Novel online measures of cognition in the Twins Early Development Study

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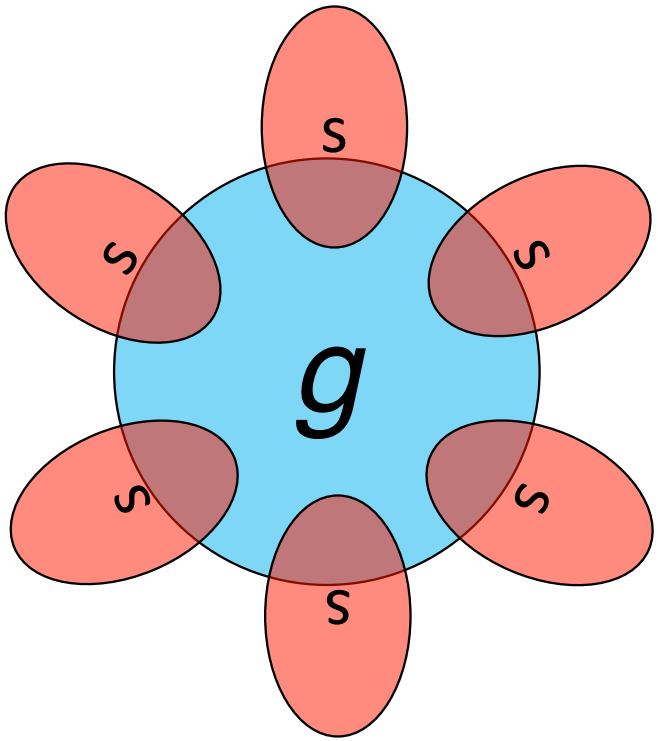
General cognitive ability (*g*)

- Psychometric construct – indexing covariation between cognitive abilities
- Stable over development and associated with important life outcomes
- Difficult to collect reliable data on general cognitive ability in large cohorts



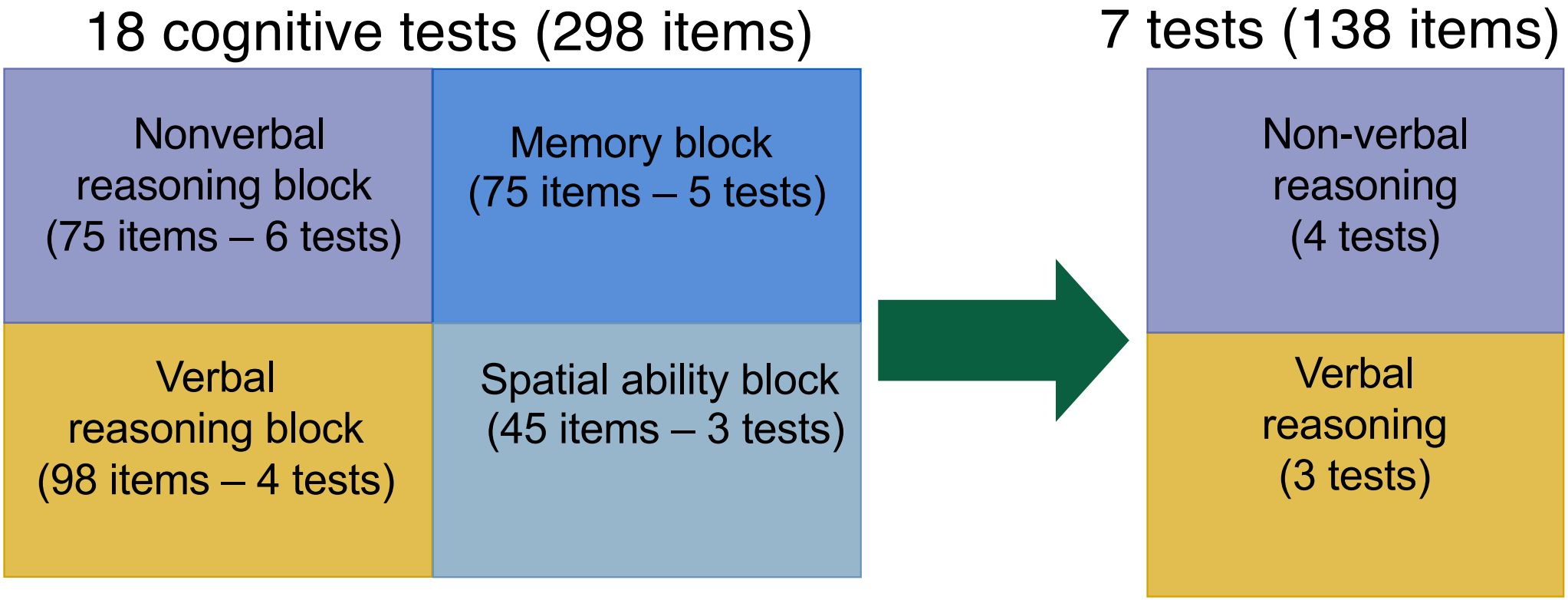
Spearman, 1904; Ceci, 1991; Carroll, 1993; Deary, 2013

Pathfinder: A brief online measure to overcome these challenges

Over 4 studies, we developed a measure of *g* that is:

- Brief (15-minutes)
- Reliable (*g* total score + Verbal and Nonverbal composites)
- Administered online
- **Embedded in a gamified story line**

Study 1



r (*g* 18 tests, *g* 7 tests) = .852, p < .001, *N* = 126

Study 2

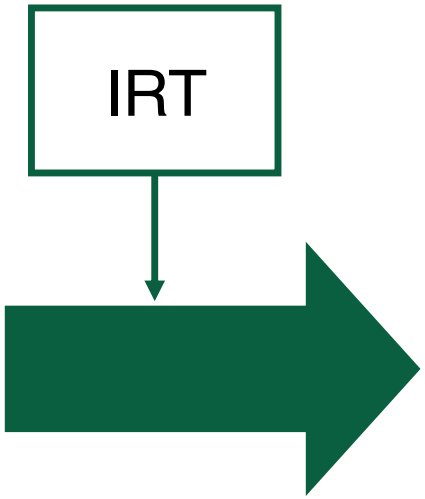
7 tests (138 items)

Nonverbal reasoning (4 tests)

NV reasoning – Sequences
NV analogies
NV reasoning – Groups
Matrix reasoning

Verbal reasoning (3 tests)

