordance
  - Mean differences
  - Test-retest reliability
  - Diagnostic validity

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Matched Samples: Clinical

- Pediatrics
- Neuro-oncology
- HIV
- Multiple sclerosis

Ransom et al., 2020; Gardner et al., 2021; Levy et al., 2023; Kohli et al., 2023

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Counter-balanced: In-Clinic

- Healthy adults
- Subjective cognitive deficits
- MCI or Alzheimer's disease

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Counter-balanced: In-Clinic

Assessment. 2006 Dec;13(4):385-90. doi: 10.1177/1073191106289065.

Feasibility of telecognitive assessment in dementia

C Munro Cullum [1], Myron F Weiner, Helena R Gehrmann, Linda S Hynan

Published in final edited form as:
J Int Neuropsychol Soc. 2014 November ; 20(10): 1028–1033. doi:10.1017/S1355617714000873.

Teleneuropsychology: Evidence for Video Teleconference-Based Neuropsychological Assessment

C. Munro Cullum[1,2], L.S. Hynan[3], M. Grosch[1], M. Parikh[1], and M.F. Weiner[1,2]

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Counter-balanced: In-Clinic

Video Teleconference Administration of the Repeatable Battery for the Assessment of Neuropsychological Status

Jeanine M. Galusha-Glasscock, Daniel K. Horton, Myron F. Weiner, C. Munro Cullum

Archives of Clinical Neuropsychology, Volume 31, Issue 1, February 2016, Pages 8–11,
https://doi.org/10.1093/arclin/acv058

Remote Neuropsychological Assessment in Rural American Indians with and without Cognitive Impairment

Hannah E. Wadsworth, Jeanine M. Galusha-Glasscock, Kyle B. Womack, Mary Quiceno, Myron F. Weiner, Linda S. Hynan, Jay Shore, C. Munro Cullum

Archives of Clinical Neuropsychology, Volume 31, Issue 5, August 2016, Pages 420–425,
https://doi.org/10.1093/arclin/acw030

20

Counter-balanced: In-home, Healthy

COVID-19 Articles

Feasibility of administering the WAIS-IV using a home-based telehealth videoconferencing model

Susan Mahon, James Webb, Deborah Snell & Alice Theadom

Pages 558-570 | Received 14 Jun 2021, Accepted 21 Sep 2021, Published online: 14 Oct 2021

Teleneuropsycological adaptation of the NEUROPSI Breve screening test

María Guadalupe González-Osornio, Martha Valeria Medina-Rivera, and Larissa Orta-Castañeda

OnlineFirst | https://doi.org/10.1177/1357633X221123412

An evaluation of the convergent validity of a face-to-face and virtual neuropsychological assessment counter balanced

Carl R. Krynicki, David Hacker, Christopher A. Jones

First published: 28 November 2022 | https://doi.org/10.1111/jnp.12300

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Counter-balanced: In-home, Clinical

Comparing Performance Across In-person and Videoconference-Based Administrations of Common Neuropsychological Measures in Community-Based Survivors of Stroke

Jodie E Chapman [1], Betina Gardner [1,2], Jennie Ponsford [1,3], Dominique A Cadilhac [4,5], Renerus J Stolwyk [1,3]

A validation study for remote testing of cognitive function in multiple sclerosis

Lisa F. Barcellos, PhD, MPH[1,2], Mary Horton, MPH[1], Xiaorong Shao[1], Kalliope H. Bellesis[2], Terrence Chinn[2], Emmanuelle Waubant[3], Nandini Bakshi, MD[4], Jackie Marcus, MD[5], Ralph HB Benedict, PhD[6,7], Catherine Schaefer, PhD[2,7]

Comparing the Reliability of Virtual and In-Person Post-Stroke Neuropsychological Assessment with Language Tasks

Erin Duricy[1,2,3,*], Corrine Durisko[1], Michael Walsh Dickey[3,4,5,6], Julie A. Fiez[1,2,3,4,5]

22

Randomized, Counter-balanced: In-home, Clinical

Investigating Equivalence of In-Person and Telehealth-Based Neuropsychological Assessment Performance for Individuals Being Investigated for Younger Onset Dementia

Aimee D. Brown[1,2], Wendy Kelso[1,3], Dhamidhu Eratne[3,4], Samantha M. Loi[3,4], Sarah Farrand[3], Patrick Summerell[3], Joanna Neath[3], Mark Walterfang[3], Dennis Velakoulis[3], Renerus J. Stolwyk[1,2,*]

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E-mail address: rene.stolwyk@monash.edu (R. Stolwyk).

