Title	Improving the working memory capacity of children learning support programmes: A comparison of two intervention programmes
Author(s)	Kerry Lee, Su Yin Ang, Rebecca Bull, Kenneth Poon, Fiona Cheam and Alethea Kerk
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Kerry Lee, Su Yin Ang, Rebecca Bull, Kenneth Poon
National Institute of Education
Fiona Cheam & Alethea Kerk
Ministry of Education

IMPROVING THE WORKING MEMORY CAPACITY OF CHILDREN LEARNING SUPPORT PROGRAMMES: A COMPARISON OF TWO PROGRAMMES

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Math Performance in Singapore

- Singapore has performed well in international comparisons of mathematics achievement
  - Trends in International Mathematics and Science Study
  - Programme for International Student Assessment
- A relatively large tail-end compared to other high performing systems
- Around 5.5% of children struggle with math on entry to primary schools

Contributing Variables

- System
  - Societal expectation
  - Education system
  - Effort and quality of teachers
- Individual
  - Social or motivational (e.g., Ashcraft, Kirk, & Hopko, 1998)
  - Biological (see Geary, 1993, for a review)
  - Cognitive

Working Memory

What is Working Memory?

- Sir Humphrey's longest sentence from “Yes, Minister!”
  - "Well, it's clear that the committee has agreed that your new policy is a really excellent plan but in view of some of the doubts being expressed, may I propose that I recall that after careful consideration, the considered view of the committee was that while they considered that the proposal met with broad approval in principle, that some of the principles were sufficiently fundamental in principle and some of the considerations so complex and finely balanced in practice, that, in principle, it was proposed that the sensible and prudent practice would be to submit the proposal for more detailed consideration, ...”.

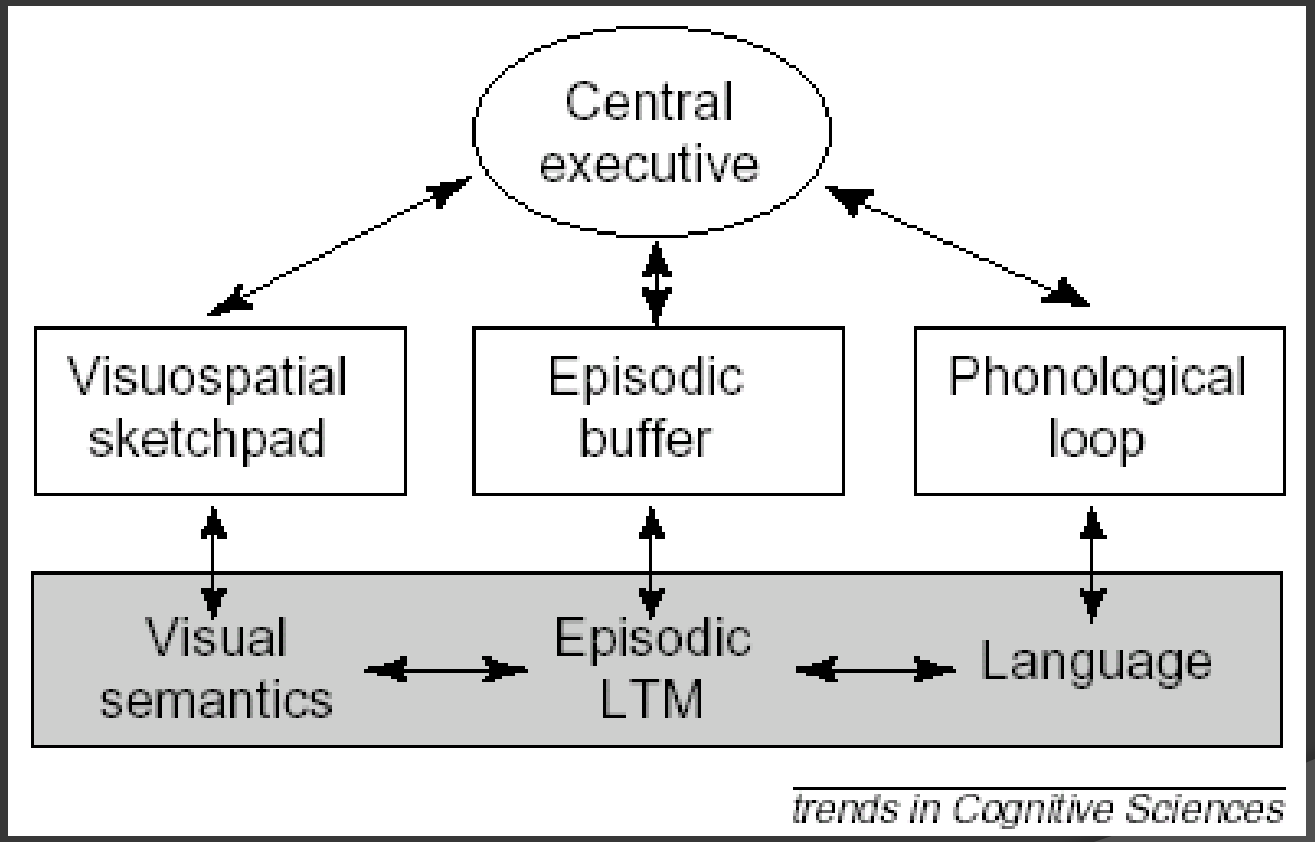
- 259 + 36 = ?
- 764 / 4 = ?