V reasoning – Missing letter
V analogies
Vocabulary



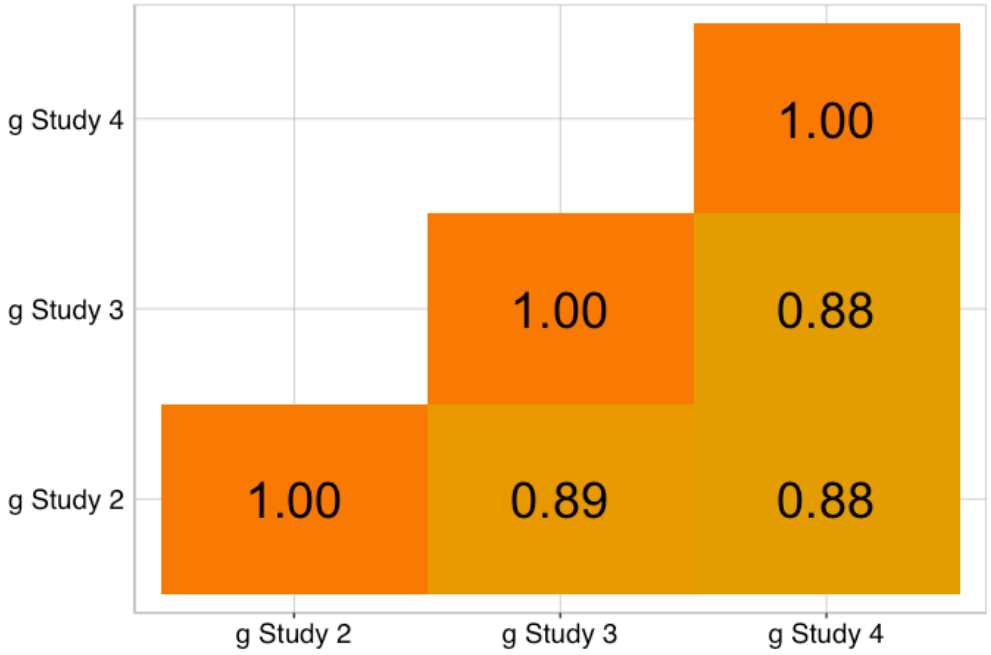
40 items:

