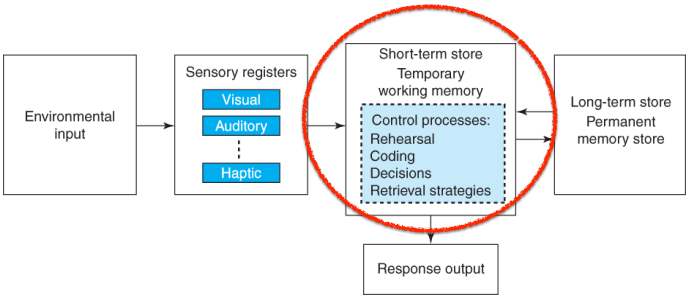
Chapter 5

Short-Term Working Memory

Atkinson Shiffrin "Standard Model"



STM / WM

- STM Capacity
  - Bottleneck, Limits, Forgetting
- STM Retrieval
  - Serial Position effect, Scanning
- Working Memory
  - Central Executive, Phonological Loop, Visuospatial Sketchpad, Episodic Buffer
- Research Methods
  - Dual Task, Span
- Other systems
  - Attention, LTM, Reasoning

Terminology

- Modern Terms:
  - Short Term Memory (STM)
  - Working Memory (WM)
- Alternative Terms:
  - Short-Term Store (STS)
  - Primary Memory
  - Elementary Memory
  - Immediate Memory
  - Temporary Memory
  - Supervisory Attention System (SAS)

Common Misconceptions

- Statment
  - "I have a short-term memory"
- Meaning
  - "I don't remember things for very long"

- How to state this with proper terminology?

Elementary Memory

- Elementary memory makes us aware of ... the just past. The objects we feel in this directly intuited past differ from properly recollected objects. An object which is recollected, in the proper sense of that term, is one which has been absent from consciousness altogether, and ... is brought back ... from a reservoir in which, with countless other objects, it lay buried and lost from view. But an object of primary memory is not thus brought back; it never was lost; its date was never cut off in consciousness from that of the immediately present moment. In fact it comes to us as belonging to the rearward portion of the present space of time, and not to the genuine past. (James, 1890)

STM vs WM

- Short Term Memory (STM)
  - storage
- Working Memory (WM)
  - storage (multiple kinds)
  - focus, attention, "executive functioning"
  - processing

STM Capacity

- Limits…
- Chunking
  - Recoding
- Forgetting
  - Decay vs. Interference
  - Proactive vs. Retroactive

WM Limits

- Miller's "magical number 7 ± 2" (1956)
- "span of apprehension"
- "memory span"
  - digit span, letter span, picture span…
- Important subtest of most IQ tests
- Cowan (2010) : may actually be 4 ± 1
  - (Miller's result includes chunking)

Chunking

- combining simple items into a more rich or complex concept.

Recoding

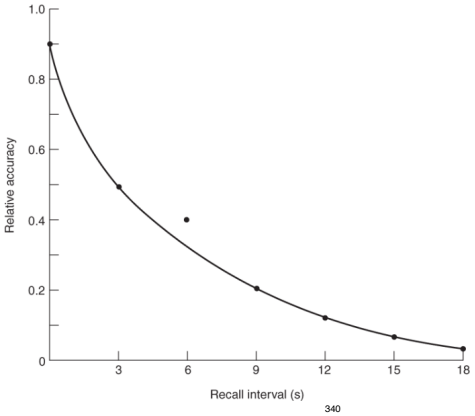
- A kind of chunking
- forming groups of items then remembering the group
- Requirements
  - enough time
  - familiar groups already in LTM
- With training Digit Span of 82 has been achieved (Chase & Ericsson, 1982)

