Consolidating working memory: Enhancing cognitive performance through effective encoding

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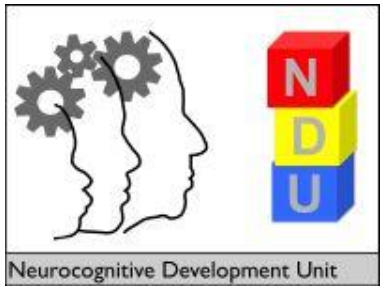

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Consolidation of LTM

- 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

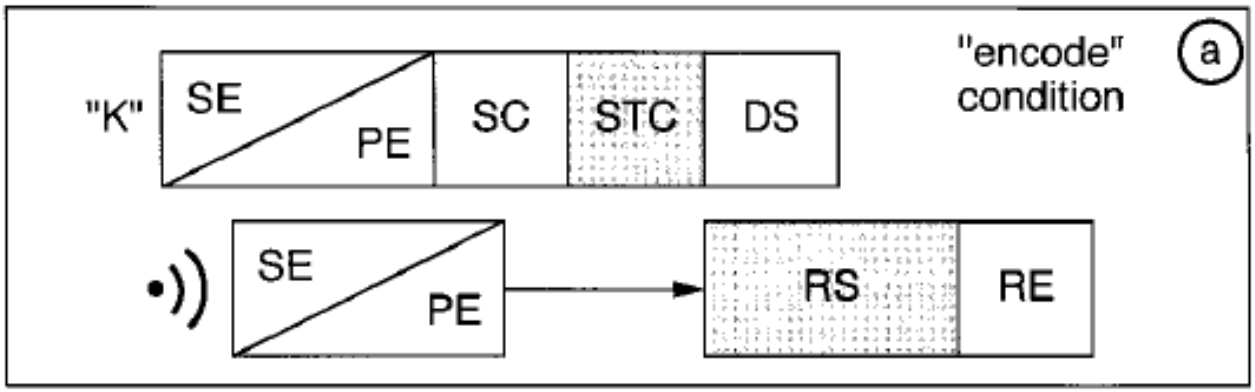
Consolidation of LTM

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

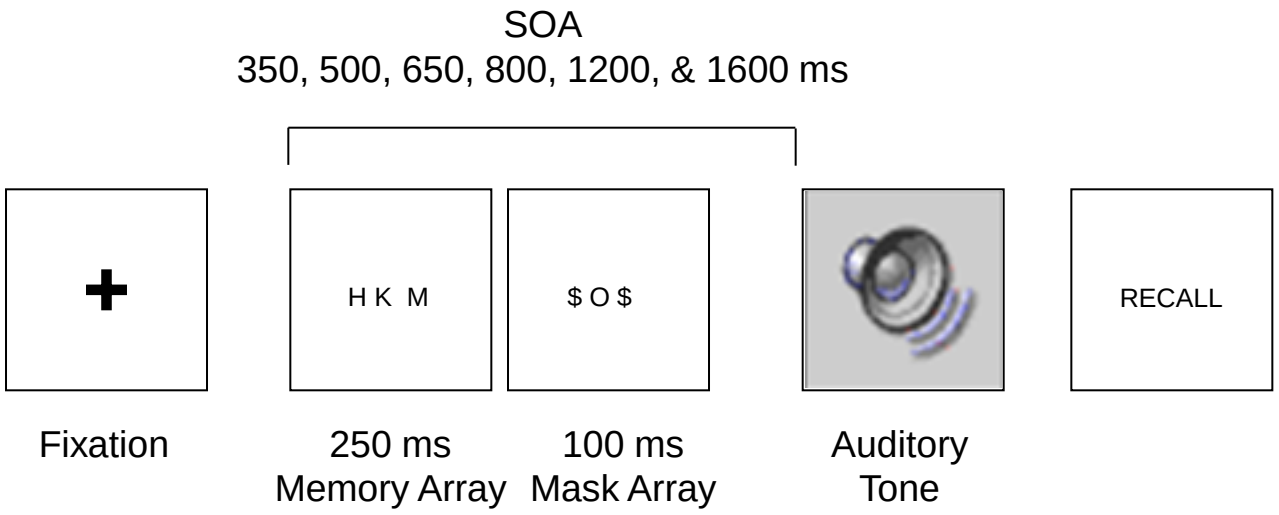
Consolidation of STM

- 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



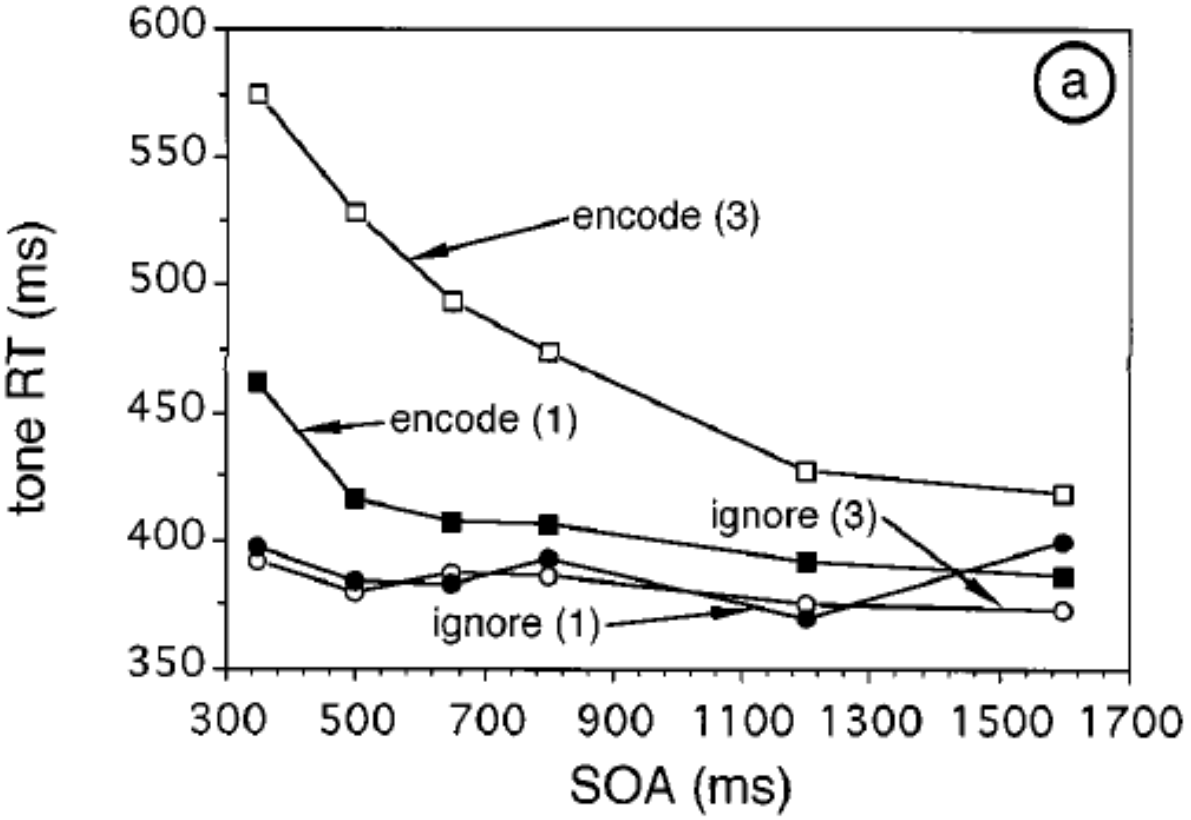
Consolidation of STM

- Jolicoeur and Dell'Acqua (1998)