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Non-Counter-balanced: In-home, Clinical

J Int Neuropsychol Soc. 2023 Feb;29(2):193-204. doi: 10.1017/S1355617722000777. Epub 2022 Dec 13.

Concurrent validity and reliability of at-home teleneuropsychological evaluations among people with and without HIV

Maulika Kohli [1,2], Arin Fisher [2], Ni Sun-Suslow [2], Anne Heaton [2], Matthew S Dawson [2], Jennifer Marquie [2], Donald R Franklin [2], Maria Marquine [2,3], Jennifer E Iudicello [2,3], Robert K Heaton [2,3], David J Moore [2,3]

J Int Neuropsychol Soc. 2024 Dec;30(10):954-965. doi: 10.1017/S1355617724000432. Epub 2024 Oct 21.

Tele-neuropsychology in memory clinic settings: Reliability and usability of videoconference-based neuropsychological testing

Elke Butterbrod [1,2], Dominique M J van den Heuvel [3,4], Pia Zevenhoven [2], Lisa Waterink [2], Mardou van Leeuwenstijn [2], Roos J Jutten [5], Wiesje M van der Flier [2,6], Sietske A M Sikkes [1,2]

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Counter-balanced: In-home, Clinical

Neuropsychology

Agreement, Reliability, Feasibility, and Acceptability of Home-Based Telehealth Versus Face-to-Face Pediatric Neuropsychological Testing: A Within-Person Crossover Study

Kristina M. Haebich[1, 2], Hayley Darke[1], Francesca Lami[1, 2], Alice Maier[1, 2], Anita K. Chisholm[1, 2, 3], Alex Ure[1, 4, 5], Natasha L. Hogan[2], Yu Fan Eng[1], Jacquie Wrennall[3], Stephen J. C. Hearps[1], Daryl Efron[1, 2, 3], Nicki Joshua[6], Gabriel Dabscheck[1, 2, 3], Kathryn N. North[1, 2], Vicki A. Anderson[1, 2, 7], and Jonathan M. Payne[1, 2, 3]

Home-Based Pediatric Teleneuropsychology: A validation study

Lana Harder[1,2,3,*], Ana Hernandez[1], Cole Hague[4], Joy Neumann[1,2], Morgan McCreary[3], C. Munro Cullum[2,3,5], Benjamin Greenberg[3,6]

Remote Assessment of Pediatric Patients with Daytime Sleepiness and Healthy Controls: A Pilot Study of Feasibility and Reliability

Jennifer Worhach, MA,[1] Madeline Boduch, BS,[1] Bo Zhang, PhD,[1,2] and Kiran Maski, MD, MPH[1]

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Validity

> Arch Clin Neuropsychol. 2018 Dec 1;33(8):1040-1045. doi: 10.1093/arclin/acx140.

Validity of Teleneuropsychological Assessment in Older Patients with Cognitive Disorders

Hannah E Wadsworth[1], Kaltra Dhima[1], Kyle B Womack[1 2], John Hart Jr[1 2], Myron F Weiner[1], Linda S Hynan[1 3], C Munro Cullum[1 2 4]

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Reliability and Validity of In-home Tele-Neuropsychological Testing in Patients with Parkinson's Disease: A Randomized Trial

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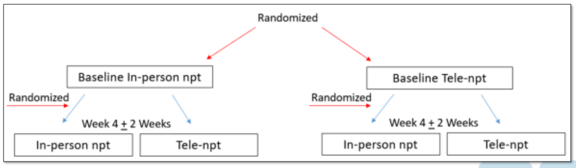

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- The Dot Counting Test
- Test of Premorbid Functioning
- Montreal Cognitive Assessment, Form 7.3
- Wechsler Adult Intelligence Scale - Fourth Edition: Digit Span
- Wechsler Adult Intelligence Scale - Fourth Edition: Matrix Reasoning
- Wechsler Memory Scale - 3rd Edition: Letter-Number Sequencing
- Wechsler Memory Scale – 3rd Edition: Logical Memory
- Hopkins Verbal Learning Test-Revised, Form 1
- Neuropsychological Assessment Battery: Shape Learning
- Rey Complex Figure Test: Copy
- Judgement of Line Orientation – Form H
- Delis-Kaplan Executive Function System: Verbal Fluency
- Delis-Kaplan Executive Function System: Color-Word Interference
- Wisconsin Card Sorting Test
- Boston Naming Test - Second Edition
- Symbol Digit Modalities Test: Oral
- Geriatric Depression Scale
- Geriatric Anxiety Inventory
- Apathy Scale
- Parkinson's Disease Questionnaire-8