Forgetting in STM

- Limited Capacity
- Limited Duration
- Forgetting
  - Decay
  - Interference

Brown-Peterson Task

- Results: dramatic forgetting
- Conclusion: Decay not Interference

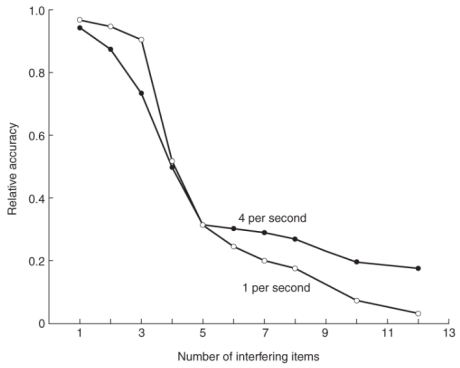


Waugh & Norman (1965)

- List of number, last number is "probe"
- 7 4 6 9 — 4
- correct answer : "6"
- Dependent Variable:
  - rate of presentation: 1 to 4 per second

Waugh & Norman (1965)

- Results: Time is not important, # of items is.
- Conclusion: Interference, not Decay



Decay vs. Interference?

- Still controversial but
- Main factor: Interference
- Smaller factor: Decay

Proactive and Retroactive Interference

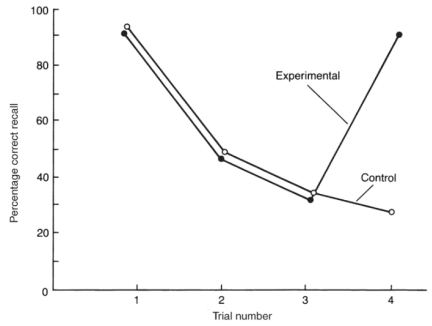
- On Brown Peterson task, first trial is easy, later trials get much harder.
- PI: old information interferes with new
- RI: new information interferes with old

Release from PI

- Wickens (1972)
- Do these sample trials:
  - Dog, Cat, Mouse: 745
  - Rabbit, Horse, Tiger: 687
  - Elephant, Zebra, Lion: 496
  - Cow, Bear, Wolf: 313
  - Doctor, Lawyer, Baker: 891 Release!

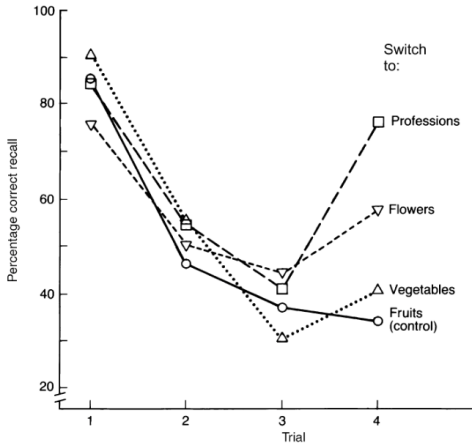
Release from PI

- Wickens (1972)
- Multiple Brown/Peterson trials using Words.
- One group switches to Numbers



Release from PI - Semantic Distance

- Dependent Variable: semantic category



STM Retrieval

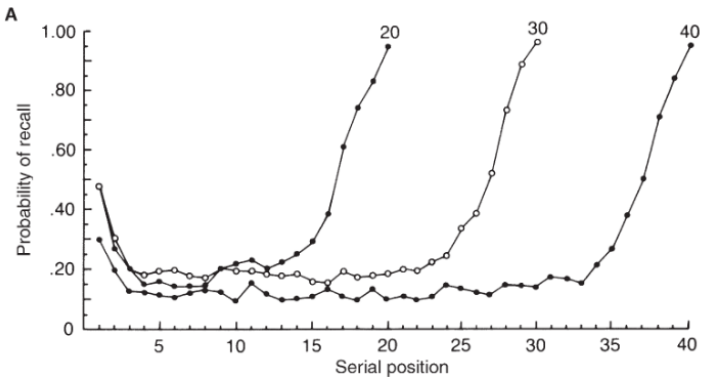
- Serial Position Effects…
- Scanning…

Serial Position Effects

- Methods:
  - Free Recall
  - Serial Recall
- Stimuli:
  - lists of items (words, etc.)
- Dependent variable:
  - position in list
- Independent variable:
  - % accuracy