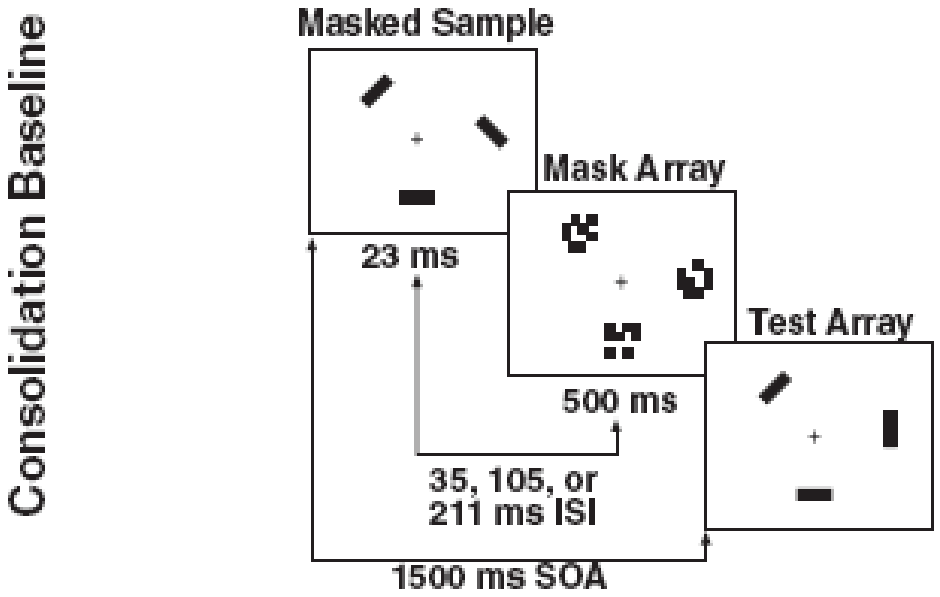
Consolidation of STM

- Jolicoeur and Dell'Acqua (1998)



Consolidation of STM

- Woodman & Vogel (2005)



