Newcastle University
Speech & Language Sciences

BαS British Aphasiology Society

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NEWCASTLE UNIVERSITY

KEYNOTE SPEAKERS

Prof. Deborah Hersh - Edith Cowan University, Australia
Prof. Beth Jefferies - University of York, UK
Prof. Brenda Rapp - Johns Hopkins University, USA

For call for abstracts and programme details, please follow updates on the BAS website

The nature of non-verbal cognition in aphasia and its clinical implications

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Aims

(1) To describe the nature and integrity of non-verbal cognition in aphasia, based primarily on a framework of executive functions

(2) To discuss the clinical implications that arise from non-verbal cognitive impairments for recovery, treatment choices, and outcomes

(3) To consider issues relating to defining and possibly redefining aphasia in the context of non-verbal cognitive impairments and underlying neurological aetiology

Overview

Part 1: Foundational concepts

Part 2: Non-verbal cognition in aphasia – focus on executive functions:

working memory

attention

inhibitory control

Part 3: Clinical implications

Part 4: Defining, redefining (or not) aphasia

Part 1

Foundational concepts

(which we often overlook)

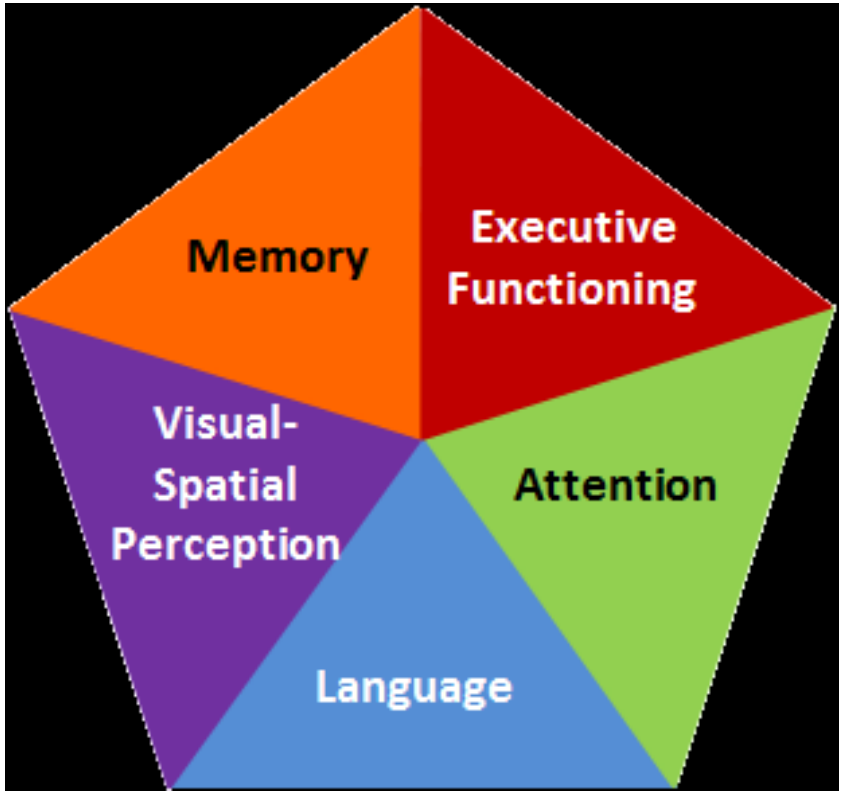
Unpacking the title - aphasia

Typically understood as a disorder of language (anomia, main feature)

McNeill (1988), McNeill & Pratt (2001):

- Multimodal inefficiency of **verbal** **symbolic** **manipulations** **(omits language)**
- Affected by and affecting other information processes to the degree that they support, interact with, or are supported by the **symbolic** deficits
- Symbol is a representation of a concept or relation between concepts

Unpacking the title - cognition



… and processing speed

- The 5 main constructs of cognition (and processing speed)
- Language is part of cognition
- In real-life communication they happen together

Constructs vs. measures (Edwards & Bagozzi, 2000)

- **Construct:** Conceptual term that describes a phenomenon of interest; such phenomena are real

Simply put: Ability

- **Measure:** An observed score (or recorded trace) gathered through self-report, interview, observation or some other means

Simply put: Test or task

Example – Language construct

Spoken comprehension

- Western Aphasia Battery
- Verb & Sentence Test
- Token Test
- PALPA
- Functional understanding in clinic vs. a busy restaurant

Issue of measure or task impurity

- Assessment (and treatment) tasks never sample/measure only the purported ability

- In the context of **non-verbal cognitive** tasks:

  Understanding task instructions (spoken and/or written)

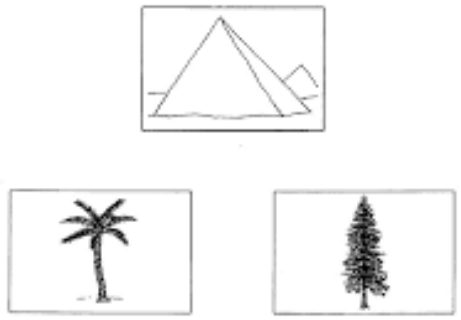
  Visual perception and processing

  Auditory perception and processing

  Memory, and attention

  Inferencing, decision-making

  Conceptual understanding



The implications

- If constructs are reliant on measures
- If measures by their very nature have an inherent impurity (and “bias”)
- If measures tap into more than one construct
- If different statistical analyses are carried out

Then,

Interpretation of test results is likely to be complex and difficulty

Can result in confusion in research and clinical practice

Part 2

Non-verbal cognition in aphasia

(emphasis on executive functions)

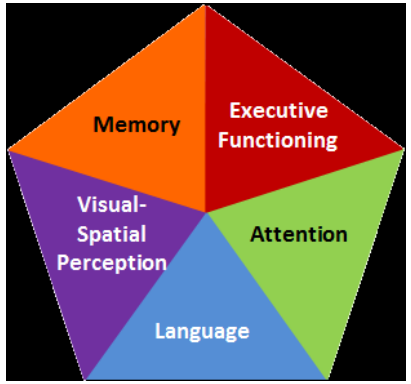
Executive functions

"General-purpose **control mechanisms** that modulate the operation of various cognitive subprocesses and thereby **regulate** the dynamics of human cognition" (Miyake et al., 2000: p. 50)

"The essential apparatus for **organising** intellectual activity as a **whole**, including the **programming** of the intellectual act and the **checking** of its performance" (Luria, 1973: p. 340)

Executive functions support communication

- goal formation
- initiation
- direction of thinking
- planning, sequencing
- self-monitoring
- multi-tasking
- problem solving
- inferencing
- integration
- cognitive flexibility