Serial Position Curve

- Primacy & Recency effects

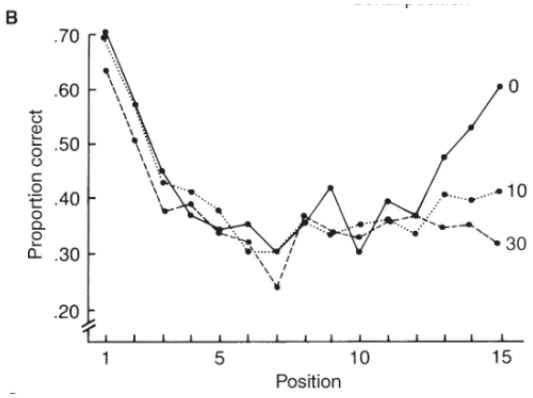


Primacy & Recency

- Primacy:
  - A long-term memory effect.
  - First items in a list get the best and most rehearsal.
- Recency:
  - A short-term memory effect.
  - Last items still in STM at time of recall.

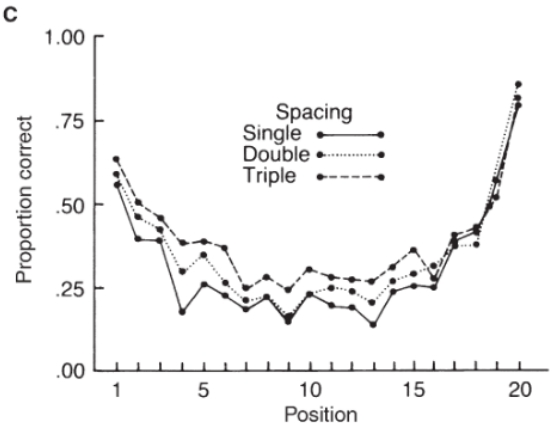
Serial Position Curve

- Recency can be blocked with distractor task

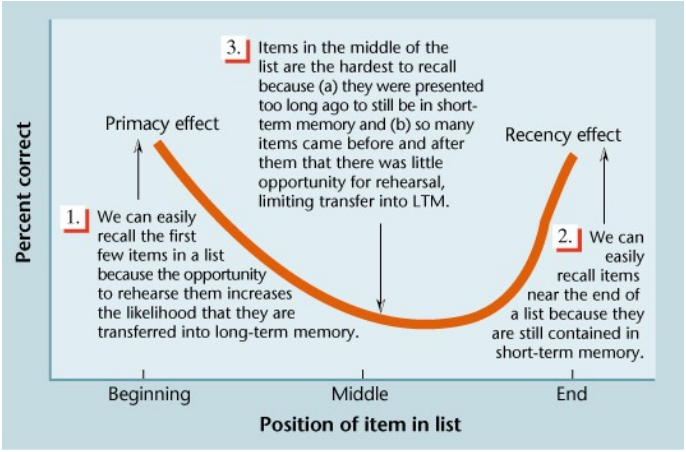


Serial Position Curve

- Presentation Rate (time) doesn't matter



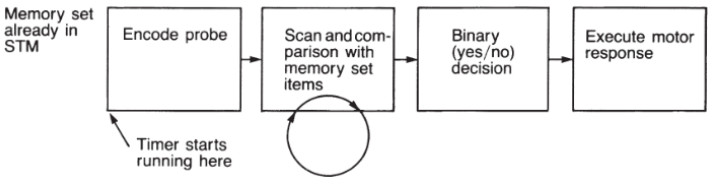
Idealized Serial Position Curve



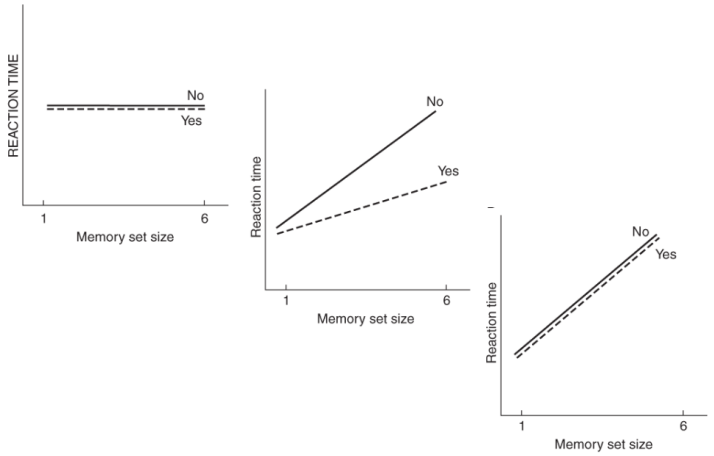
Scanning in STM

- Parallel
  - are my keys on the table?
- Serial
  - Self-Terminating
    - are my keys…
      - under the couch? no
      - on the table? no
      - in the kitchen? YES - Stop looking
  - Exhaustive
    - e.g. a police lineup

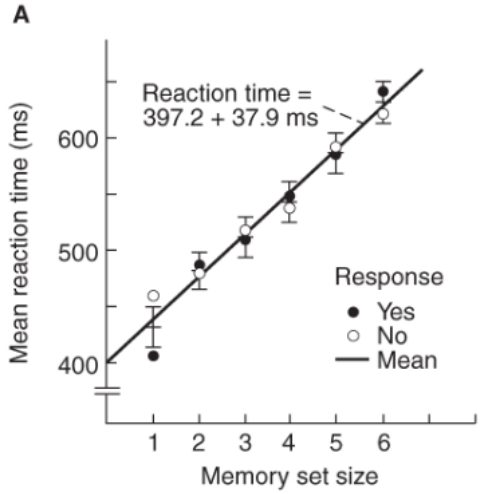
Sternberg Task: Process Model



Sternberg Task: Predictions



Sternberg Task: Results



Scanning in STM Summary

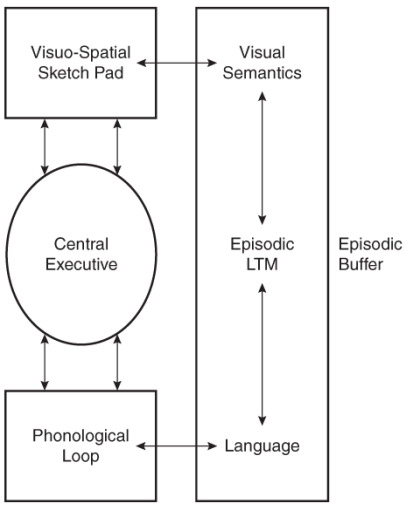
- People scan STM in a serial exhaustive fashion (don't stop even if a match is found).
- The scan rate is about 38 msec per item (Sternberg's slope).
- The intercept represents the time it takes for all other stages in Sternberg's model.

Working Memory

- Challenges to basic STM theory…
- Components of WM…

STM Problems

- Clinical examples:
  - Patient A
    - STS (digit span) of 2 items
    - Yet otherwise normal
  - Patient B
    - word span : 1 item
    - can repeat 7 word sentences
- Conclusion: STM is too simple - must be other parts



Working Memory Components

- Baddeley (2000)
- Episodic Buffer is new: stores & links information (e.g. sound of voice, image of face)

WM: Central Executive

- Planning, control, initiates retrieval, combining information, decision making.
- Computer Analogy: CPU (central processing unit)

WM: Phonological Loop

- Speech and sound storage
- Phonological store
  - holds verbal information
  - ex: imagining music
- Articulatory loop
  - refreshes the phonological store
  - "rehearsal"
  - ex: talking to yourself