20 Verbal
20 Nonverbal

Study 3 & 4

Study 3: test-retest reliability (40 items), *N* = 132

Study 4: test-retest reliability (40 items) **gamified** version, *N* = 123



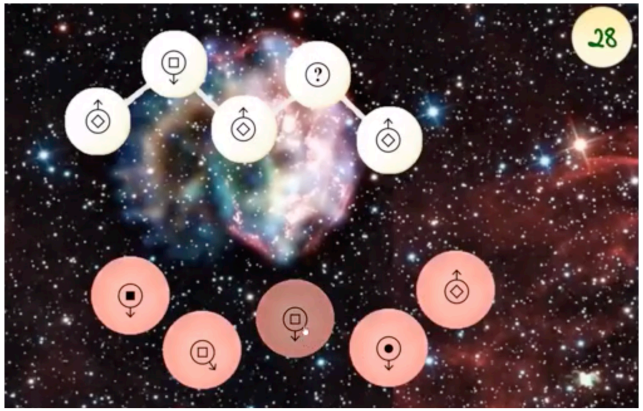
Pathfinder gamified tests

A

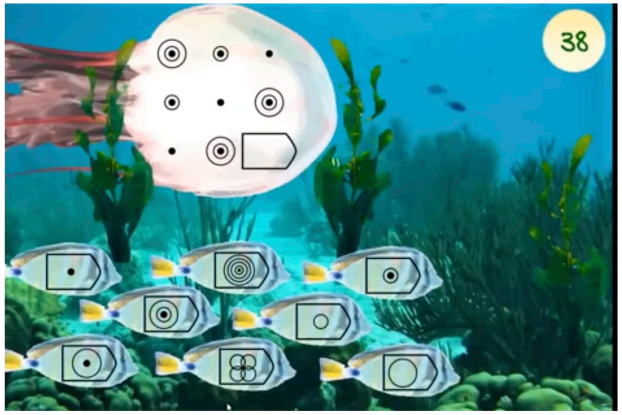
B

C

D

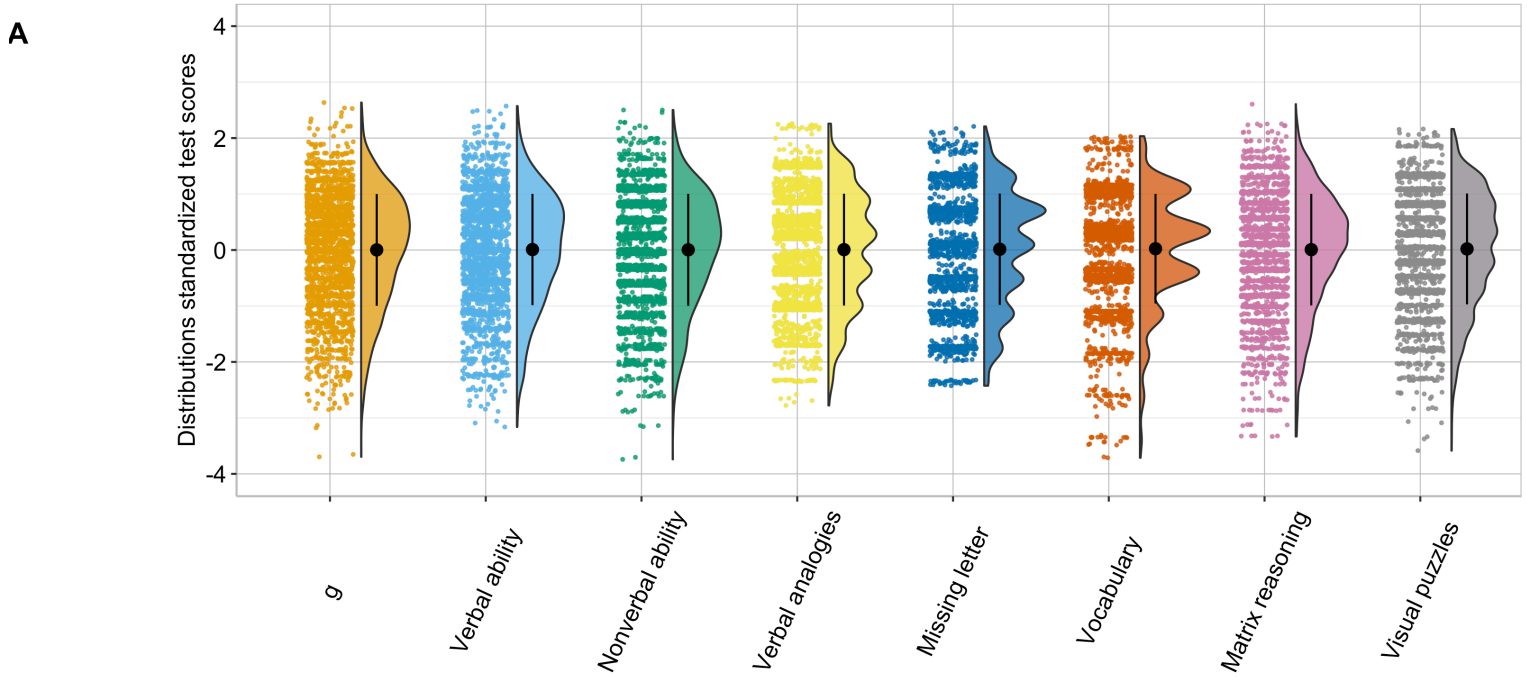


E



F

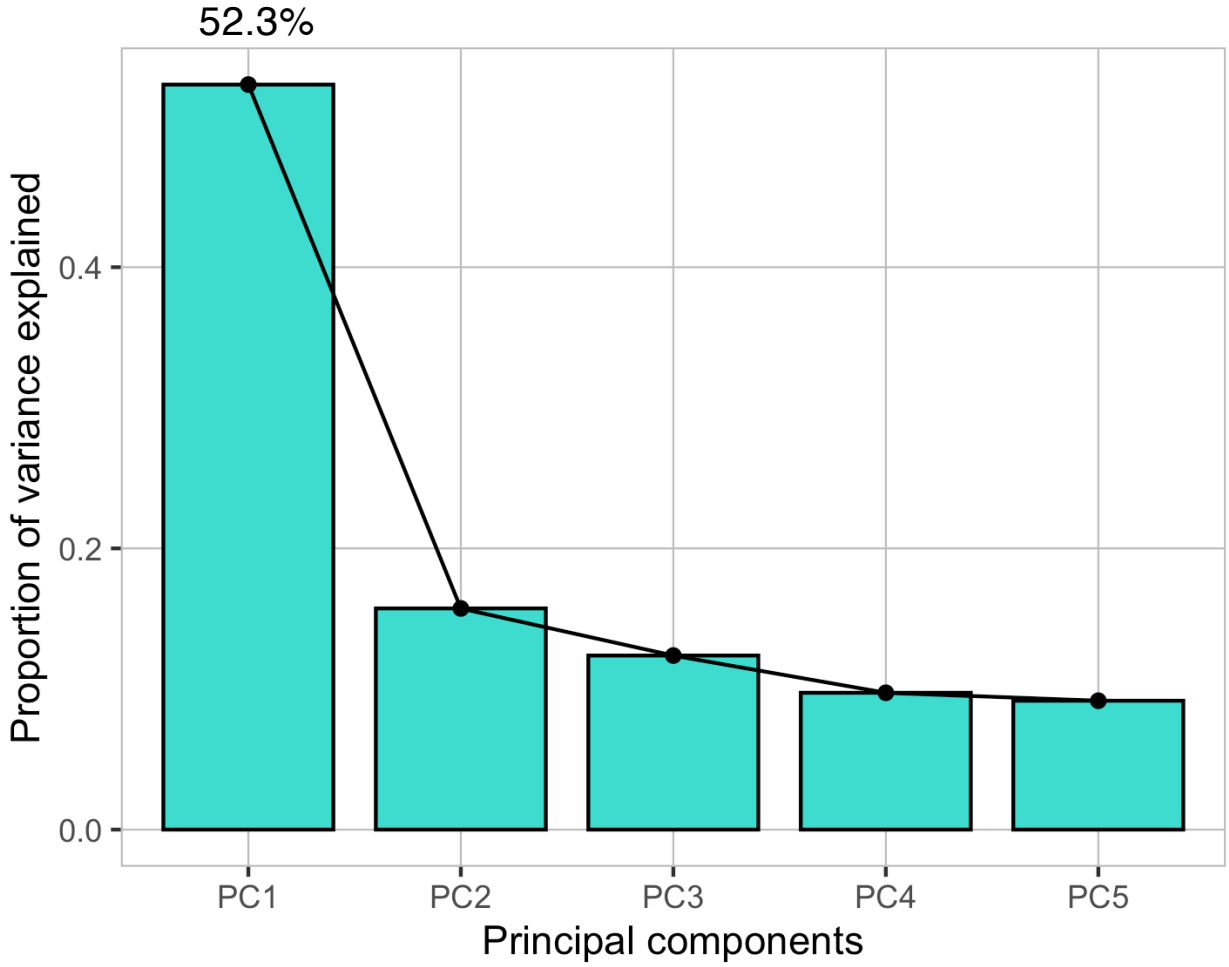
Study 5 – Pathfinder in a large, longitudinal sample



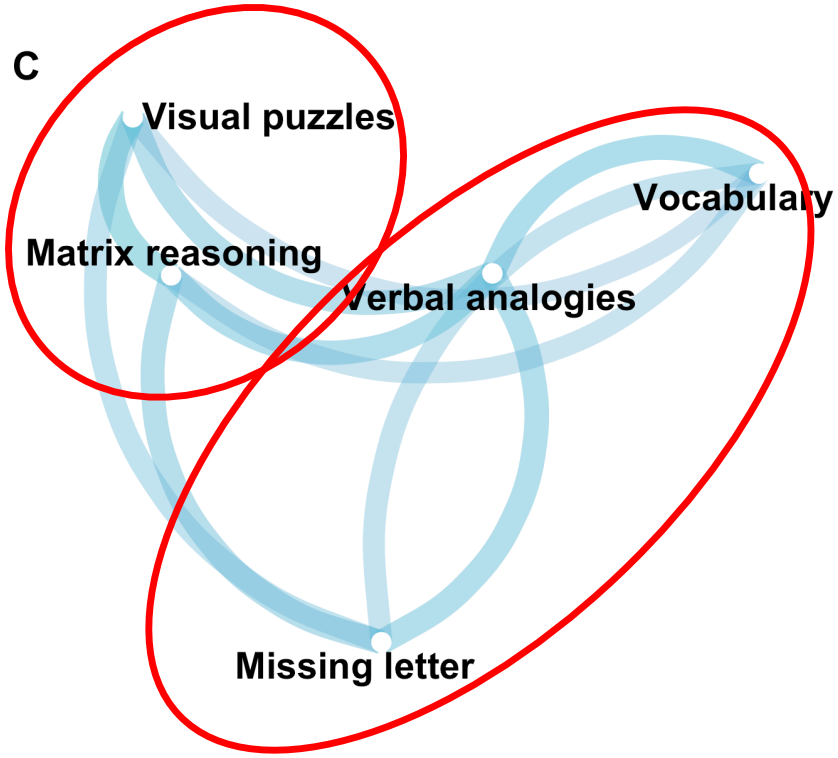
N = 4,548 young adults (age 23-25)
N complete twin pairs = 1,416