Consolidation of STM

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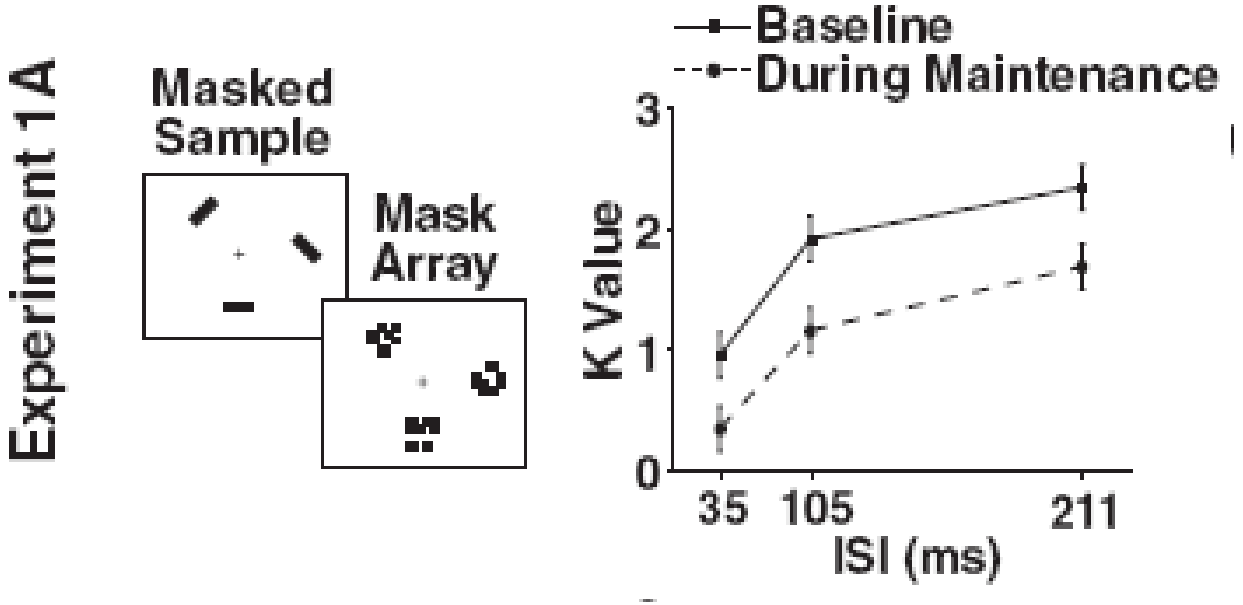
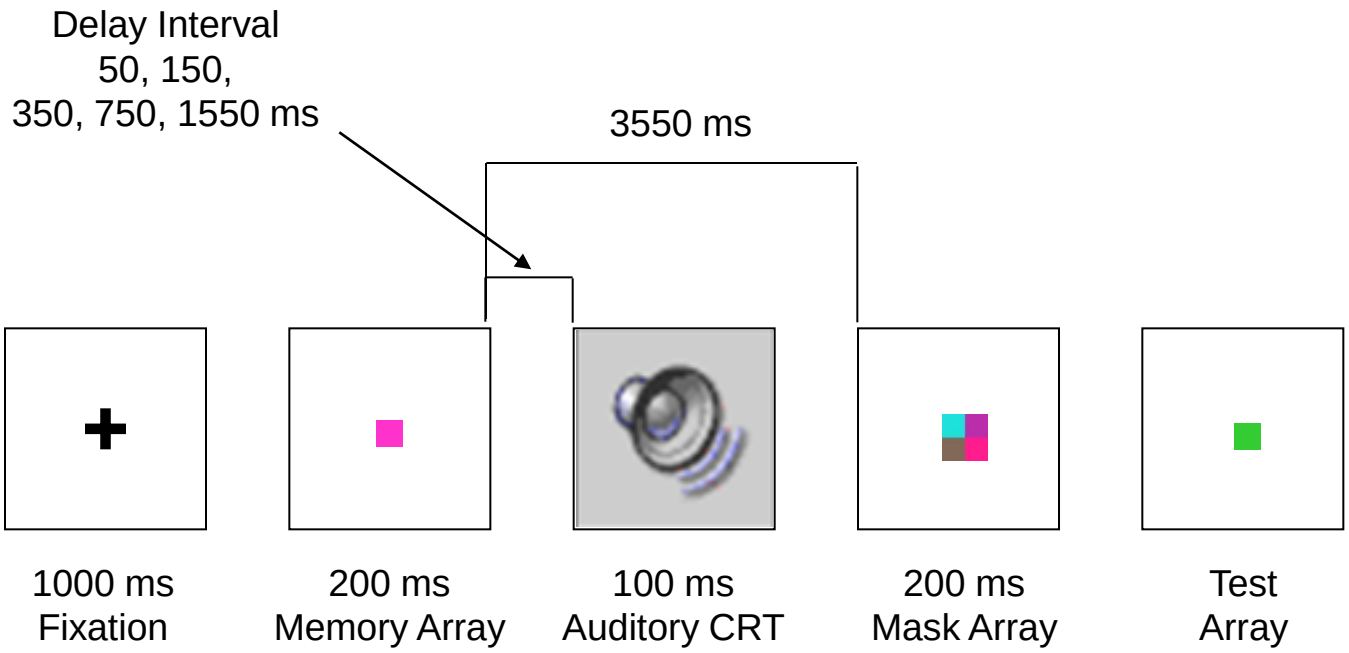