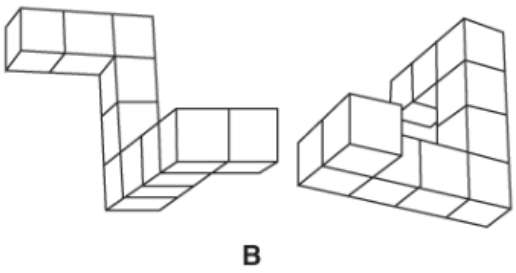
Limits to Phonological Loop

- Articulatory Suppression Effect
  - Speaking impairs memory for list of words
- Irrelevant Speech Effect
  - environmental speech impairs memory
- Phonological similarity Effect
  - hard to remember list of words if they are phonological similar (sound alike)
    - boat bowl bone bore
    - stick pear friend cake
- Similar results for non-speech stimuli (music and ASL)

WM: Visuospatial Sketch Pad

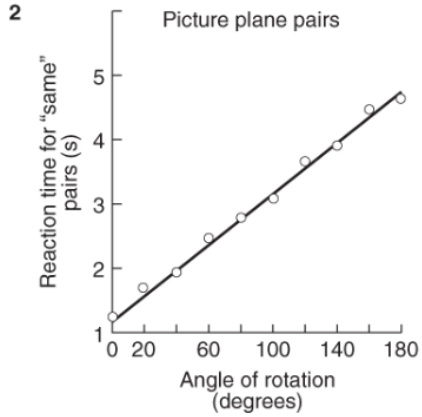
- Visual / spatial storage (buffer)
- Manipulation of objects
- (see CogLab 5 : Mental Rotation)

Mental Rotation



Mental Rotation Results

- RT depends on angle of rotation



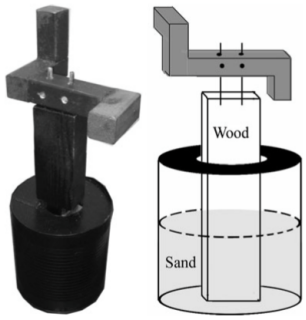


Fig. 2 An image and schematic of the rotation platform used for physical rotation training. The wooden Shepard and Metzler objects were mounted on the rods protruding from the top

WM: Embodied Cognition

- performance improved by holding physical object of same shape
- harder to mentally rotate objects that are physically harder to rotate

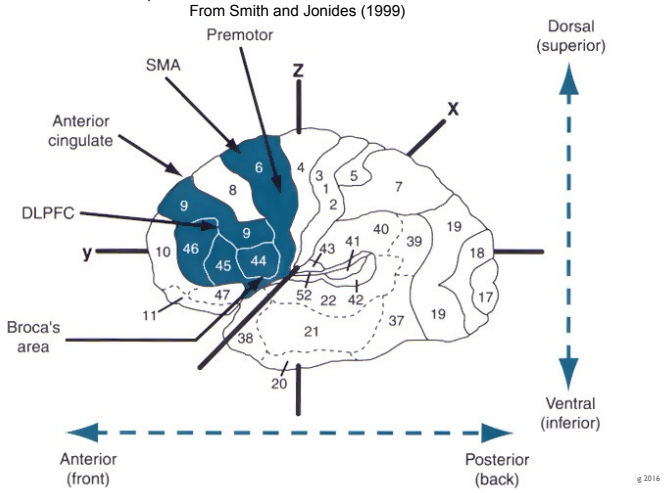
WM: Visuospatial Sketch Pad

- Boundary Extension
  - people remember more of a scene than was actually seen
- Representation Momentum
  - people remember an object moving further than it did

