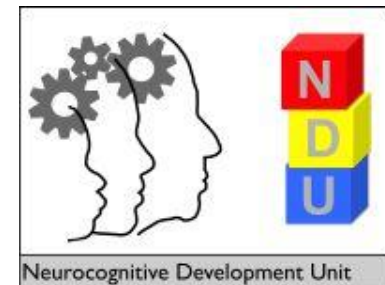


# Consolidating working memory: Enhancing cognitive performance through effective encoding

**Donna Bayliss**  
**Neurocognitive Development Unit**  
**School of Psychology**  
**University of Western Australia**



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# Consolidation of LTM

- Wixted (2004; 2005)
  - memory traces become more durable and less vulnerable to interference over time
  - process of consolidation
  - new memories interfere with previously established memory traces that have not had a chance to consolidate

# Consolidation of LTM

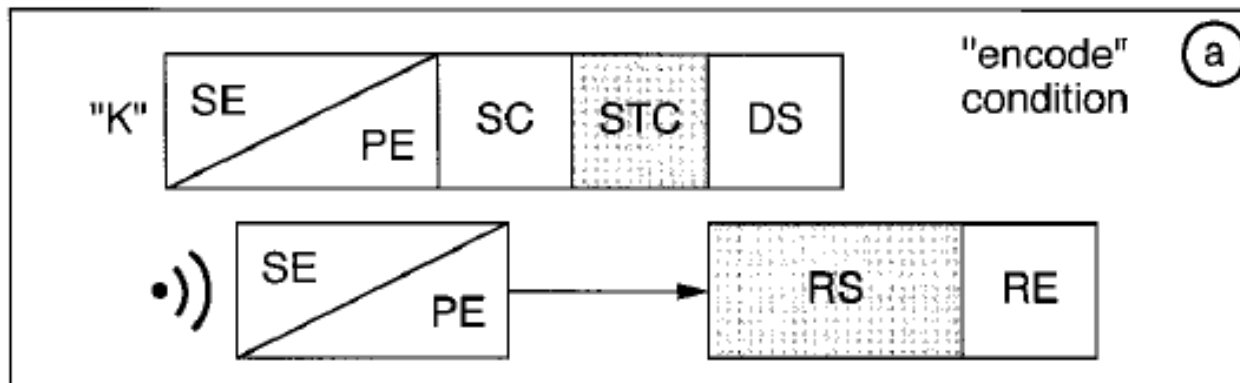


# Consolidation of STM

- Jolicoeur and Dell'Acqua (1998)
  - sensory encoding
    - massively parallel, transmission of information about different attributes of stimuli, sensory persistence
  - perceptual encoding
    - pattern recognition, letter identification, representations remain active while sensory input is available, otherwise, subject to rapid decay

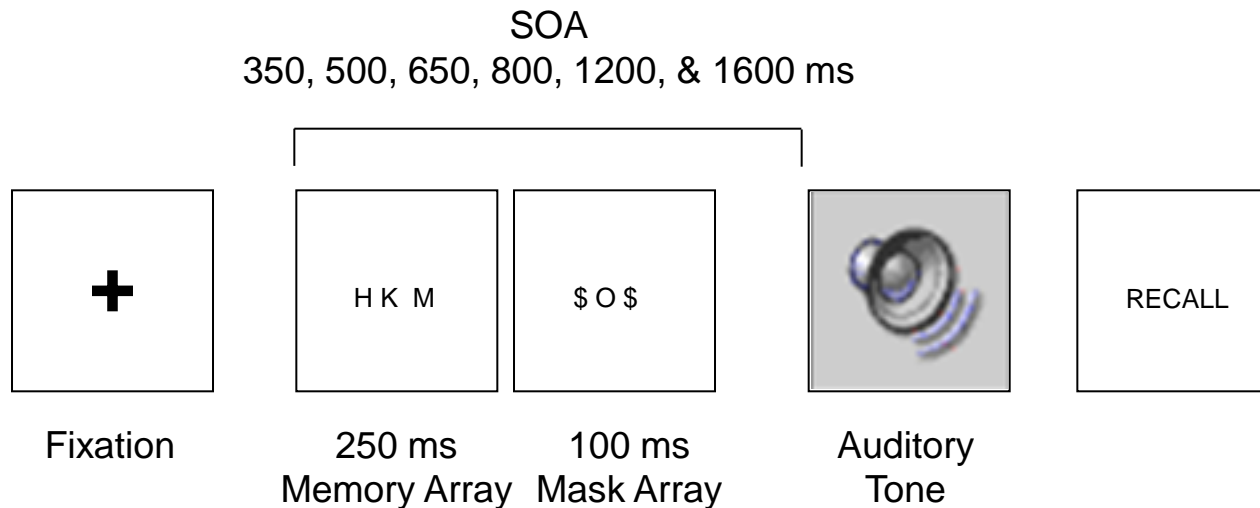
# Consolidation of STM

- Jolicoeur and Dell'Acqua (1998)
  - short-term consolidation
    - the process of encoding information into a more durable form of memory, which allows for further processing and delayed report
    - time consuming, requires central mechanisms



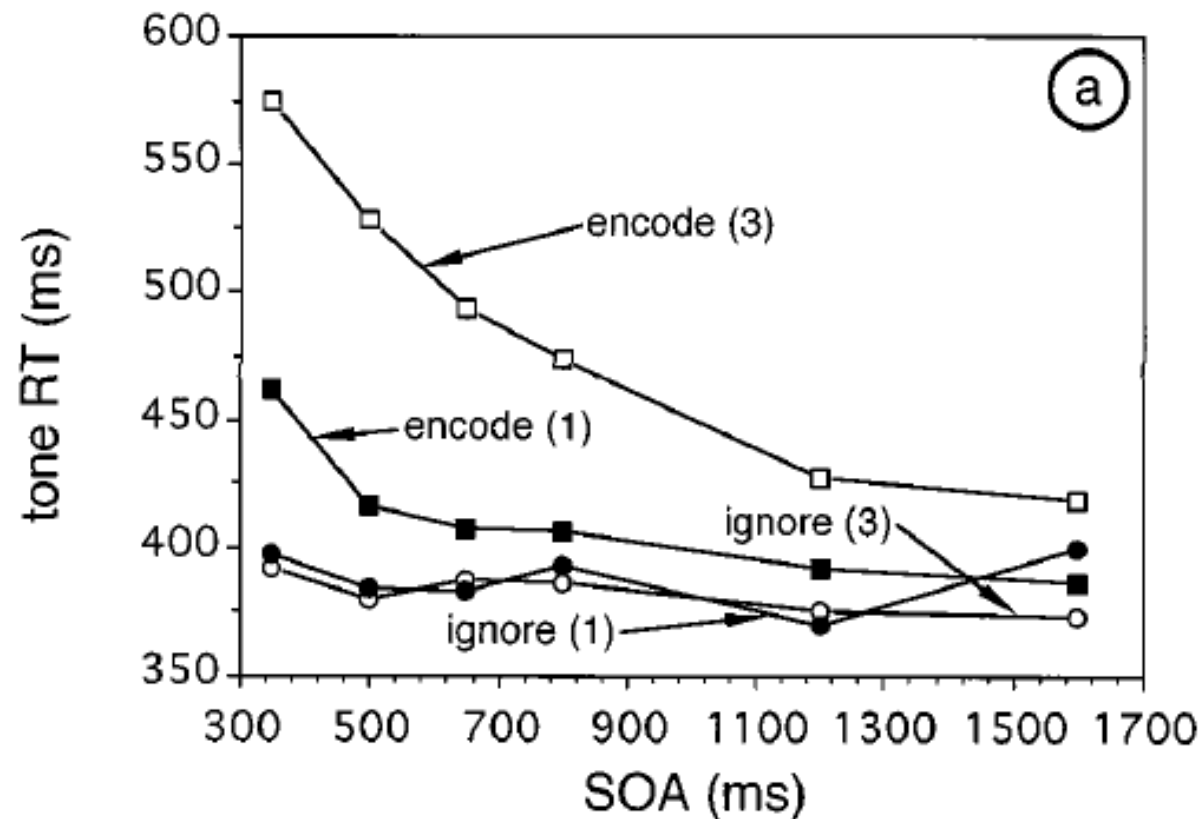
# Consolidation of STM

- Jolicoeur and Dell'Acqua (1998)