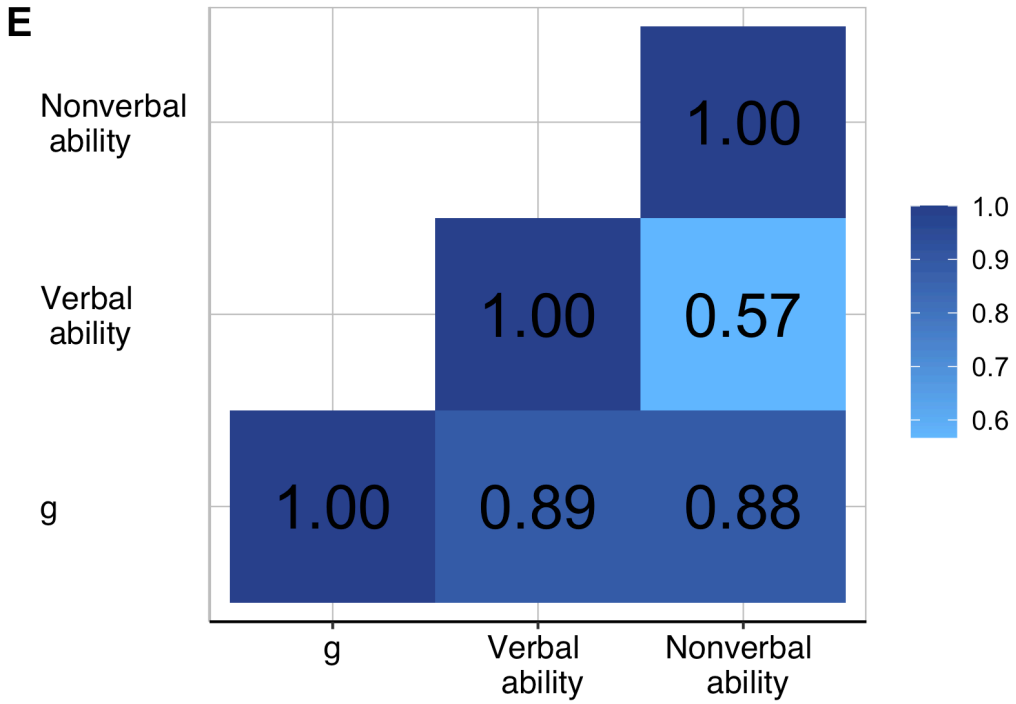
TEDS

PCA

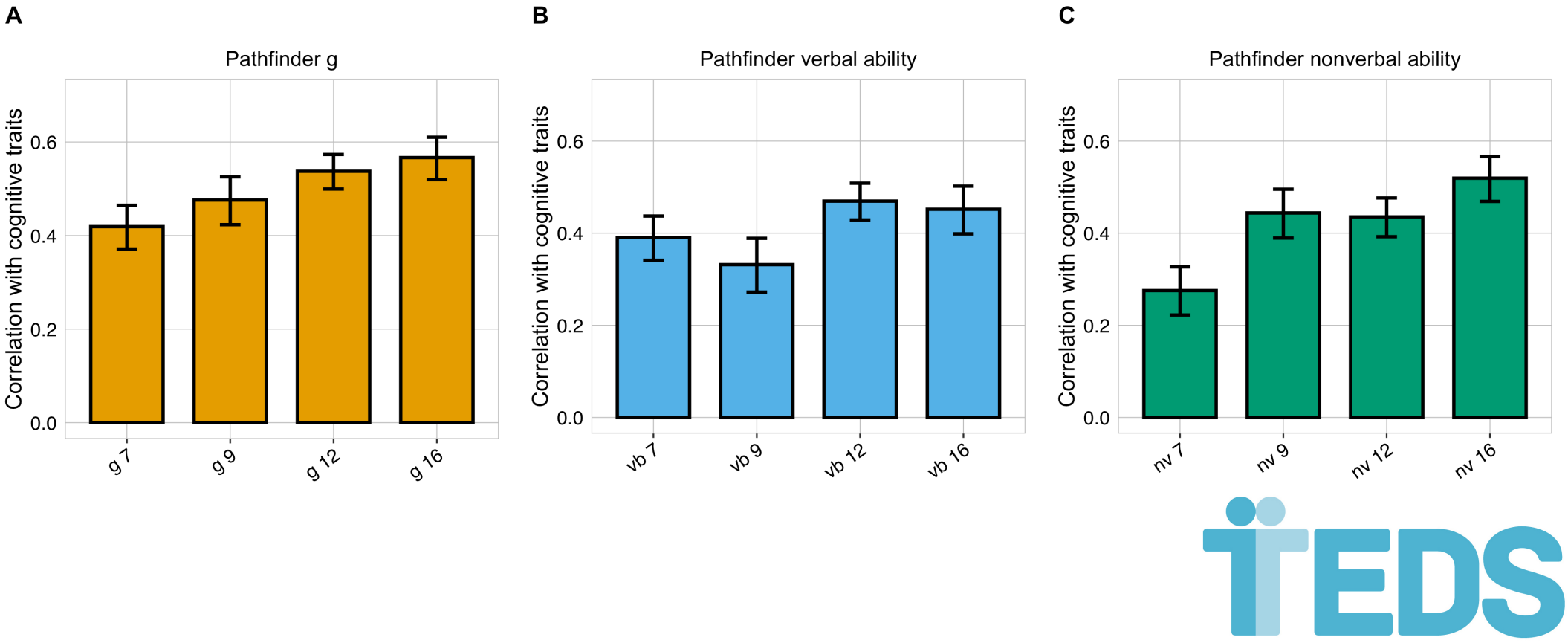

52.3%
Proportion of variance explained
0.4
0.2
0.0
PC1
PC2
PC3
PC4
PC5
Principal components

