Considering Cognitive Testing via “Test My Brain”

EPI-CAL Cognitive Testing

- Proposed to use 4 subtests of the Penn CNB
  - Matrix Reasoning → Provides estimate of nonverbal IQ, not provided by BACS
  - Word Memory Test
  - Digit Symbol Substitution
  - Emotion Recognition → not provided by BACS
- Our CAB is collected via the Beehive app on iPads or via a website
  - Embedded in clinical care as quality improvement, so no study consent for CAB – study team does not have access to PHI. Allows for ease of enrollment BUT prevents direct contact of participants by study team.
- Originally planned to provide laptops to sites for cognitive test administration
  - Can only use Penn CNB on a laptop or desktop (not iPad or phone compatible)
  - Would require site staff to set it up and link it to outcomes data on Beehive. This includes entering the GUID from Beehive into the Penn CNB portal

New Considerations for our Sites

- Needs to be deployed remotely b/c majority of clinical services are still remote
  - EPI-MINN has been able to send links to participants, but paid for this option AND they have ability to contact their participants
- Needs to be compatible with iPad or phone as many clients do not have a laptop or computer at home.
- Site staff are reporting feeling overwhelmed and unsure for how to deploy both our outcomes eval AND the cognitive testing
  - We worry cognitive testing will not be administering to many participants due to the increased administrative burden.
- How can we ensure linkage of our study GUID to the computer data…?
  - Would need to pay to develop any sort of study specific portal or link to our testing app
- How is the data managed and maintained by Penn CNB?
  - Would we have to pay for them to manage cognitive testing data for a multi-year study?

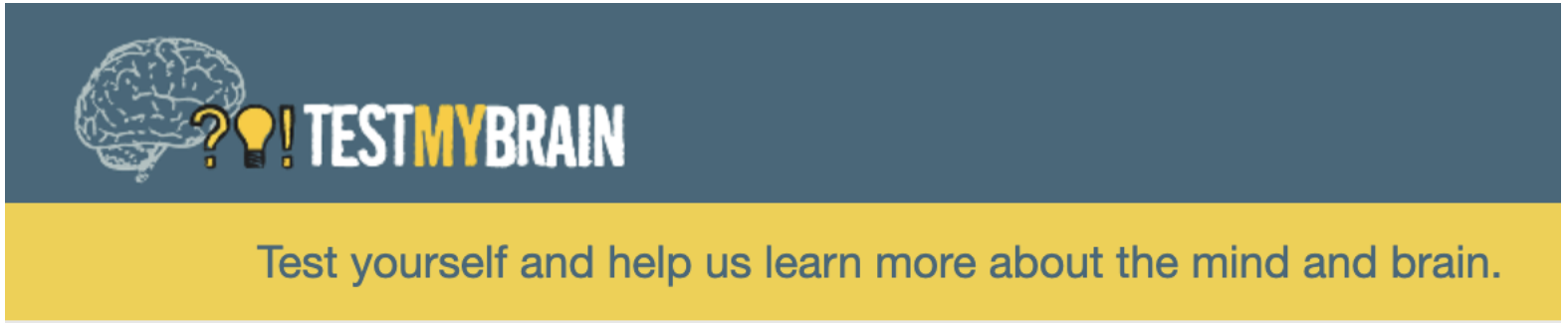
LEAP Cognitive Testing

- We proposed to use PENN-CNB
- Clinical sites have expressed concern about staff burden from PENN-CNB or the BAC-APP
  - Unlikely to be systematically collected in our setting unless we can identify an approach that does not require proctoring
- We use an interface called mindLAMP developed by John Torous and team
- Assessments collected within QI format; include data from all people served in the clinics
- Ideal cognitive assessment is one that can be administered on multiple platforms including iPad and smartphone and without need for proctoring

Test My Brain (“TMB”)

- Developed by Laura Germine, Ph.D. at Harvard
- Supports web/cloud-based testing of a variety of measures for a variety of purposes, across a variety of devices
- Has ability to administer comparable versions of the 4 Penn subtests
- Already being widely used (400+ sites), so this is not an academic project that needs to be validated (for example) where support is dependent on fluctuating federal funding.