Theories of Working Memory

- Close relationship between attention and WM
  - Multiple component model
    - Baddeley & Logie, 1999, Baddeley & Hitch, 1974)
  - Embedded processes model
    - (Cowan, 1988, 1999)
  - Controlled attention network
    - (Engle, Kane, & Tuholski, 1999)
  - ACT-R model
    - (Lovett, Reder, & Lebiere, 1999, Anderson, Reder, & Lebiere, 1996)
- Symbolic computational models
  - Executive process/interactive control model
    - (Kieras, Meyer, Mueller, & Seymour, 1999, Meyer & Kieras, 1997)
  - SOAR architecture
    - (Young & Lewis, 1999, Laird, Newell, & Rosenbaum, 1987)
  - Long term working memory framework
    - (Ericsson & Delaney, 1999)
- WM as emergent property
  - Interactive cognitive subsystems model
    - (Barnard, 1985, 1999)
  - Controlled and automatic processing architecture
    - (Schneider & Detweiler, 1987)
  - Biologically based model
    - (O'Reilly, Braver, Cohen, 1999)

From Miyake and Shah (1999)

Baddeley (2000)

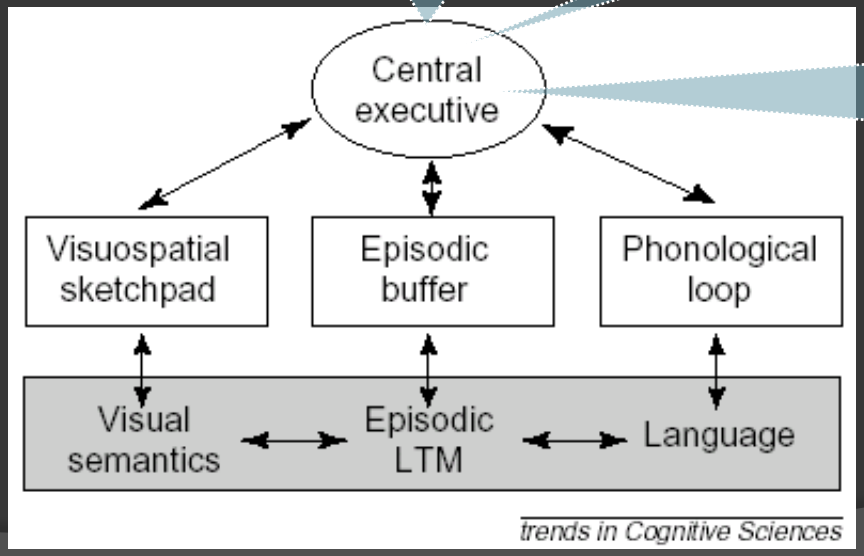


Executive Functions

Updating: replacing old information with new while retaining the relevant

Switching: shifting from one strategy/domain of knowledge to another

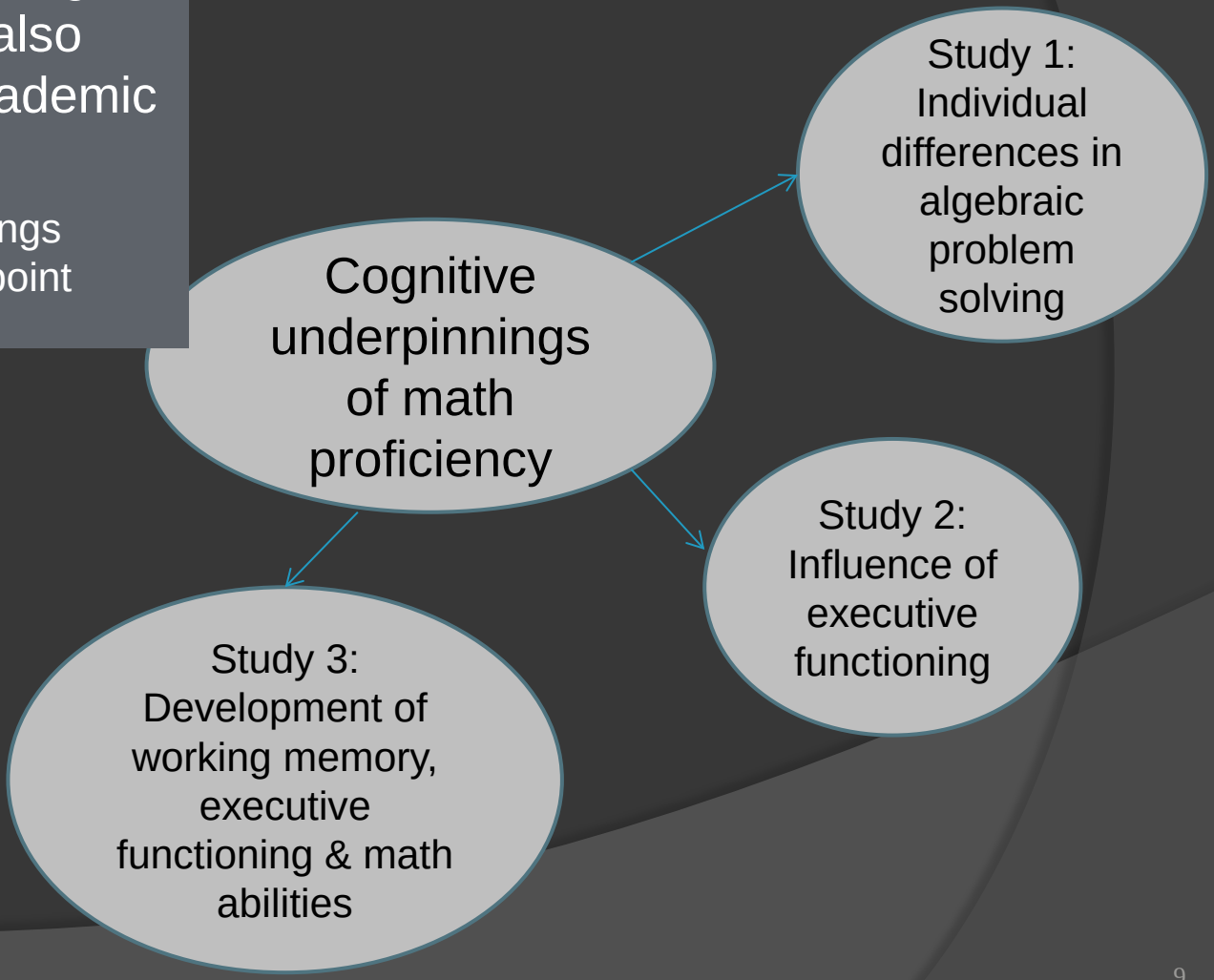
Inhibiting: resisting or ignoring interference from unwanted information