Associations between tests and domains

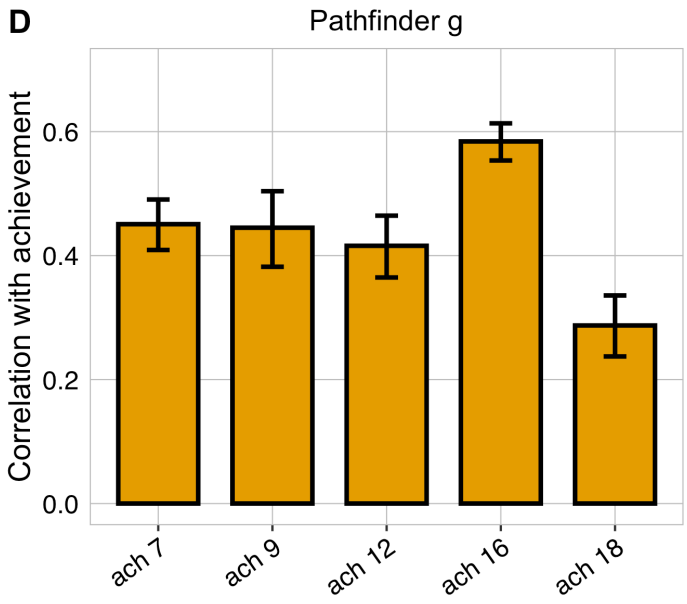


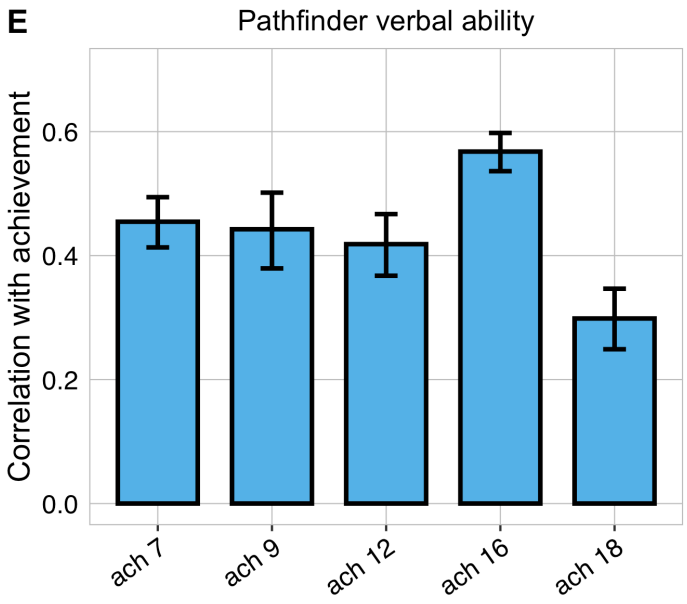


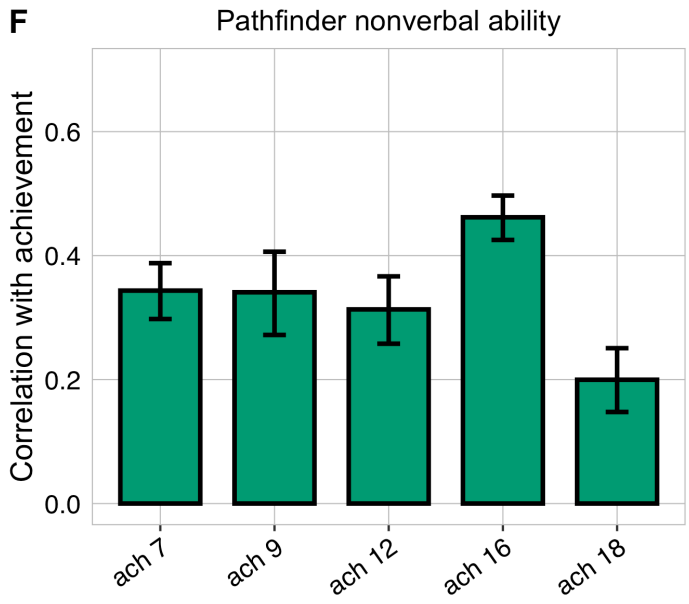
External validity 1: Correlations with cognitive ability over development



External validity 2: Correlations with academic achievement over development

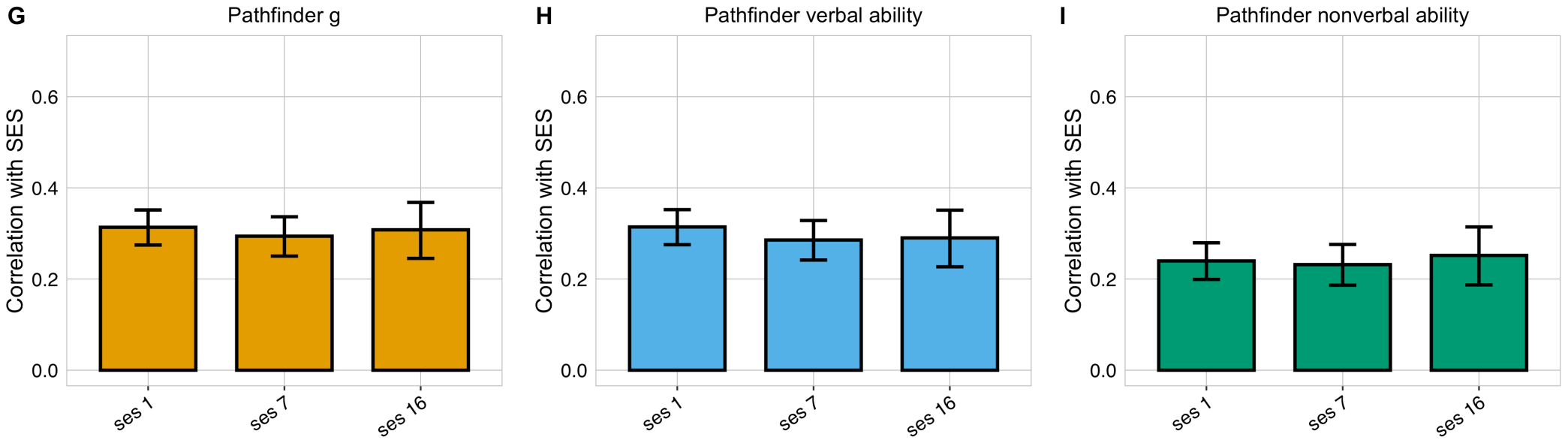






TEDS

External validity 3: Correlations with SES over development



New Results

Pathfinder: A gamified measure to integrate general cognitive ability into the biological, medical and behavioural sciences

Margherita Malanchini, Kaili Rimfeld, Agnieszka Gidziela, Rosa Cheesman, Andrea G. Allegrini, Nicholas Shakeshaft, Kerry Schofield, Amy Packer, Rachel Ogden, Andrew McMillan, Stuart J. Ritchie, Philip S. Dale, Thalia C. Eley, Sophie von Stumm, Robert Plomin

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Conclusions

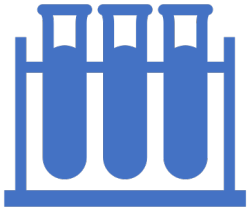
- Over 4 pilot studies: Brief, reliable, **engaging** measure of *g*
- Freely available to all researchers www.pathfindertestgame.com
- Advance discoveries across the biological, medical and behavioural sciences

Spatial ability

- A strong predictor of several important outcomes, including success in science, technology, engineering, and mathematics (STEM) subjects and careers
- Multifactorial?
- Separable from g?

Game development

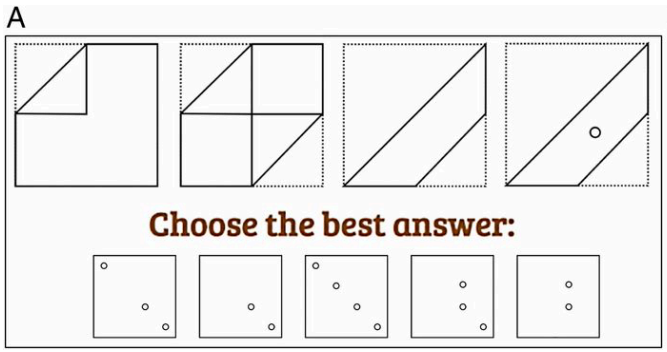
From 27 varied tests → 10 test
(Pilot on pencil and paper, ~2.5 h)