What is TestMyBrain?

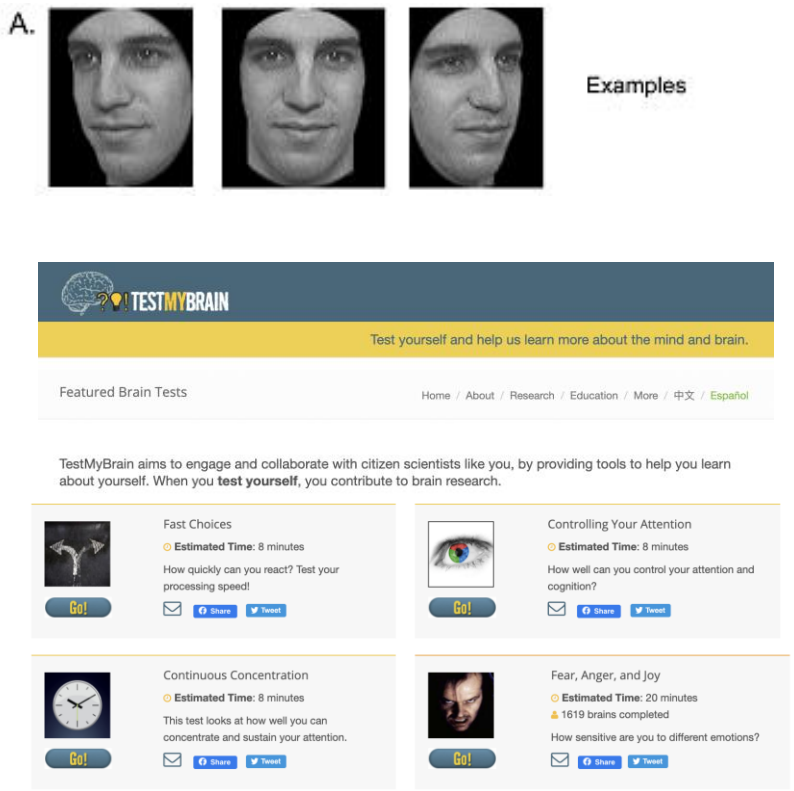


TestMyBrain is a digital research laboratory and a software platform for cognitive assessment. In addition to a public-facing front page and free cognitive assessment tools, it also provides custom software infrastructure for research studies that include digital cognitive assessment.

The TestMyBrain platform is collaboratively supported by the nonprofit (501c3) Many Brains Project and the McLean Laboratory for Brain and Cognitive Health Technology.

All tests are developed under a LGPL 3.0 open-source license that permits flexible use, broad dissemination, and software transparency.

TestMyBrain: A Brief History



- **2005:** Development of first web-based neuropsychological assessments of visual recognition memory (e.g. Germine et al., 2011 *Cognition*)
- **2008:** TestMyBrain.org launched – broader neuropsychological assessments for lab-based translational research in a *citizen science* model
- **2012:** First integrations into clinic-based research at Massachusetts General Hospital and McLean Hospital
- **2015:** Establishment of the Many Brains Project 501c3 to support research-based cognitive assessment
- **2016:** Establishment of the Laboratory for Brain and Cognitive Health Technology at McLean Hospital
- **2018:** Creation of the TestMyBrain Open Research and Education Page and establishment of the NIH General Cognitive Index (GCI)
- **2020:** Creation of the TestMyBrain Digital Neuropsychology Toolkit
- **Present:** 2.5 million participants, integrated into 400+ research and education sites, with funding across NIH institutes (NIMH, NIA, NIDDK, NCI, NIEHS)