# Consolidation of STM

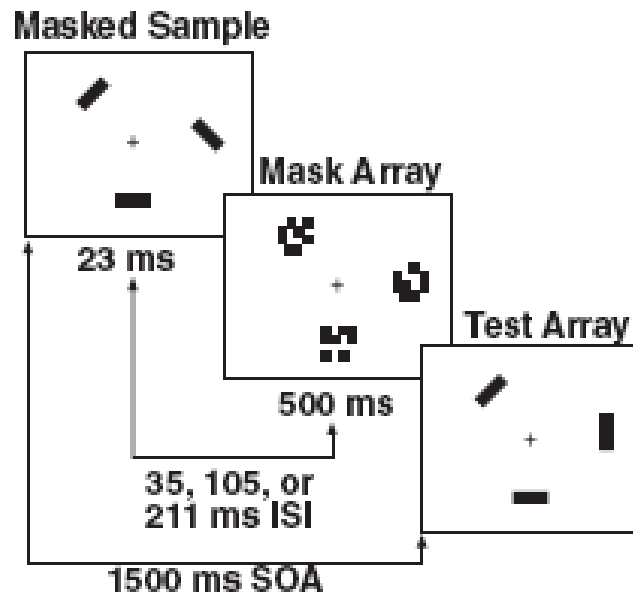
- Jolicoeur and Dell'Acqua (1998)



# Consolidation of STM

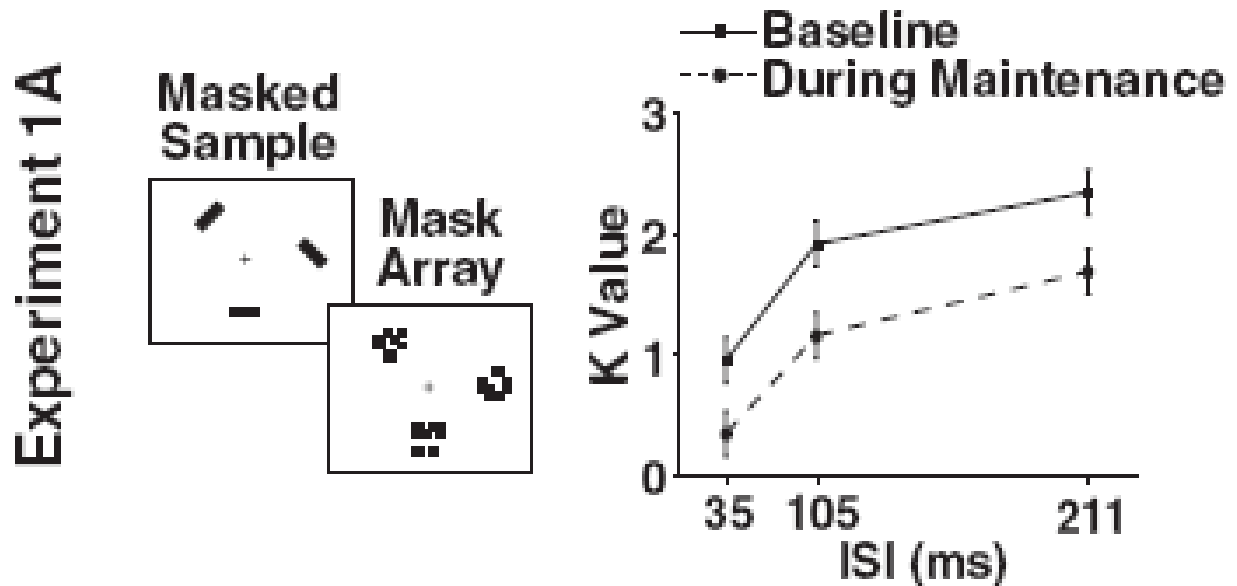
- Woodman & Vogel (2005)

Consolidation Baseline



# Consolidation of STM

- Woodman & Vogel (2005)

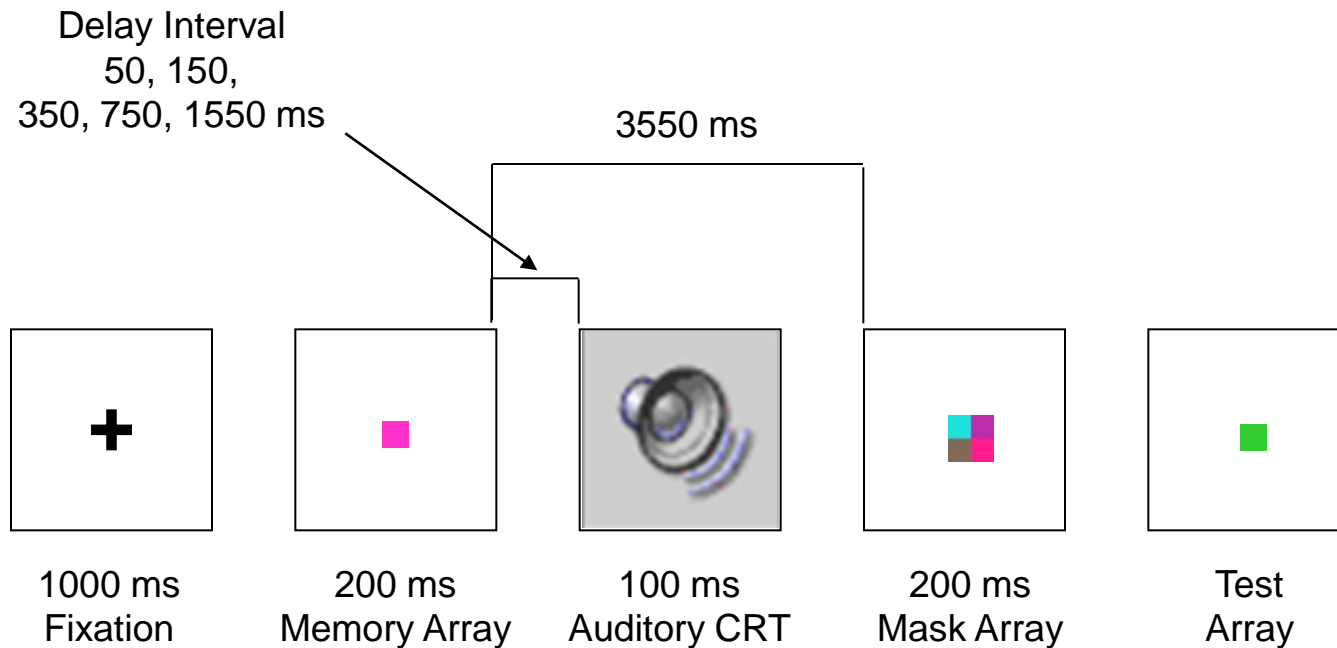


# Development of consolidation

- Is the process of memory consolidation evident in children?
- Is memory consolidation important for working memory performance?
- Is memory consolidation important for educational achievement?