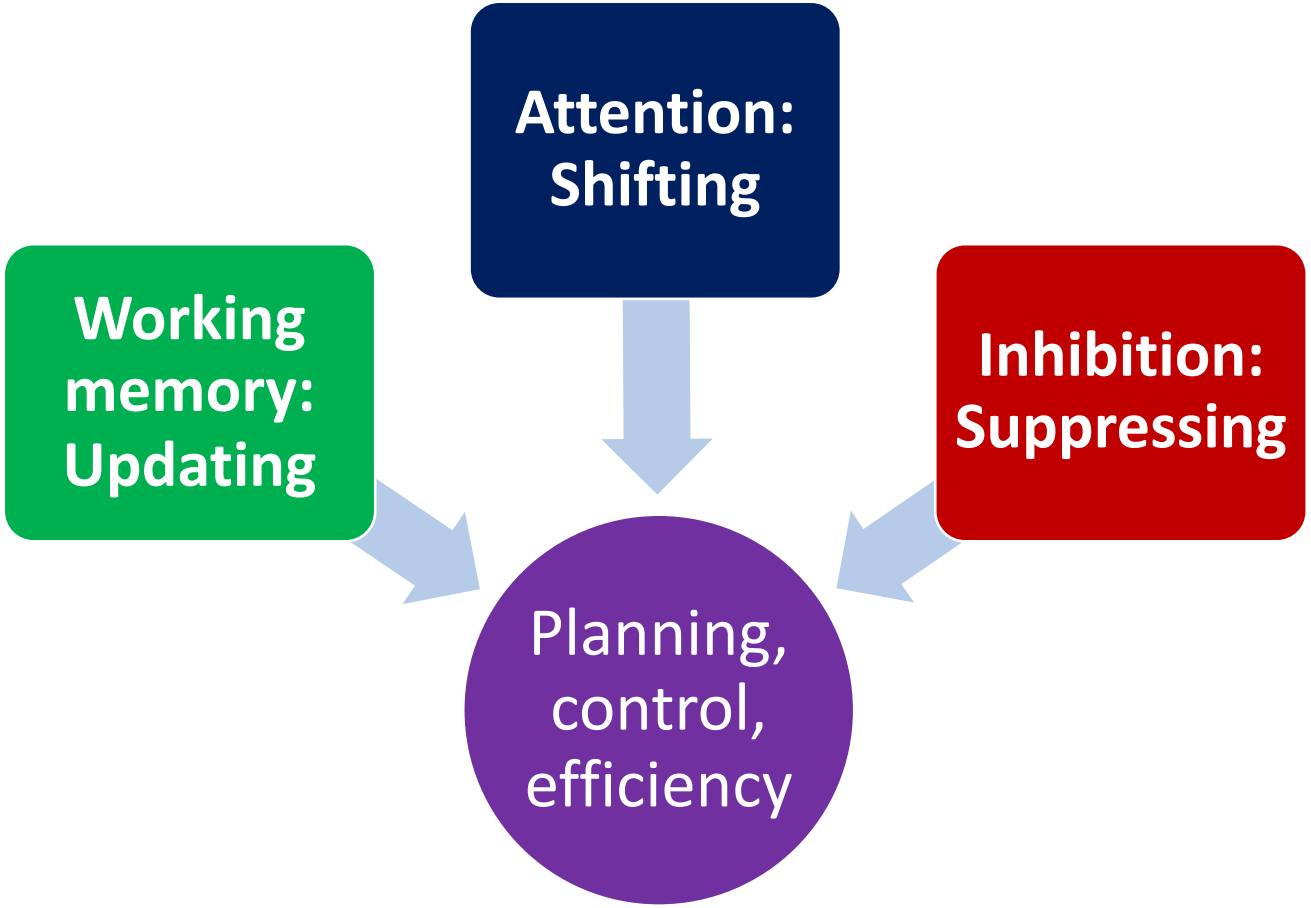
- social functioning
- impulse control
- emotional regulation
- personality
- ethical and moral behaviour

Terms and models relating to Executive Functions

- Executive control (Engle & Kane, 2004; Logan, 2003)
- Executive attention (McCabe et al., 2010)
- Attentional control (Balota et al., 1999)
- Controlled attention (Engle et al., 1999)
- Inhibitory control (Hasher, Zacks et al., 2007)
- Central executive (Baddeley, 2012)
- Cognitive control (Lambon-Ralph, Jefferies et al., 2017)

- Executive functions, functioning OR function*

Miyake, Friedman et al. (2000, 2017)



- College students (N = 137)
- 9 tasks altogether, 3 per construct
- 2 of 3 tasks verbal in each construct
- 1 of 3 tasks non-verbal

- **Latent/hidden** constructs based on statistical modelling
- **<u>Not task-based</u>** constructs

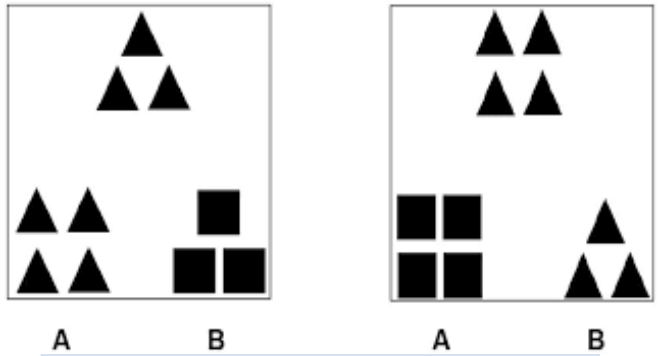
Miyake, Friedman et al. (2000)

Updating

- Tone monitoring
- High, mid, low pitch
- Respond on the 4th tone of each particular pitch

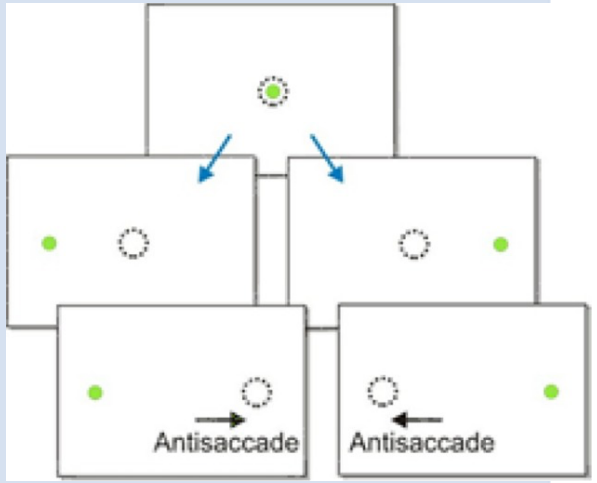
Shifting

- Local-global task



Suppressing

- Antisaccade



Working memory

Non-verbal working memory in aphasia (and short-term memory)

Short-term vs. working memory

- **Short-term memory:** Storage of information for a brief period of time, usually a few seconds (< 30), in a relatively unprocessed state

- **Working memory:** Storage **and mental manipulation (or updating)** of information to achieve a particular goal or plan for a brief period of time

- Short-term memory is a prerequisite for working memory

- Both systems are time-limited

- Activated portions of long-term memory

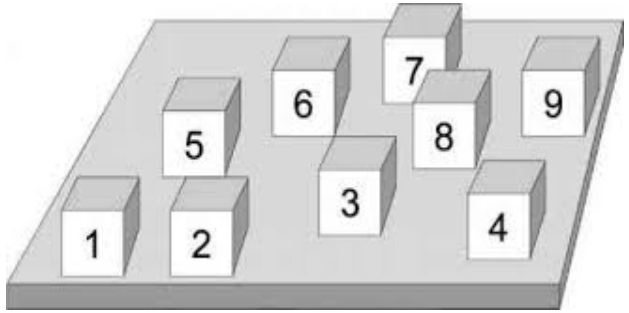
- Simple vs. complex tasks

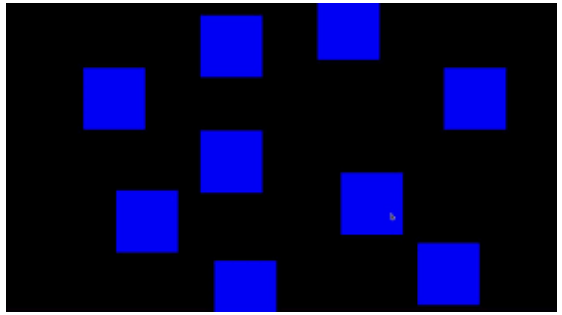
- Short-term memory: Serial or free recall or recognition

- Working memory: Order does not matter

(Baddeley, 2012; Cowan, 2010)

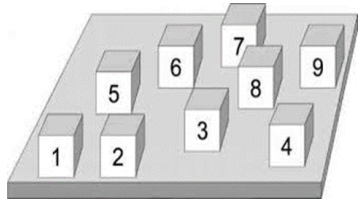
Short-term, working memory (updating function)





- Visual, spatial
- Corsi task (Corsi, 1972)
- Forward recall: STM
- Backward recall: WM

Non-verbal short-term/working memory



- Impaired in many, though not all people with aphasia (PWA)

(Basso & Burgio, 1997; De Renzi & Nichelli, 1975; Dronkers/Baldo et al. 2018; Kasselimis/Potagas et al., 2011; 2013; 2018)

- Deficits independent of aphasia in LH damage?