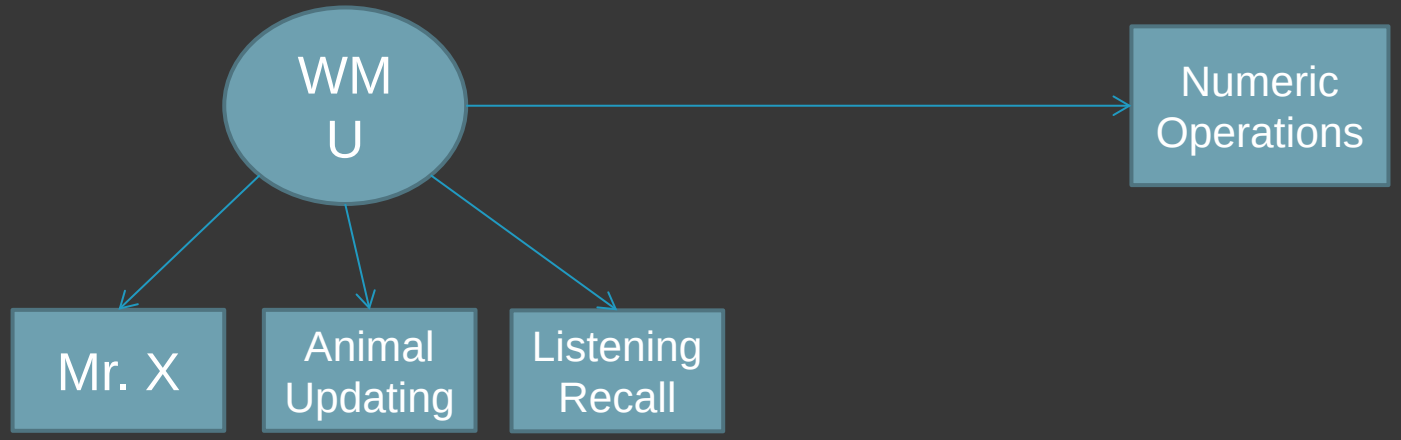
Cognitive Underpinnings

Will improving working memory capacity also improve children's academic performance?

1. Correlational findings
2. Intervention time-point



Concurrent Relations



Age	K2	P1	P2	P3	P4	P5	P6	S1	S2	S3
Num Op on WMU	0.16	0.66	0.63	0.50	0.47	0.55	0.50	0.49	0.59	0.55

Relation between Updating and Math peaked at P1, P2

Improving Updating/Working Memory Capacity

Design Parameters

Overall Approach

- Targeted updating capacity rather than working memory per se
- Intervention not involving counting or overtly mathematical content

Game Play

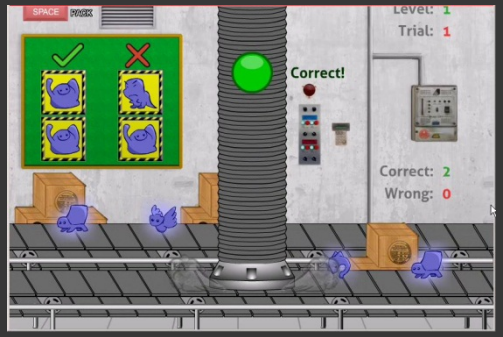
- Adaptive algorithm for progression
- Fun and engaging
- Uses visual stimuli to reduce reliance on verbal recoding