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Demographic Characteristics

- N = 79
- Mean age = 68 (SD=8.4)
- Predominately white, well-educated, and male
- Mild to moderate PD severity
- High familiarity and comfort with technology

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Between Group Differences at Baseline

	Baseline In-person (N=41)	Baseline Tele-npt (N=36)	p-value
Language			
Boston Naming Test-2	57.0 (2.3)	57.5 (2.2)	0.071
D-KEFS: Category Fluency	40.2 (7.0)	39.9 (6.0)	0.84

	Baseline In-person (N=41)	Baseline Tele-npt (N=36)	p-value
Visuospatial			
RCFT Total Copy	33.0 (2.8)	31.5 (4.2)	0.15
Judgement of Line Orientation	27.2 (3.2)	27.7 (2.8)	0.30

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Between Group Differences at Baseline

	Baseline In-person (N=41)	Baseline Tele-npt (N=36)	p-value
Memory			
WMS-3: Logical Memory I	38.6 (7.9)	39.7 (8.8)	0.63
WMS-3: Logical Memory II	24.1 (7.8)	23.3 (6.5)	0.56
HVLT-R Total Recall	23.9 (5.8)	24.3 (3.3)	0.48
HVLT-R Delayed Recall Total	8.5 (3.0)	8.2 (2.9)	0.93
NAB Shape Learning: Immediate Recognition	16.6 (3.1)	15.7 (2.9)	0.39
NAB Shape Learning: Delayed Recognition	5.9 (1.3)	5.0 (1.6)	***0.029***

	Baseline In-person (N=41)	Baseline Tele-npt (N=36)	p-value
Executive Functioning			
WCST Total Errors	31.2 (24.7)	39.0 (26.8)	0.44
D-KEFS: Letter Fluency	45.0 (12.9)	41.6 (10.9)	0.61
D-KEFS: Category Switching: Total Correct Responses	13.5 (3.1)	15.0 (2.7)	***0.023***
WAIS-IV: Matrix Reasoning	17.9 (4.9)	17.8 (4.9)	0.29
D-KEFS: Inhibition	66.6 (26.6)	68.9 (18.6)	0.81
D-KEFS: Inhibition/Switching	78.4 (35.6)	73.5 (20.4)	0.18

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Between Group Differences at Baseline

	Baseline In-person (N=41)	Baseline Tele-npt (N=36)	p-value
Performance Validity, Premorbid Functioning, and Cognitive Screening			
Dot Counting E-Score	11.2 (3.5)	13.7 (2.9)	***0.013***
TOPF	53.5 (10.8)	50.4 (14.1)	0.85
MoCA	25.4 (2.3)	26.5 (2.5)	***0.004***

	Baseline In-person (N=41)	Baseline Tele-npt (N=36)	p-value
Attention, Working Memory, & Processing Speed			
WAIS-IV Digit Span: Total	29.2 (4.7)	28.2 (5.5)	0.74
WMS-3: Letter-Number Sequencing	10.0 (2.7)	9.9 (2.6)	0.62
D-KEFS: Color Naming	33.1 (6.8)	37.5 (7.4)	***0.009***
D-KEFS: Word Reading	24.8 (5.0)	30.1 (9.7)	***0.005***
SDMT Oral	48.8 (10.4)	41.3 (10.9)	***0.003***

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Test-Retest Reliability

	Repeated in-person npt (N=21)	Repeated in-home tele-npt (N=18)
TOPF	0.981 (0.954, 0.992)	0.849 (0.648, 0.940)* ł
D-KEFS: Color Naming	0.937 (0.853, 0.974)	0.670 (0.319, 0.861) ł

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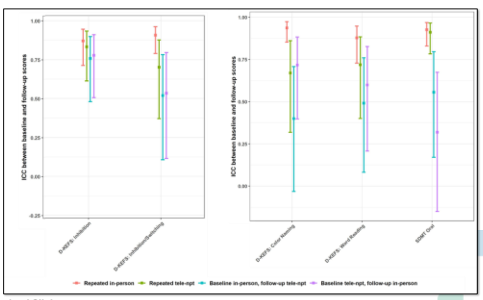