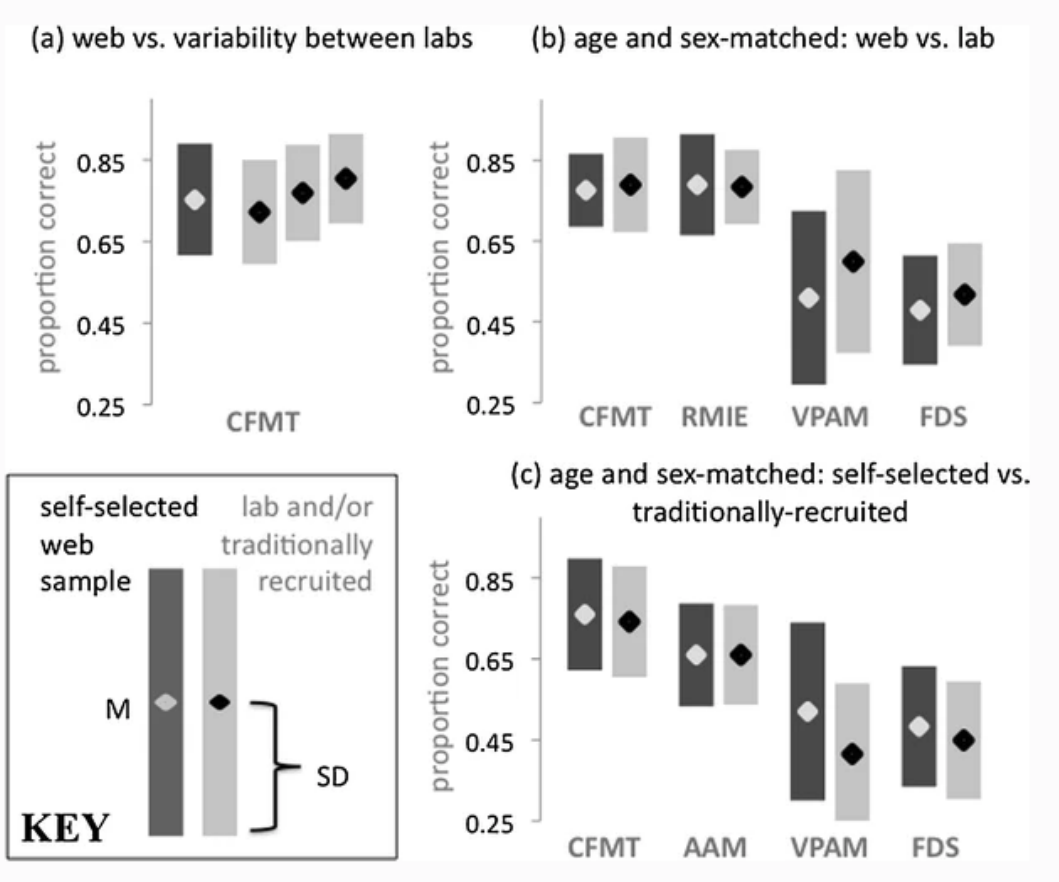
Validity and Reliability

Brief Report | Published: 25 July 2012

Is the Web as good as the lab? Comparable performance from Web and lab in cognitive/perceptual experiments

Laura Germine ✉, Ken Nakayama, Bradley C. Duchaine, Christopher F. Chabris, Garga Chatter
Jeremy B. Wilmer