Four Games

- Post Bear

- Greedy Goldfish

- Alien Toy Factory

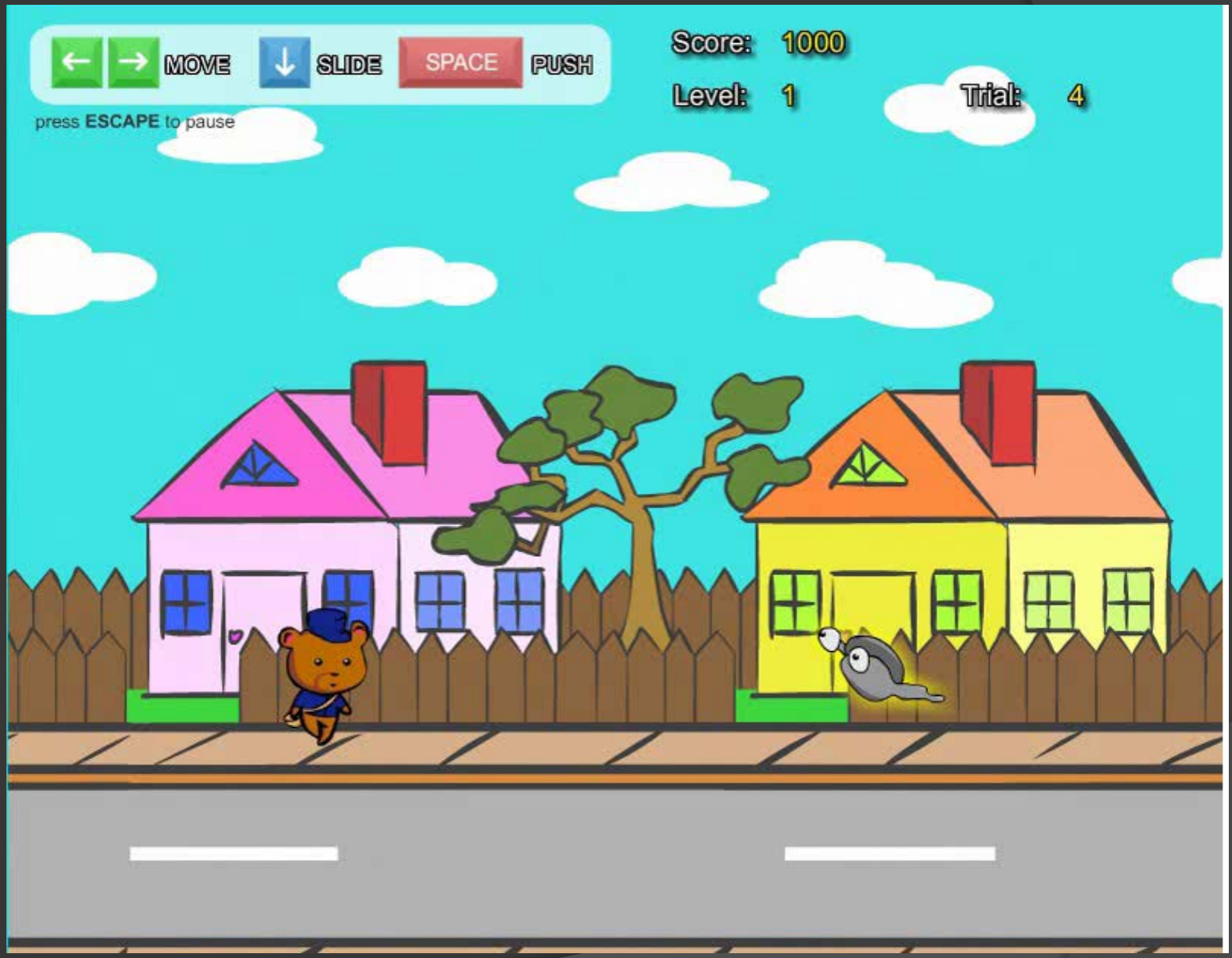


- Squirrel's Snapshot

Continuous performance paradigm

Keep track paradigm

An Example


MOVE
SLIDE
SPACE
PUSH
press ESCAPE to pause
Score: 1000
Level: 1
Trial: 4

Format

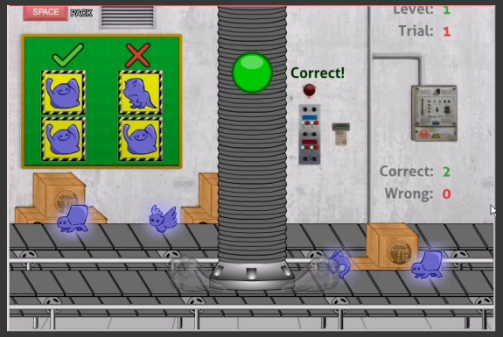

SLIDING
press ENTER to continue,
BACKSPACE to go back
BACK
NEXT
To slide, hold down the SLIDE button
SLIDE
PUSHING
press ENTER to continue,
BACKSPACE to go back
BACK
NEXT
To push, hold down the PUSH button
SPACE
WARNING!
press ENTER to continue,
BACKSPACE to go back
BACK
NEXT
When you see the warning sign above Postbear:
start memorising the aliens
Post Bear meets!

Four Games

- Post Bear

- Greedy Goldfish

- Alien Toy Factory



- Squirrel's Snapshot

Continuous performance paradigm

Keep track paradigm

Participants

- Participants
  - Seventy 7-year-olds identified as needing learning support in mathematics on entry to primary school
    - Sub-clinical
    - Original intention was to screen all children with working memory and standardised mathematics measures prior to admission
    - A competing national study on the same population curtailed recruitment

Design

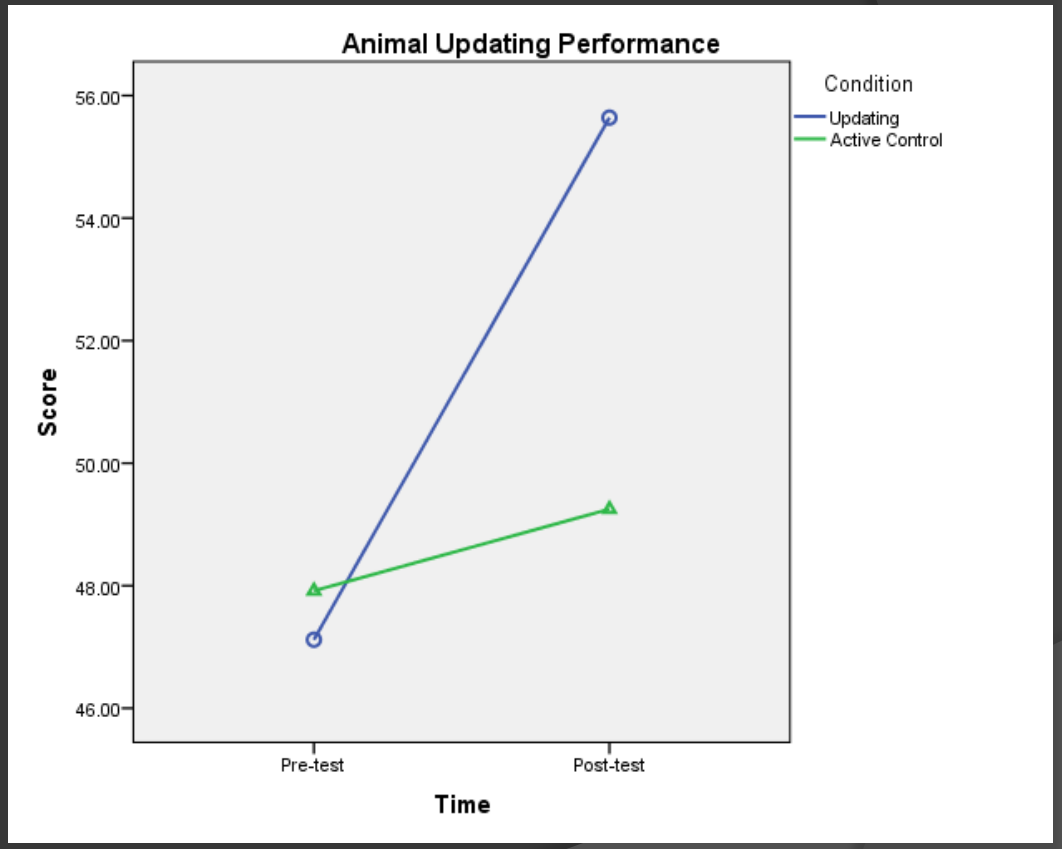
- Three conditions
  - Experimental (*n* = 25)
    - 20 sessions, twice per week, 30 min per session
  - Active control (*n* = 24)
    - Same frequency and duration of participation as experimental on a version of the game that did not contain a memory recall screen
  - Passive control (*n* = 21)
    - Business as usual

Procedure

- Pre-test
  - Working and short-term memory measures
    - Animal Updating, Block Recall, Listening Recall, Backward Digit Recall, Forward Digit Recall
  - Standardised mathematics measures
    - WIAT Numerical Operations, Math Problem Solving, Math Fluency Addition and Subtraction
  - Intelligence measures
    - WISC Vocabulary and Block Design subtests
- Intervention
- Immediate post-test
  - Same as pre-test

Results

- At pre-test
  - The children did not have poorer scores on our standardised mathematics test than normally achieving children
- At post-test
  - No significant interaction effects



Supplementary Study

- Massed versus distributed practice
  - Massed
    - Training ~ once a day
- Forty-five 7-year-olds
- Results
  - Significant interaction effect
    - Intervention effect
      - Massed > Distributed
        - Block Recall, WISC Vocabulary
      - Distributed > Massed
        - WISC Block Design