Development of consolidation

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

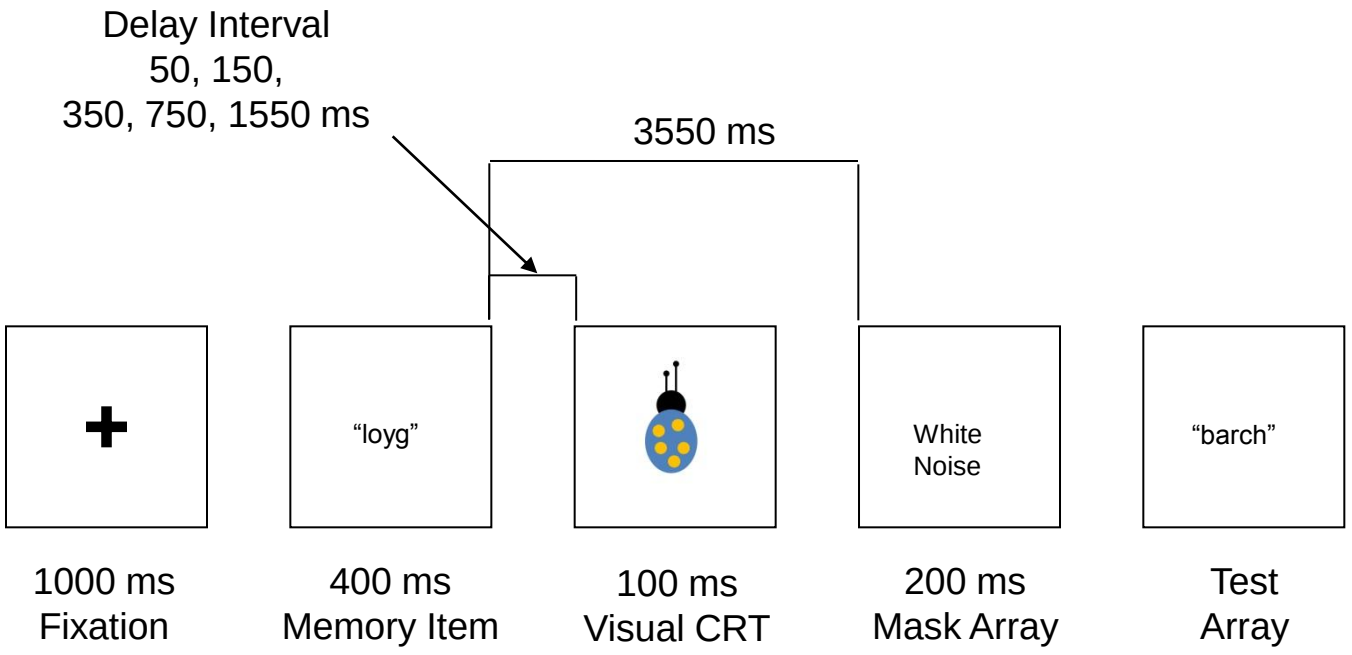
Development of Consolidation