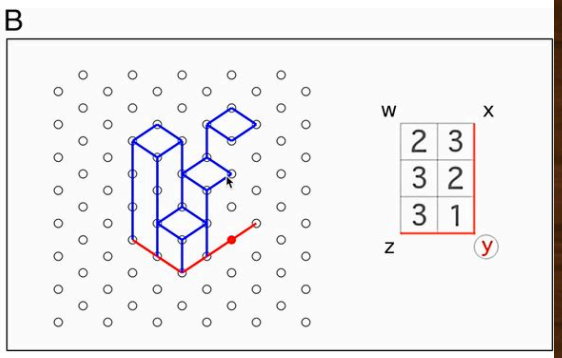


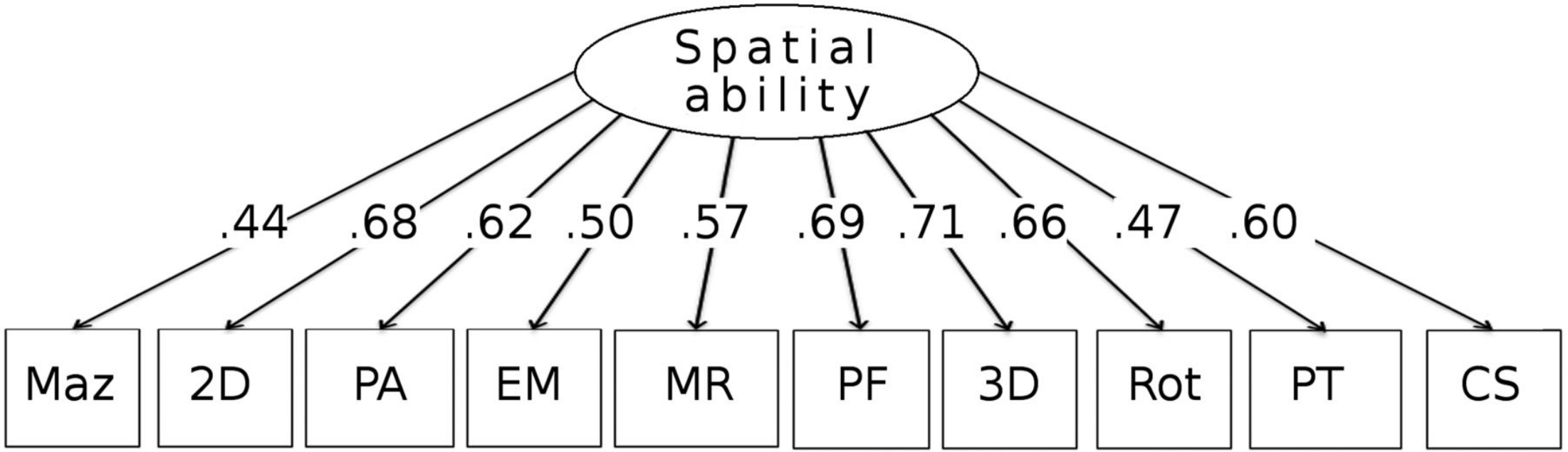
Test re-test on 10 tests ~.65

Gamification done by Helmes

King’s Challenge

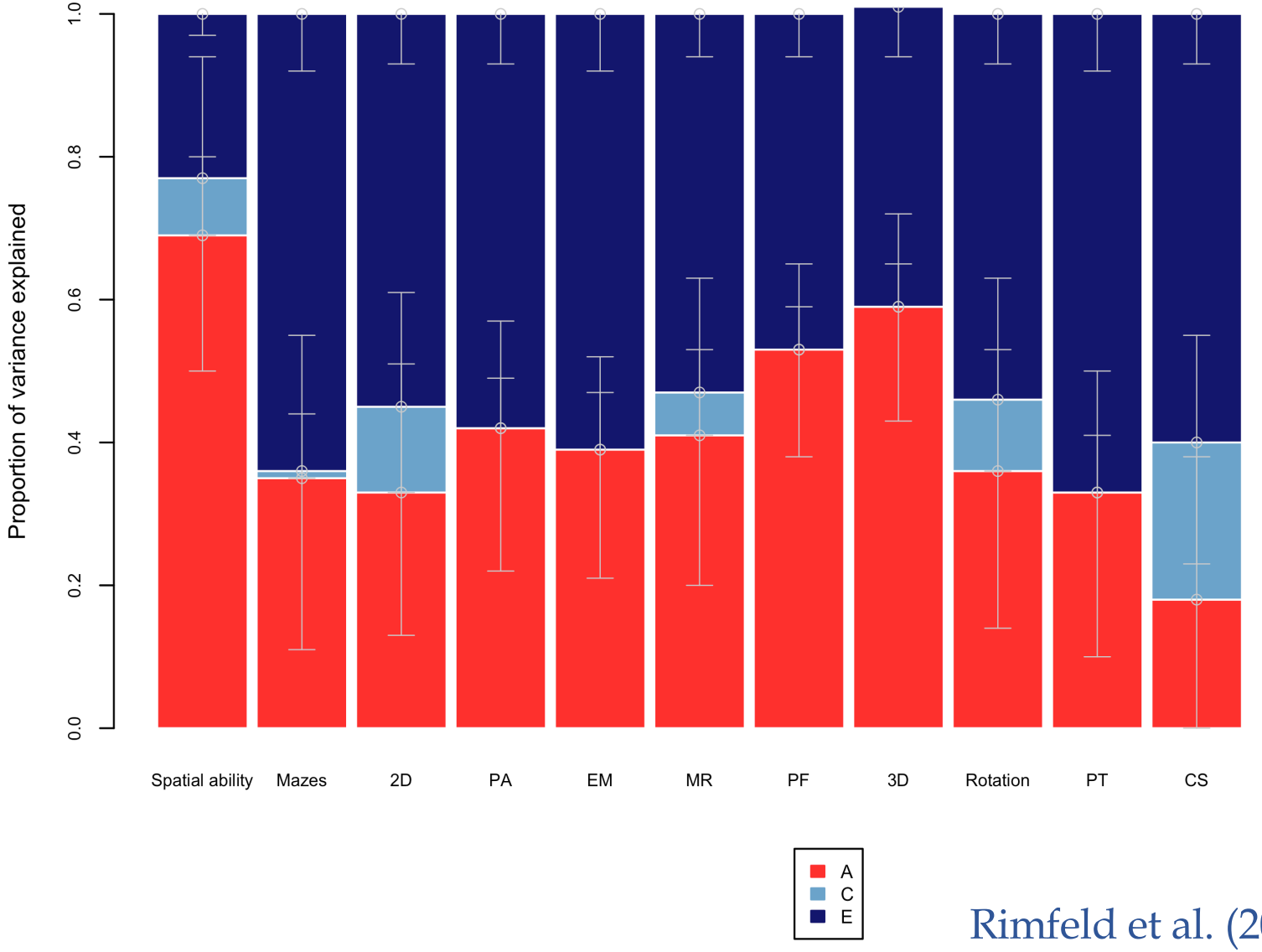






N= 1,367 twin pairs (age 19–21)

Rimfeld et al. (2017) *PNAS*



Rimfeld et al. (2017) *PNAS*

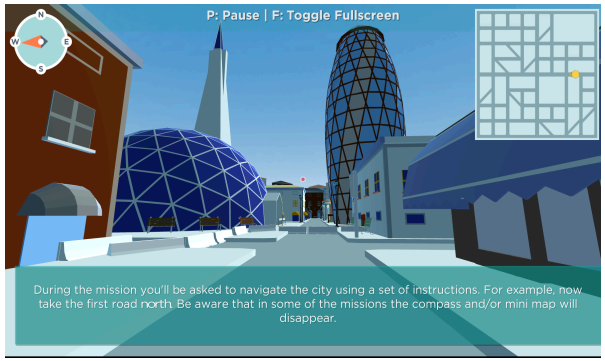
In hindsight: Evaluating the King's Challenge

- Web and mobile administration ✓ ✗
- Scientifically-grounded selection of the best tests available ✓
- Highly validity and reliability ✓
- Motivational component to the assessment (Fun ✗ / Feedback ✓)
- Brevity (~45 minutes to complete) ✗

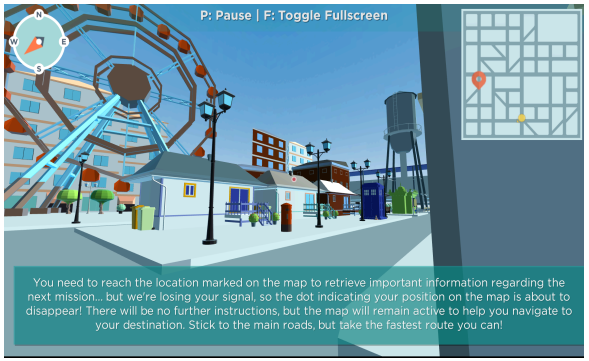
Phase 2: Spatial Spy –Navigation ability

- large vs. small scale spatial ability?
- Navigation ability different from spatial ability?
- Comprehensive literature search on navigation ability for web assessment through a 3D virtual environment
- Selection of main navigation abilities identified in the literature
- 4 navigation contexts + 1 scanning and 1 perspective taking
- Collaboration with the team of developers (Unity; ETT Ltd.)