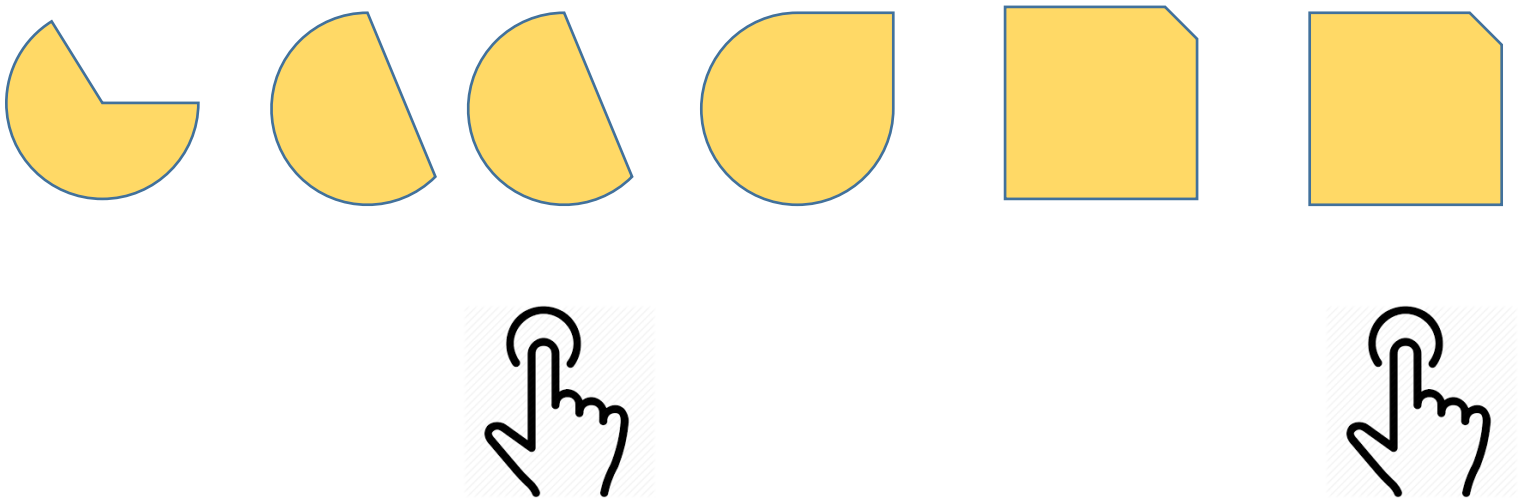
No (De Renzi & Nichelli, 1975; Kasselimis et al., 2018)

Why are PWA impaired?

- Verbally-mediated skills (inner speech, covert vocalisation)
- Successive stimulus processing (speed, integration of movements to a whole)
- Conceptual component
- Interference – ‘wiping clean’ previous trials

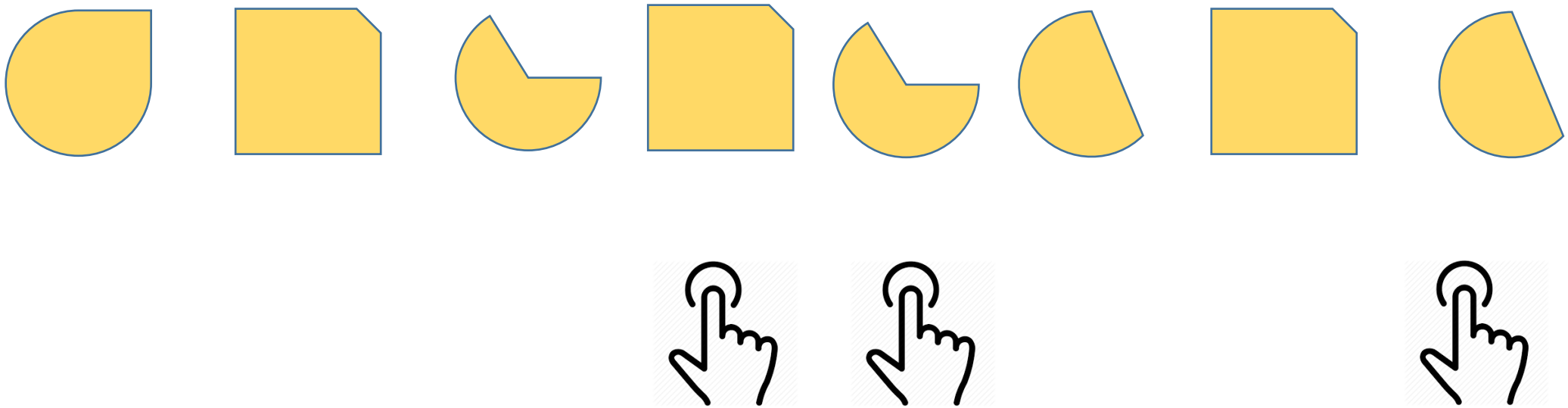
Non-verbal working memory: Updating (n-back task)

1-back



Non-verbal working memory: Updating (n-back task)

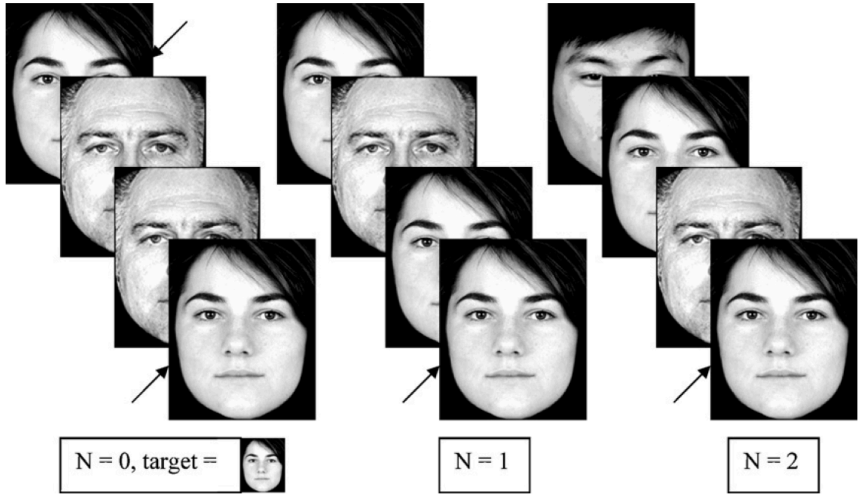
2-back



Non-verbal working memory: Updating in aphasia

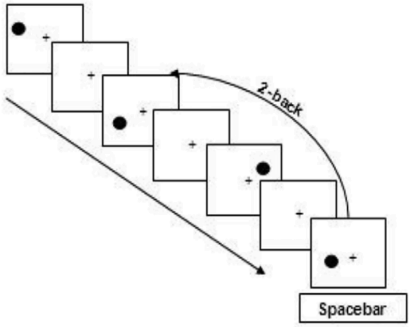
Mayer & Murray (2012)