Visual Change-Detection Task



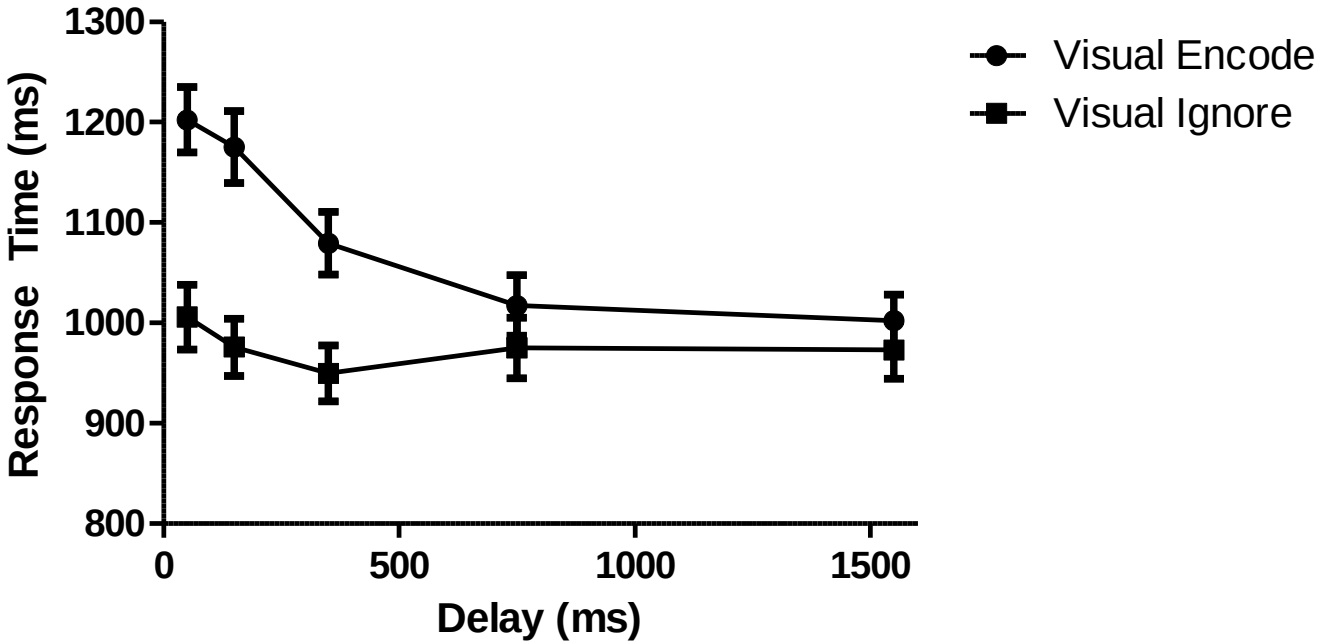
Development of Consolidation

Verbal Change-Detection Task



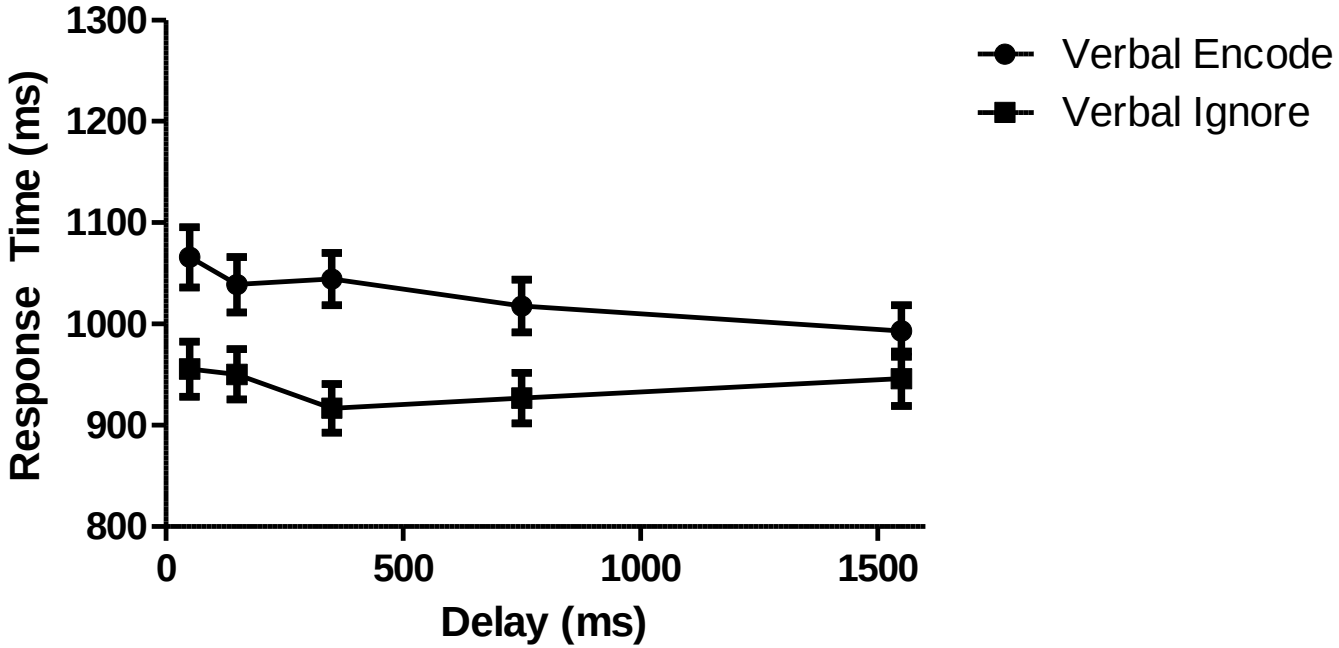