Psychonomic Bulletin & Review **19**, 847–857(2012) | Cite this article

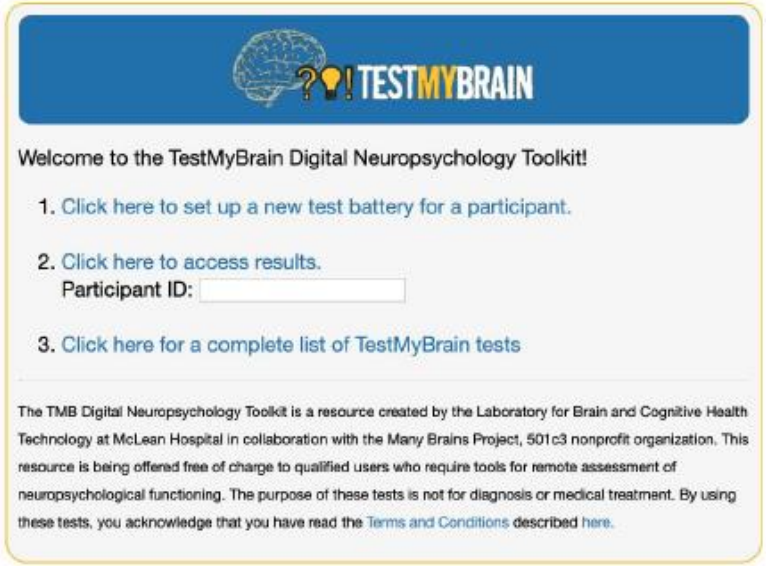


- Comparable reliability and distribution characteristics (mean, SD) for tests administered through the web browser and in the laboratory for research measures of cognition and perception.
- Also comparable reliability and distributions for web recruitment vs. traditional recruitment

TMB Digital Neuropsychology Toolkit

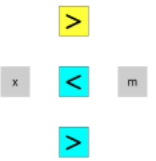
Supported by the Many Brains Project (nonprofit 501c3) and McLean Hospital / HMS

- Created in response to Covid-19
- Free resource for self-administered remote assessment
- 1200 researchers / clinicians currently registered
- Normative data based on web-based administration (N= 4,000-60,000)
  - Age (12-90)
  - Sex
  - Education
  - Device (i.e. laptop, iPad, smartphone)
- See also TMB Open Research and Education Page for Teachers / Researchers. Includes downloadable raw data from N=1000 across the lifespan for each test.



TMB Digit Symbol Matching

TMB Matrix Reasoning



TMB Simple & Choice RT

538

TMB Digit Span

TMB Gradual Onset CPT

TMB Trail Making Test

TMB Verbal and Visual Paired Associates

TMB Comparison with WAIS IV

> Clin Neuropsychol. 2021 Jan;35(1):148-164. doi: 10.1080/13854046.2020.1811893.
Epub 2020 Sep 3.

Construct validity, ecological validity and acceptance of self-administered online neuropsychological assessment in adults

Naomi S Chaytor [1], Celestina Barbosa-Leiker [2], Laura T Germine [3 4],
Luciana Mascarenhas Fonseca [1], Sterling M McPherson [1 5 6], Katherine R Tuttle [5 6]

Affiliations + expand

PMID: 32883156 DOI: 10.1080/13854046.2020.1811893

WAIS-IV Test	TMB Test	Domain	Pearson r*
WAIS-IV Coding	TMB Digit Symbol matching	Processing Speed	0.66 (0.74)
WAIS-IV Digit Span Forward	TMB Forward Digit Span	Attention / Short-term Memory	0.53 (0.69)
WAIS-IV Digit Span Backward	TMB Backward Digit Span	Working Memory	0.54 (0.72)
WAIS-IV Letter Number Sequencing	TMB Letter Number Sequencing	Working Memory	0.59 (0.75)
WAIS-IV Matrix Reasoning	TMB Matrix Reasoning	Nonverbal Reasoning	0.49 (0.54)
WAIS-IV Vocabulary	TMB Vocabulary	Verbal Reasoning	0.58 (0.65)

- Comparing in person, traditional neuropsychological assessment (WAIS IV) with TestMyBrain self-administered online assessments
  - High correlations between WAIS and TestMyBrain versions of tests
  - Comparable reliability
  - Comparable discriminant and convergent validity
  - High acceptability of TestMyBrain assessments

Penn Computerized Neurocognitive Battery (Penn CNB)

The Penn Computerized Neurocognitive Battery provides about a dozen measures that have been widely used in neuropsychiatry and neuroimaging research, as well as part of the PhenX Toolkit.