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Reliable Change

Frequency and percentage of participants exceeding the SRB change threshold

	Repeated in-person npt (N=21)	Repeated in-home tele-npt (N=18)	In-person/tele-npt (N=20)	Tele-npt/in-person (N=18)	p-value
TOPF	2 (9.52)	11 (61.11)	9 (45.00)	4 (22.22)	***0.003**[a,b]*
D-KEFS: Word Reading	2 (9.52)	3 (16.67)	2 (10.00)	8 (44.44)	***0.037**[c]*
D-KEFS: Letter Fluency	2 (9.52)	4 (22.22)	7 (35.00)	0 (0.00)	***0.015***
D-KEFS: Inhibition	2 (9.52)	3 (16.67)	6 (30.00)	0 (0.00)	***0.049***
WMS-3: Logical Memory II	0 (0.00)	8 (44.44)	5 (25.00)	2 (11.11)	***0.002**[a,b]*
NAB Shape Learning: Immediate Recognition	1 (4.76)	1 (5.56)	9 (45.00)	3 (16.67)	***0.004**[b]*
Judgement of Line Orientation	3 (14.29)	9 (50.00)	7 (35.00)	2 (11.11)	***0.026**[a]*

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Diagnostic Validity

Cognitively impaired patients based on neuropsychological tests

		z-score <=-1 as impairment		z-score <=-1.5 as impairment		z-score <=-2 as impairment	
	N	Cognitively Impaired	p-value	Cognitively Impaired	p-value	Cognitively Impaired	p-value
Baseline			0.12[a]		0.47[a]		0.18[a]
In-person	41	21 (51.2)		13 (31.7)		5 (12.2)	
Tele-npt	38	26 (68.4)		15 (39.5)		9 (23.7)	
Week 4			0.087[a]		0.12[a]		0.26[b]
In-person	39	13 (33.3)		9 (23.1)		2 (5.1)	
Tele-npt	38	20 (52.6)		15 (39.5)		5 (13.2)	

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Diagnostic Validity

Agreement of cognitive diagnosis groups between Baseline and Week 4

		z-score <=-1 as impairment		z-score <=-1.5 as impairment		z-score <=-2 as impairment	
	N	Agreement	p-value	Agreement	p-value	Agreement	p-value
Overall	77	57 (74.0)		59 (76.6)		62 (80.5)	
By testing groups			0.10		0.77		0.44
Repeated in-person npt	21	17 (81.0)		17 (81.0)		19 (90.5)	
Repeated in-home tele-npt	18	11 (61.1)		14 (77.8)		13 (72.2)	
In-person/tele-npt	20	18 (90.0)		16 (80.0)		15 (75.0)	
tele-npt/in-person	18	11 (61.1)		12 (66.7)		15 (83.3)	

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Acceptability

- Very easy/easy to use technology (89%)
- Very satisfied/satisfied (90% in-person; 89% tele-npt)
- Comfortable recommending services (93% in-person; 92% tele-npt)
- Accurately reflected abilities (80% in-person; 72% tele-npt)

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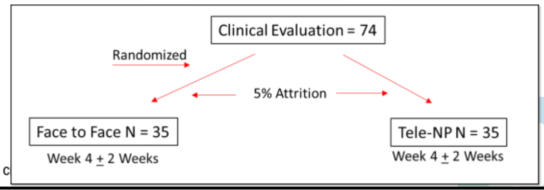
Tele-NP in General Neurology

- Acceptability, reliability, & diagnostic validity
- Moderating effects of depression and anxiety
- Cost savings



40

- High provider and patient satisfaction
- Achievable testing Goals
- Costs are low
- PSYPACT
- 90% of Americans use the internet
- 75% own a desktop or laptop
- 77% home broadband
- Little difficulty connecting to the internet
- Closing regional differences in access

Parikh et al., 2013; Parsons et al., 2022; Parsons et al., 2022; (19); https://psypact.site-ym.com/page/psypactmap. Published 2022. Accessed July 24, 2022; www.pewresearch-org-preprod.go-vip.co/internet/2021/06/03/mobile-technology-and-home-broadband-2021/

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Conclusions

1) There is strong evidence supporting the feasibility, acceptability, and reliability of tele-npt in diverse populations

2) In-home tele-npt in Parkinson's disease is a feasible and reliable means of obtaining diagnostically valid results

3) The use of in-home tele-npt requires consideration of test, patient, and environment specific factors

4) Broad application of tele-npt can reduce inequities in healthcare access

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