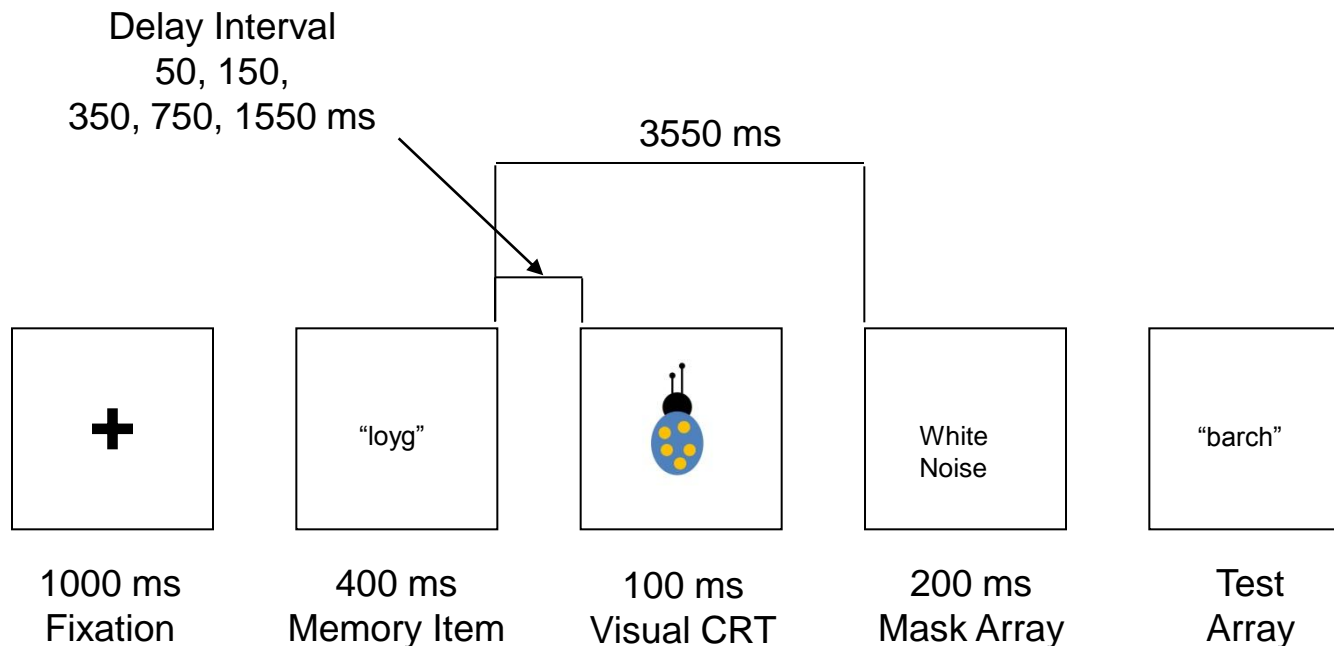
# Development of Consolidation

## Visual Change-Detection Task



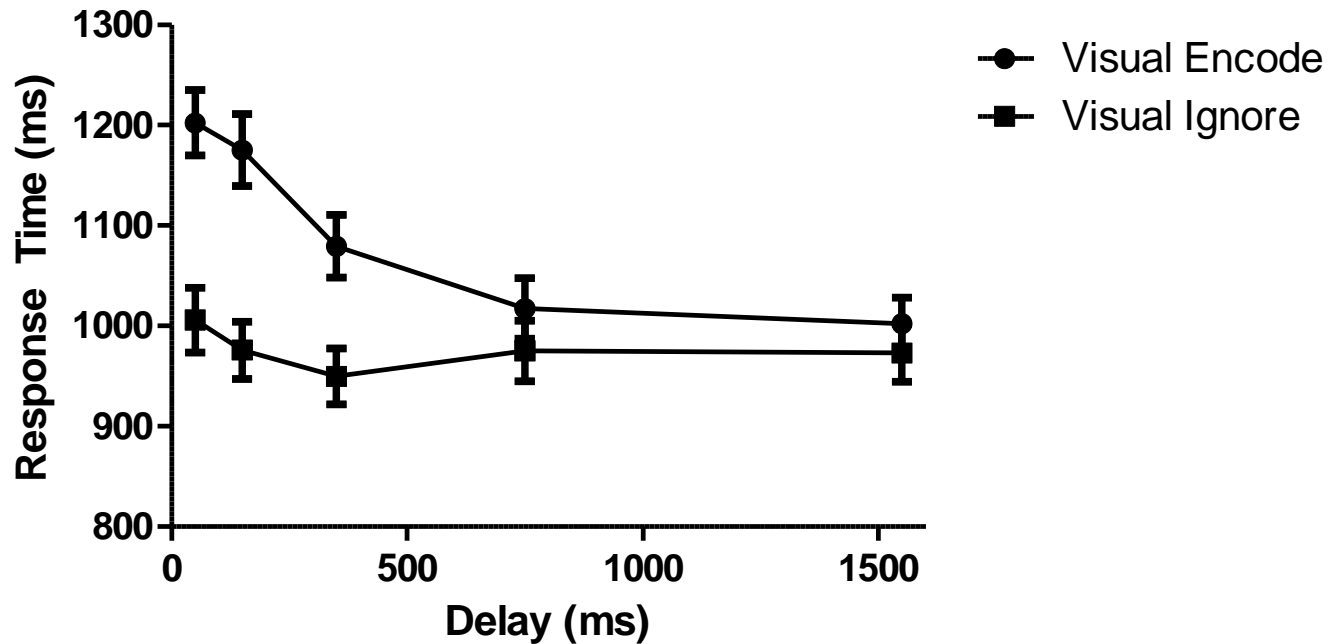
# Development of Consolidation

## Verbal Change-Detection Task



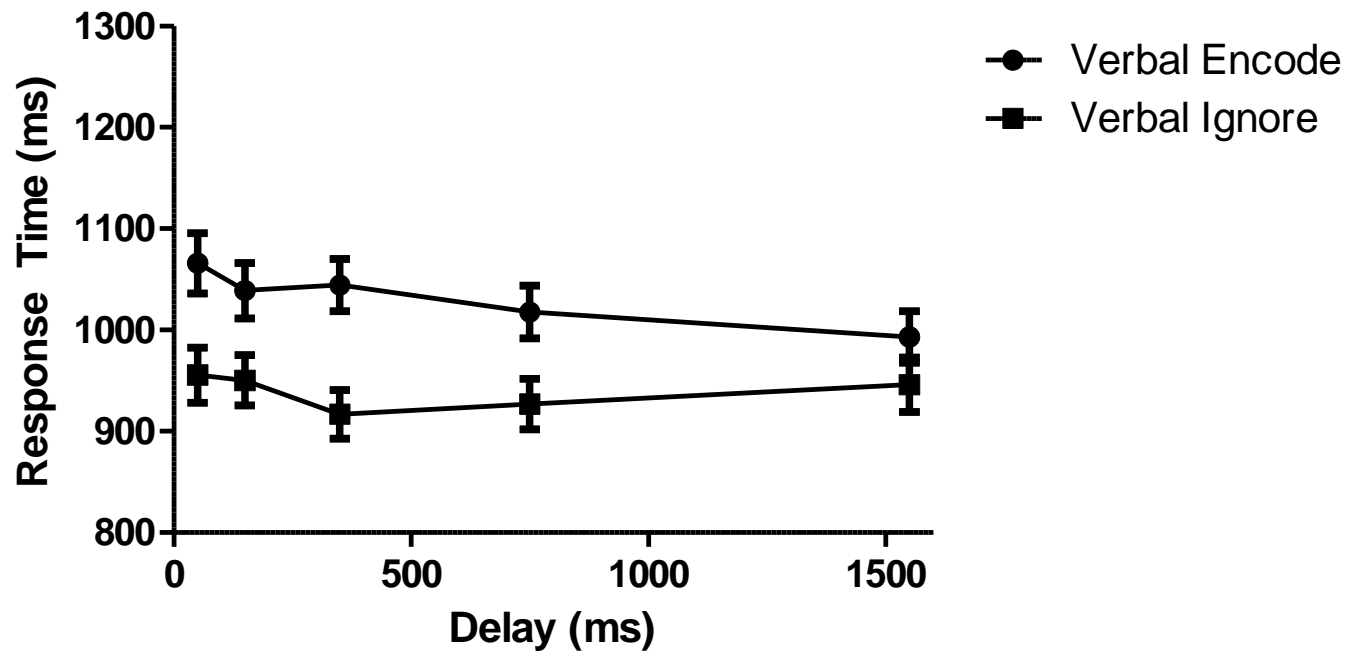
# Development of Consolidation

- Visual ( $N=39$ )



# Development of Consolidation

- Verbal ( $N=48$ )



# Development of Consolidation

	Verbal 50ms	Verbal 150ms	Verbal 350ms	Verbal 750ms	Verbal 1550ms	Visual 50ms	Visual 150ms	Visual 350ms	Visual 750ms	Visual 1550ms
Verbal 50ms	1	.717**	.667**	.731**	.588**	-.052	-.013	-.113	-.162	-.200
Verbal 150ms		1	.758**	.768**	.716**	.049	-.017	.074	-.127	.071
Verbal 350ms			1	.758**	.728**	.145	.155	.100	.011	.087
Verbal 750ms				1	.748**	-.025	-.009	-.159	-.235	-.197
Verbal 1550ms					1	-.223	-.129	-.131	-.267	.016
Visual 50ms						1	.481**	.511**	.588**	.441**
Visual 150ms							1	.474**	.354*	.201
Visual 350ms								1	.643**	.550**
Visual 750ms									1	.619**
Visual 1550ms										1

