Cognitive Testing on Mobile & Wearable Devices

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Overview

A neuroscience digital health company - Measuring cognition accurately

- Validated by over 30 years of neuroscience research
- A measure of cognitive function in over 100 indications
- Trusted by the world’s top pharmaceutical companies
Technology Platforms for Cognitive Testing

**Research tools**
Tools for clinical and research trials to detect effects of drugs and environmental changes.

**At-home testing**
Cognitive tests that can be completed by participants at home.

**High Frequency testing**
Frequent monitoring of cognitive ability using wearable devices.

**In-clinic tools**
Cognitive assessments for clinical use that can identify those who require further investigation.

**Neuroanalytics Consultancy**
We provide expertise in the design, analysis and interpretation of neuropsychological endpoints in cognitive studies and clinical trials with extensive experience using research and analytic approaches.
CANTAB has been used to assess over 250,000 Participants worldwide.
Specific to Cognitive Domain

- **Psychomotor speed**
  - Reaction Time

- **Attention**
  - Rapid Visual Information Processing

- **Memory**
  - Paired Associates Learning
  - Delayed Matching to Sample or Spatial Working Memory
  - Pattern or Spatial Recognition Memory
  - Verbal Recall / Recognition Memory

- **Executive function**
  - Spatial Working Memory
  - Stockings of Cambridge
  - Attention Switching Task
  - Stop Signal Task

- **Social cognition**
  - Emotion Recognition Test
  - Affective Go/No-go
Specific to Neural Mechanisms – Digital Biomarker

- Reaction Time
- Spatial Working Memory
- Rapid Visual Information Processing
- Episodic Memory

Cognition Kit
Sensitive to Disease State – Cognitive Signature

Worse performance

- Attention
- Executive Function
- Episodic Memory
- Processing speed
- Working Memory

diagnosis
- AD
- MCI
- PD

Cognition Kit
Cognition is subject to daily fluctuations
How to measure Cognition in the real world

Implementation on Mobile and Wearables

Customisation

Researchers Clinicians Carers

Triggers

Experience

Cognitive Test Design and Interpretation

Users Patients Participants
Daily assessment across platforms and devices

Cognition Kit software enables an individual to complete an assessment on a range of mobile and wearable devices without having to visit a clinic or be helped by a health care professional.

- **Drawing tasks** to measure memory and executive function.
- **Emotional recognition tasks** to measure social cognition.
- **N-back tasks** to measure memory and attention.
Best Practice Approach

Decisions are made with the individual in mind

Patient Experience

Cog Test Validity

Cognitive test selection and adaptation designed with scientific rigor

Meaningful Data

Large Data Sets of objective cognitive measurement and passive data points

Cognition Kit
Cognition Kit – Validation Process
N-back task activates a network of areas in the brain including frontal and parietal regions (Owen et al., 2005).

There is significant variation across and within days on n-back performance, partly linked to mood and motivation (Brose et al., 2012).

Phase 1: Proof of concept study in healthy volunteers

Study design:

- 10 (4 females) aged 25-55
- Sensor data (heart rate, skin temperature, GSR) measured continuously between 0900-1900
- 4 CANTAB tasks (SWM, RVP, AST, ERT) and the PANAS administered each day after 1700
- Cognitive & mood assessment scheduled hourly

Presentation = 600 ms
ISI = 600 ms

2-back match

Cormack et al, AAIC 2016
1-minute micro-tests capture meaningful across-time variation and correlate with gold-standard computerised tests.

Revealed issues with device and dynamic range of the test.

Baseline performance

Phase 1: Detailed cognitive data

Cormack et al, AAIC 2016
Phase 2: Design refinement using web-based testing

Findings from phase 1:
- A number of participants rapidly reached ceiling
- People were giving symbols names — verbal recording of the stimuli, and familiarity with symbols over time
- Issues with the device used in the proof-of-concept: battery life, limited display, discontinuation

Questions for phase 2:
- Change of symbol design and larger bank of symbols to reduce availability of verbal strategies
- Could we titrate the difficulty level without increasing the n: role of symbol complexity, timing parameters, and number of symbols
- Decision to use Apple iWatch
Phase 2: Participant Experience

- Refining task to increase dynamic range
- Converted task for web-based testing with redesigned stimuli
- Crowd-sourced A-B testing using Amazon m-turk
- Series of experiments exploring the impact of task parameters on participant performance using:
  - Presentation time
  - Symbol design
  - Number of unique symbols

\( n = 994 \) participants aged 20–64 in total

\( n = 88 \) also completed CANTAB Spatial Working memory test and CANTAB PAL (episodic memory)
Phase 2: Cognitive Test Validity

Iterative A-B experimentation determined:

- Significant effect of stimulus presentation time on performance
- Significant impact of number of symbols in trial
- Symbol design (e.g. number of segments + arrangement) did not significantly impact performance

Correlations with CANTAB test — significant association with SWM, but not PAL.

Confirms sensitivity to working memory performance.
Phase 3: In-person testing and iterative design

- Would the same parameters work on the watch?
- How would participants perform over an extended time? Is the paradigm and testing schedule tolerable?
- What are some of the barriers to compliance? How can we make sure that patients understand the app and the tasks?

- N=7 subjects over 3 weeks.
- Apple watch
- N-back testing x3 times a day

Cognition Kit
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