Spatial Spy –Navigation ability

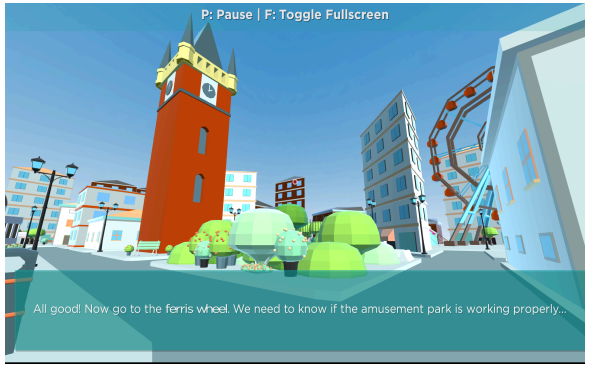


Navigating with a map
(most efficient route + time)
Test-retest *r* = .603**

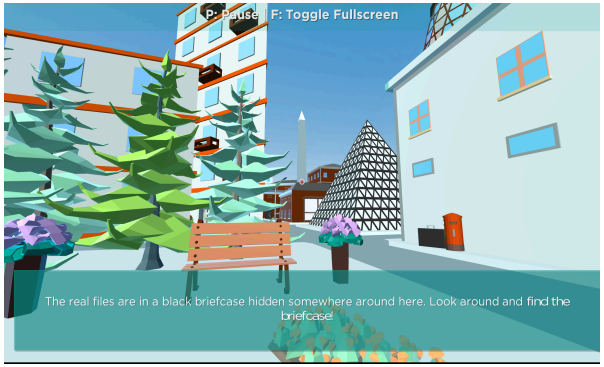


Navigating with map from memory
(most efficient route + time)
Test-retest r = .686**

Navigating with cardinal points – compass (3 iterations + 2 no compass)
(efficacy, max 3 consecutive mistakes per iteration+ time) test-retest *r* = .894**



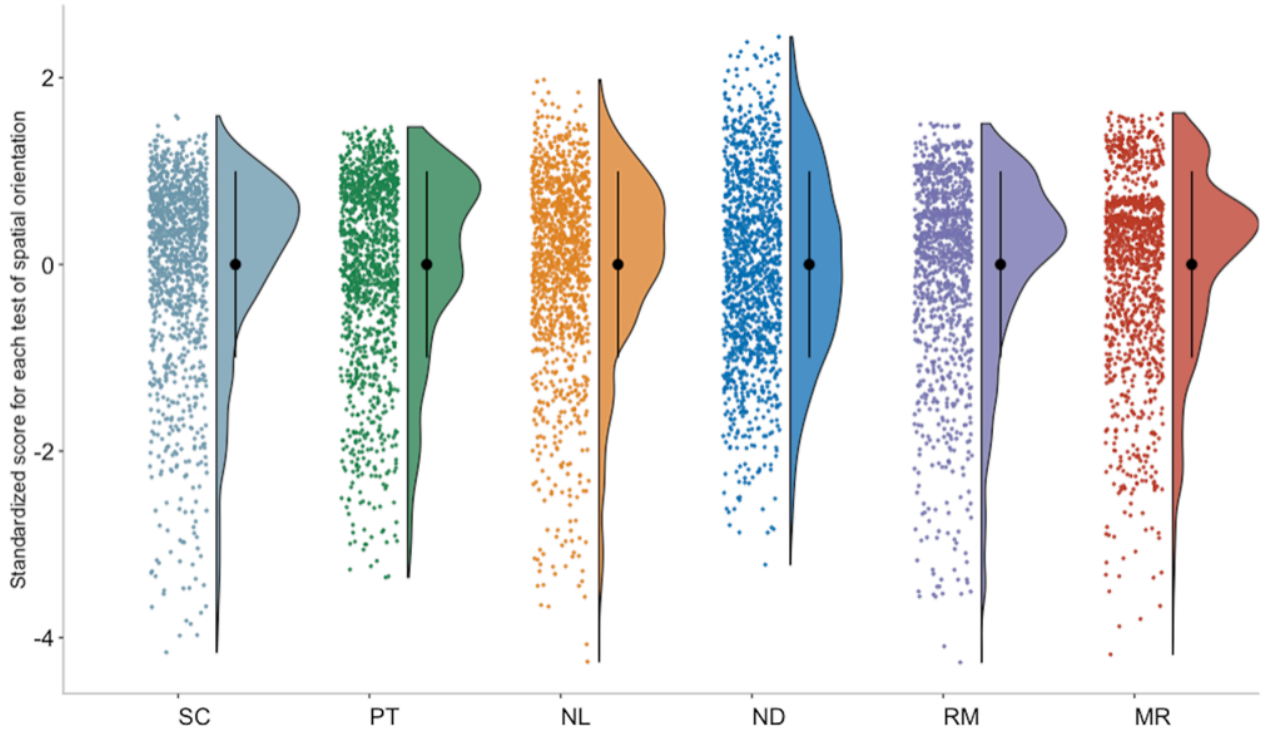
Navigating based on landmarks
(efficacy + time)
Test-retest *r* = .799**