# Development of Consolidation

- RT data consistent with a consolidation process in children
- similar RT functions evident for both verbal and visual information, albeit weaker for verbal
- partial support for a central attentional account
  - memory item and choice-RT task are from different modalities
  - but, no correlations across verbal and visual tasks

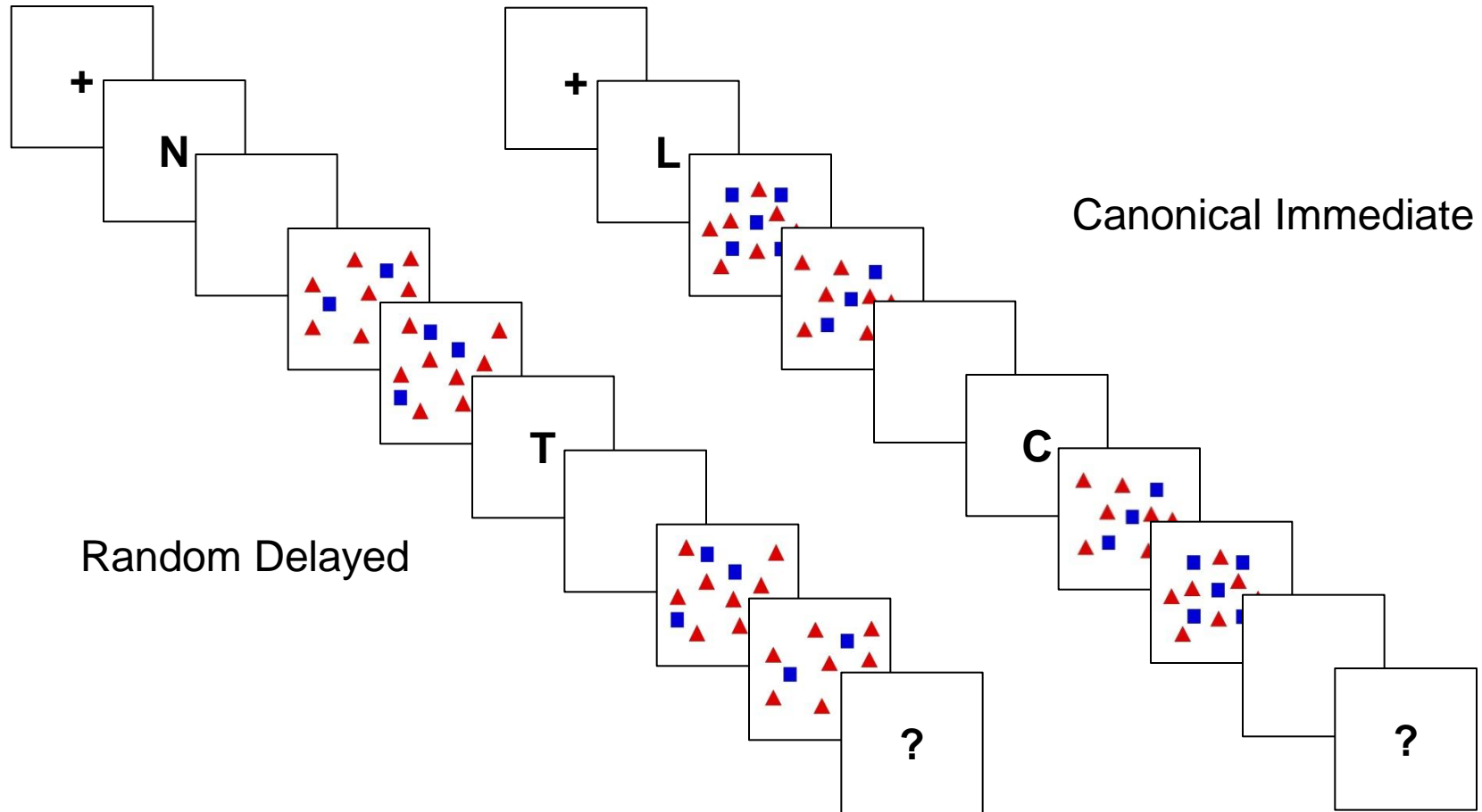
# Consolidation and Working Memory

- Is the process of memory consolidation evident in children?
- Is memory consolidation important for working memory performance?
- Is memory consolidation important for educational achievement?

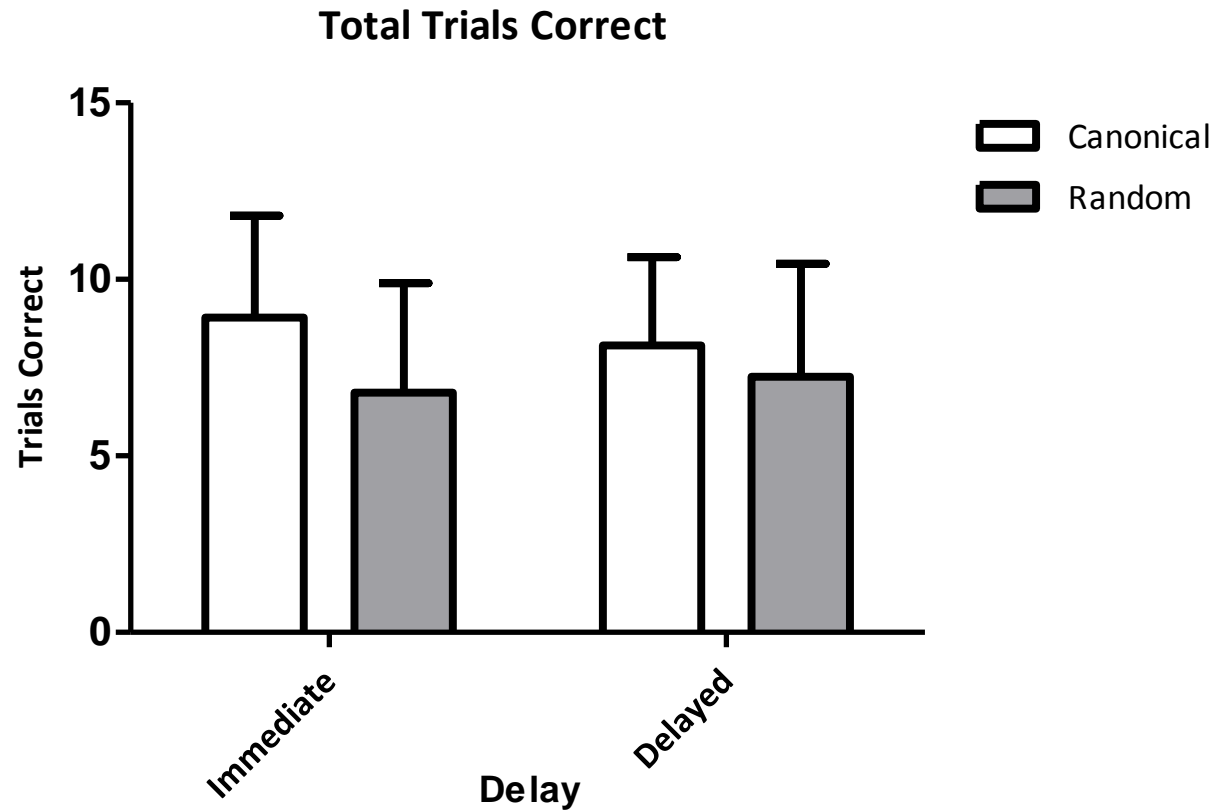
# Consolidation and Working Memory

- working memory often assessed using working memory span tasks that involve rapid switching between storage and processing
- consolidation is slowed in individuals with schizophrenia
- experiments showing an effect of processing pace on working memory performance have often confounded fast pace with less opportunity for consolidation