Conclusions

- By and large, the intervention failed to have a facilitative effect on our normally developing children who suffer from some relative performance deficits
  - Findings of significant differences between the massed vs. distributed conditions were promising
- Why did the intervention not produce a facilitative effect?
  - Sample – children did not have significant deficits?
  - Dosage – insufficient exposure to training?
  - Product design - our games do not provide a suitable platform for altering updating capacity?
  - Construct – updating capacity not amenable to short term improvement

Beta 2

Improvements

- Applied a stricter inclusion criterion
  - Only children in the learning support programme with both working memory deficits and mathematical difficulties were recruited
- Added new games that had more engaging game play and stimuli that were not more amendable to verbal recoding

The New Games

- Monster Smash

- Ant Rush

- Treasure Hunter

- Food Mania

Continuous performance paradigm

Keep track paradigm

CogMed

- Klingberg et al. (2005); Thorell et al. (2009)
  - Improved performance on WM and intelligence measures
- Holmes, Gathercole, and Dunning (2009); Holmes et al. (2010); Dunning, Holmes, and Gathercole (2013)
  - Improved performance on memory measures, but not in intelligence

Cogmed

- Strong visuo-spatial component
- Targets various components of WM

Research questions

- How do Cogmed and our Updating intervention programme compare in improving working memory?
- Do improvements in working memory/ updating result in better mathematical performance?

Participants & Design

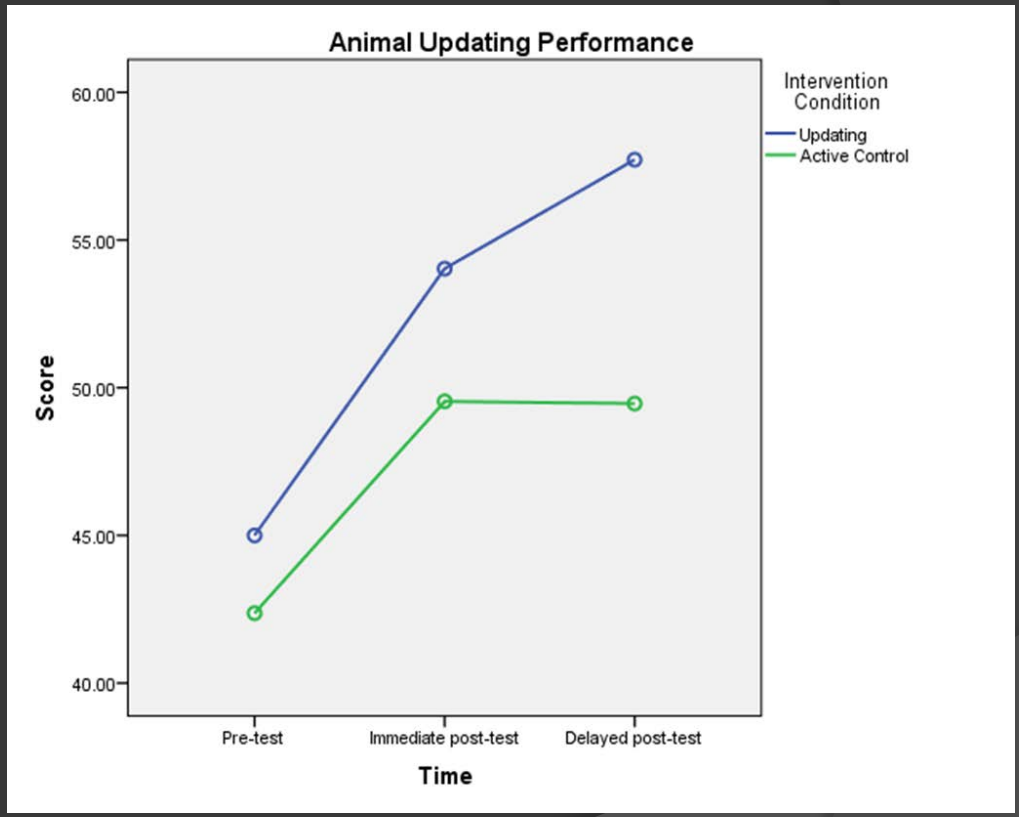
- Participants
  - 86 7-year-olds with working memory and mathematical difficulties
- Three conditions
  - Experimental – Updating (n = 32)
    - Averaged 23 sessions, 3-4 sessions per week, 30 min per session
  - Experimental – CogMed (n = 25)
    - Averaged 24 sessions, 3-4 sessions per week, 45 min per session
  - Active control (n = 28)
    - Averaged 22 sessions, 3-4 sessions per week, 30 min per session
  - Passive control (n = 26)
    - Business as usual

Tasks & Procedure

- Screening
- Pre-test
  - Working and short-term memory measures
    - Animal Updating, Corsi Blocks (Block Recall), Letter Rotation, Backward Letter Recall, Forward Letter Recall
  - Standardised mathematics measures
    - WIAT Numerical Operations, Math Fluency Addition and Subtraction
  - Intelligence measure
    - Raven's Coloured Progressive Matrices
  - Covariates
    - Language: Bilingual Language Assessment Battery (BLAB)
    - Literacy: Schonell Reading Test
- Intervention
- Immediate post-test
  - Week after termination of intervention
- Follow-up post-test
  - ~ 6 months after termination of intervention