Large scale Scanning
(correct -max 4 attempts- + time)
Test-retest *r* = .798**

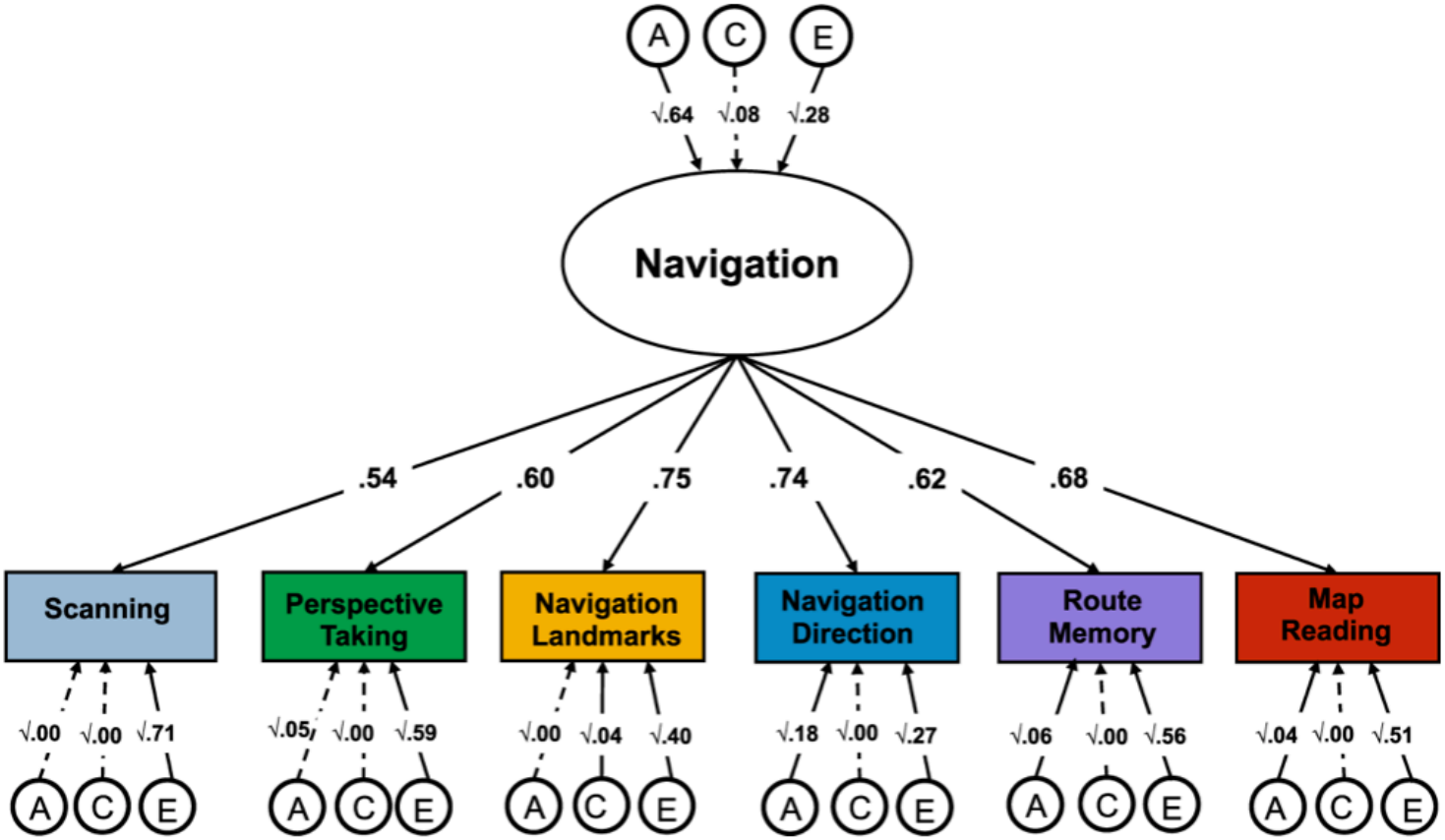
Large scale Perspective taking
(correct -max 4 attempts- + time)
Test-retest *r* = .671**

Spatial Spy



N = 2660; aged 19–22

Malanchini , Rimfeld et al (2020)
npj Science of Learning



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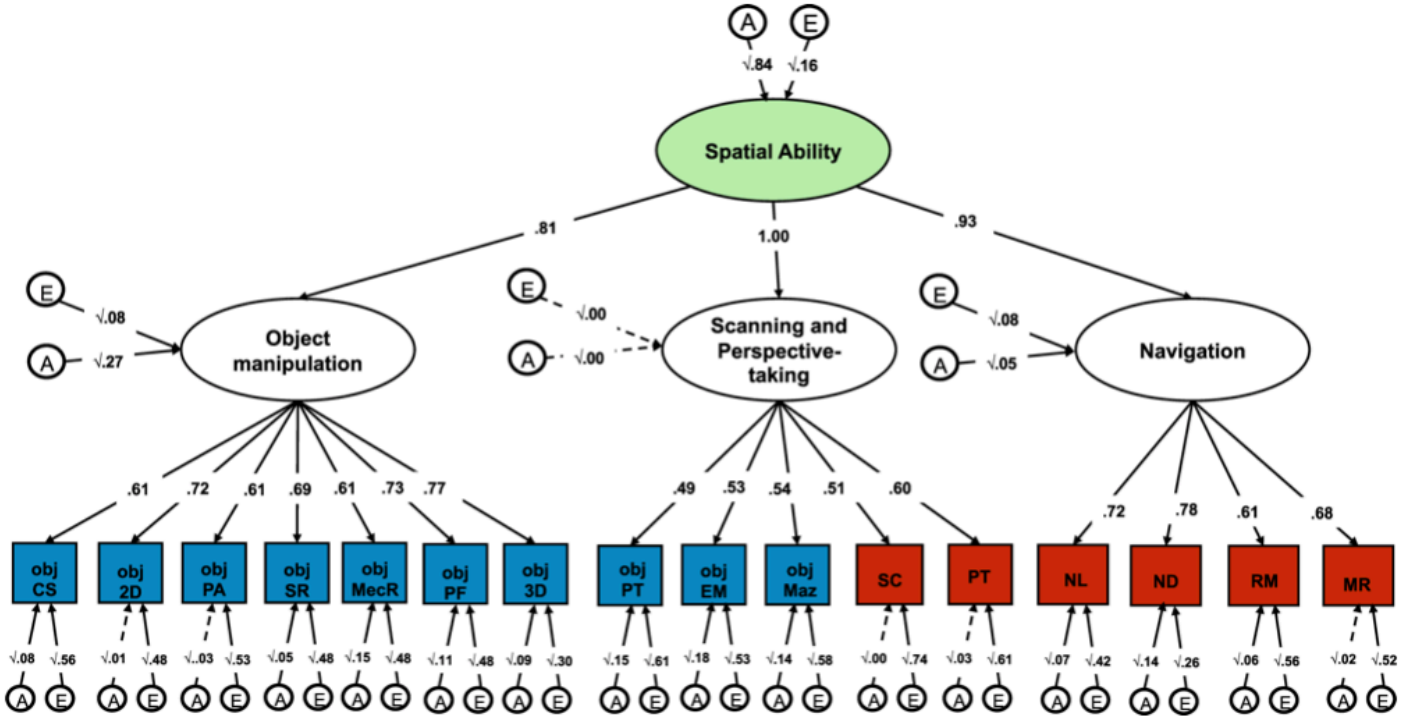

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npj Science of Learning

Gamified tests for large samples

- Gamified tests ideal to be administered to large cross-cultural samples and Biobanks (fast and fun)

- Gamification is a complex process (but really quite fun!) that MUST be imbedded within a solid scientific methodology from literature to reliability and validity

- Private companies currently on the market that develop 'cognitive games' mostly don't apply scientifically grounded approaches

Their mantra: Let's be innovators NOT scientists

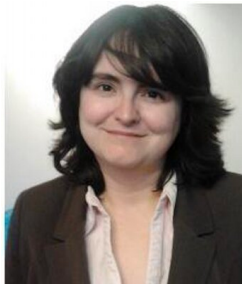
- Scientifically grounded gamified assessments are a real possible avenue for psychological assessment (Not only for cognitive skills?)

Acknowledgements









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