N = 14

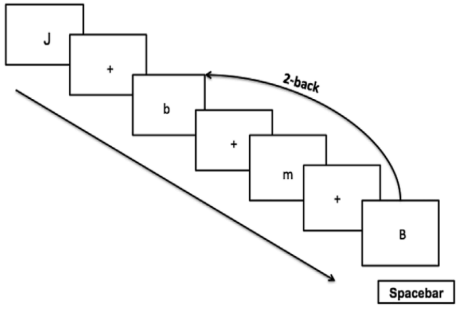


Christensen et al. (2018)

N = 14

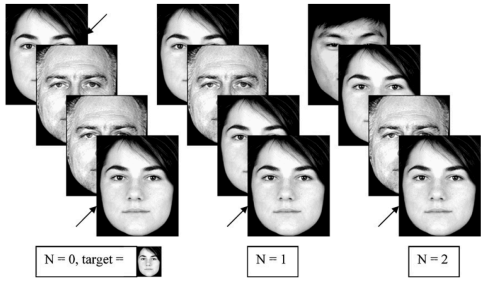


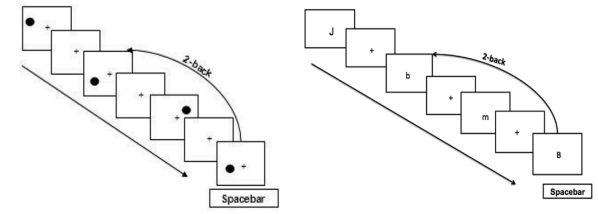
2-back spatial task



2-back verbal task

Non-verbal working memory: Updating in aphasia





2-back spatial task *2-back verbal task*

Aphasia ≠ controls

Performance got worse as memory load n increased

Aphasia = controls

Only 2-back condition was reported

Attention

Non-verbal attention in aphasia

Attention - shifting

Some types or levels

- Vigilance, orientation
- Selective (or focused)
- Sustained
- Divided
- Shifting (switching)

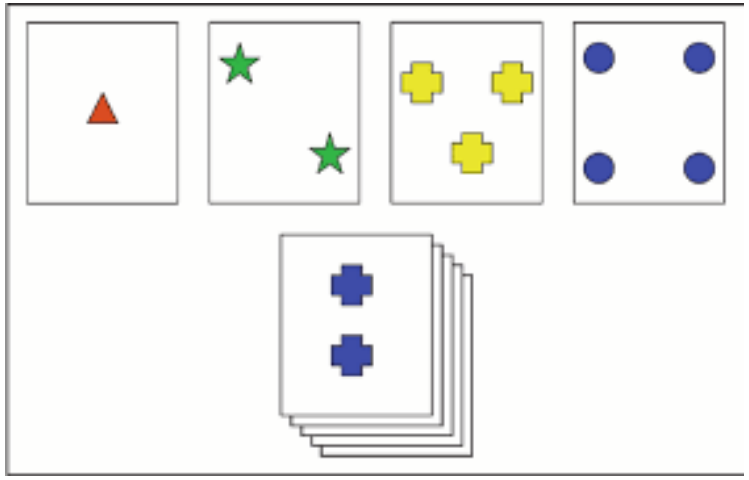
Simple non-verbal tasks

- Trail making

Complex non-verbal tasks

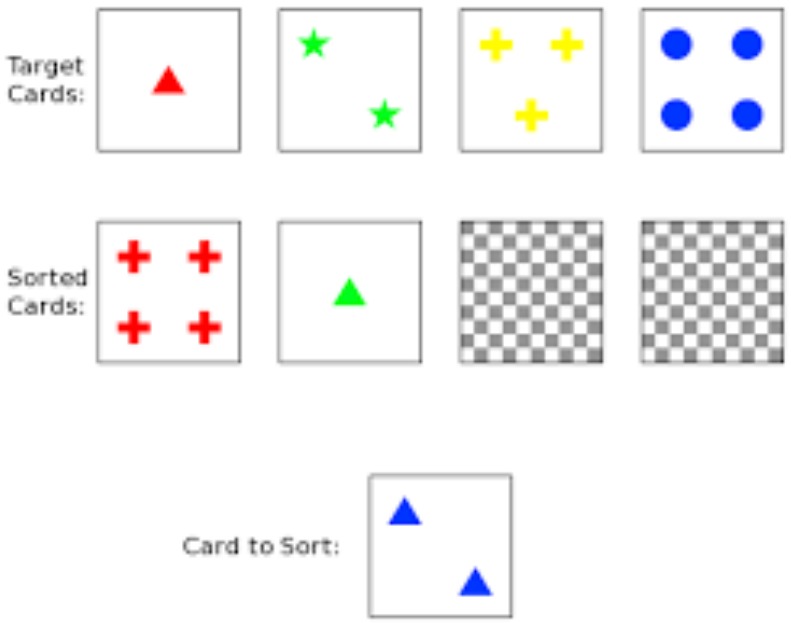
- Wisconsin Card Sorting (Berg, 1948)

Complex attention task - Wisconsin Card Sorting Test (Berg, 1948)



- Features prominently in many models of Executive Functions
- Cognitive flexibility
- Shifting attention component (Miyake et al., 2000)
- Conceptual component (Greve et al., 1997)

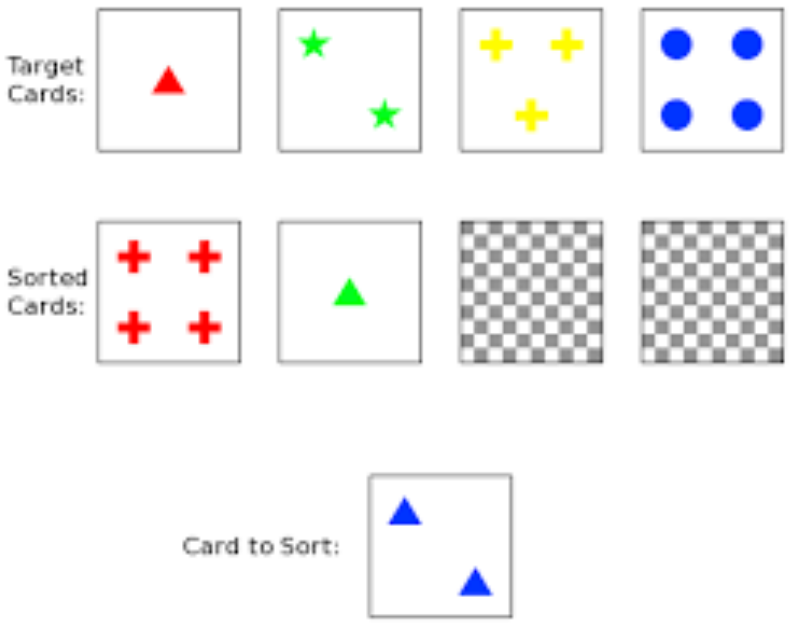
Complex attention task - Wisconsin Card Sorting Test (Berg, 1948)



How it works:

- Sorting of cards based on colour, number, or shape
- Person needs to figure out a rule (e.g., colour) and sort cards according to that rule
- Not told what the rule is (person knows that)
- Person starts sorting cards