# Consolidation and Working Memory

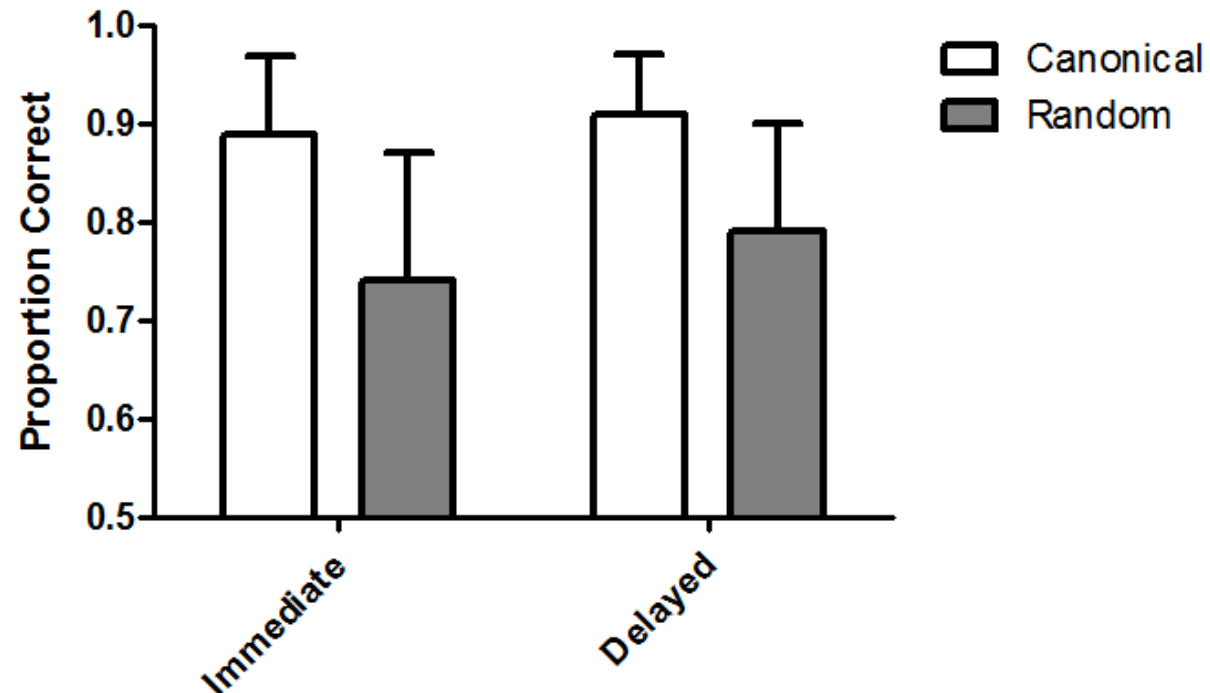


# Consolidation and Working Memory

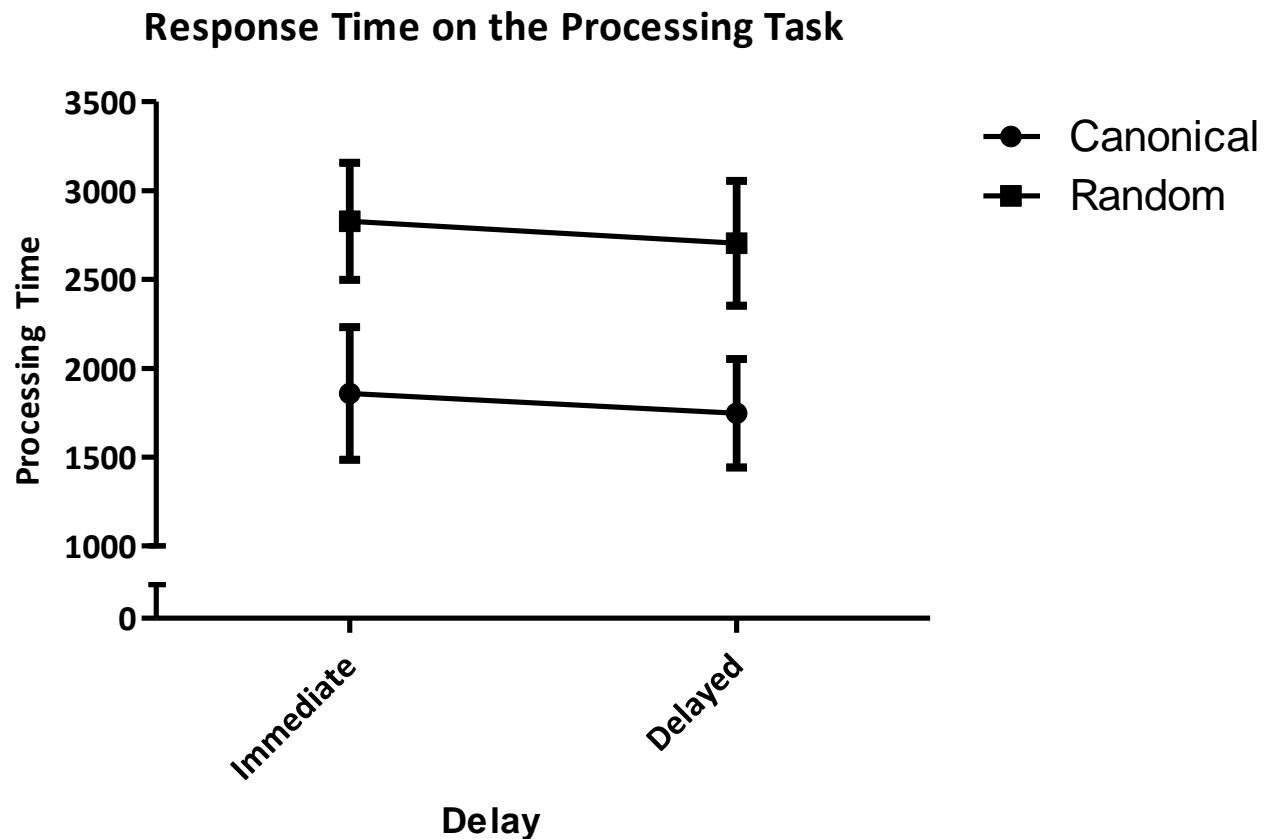


# Consolidation and Working Memory

Processing Accuracy



# Consolidation and Working Memory



# Consolidation and Working Memory

- providing an opportunity for consolidation does improve working memory performance, especially for difficult tasks
- processing of information presented immediately after a to-be-remembered stimulus is likely to be impaired
- processing of information presented immediately after a to-be-remembered stimulus is likely to be slowed

# Consolidation and Educational Achievement

- Is the process of memory consolidation evident in children?
- Is memory consolidation important for working memory performance?
- Is memory consolidation important for educational achievement?

# Consolidation and Educational Achievement

- working memory is predictive of educational achievement
- variation in working memory that remains once variation in processing and storage is removed is predictive of reading and mathematics (Bayliss et al., 2003; Jarrold & Bayliss, 2007)

# Consolidation and Educational Achievement

- inserting pauses at syntactic boundaries improves older adults' memory for stories (Holland & Fletcher, 2000)

**75 wpm**

Susan was excited.            The present had arrived,            at last!

**115 wpm**

Susan was excited.    The present had arrived,    at last!

**175 wpm**

Susan was excited. The present had arrived, at last!