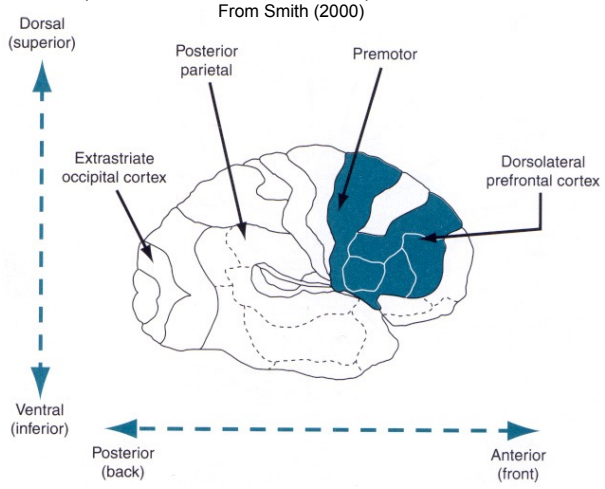
WM: Episodic Buffer

- Where chunking happens
- combines information across modality:
  - visual + auditory
  - meaning + words

The **Left** hemisphere regions of the frontal lobe of the brain that are especially important in verbal working memory tasks: the premotor and supplementary motor area, Brodmann area 6; the anterior cingulate and the dorsolateral prefrontal cortex, Brodmann area 9; and Broca's area, Brodmann area 44.
From Smith and Jonides (1999)



The Right hemisphere regions of the brain that are especially important in visual and spatial working memory tasks: The extrastriate occipital cortex; the posterior parietal lobe, the premotor area, and the dorsolateral prefrontal cortex.
From Smith (2000)



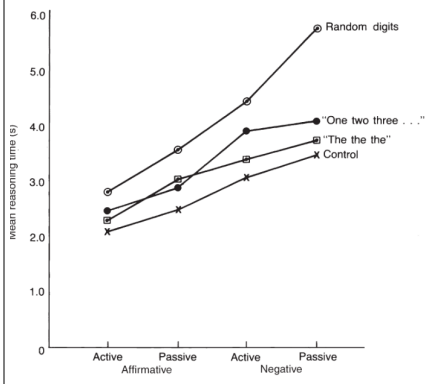
Assessing WM

- Dual Task…
- Working Memory Span…

Dual Task Paradigm

- Two tasks
  - Primary
  - Secondary
- Dependent Variables:
  - Vary nature of task and stimuli
- Independent Variable:
  - performance (accuracy, reaction time)
- Conclusion:
  - whether tasks do or do not interfere (using same resources)

Dual Task Reasoning Experiment



- Main Task:
  - AB: "A is not proceeded by B"
- Second Task:
  - repeat "the"
  - counting
  - remember digits

Working Memory Span

- Short Term Memory Span
  - storage only
- Working Memory Span
  - storage and processing

$(6 \times 2) - 2 = 10?\ SPOT$

$(5 \times 3) - 2 = 12?\ TRAIL$

$(6 \times 2) - 2 = 10?\ BAND$

Reading Span

- Daneman & Carpenter (1980)
- Read unrelated sentences
- Remember last word of each sentence

- Reading span score highly correlated with SAT scores (0.59) and reading comprehension

WM Conclusions

- WM = STM + controlled attention (Engle,2002)

- WM Training?
  - with 10 hours of video games, Female Visuospatial scores equaled Male scores.
  - Meditation

WM and Cognition

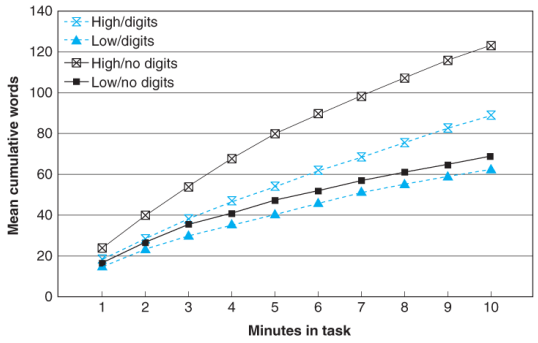
- WM and
  - Attention…
  - LTM…
  - Reasoning…

WM and Attention

- Auditory Shadowing Test with 'cocktail party' effect (subject's Name said in other ear)
  - High vs. Low WM Span Subjects
    - 65% vs. 20% detected name
  - Conclusion
    - High WM spans —> better concentration
- Modified Stroop test with only 20% "different"
  - Low WM Span subjects made 2x errors
  - Conclusion
    - Low WM spans —> forgetting task goal

WM and LTM

- Animal Category Fluency
- Secondary task: monitor digits
- High WM subjects more affected



WM and Reasoning

- Studies show those with higher WM spans better at logic, reasoning problems.
- Low WM subjects used simpler approaches.

