Neuropsychological Test Battery

Zach Wolpe

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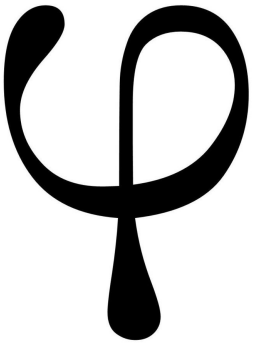
Abstract

A descriptive account of psychological & neurological tests conducted during my masters research. A theoretical breakdown of the procedure, protocol & implications of the tests conducted. A further report is required to select specific tests for the large scale analysis. We are particularly interested in the correlation/interaction across tests - to maximize information gained in the study.



Neuropsychological Testing

A neurological test is a gauge of cognitive performance across some - or multiple - dimension/s, often undertaken to in psychological studies or for my accurate patient diagnosis [1]. These methods allow professionals to gauge the severity of the deficit of certain cognitive functions, or capture the decay of said functions over multiple tests.

Conducted to measure psychological functionality, that is hypothesised to be linked a particular neurological structure or pathway, neuropsychological tests are used for research into brain functionality or for diagnosis of clinical deficits [2].

Notably, these tasks are often administered in idealized settings (where participants are free from distraction, focused on an isolated task) and as such they are often considered to estimate peak cognitive performance [1].

Most neuropsychological tests utilize traditional psychometric theory - whereby scores are relative and an individual is contrasted with the normative scores of sample groups [11].

These tests can be partitioned into 4 main categories [11]:

1. Cognitive performance: indicative of how well individuals perform across some cognitive process with respect to some sample.
2. Left-right comparisons: contrasting the left & right side of the body.
3. Pathognomonic signs: tests that diagnosis or measure the severity of distinct disorders. Pathognomonics relate to the symptoms indicative of a particular disease or condition.
4. Differential patterns: signals that are symptomatic of particular diseases or cognitive impairments.

Categories

Tests are often characterized by the cognitive function under examination [11]. Although the segmentation can be blurred, the broad categories constitute:

- Intelligence: IQ and related metric tests - when one is working in a clinical setting, mental deterioration/decay ought to be considered.
- Memory: although debated, a clinical consensus suggests there are 5 distinct types of memory. **Working memory** describes short term memory, long term memory is divided into *declarative/explicit memory* which includes **Semantic memory** and **episodic memory**; and *non-declarative/implicit memory* which is decomposed into: **procedural memory** and **priming/perceptual learning**.
- Language: tests associated with speech, reading & writing.
- Executive Function: constitutes various cognitive processes and sub-processes, capturing abstractions like: problem solving, planning, organizational skills, selective attention, inhibitory control and some aspects of short term memory.
- Visuospatial: concerned with visual perception, construction and integration. Often associated with the parietal lobe.

- Dementia specific: Attempt to quantify one's severity of dementia.
- Batteries assessing multiple neuropsychological functions: combining a series of tests to provide an overview of cognitive skills. Tests may have interaction effects.

Wisconsin Card Sorting Test (WCST)

WCST is a set shifting (or task switching) test - testing one's ability to display flexibility under changing conditions - one's ability to shift attention.

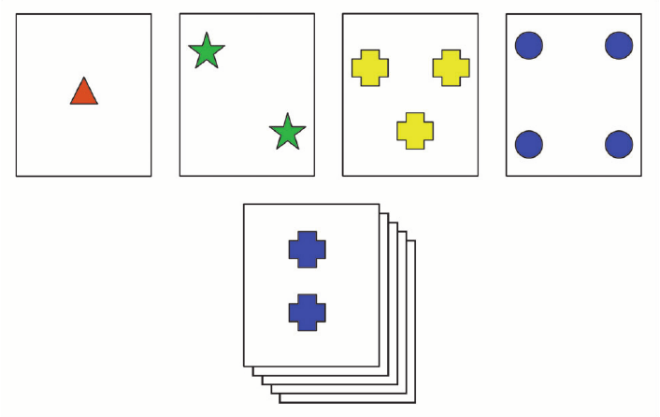


Figure 1: A WCST instance, the participant is tasked with matching the card below with one of the 4 card above it. The card could be matched on a number of dimensions (colour, shape, orientation or number of symbols).