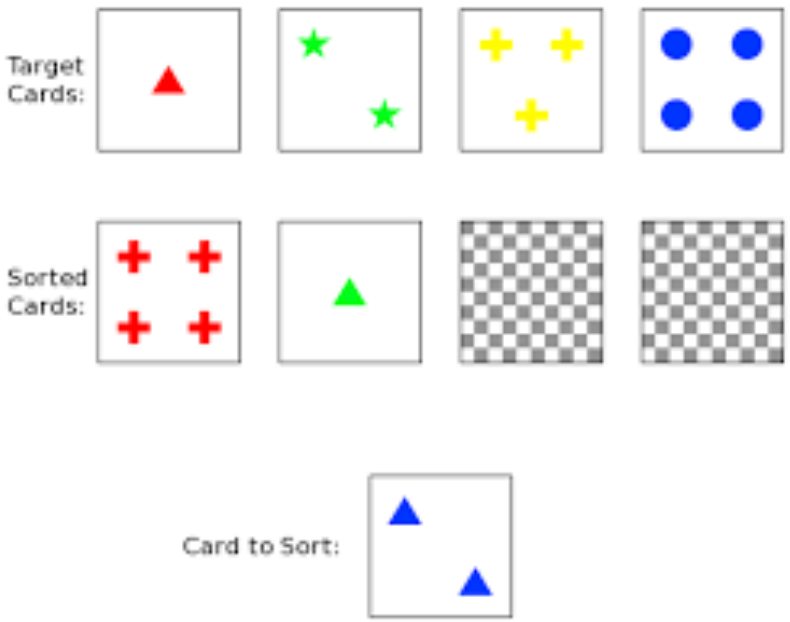
Complex attention task - Wisconsin Card Sorting Test (Berg, 1948)



How it works:

- If the person finds the rule, at each card sorted correctly, assessor say “right”
- If person has not figured out the rule, then assessor says wrong
- The rule changes after 6 correct cards and assessor says “the rules now changes, I want you to find another rule”

Complex attention task - Wisconsin Card Sorting Test (Berg, 1948)



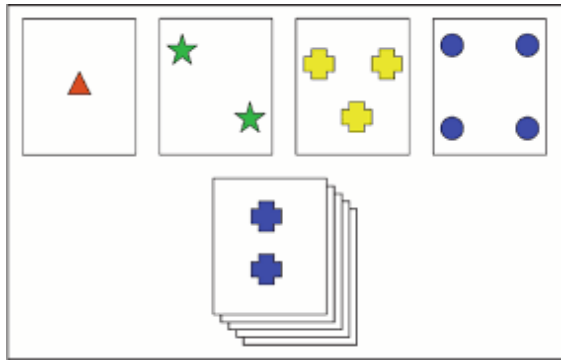
Main types of scores, based on correct/error patterns

Categories correct = complete 6 ”correct”

Perseverative errors = ignoring error or feedback

Comprehension issue: Person needs to sort at least 1 category correctly (Baldo et al., 2015)

Baldo, Dronkers et al. (2005, 2015)



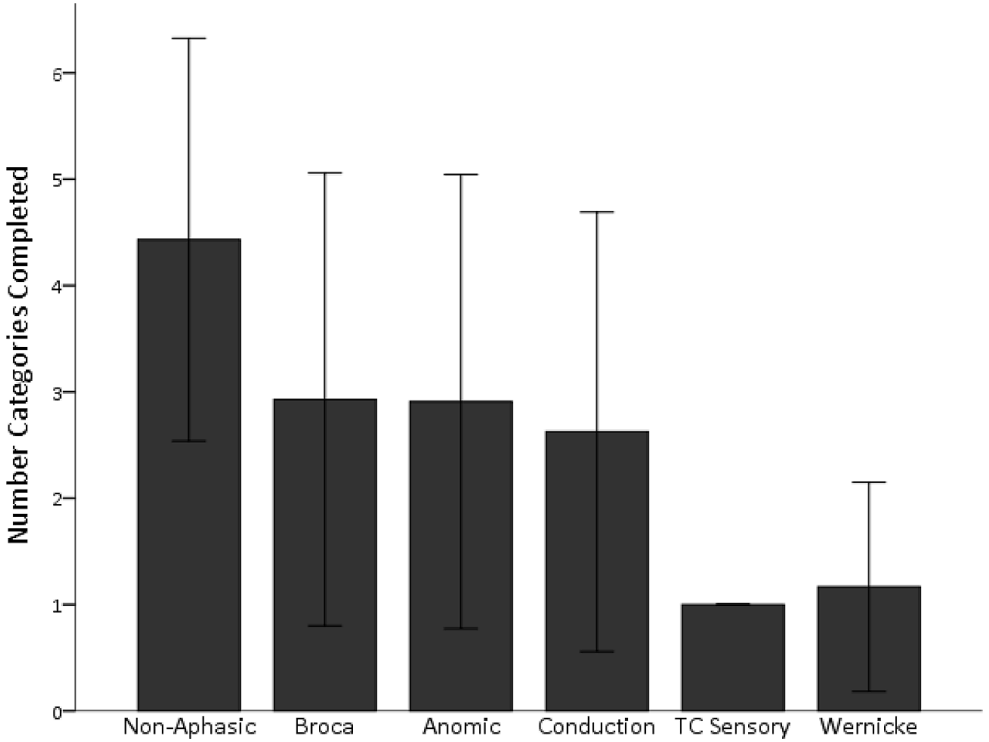
N = 81 left hemisphere stroke

- n = 35 “non-aphasic by WAB”
- n = 46 aphasia

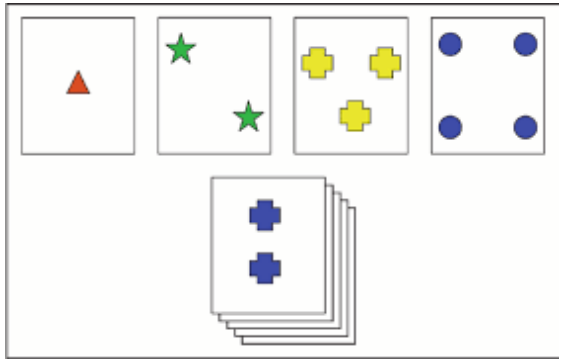
non-aphasia = 4.4 categories correct (max. 6)

aphasia = 2.6 categories correct (max. 6)

corrected for age, education, ideo-motor apraxia, time-post onset



Purdy (2002)



- Nine of 15 people did not complete more than two categories

- **Qualitative analysis – clinically useful:** People were asked if they could think of another way to sort the cards

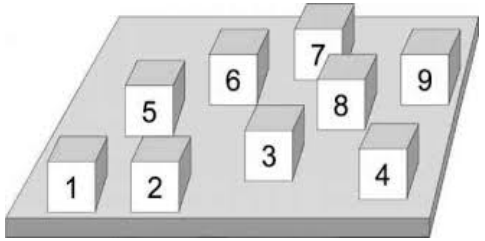
- When given this minimal cue, 6 people completed additional categories

- Possible difficulty in **initiating shifting** behaviour, not in categorisation per se (i.e., conceptual)

Inhibitory control

Non-verbal inhibitory control in aphasia

Inhibitory control (or interference control)



The ability to **suppress**:

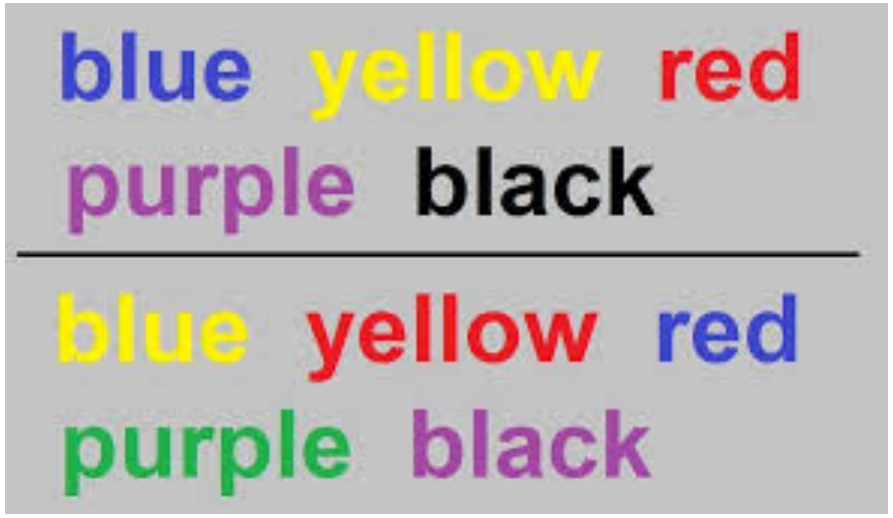
irrelevant, distracting, or interfering information

for optimising and ultimately achieving a particular goal

In the inhibitory control literature, different taxonomies have been proposed (e.g., Friedman & Miyake, 2004; Tiego et al., 2018)

Clinically, perseveration is an obvious manifestation of lack of inhibitory control

Inhibitory control: Verbal Stroop

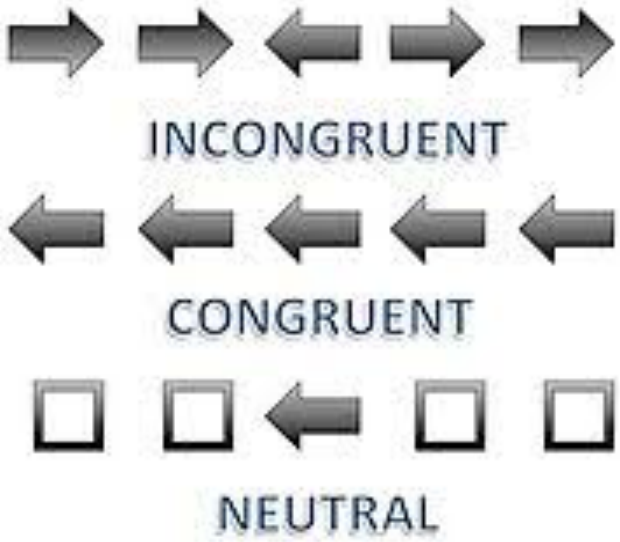


Interference effect: Congruent minus incongruent as accuracy or response time

Inhibitory control: Non-verbal tasks

Flanker

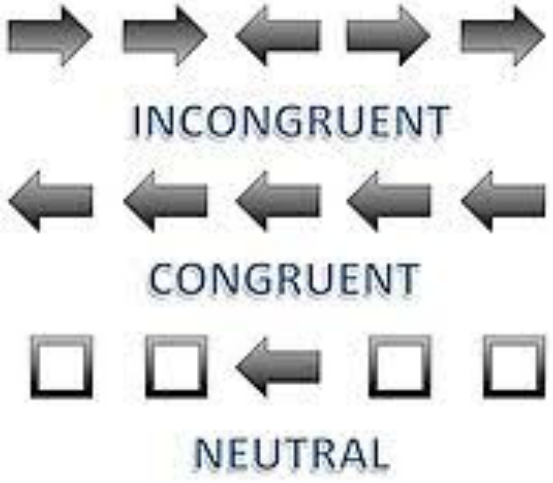
(Eriksen & Eriksen, 1974)



Determine the direction (L or R)
of the central arrow by pressing one of two
response keys

Non-verbal inhibitory control in aphasia

Kuzmina & Weekes (2017)



N = 31 people with aphasia

Reaction time, not accuracy

People with aphasia slower than controls

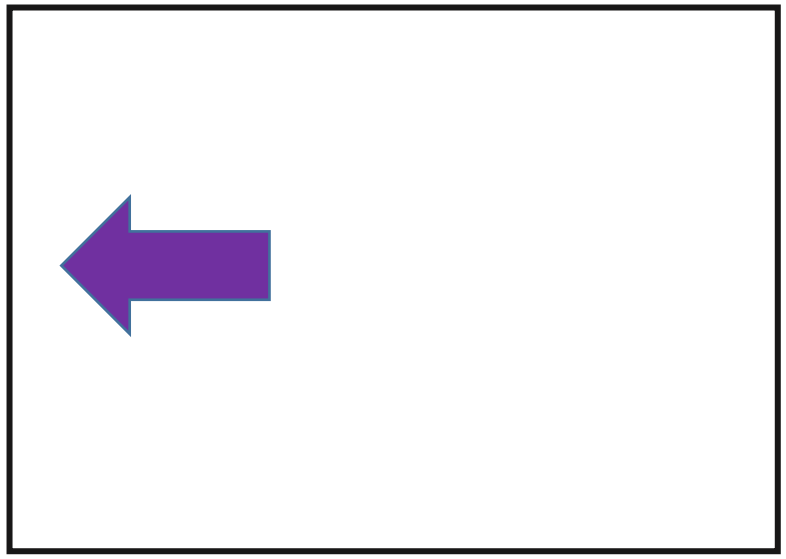
No difference between fluent and non-fluent aphasia

Inhibitory control: Non-verbal tasks

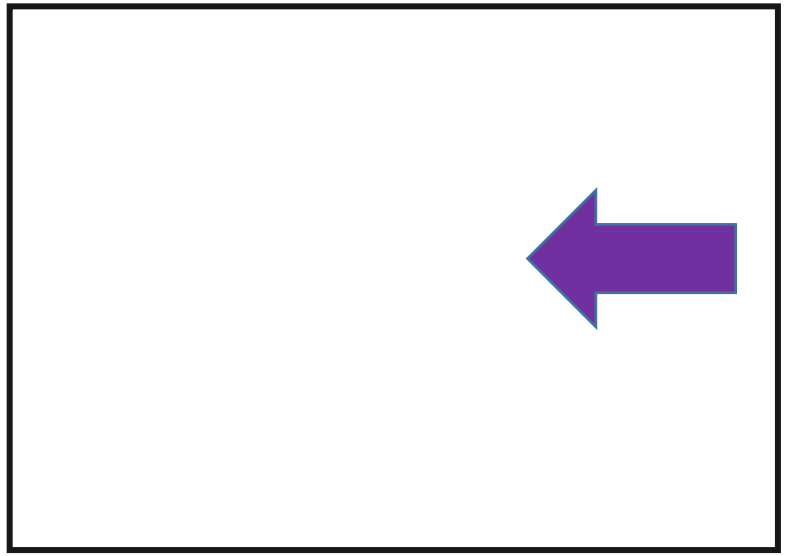
Spatial Stroop

(Clark & Brownell, 1975)