# Consolidation and Educational Achievement

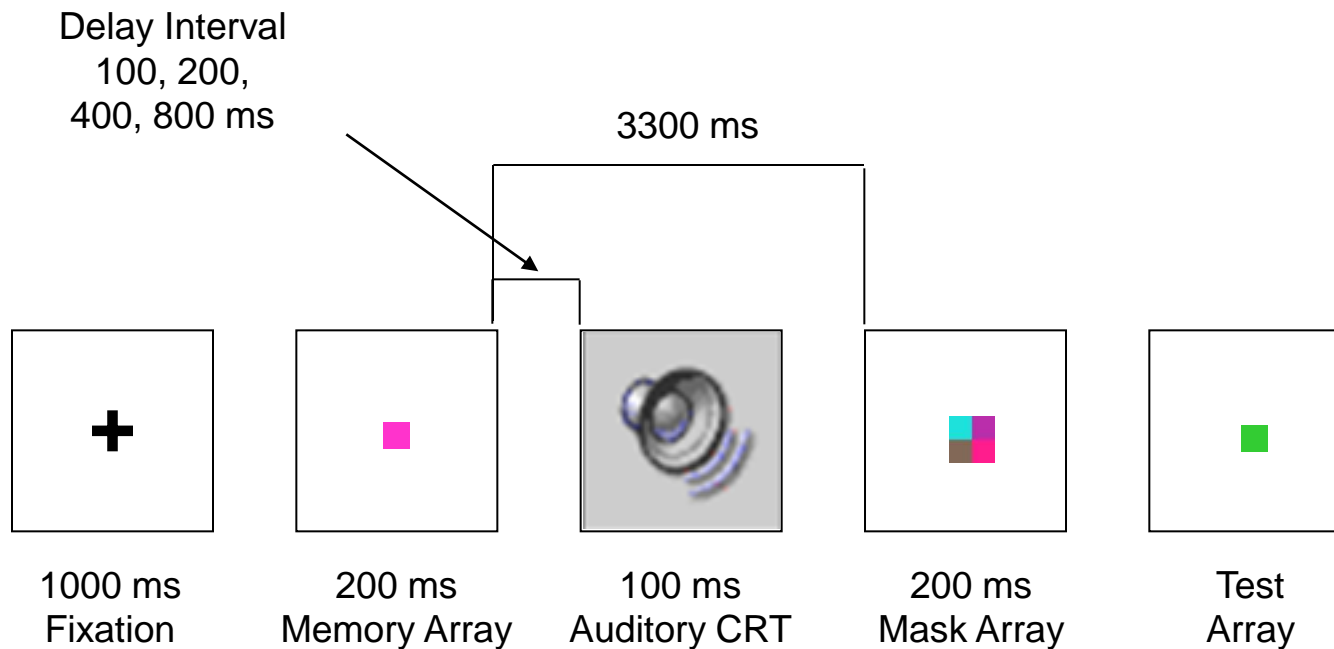
- inserting pauses at syntactic boundaries improves older adults' memory for stories

Task	Speech Rate		
	75 wpm	115 wpm	175wpm
Recall	50.6	48.3	41.8
Recognition	72.7	70.7	66.2

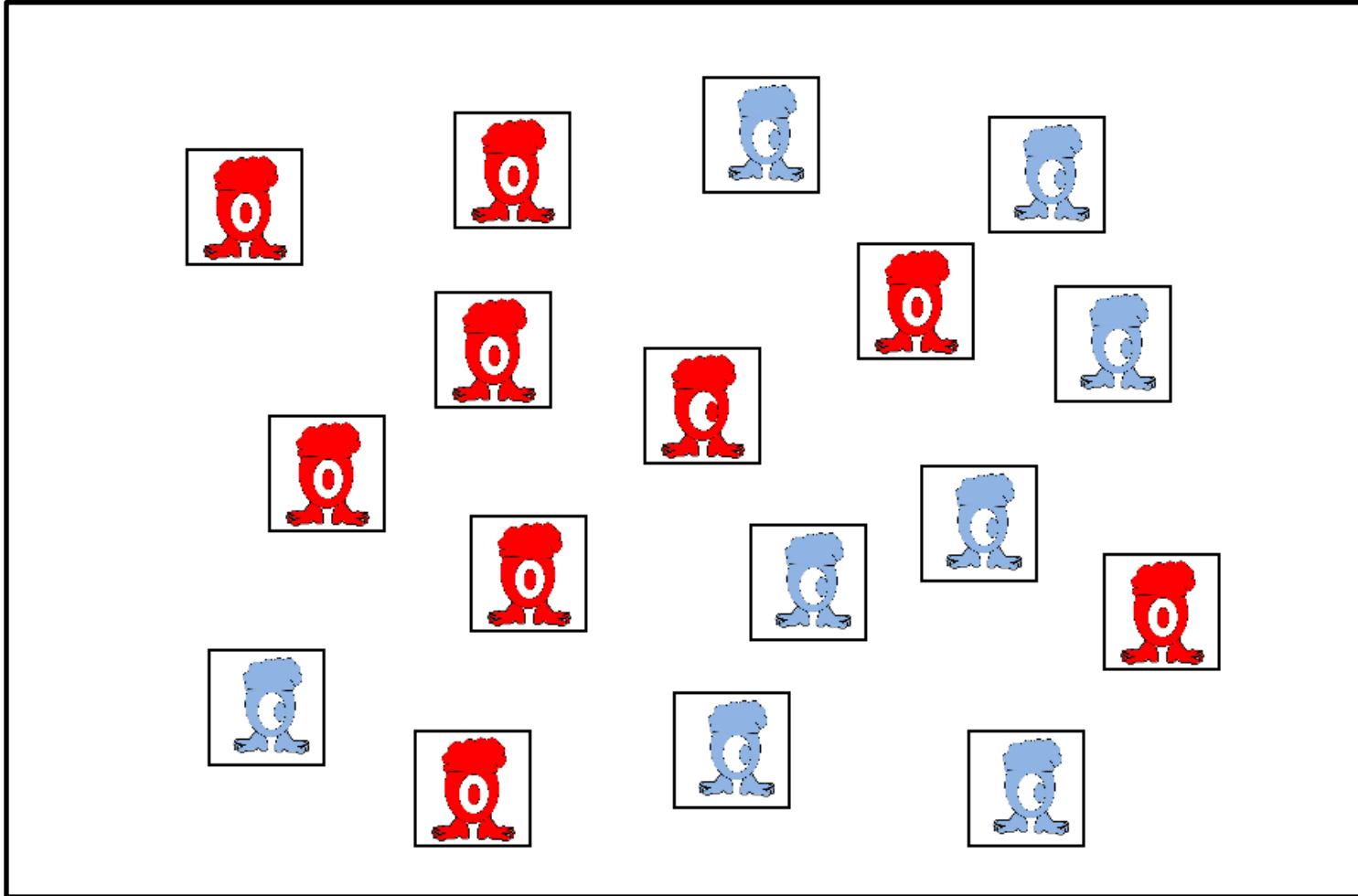
Holland & Fletcher (2000). *Aust. J of Psyc*, 52, 149-154