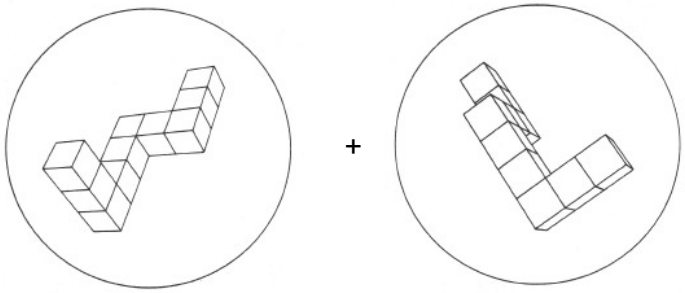
Is high WM capacity ever bad?

- Block & DeCaro (2007)
- Task: Math problems, some of which required simple solution
- Finding: High WM subjects had trouble using the simple strategy

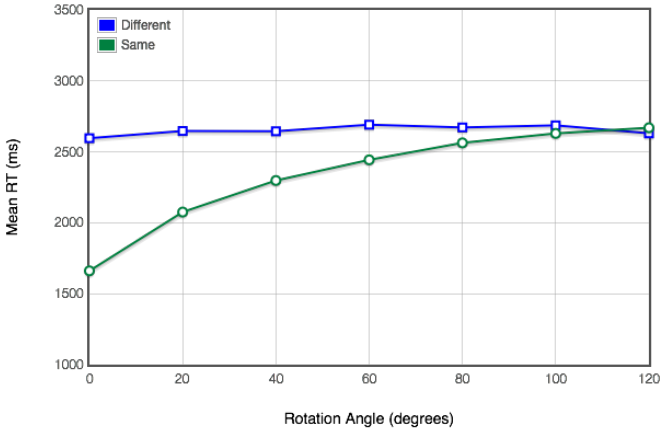
CogLab 5: Mental Rotation

- Methods:
  - See two 3D shapes
  - determine if the shapes are the same (by mentally rotating one or the other)
- Theory
  - Visuospatial sketchpad
  - Rotation will take time

CogLab 5: Mental Rotation

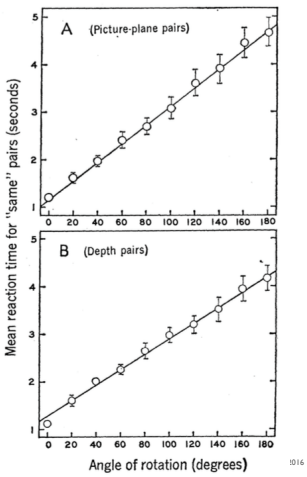


Mental Rotation: Global Data



Shepard & Metzler (1971)

- Reaction time for "same" pair is quite linear
- Results same for two kinds of rotation (around X or Z axes)
- Different pairs: constant, about 1000msec longer



Mental Rotation

- Debriefing
  - Methods
    - differences?
  - Predictions
    - rotation takes time
    - same vs. difference?
  - Robust? Limitations?

Clinical Evidence

Clinical Terminology

- Amnesia
  - failure to access information in LTM (retrieval)
  - failure to transfer information to LTM (learning)
- There is no clinical term for "impaired working memory"?

Clinical Examples

- Daniel Tammet -
  - has amazingly GOOD working memory
  - Hx of epilepsy and autisism-spectrum-disorder
  - Can multiply & divide long numbers in his head
- "I'm seeing the numbers, but I'm not seeing them, it's strange, I see pictures, shapes, patterns, like water, drops, ripples, almost metallic"
- Also good with words:
  - Knows 9 languages