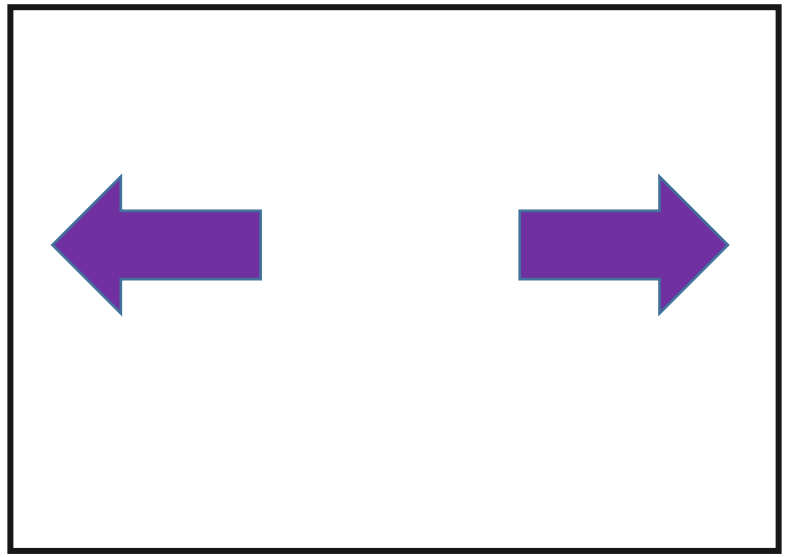
Congruent:
Arrow direction matches position on screen



Incongruent:
Arrow direction does not match position on screen



Non-verbal inhibitory control in aphasia

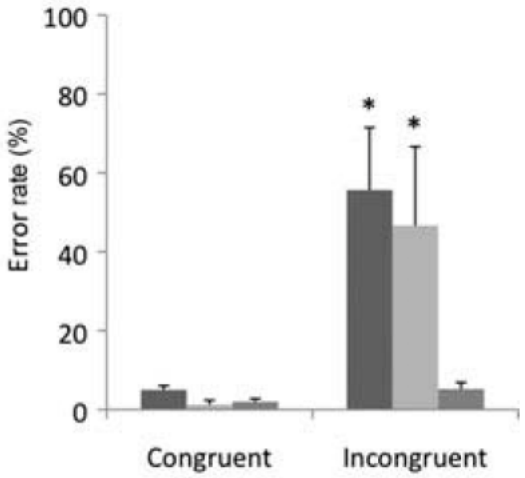


Zakariás et al. (2013)

N = 5

Errors

People with aphasia:
more errors than healthy controls



Interim summary

- People with aphasia have difficulties in non-verbal executive functions:

  Updating function of working memory

  Shifting attention

  Inhibitory control

- Most tasks (though not Corsi) can be described as continuous performance tasks, successive stream of stimuli requiring specific responses at specific points
- Main elements: Encoding, monitoring, action
- Although tasks are minimally non-verbal, they require conceptual processing in changing circumstances (even in the Corsi)

Part 3

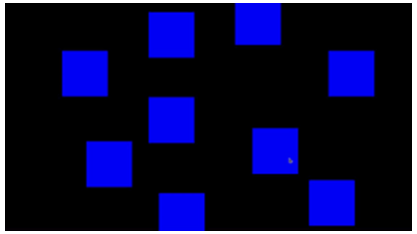
Clinical implications

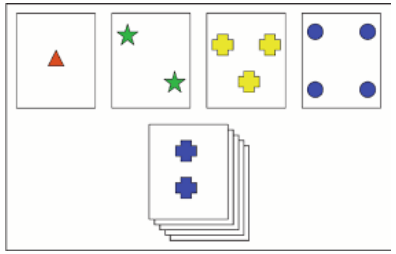
Non-verbal cognition and aphasia recovery

- **El Hachioui et al. (2014)** – N = 115 (3, 12 months)

Visual memory

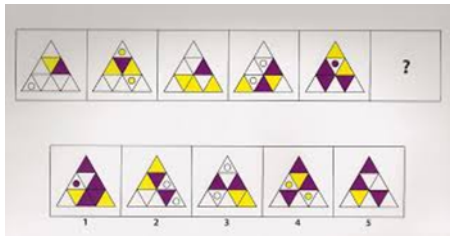
Attention





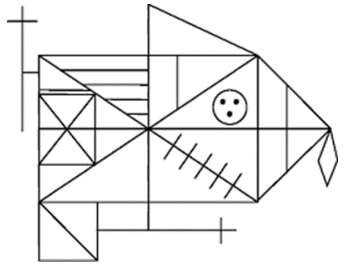
- **Fonseca et al. (2018)** – N = 39 (<1, 3 months)

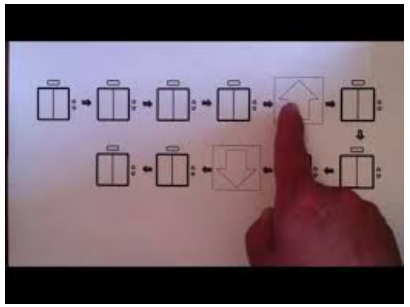
Matrix reasoning



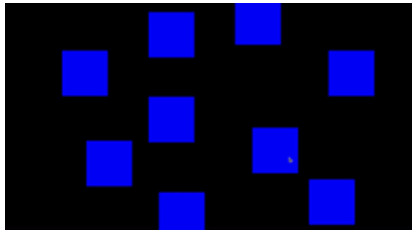
Non-verbal cognition and treatment outcomes

- **Lambon-Ralph et al. (2010)** – N = 33





- **Harnish & Lundine (2015)** – N = 8

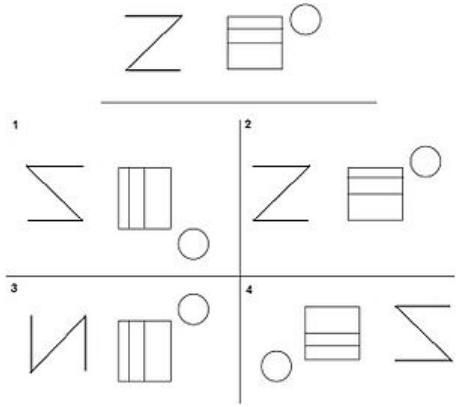


Backward recall predicted naming treatment gains

May suggest close relationship between non-verbal cognition and verbal learning

Non-verbal cognition and treatment outcomes

- **Seniow et al. (2009)** – N = 47 (time post onset < 6 months)



Benton Visual Retention test predicted aphasia treatment outcome

Short-term (long-term?) memory

Raven's matrices did not predict treatment outcome

Non-verbal executive functions and generalisation

- Generalisation = transfer of skill(s) from:

one context, usually clinical, distraction free, 1:1

to other context, real-life, multi-tasking, distraction

Patterns of non-verbal vs. verbal cognitive impairments in aphasia

(Nicholas, 2019)

- **Severe aphasia:**
  1. Significant deficit in language **and** non-verbal domains
  2. Significant language impairment with relatively **better** non-verbal
  3. Significant language deficit with **no** non-verbal

- **Milder aphasia:**
  4. Milder deficits in both language **and** non-verbal domains
  5. Milder deficits in language with **no** non-verbal deficit

Clinical challenges

Clinical assessment of aphasia is complex and time-consuming:

Spoken & written language

Digital technology

Psychosocial impact

Concomitant conditions (apraxia of speech, gesture)

- Takes place in different recovery periods, different physical locations

- What priority should one give to non-verbal cognition?
- ? Greater priority in more severe patients, links to AAC, computerized treatment

Clinical challenges

- And, given the inherent variability between (and often within) patients, which assessment tasks should one use?