# Consolidation and Educational Achievement

## Visual Change-Detection Task

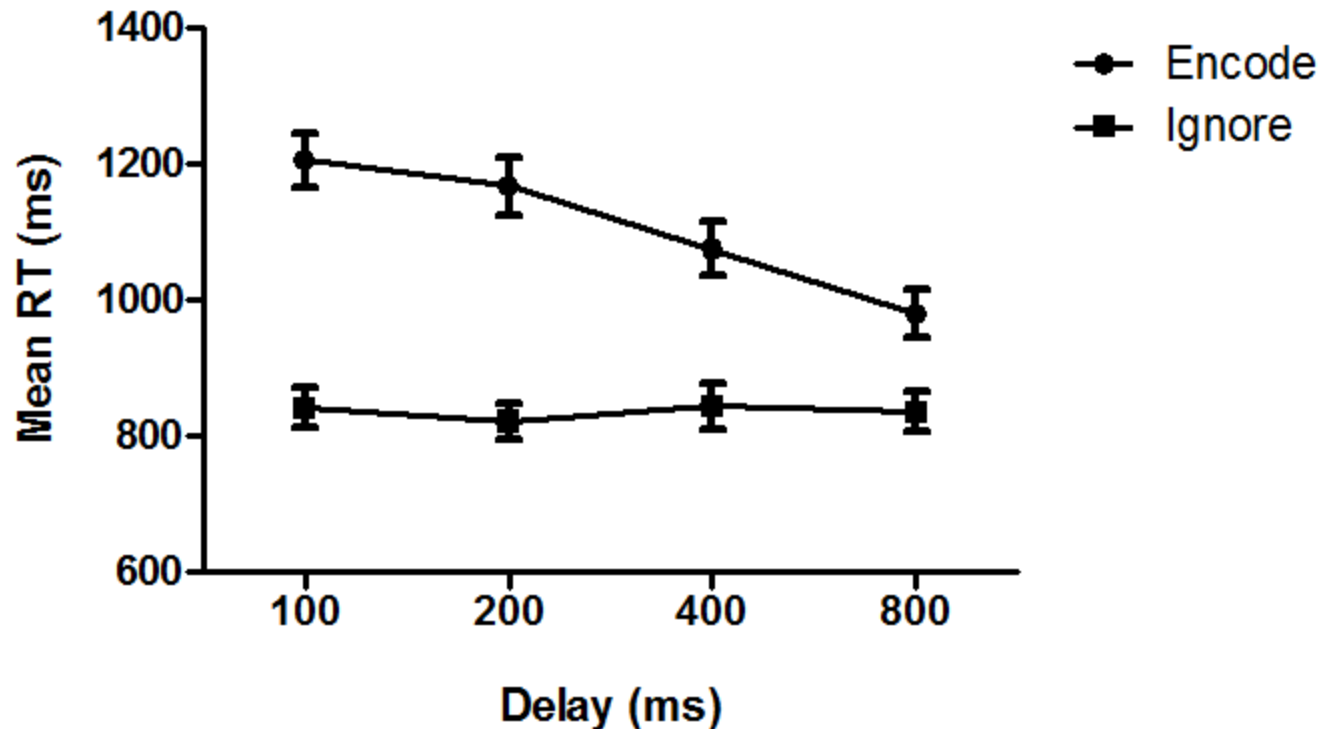


# Consolidation and Educational Achievement



# Consolidation and Educational Achievement

- Visual Change-Detection Task



# Consolidation and Educational Achievement

	Reading Comp	Maths	Spatial STM	Spatial WM	Visual 100ms	Visual 200ms	Visual 400ms	Visual 800ms
Reading Comp	1	.595**	.230	.306	.237	.043	.106	.111
Maths		1	.425**	.490**	-.092	-.162	-.068	.065
Spatial STM			1	.443**	-.141	-.071	-.250	-.065
Spatial WM				1	-.339**	-.317	-.289	-.112
Visual 100ms					1	.773**	.757**	.625**
Visual 200ms						1	.704**	.640**
Visual 400ms							1	.660**
Visual 800ms								1

N = 37

# Consolidation and Educational Achievement

- working memory is associated with individual differences in reading and maths performance
- individual differences in short-term memory consolidation are associated with working memory performance in children
- individual differences in short-term memory consolidation do not appear to be associated with reading and maths performance

# Practical Implications

- consolidation of information into working memory is a time-consuming, attentionally demanding process
- this may impact on a child's working memory performance and educational achievement
- learning situations that provide the opportunity for consolidation of information are likely to maximise the retention of that information

# Practical Implications

- present information in small manageable chunks, in simple language or form
- provide pauses at natural boundaries to allow meaningful chunks of information to be consolidated
- teach children to control their own encoding strategies

# Thanks to..

## Collaborators

Chris Jarrold

Jade Bogdanovs

## Funding



**Australian Government**

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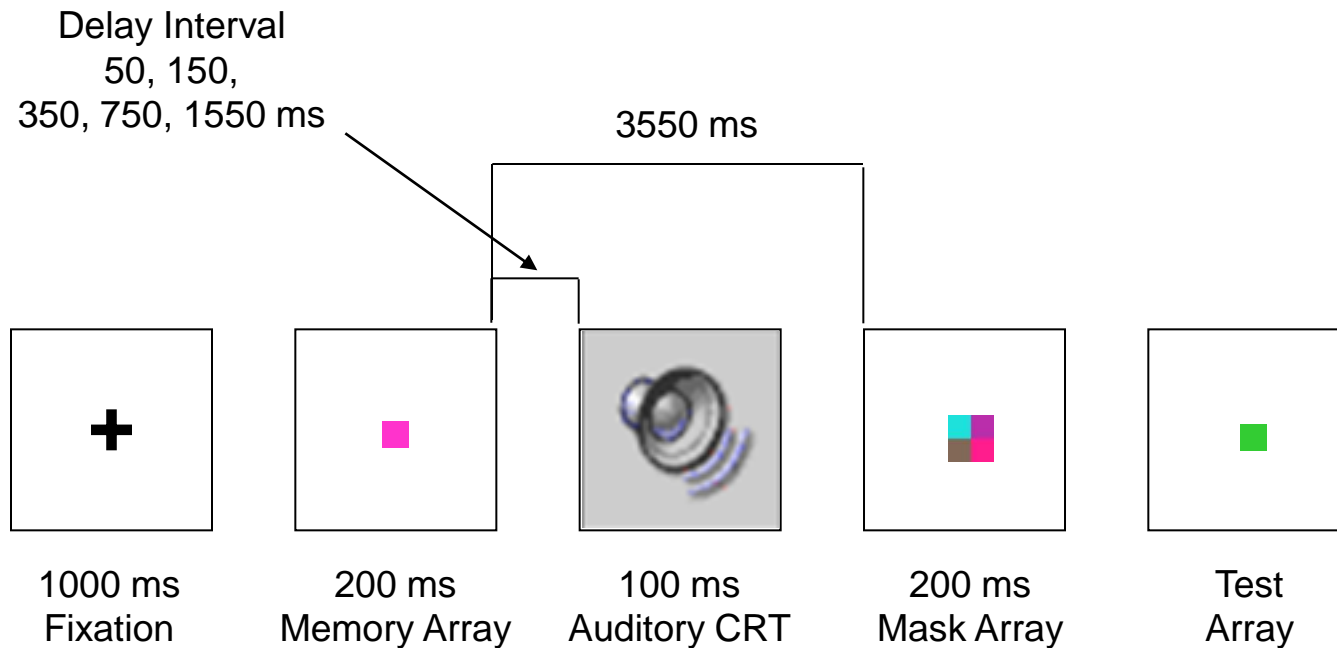
**Australian Research Council**

# Experiment 2 - Method

- 51 children (mean age: 9 years, 0 months)
  - 36 met 70% accuracy criteria on CRT
- two visual change-detection tasks
  - encode and ignore conditions
  - 5 delay intervals (50, 150, 350, 750, 1550 ms)
  - visual memory stimuli (colours or symbols)
  - auditory choice-RT task
  - articulatory suppression throughout presentation