Comparisons between the TMB and Penn CNB batteries are based on the format of the test and factor structure of test scores, within each battery. This comparison is *not based on data from a formal validation study comparing the tests.* It is expected that researchers use their discretion in determining whether a particular TMB test is an appropriate analog for a measure from the Penn CNB in their study.

TMB Comparison with Penn CNB

Penn Test	TMB Test	Domain	Similarity	Major differences
Penn Word Memory Test (PWMT)	TMB Verbal Paired Associates	Verbal episodic memory	Expected Moderate	The TMB version requires learning word pairs, rather than individual words (Penn). Distractors can either be novel, pulled from the list of other distractors, or target words from other pairs.
Penn Matrix Reasoning Test (PMAT)	TMB Matrix Reasoning	Nonverbal Reasoning	Expected High	None - both modeled on Raven's / WAIS.
Penn Digit Symbol Substitution Test (DSST)	TMB Digit Symbol Matching	Processing Speed	Expected High	None – both modeled on classic (e.g. WAIS) DSST.
Emotion Recognition Test (ER-40 / PEIT)	TMB Multiracial Emotion Identification Test	Emotion Perception	Expected High	The TMB version omits neutral faces, as performance on these faces is poorly correlated with basic emotion identification for non-neutral faces. Omission of these faces increases task reliability.

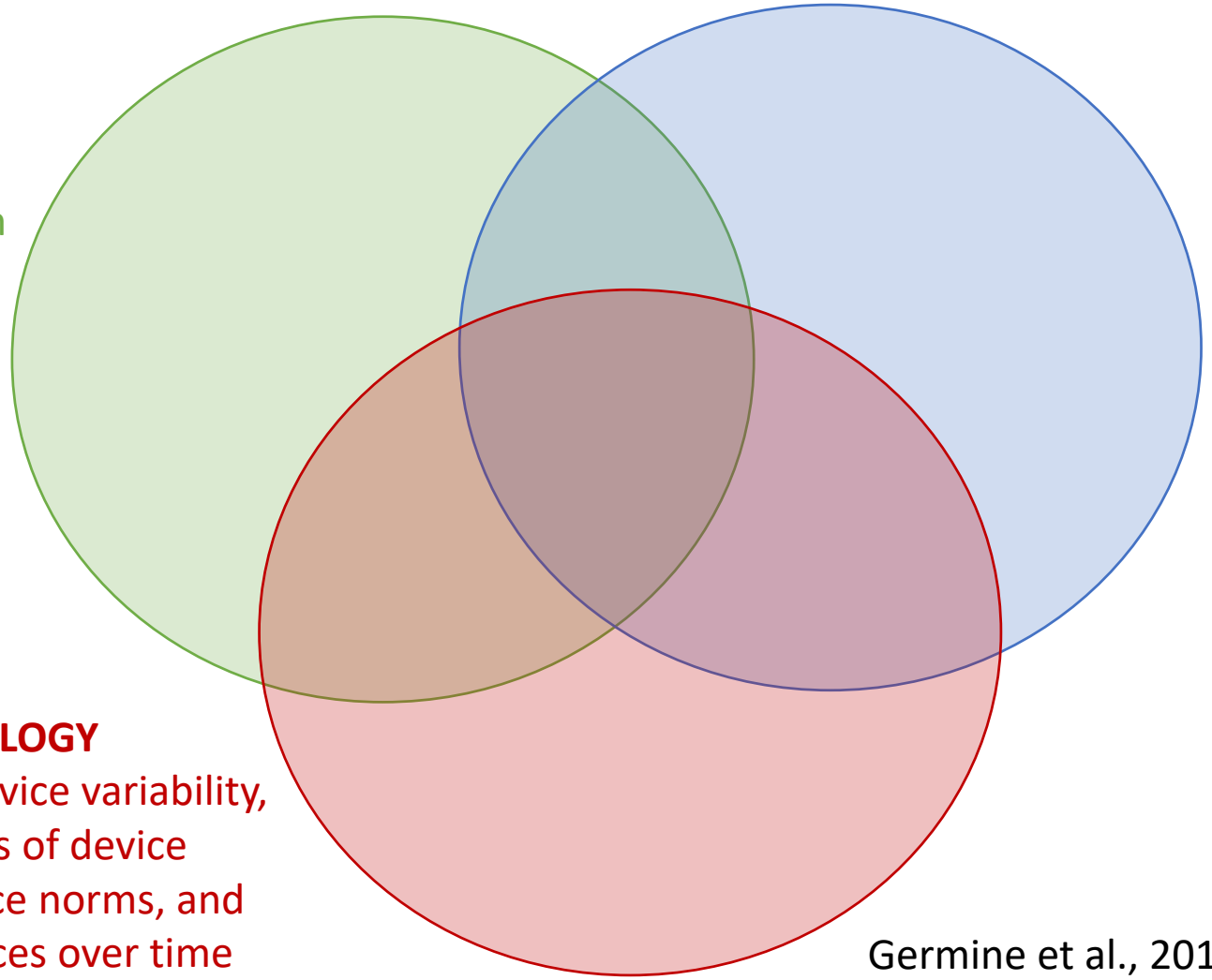
TMB is a good solution for EPI-CAL & LEAP