Methodology

The participant is provided with a set of stimulus cards & told to match the card with one of the available options. Without being told the matching rule, the participant is simply given binary feedback indicating whether or not the chosen match is correct. The experiment takes between 12 and 20 minutes and generates a number of psychometric scores pertaining to the relative numbers of categories achieved, trails, errors and perseverative errors.

Clinical use

Often used to measure a patients frontal lobe dysfunction, neuropsychologists and clinical psychologists utilize the WCST in patients with acquired brain injury, neurodegenerative disease, or mental illness such as schizophrenia. The frontal lobe is associated with, and thus can give insight into, a patients: strategic planning, organized searching, utilizing environmental feedback to shift cognitive sets, directing behavior toward achieving a goal, and modulating impulsive responding [11]. The WCST directly relies upon an array of cognitive functions, including: working memory, attention and visual processing. The task can measure a patients competence in abstract reasoning and the ability to change problem-solving strategies when needed.

N-back task

The n-back task tests working memory and working memory capacity, by requiring participants to continuously recall stimuli patterns delivered n time steps back [6].

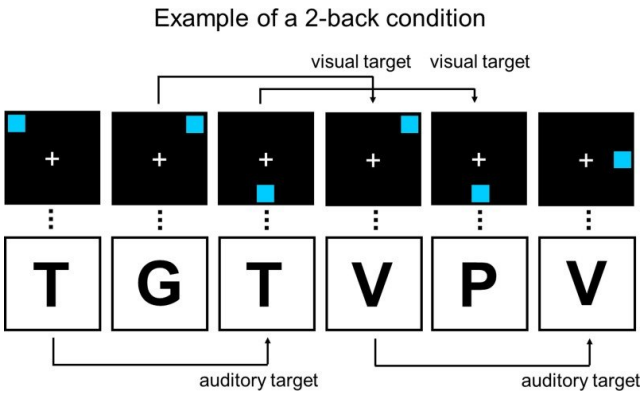


Figure 2: A depiction of an visual (above) and auditory (below) $n = 2$-back task.

Methodology

The participant is presented with stimuli and required to indicate when the current stimulus matches that of n prior time steps [6]. n is considered a *loading factor* - that scales task difficulty.

The task challenges the active part of working memory. The subject is required to both maintain & manipulate information in working memory. Not only does the candidate need to keep a representation of recently presented items in mind, but also continuously update the point of comparison.

Construct Validity

Correlation analysis has brought into question the construct validity of the n-back task [8]. Although it has achieve widespread adoption in both clinical and experimental settings, there are few studies which find weak correlations between individuals‘ performance on the n-back task and performance on other widely accepted assessments of working memory [7].

It has been hypothesized that this discrepancy is either due to the n-back task assessing different "sub-components" of working memory or, more seriously, the task depends greatly on familiarity and recognition-based discrimination processes - heavily reliant on 'active recall' [8].

Task performance, however, more closely correlated with measures of fluid intelligence than with other short term memory tasks [8].

A series of publications & media articles explored the relationship between the n-back and improved fluid intelligence - or other unrelated working memory capacities. The findings, however, are inconclusive and controversial - many of the original studies proving unreproducible.

Wider applications

The popularization of the n-back task as resulting in it's adaption outside of experimental, clinical and medical settings. Tutoring companies utilize the task in attempt to improve fluid intelligence. It has also been applied to improve focus in individuals with ADHD, and to rehabilitate sufferers of traumatic brain injury. These institutions making the claim that the effects are not transient and generalizable or transferable to general cognitive processing (for example, fluid intelligence) - although these claims are controversial.

Neurobiology of the n-back task

Neuroimaging studies have shown that the following brain regions are consistently activated during the n-back task: lateral premotor cortex; dorsal cingulate and medial premotor cortex; dorsolateral and ventrolateral prefrontal cortex; frontal poles; and medial and lateral posterior parietal cortex [16].

Corsi block-tapping test

Originating in the 1970's, this psychological task engages an individual's visuo-spatial short term working memory [10]. A researcher administering the task lays out a sequence by tapping the blocks in a particular pattern, the candidate is then required to recall the pattern. Typically, the patterns start off simple (shorter length) and grow in complexity (length) until performance suffers, with the average person achieving a sequence length - or Corsi Span - of about 5-6 [10].