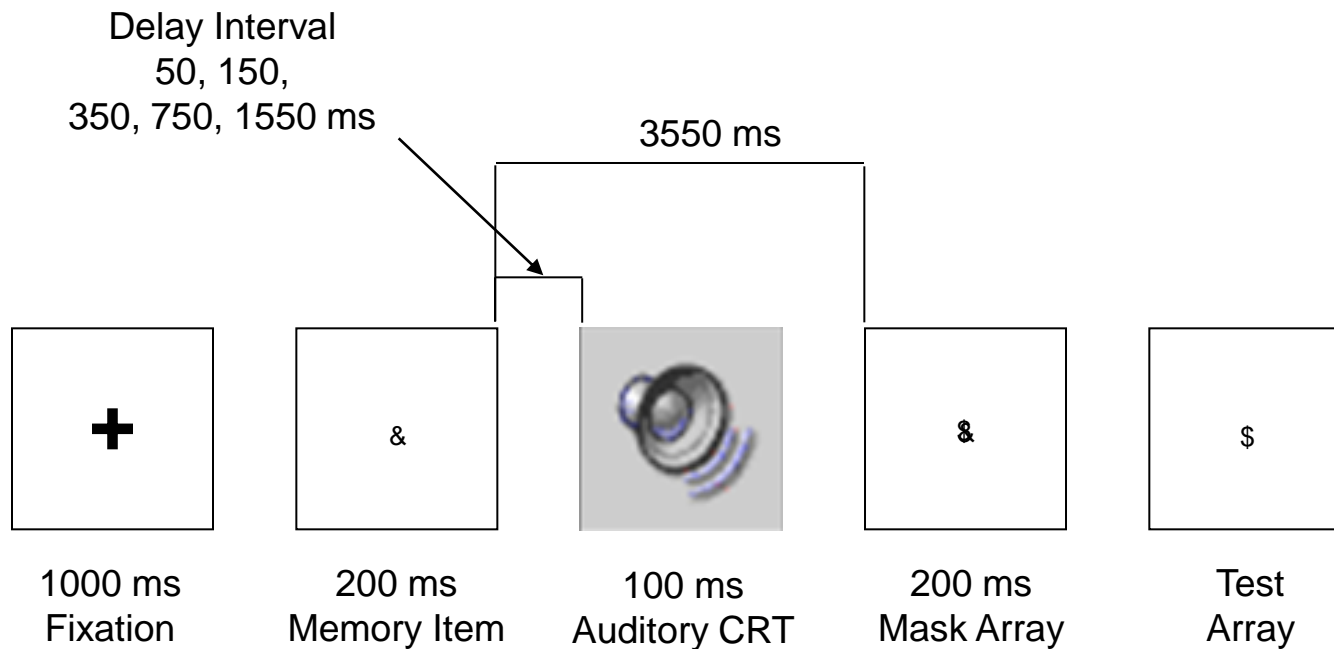
# Experiment 2

## Visual Change-Detection Task (colours)



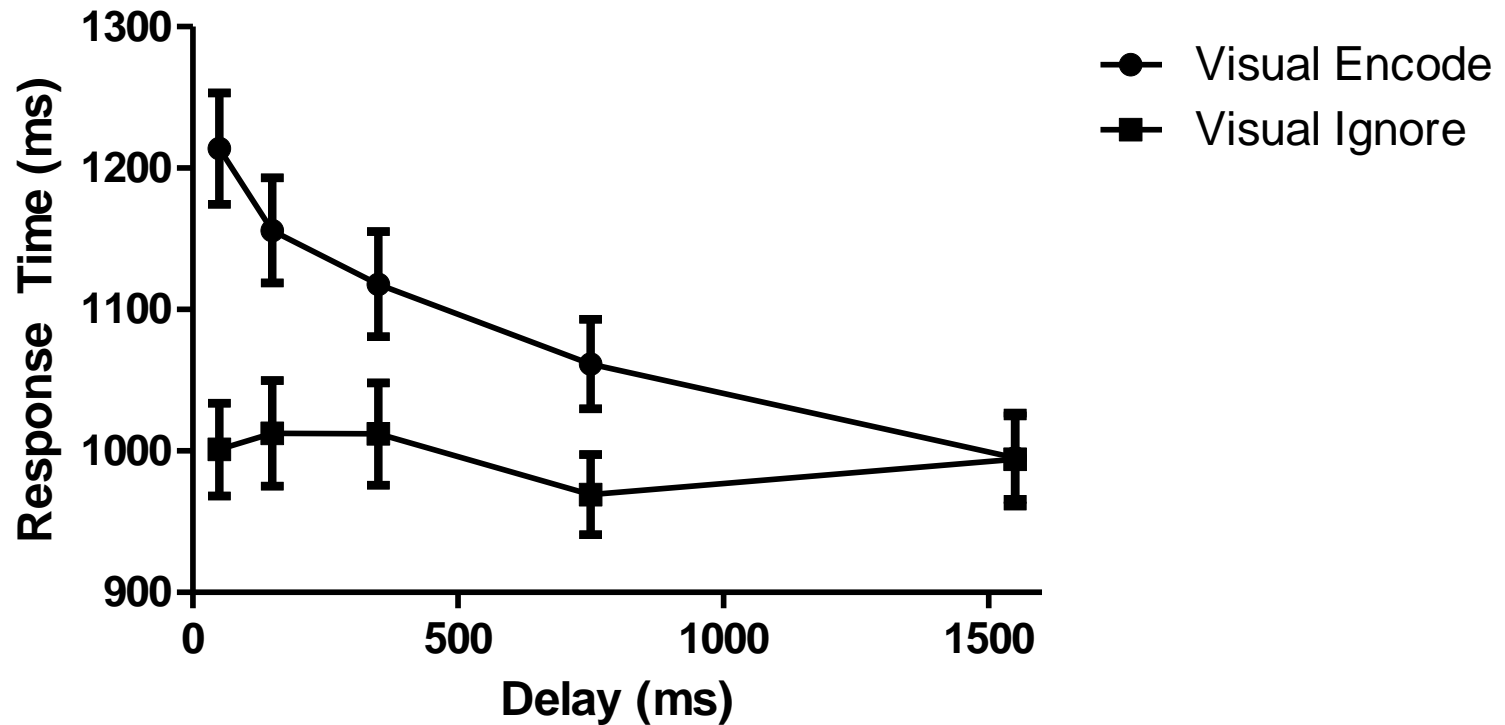
# Experiment 2

## Visual Change-Detection Task (symbols)



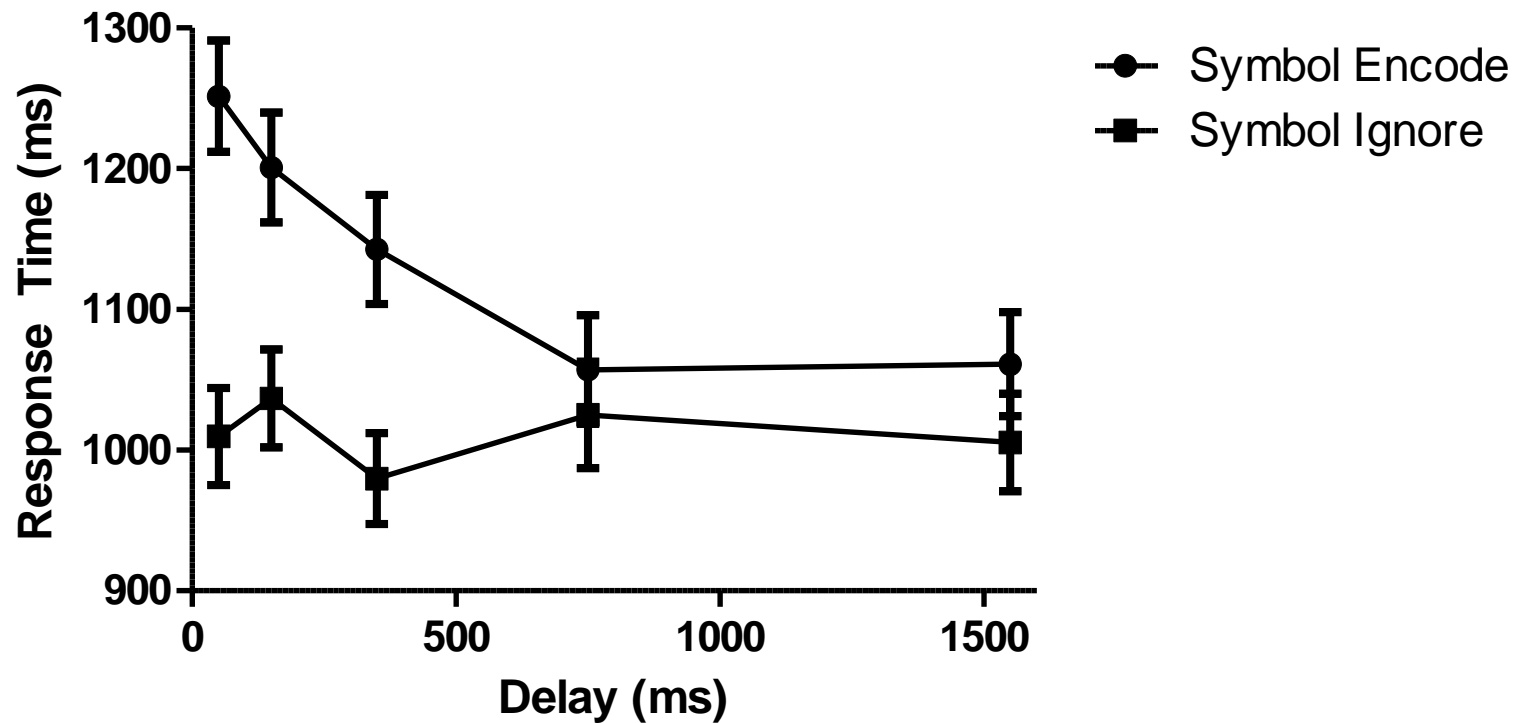
# Experiment 1

- Visual Colours ( $N=36$ )



# Experiment 1

- Visual Symbols ( $N=36$ )





# Consolidation of STM

- Woodman & Vogel (2005)