- We can embed a direct link to TMB in the Beehive application, which will take users (on their device) to the TMB site, administer the tests, and have a link to the GUID in our system
  - No need for site staff to administer
  - Creates seamless link from Beehive to cognitive testing without need for PHI
  - Provides portal where study staff can access data remotely and download for integration with CAB data
- Can create percentiles for Matrix test for “proxy IQ” measure, which is desired by our clinical sites

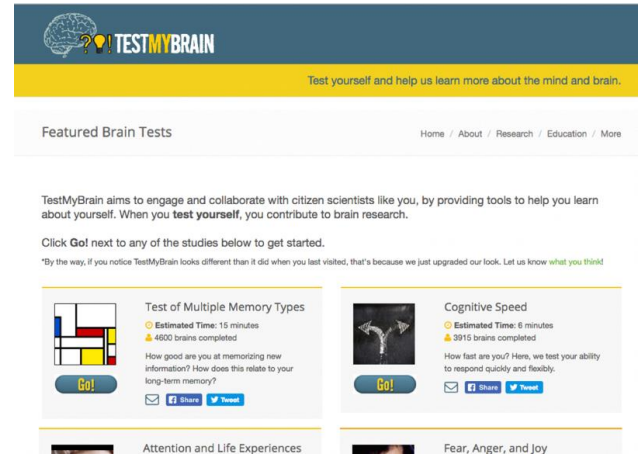
Questions?

What is Digital Neuropsychology?

PSYCHOMETRICS
Building sensitive, reliable, and *efficient* measures of information processing for between and within-person assessment