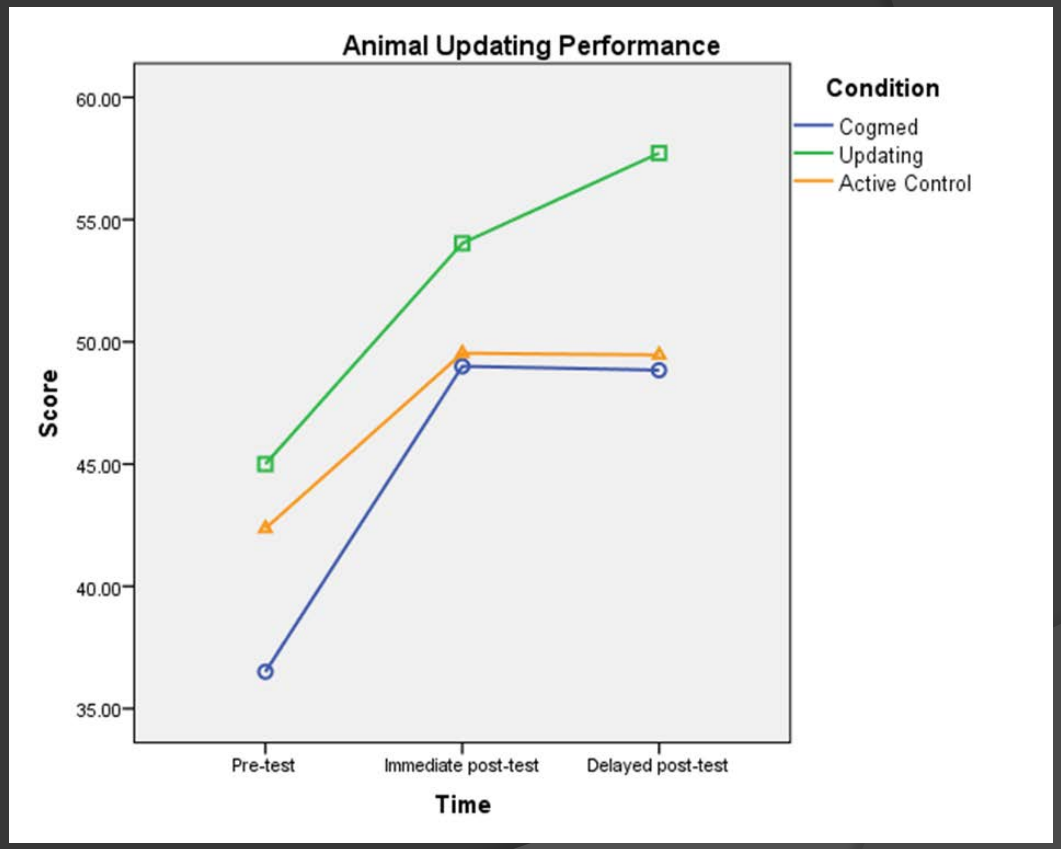
Results

- Pairwise
  - Conditions comparable at pre-test
  - Significant difference between updating intervention and active control groups at the long-term post-test



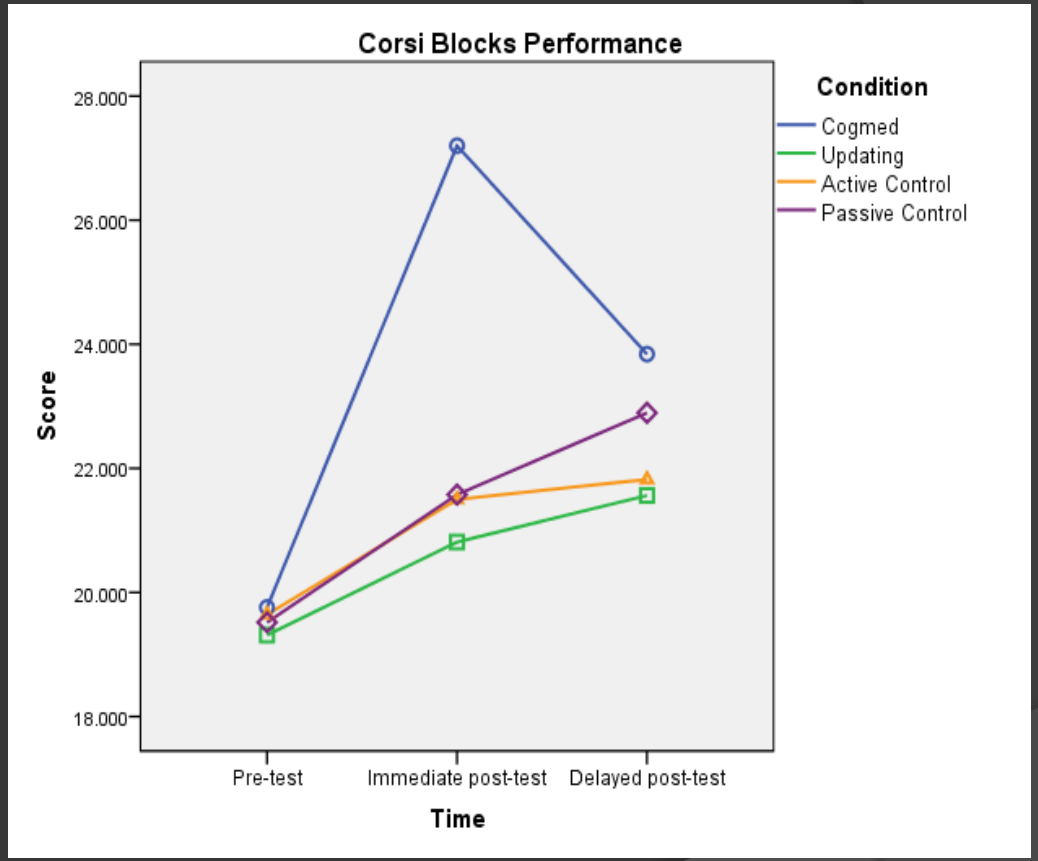
Results

- No significant interaction effect for Animal Updating
- Significant differences between updating intervention and CogMed and active control groups at the long-term post-test



Results

- Significant interaction effect for Corsi Blocks
- No significant differences between the groups at the delayed post-test



Results

- Mathematical performance & fluid intelligence
  - No significant differences at post-test
- No differences in results when various covariates (age, language and intelligence measures) were included

Summary of Findings

- Both intervention programmes tended to improve WM immediately after the intervention, but results were not statistically significant except for Corsi Blocks
- Improvements in WM were not translated into gains in mathematical performance immediately and 6-months after intervention training

Some Remaining Questions

- Can updating/working memory capacity be improved and improvement sustained?
  - Recent review studies show mixed findings

Some Successful Efforts

- Jaeggi, Buschkuehl, Jonides, and Perrig (2008); Jaeggi, Buschkuehl, Jonides, and Shah (2011)
  - Based on the n-back task
  - Increased performance on fluid intelligence tests
- Dahlin, Nyberg, Bäckman, and Neely (2008); Dahlin, Neely, Larsson, Bäckman, and Nyberg (2008)
  - Based on the running span/ keep track tasks
  - Increased performance on non-trained 3-back task compared to controls