Development of Consolidation

- 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

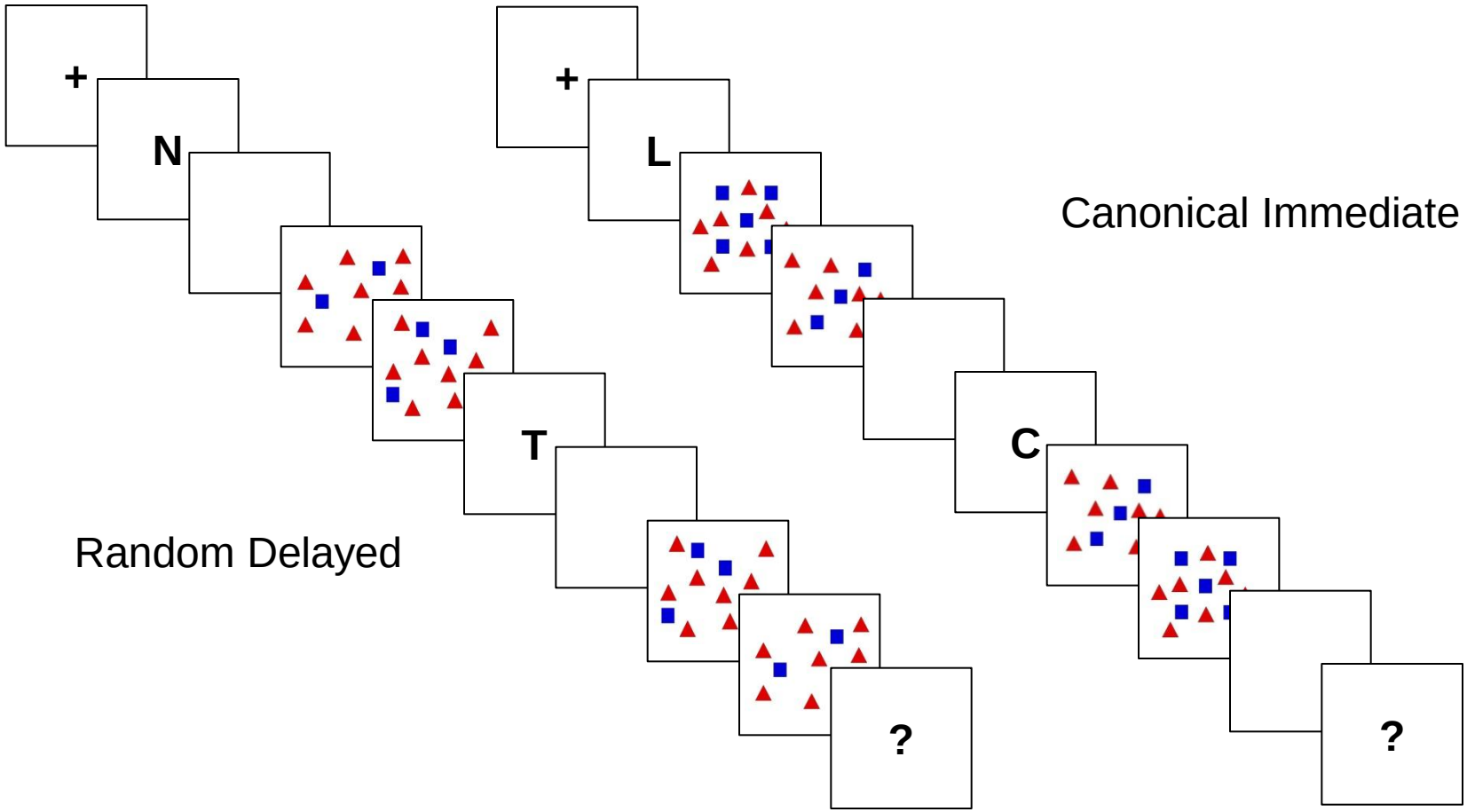
Consolidation and Working Memory