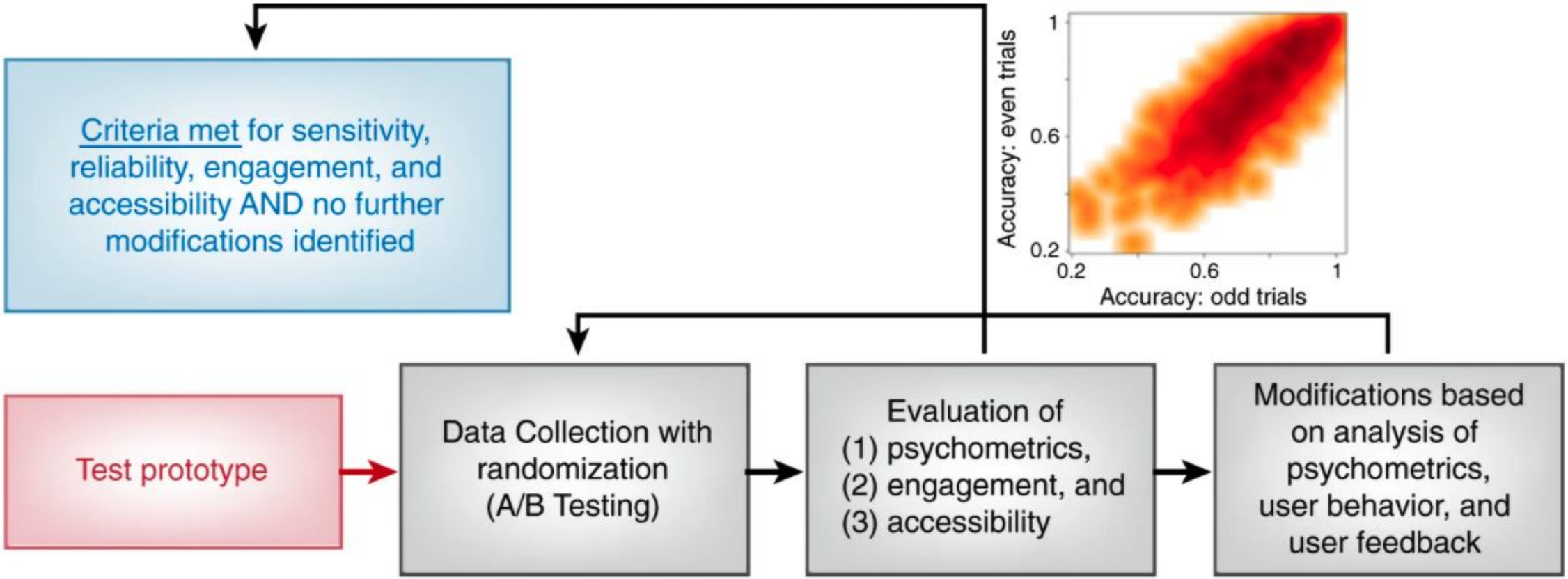
ENGAGEMENT
Return of results and user-centered/universal design principles



TECHNOLOGY
Understanding device variability, demographics of device ownership, device norms, and changes in devices over time

Germine et al., 2019 *The Clinical Neuropsychologist*
Germine et al., 2021 *Neuropsychopharmacology*