Not Always Successful

- Melby-Lervåg and Hulme (2012)
  - Might not always be effective
- Chooi and Thompson (2012); Thompson et al. (2013); Redick et al. (2013)
  - Failure to replicate Jaeggi et al.'s findings
- Debate on Cogmed in a 2012 issue of the *Journal of Applied Research in Memory and Cognition*

Next Steps

- For intervention that works, why is generalisation to math performance poor?
  - Cannot deploy newly developed capabilities
  - Can deploy new capabilities, but do not know when to deploy
- Why do some intervention work better than others?
  - Dosage
  - One-to-one coaching
  - Targeted capabilities

Applied Cognitive Development Lab

- Principal investigators
  - Kerry Lee
  - Rebecca Bull
- Research Scientists/Fellows
  - Ang Su Yin
  - Fannie Khng
  - Ng EeLynn
- Research Assistants
  - Jeremy Ng
  - Jennifer Ang
  - Juliana Koh
  - Lim Aik Meng
  - Tay Jia Xin
- Project manager
  - Yvonne Ng

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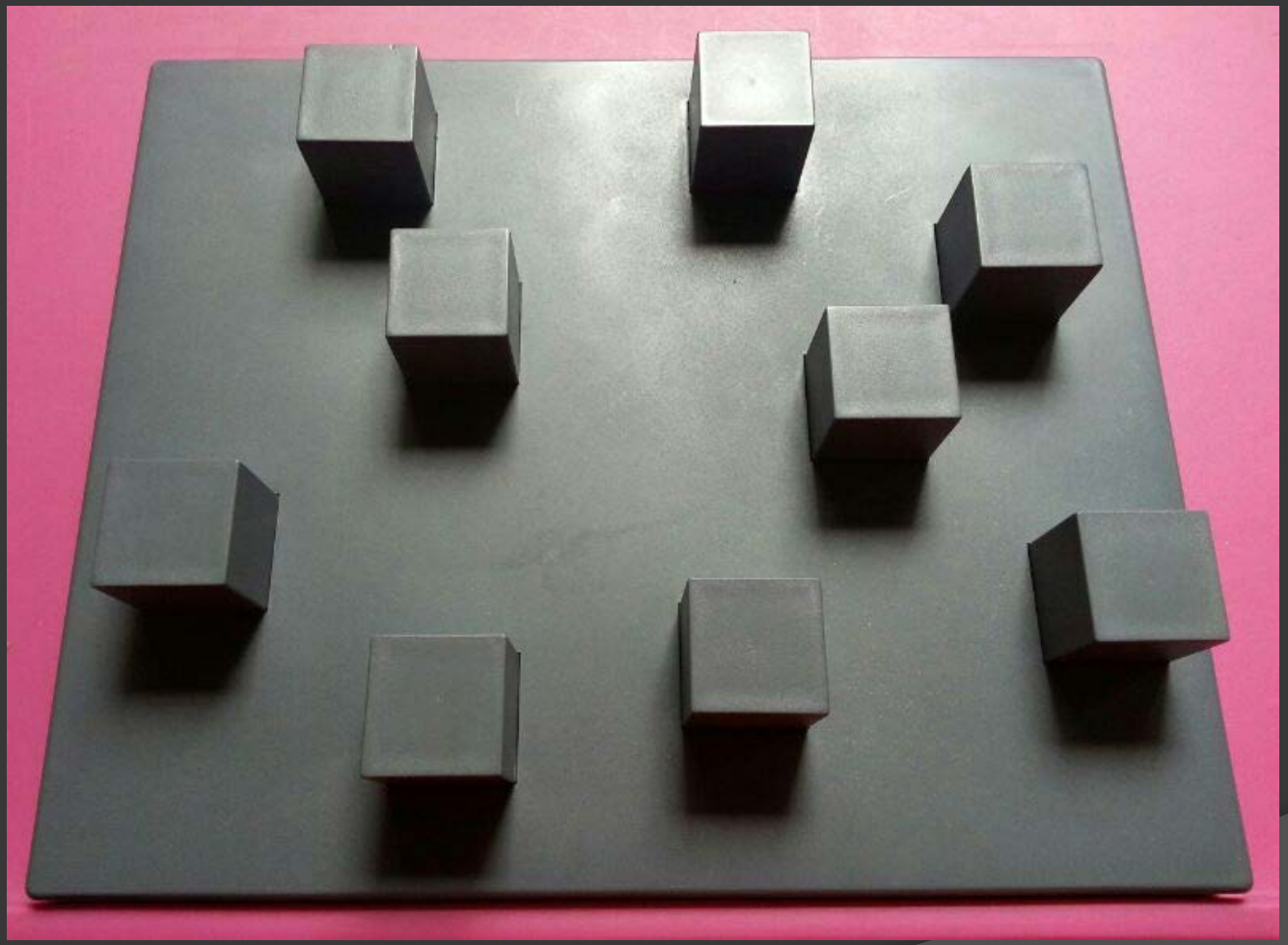
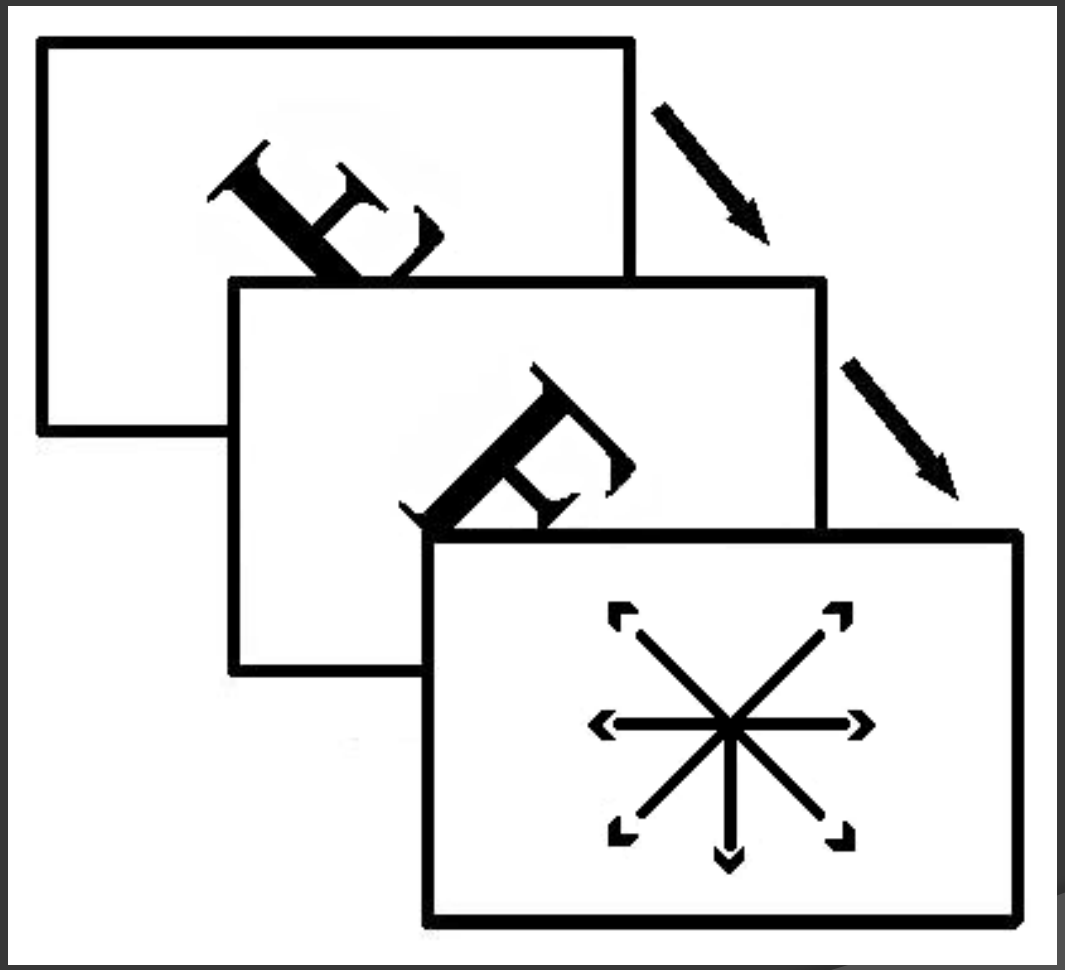
Corsi Blocks