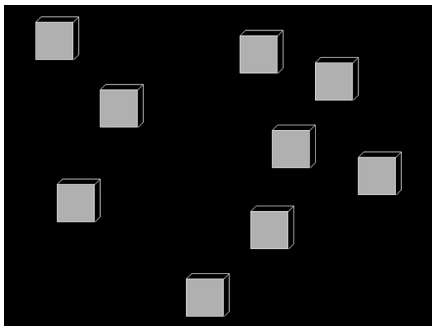


Figure 3: A typical layout of the Corsi block tapping task, prior to receiving a sequence.

Neurological activity

FMRI studies reveal that the ventrolateral prefrontal cortex is highly active when performing the task [17]. Relating the task to working memory models: one's visuospatial sketchpad is required during the task, however one's phonological loop is not [18]. Cetral executive resources are required as the sequence grows in length past 3 or 4 items. An FMRI study also indicate that brain activity does not appear to increase as the length of the sequences grow [17]. There are no significant differences in scores achieved by different genders, nor are there age related advantages past the age of 14 [4].

Utility

The Corsi block test is used to test: memory loss; testing for brain damage; spatial memory and nonverbal working memory [6].

Backward Corsi block tapping

A slightly alternative test, the Backward Corsi block tapping task requires a candidate to recall each sequence backwards. There appears to be no difference in difficulty between the forward and backward Corsi block tasks, as test scores do not differ significantly [9].

One notable study found that visuospatial learning disabled (VSLD) children performed far worse on the backward version of the task than they do on the forward version - whilst other children do not - indicating the backward task utilizing specific spatial processes [13].

Fitts' Law

Fitt's law is a mathematical model that describes the speed of movement in human-computer interaction and ergonomics, predicting how easily an individual is able to reach some target area, as a function of the distance to and size of the target [5]. The model has been adopted as on of the fundamental principles of design. The model is described as:

$$Movement\ Time = Log_2(2 \times \frac{Distance}{Size})$$

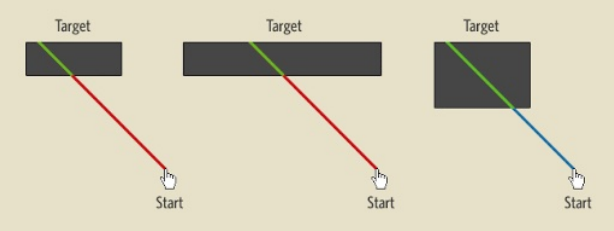


Figure 4: A instance of the Fitt's law game, quantifying movement as a function of distance and size.

This theoretical model has been studied at depth and achieves remarkable predictive power when contrasted with real experiments/data.

Implementation

The implementation of the Fitts' law as a cognitive task requires that participants move a cursor - from a given starting location - to a target. The speed can be modeled as a function of the law.

Navon Task

A Navon figure is defined as a large recognizable shape - such a a letter - that is made up of a collection of smaller, again easily recognizable, objects [15]. The work show's that individual's perceive global features before perceiving local features. Interesting work done by Jules Davidoff found that a remote culture exhibited the opposite result: local features were identified before global features [3]. Another interesting paper found patients with simultanagnosia - a rare condition were individual's are unable to identify more than a single object at a time - are unable to detect the global structure, only identifying global features. Related work found that East Asians demonstrated significantly stronger global processing than Caucasians [14].

Figure 5: An example of a Navon figure. It is probable that the observer noticed the macro-structure (the H) before noticing the micro-structure (the $x's$)

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The Navon effect

Participating in a Navon figure related tasks has revealed fascinating short term effects. Individual's tasked with reading the micro-structure of Navon figures for as little as 5 minutes have shown a deteriorating ability in facial recognition tasks [12]. The transient effects also correlate with the properties of the image [12]. The effect has been shown in across vastly different tasks, including facial recognition & golf putting.

Implementation

The implementation of the Navon task requires that individual's identify symbols within a limited time frame, the speed at which local & global structures are recognized can then be contrasted.

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