Innovation through Iterative Test Development



Germine et al., 2021 *Neuropsychopharmacology*

Validity and Reliability

Research Article

aps ASSOCIATION FOR PSYCHOLOGICAL SCIENCE

Psychological Science
1–11

DOI: 10.1177/0956797614567339
pss.sagepub.com
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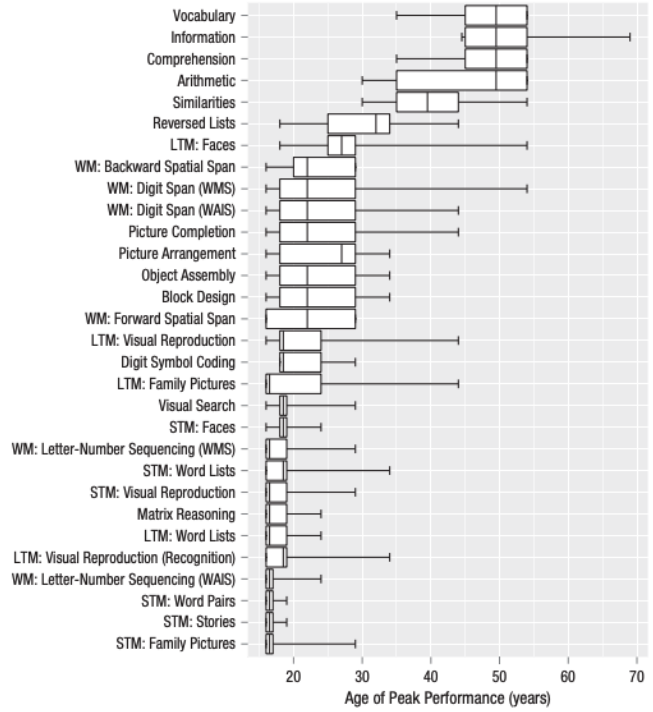
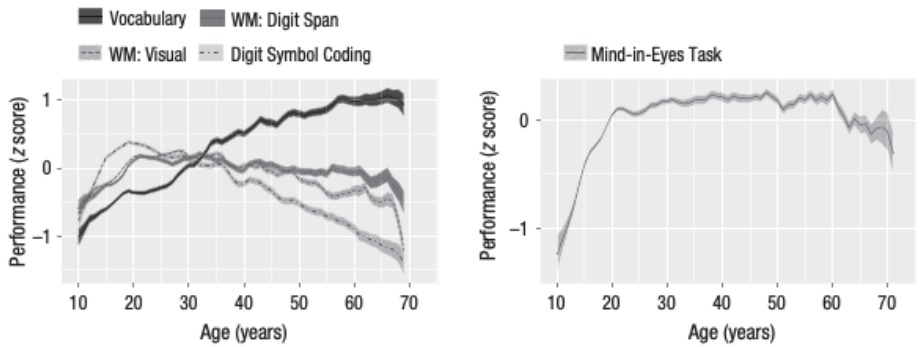
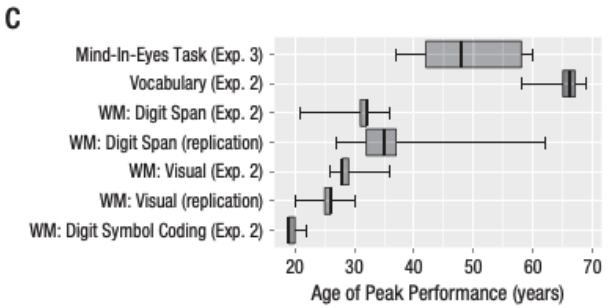
When Does Cognitive Functioning Peak? The Asynchronous Rise and Fall of Different Cognitive Abilities Across the Life Span

Joshua K. Hartshorne[1] and Laura T. Germine[2]
[1]Department of Psychology, Harvard University, and [2]Center for Human Genetic Research, Massachusetts General Hospital, Boston, Massachusetts

- Self-administered online assessments of cognition (N=20,000):
  - Replicate classic findings in the lifespan literature
  - Produce similar patterns of age-related change to traditional neuropsychological assessments (WAIS-III)
  - Can differentiate between similar but distinct trajectories of lifespan cognitive change







Example Applications

- NIMH Aurora Study (ED-based study of adverse post-traumatic neuropsychiatric sequalae) (U01)
- NIA Mobile Monitoring of Cognitive Change (U2C)
- NIEHS MEMCare Superfund (P42)
- Nurses Health Study
- NIH General Cognitive Index
- Harvard Football Players Health Study
- TMB Open Research and/or Custom Studies
- TMB Digital Neuropsychology Toolkit (N=1200 users)
- Used for cognitive testing at over 400+ sites internationally

TMB Comparison with WAIS IV

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*Correlation between scores on remote, self-administered TMB tests with supervised clinic administration of WAIS-IV are shown unadjusted, disattenuated correlations in parentheses (to correct for reliability). Test reliabilities were comparable for WAIS-IV and TMB measures. See Chaytor, N. S., Barbosa-Leiker, C., Germine, L. T., Fonseca, L. M., McPherson, S. M., & Tuttle, K. R. (2020). Construct validity, ecological validity and acceptance of self-administered online neuropsychological assessment in adults. *The Clinical Neuropsychologist*, 1-17.