- Short-term/working memory: Corsi, visual span, simpler than other tasks; quick

- Attention: Trail making, Wisconsin Card Sorting (or similar, e.g., Weigl) for cognitive flexibility, shifting attention, inhibitory control (based on perseverative errors)

- Inhibitory control per se: less clinician-friendly but can observe behaviours

Part 4

Defining, redefining (or not) aphasia

Non-verbal cognition is founded on concepts and symbols

Non-verbal cognition underpins linguistic processing

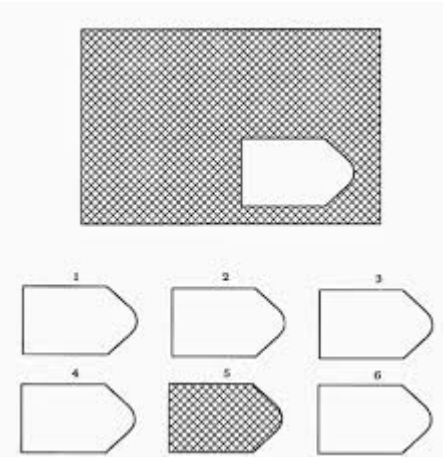
Understanding conceptual disorders is key (Gainotti, 2014)

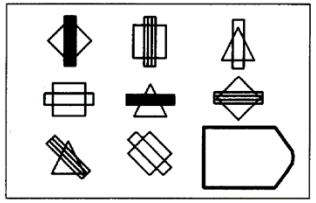
We never have language on its own, it comes with attention, memory, inhibitory control, creativity, which are governed by executive functions

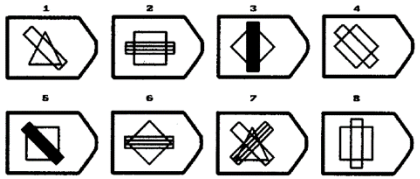
Executive function disorders are part and parcel of aphasia

Thank you for listening

Non-verbal reasoning – the ubiquitous Raven's







A visual inferencing test of non-verbal intelligence

Some language (instructions)

Similar format across items

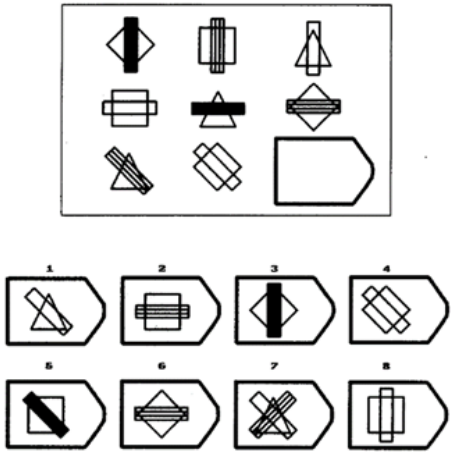
However, substantial variation in terms of "difficulty"

Analytic intelligence

Raven's in aphasia

- Presence of aphasia lowers performance (Basso et al., 1979; but see Edwards et al., 1976)
- Construction apraxia also lowers performance (Basso et al., 1979)
- No difference between fluent and non-fluent aphasia (Basso et al., 1979)
- Spoken comprehension adversely affects performance (Kertesz & McCabe, 1975; Fucetola et al., 2009)

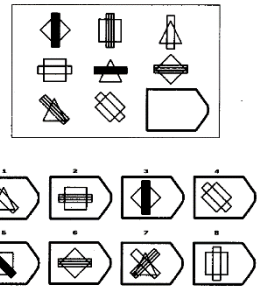
Carpenter et al. (1990) – Unravelling Raven's test

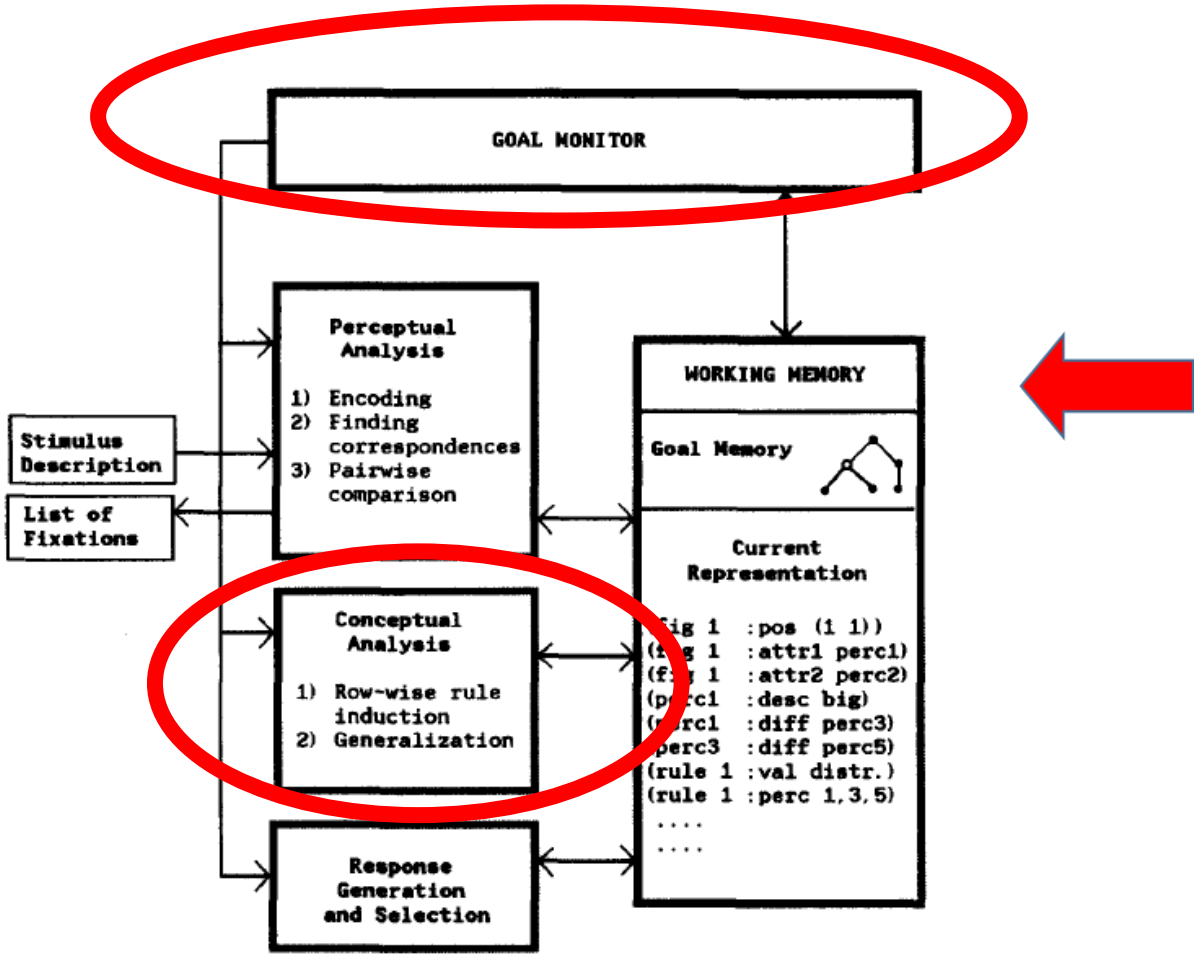


Components of reasoning ability

- Rule taxonomy; finding corresponding elements
- Experimental studies with college students (eye-tracking, other tasks)
- Computer simulation of two models:
  what distinguishes easier from harder problems?

  what distinguishes among people of different abilities?




GOAL MONITOR
Perceptual Analysis
1) Encoding
2) Finding correspondences
3) Pairwise comparison
Stimulus Description
List of Fixations
Conceptual Analysis
1) Row-wise rule induction
2) Generalization
Response Generation and Selection
WORKING MEMORY
Goal Memory
Current Representation
:pos (1 1))
:attr1 perc1)
:attr2 perc2)
:desc big)
:diff perc3)
:diff perc5)
(rule 1 :val distr.)
(rule 1 :perc 1,3,5)