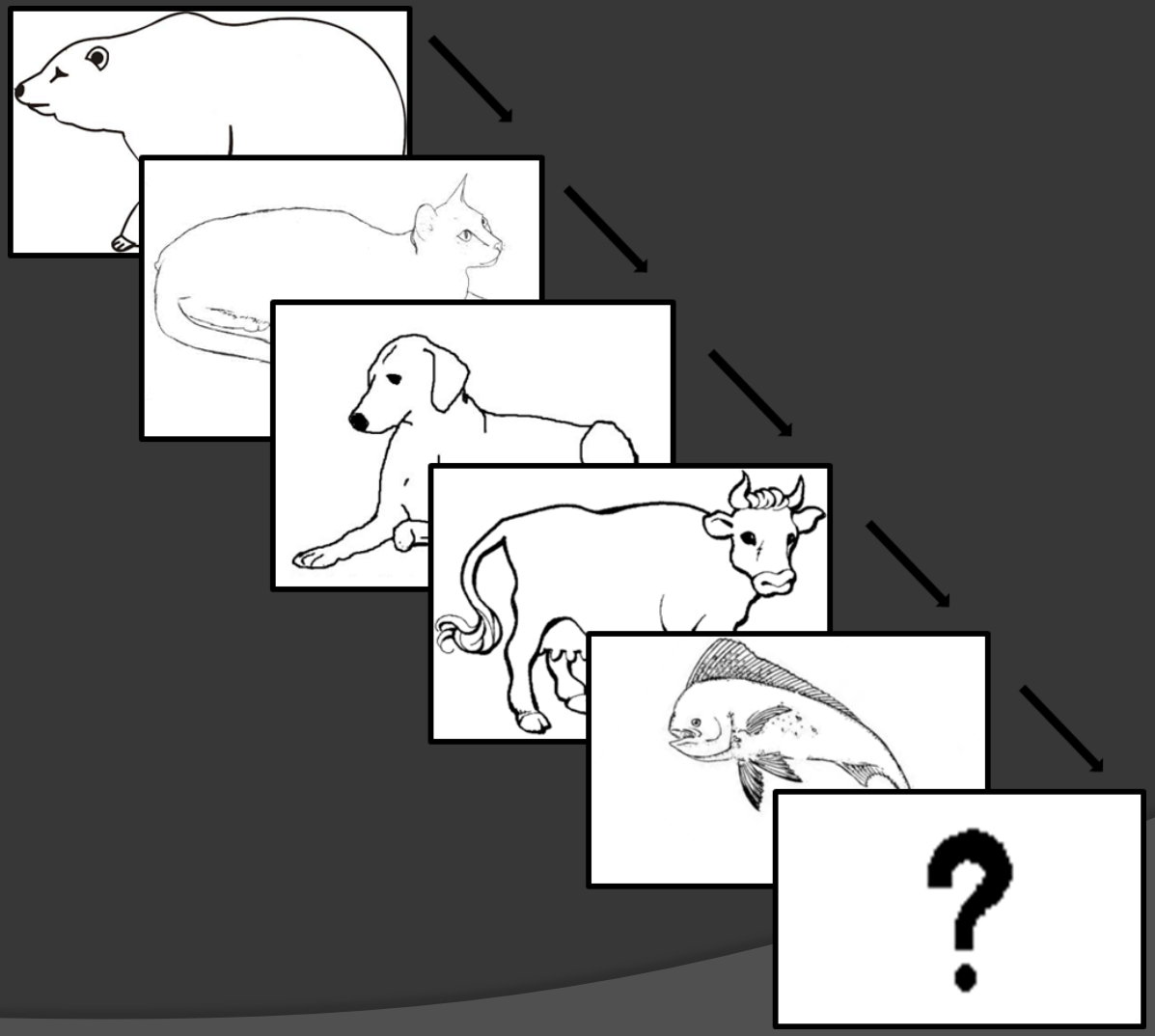


Letter Rotation



Letters used: F, J, L, P, R

Animal Updating



Raven's Coloured Progressive Matrices