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

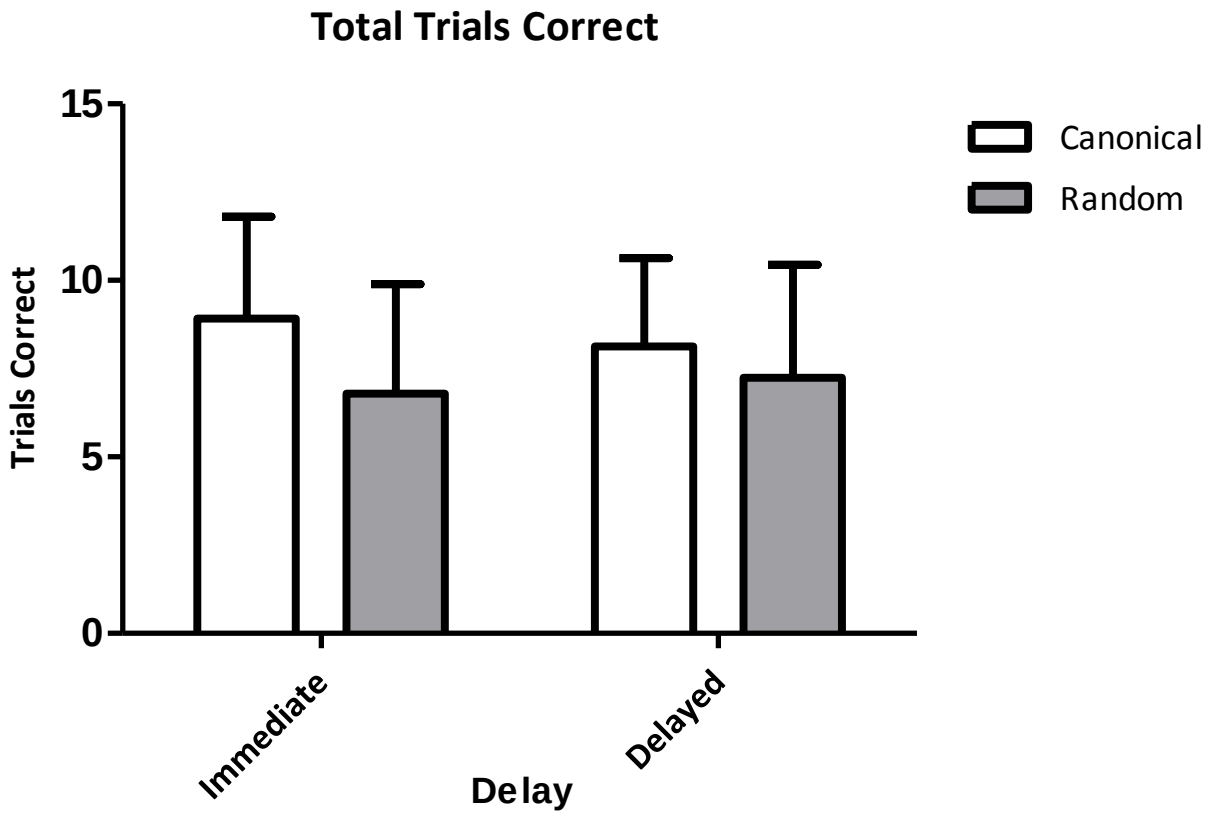
Consolidation and Working Memory

- 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

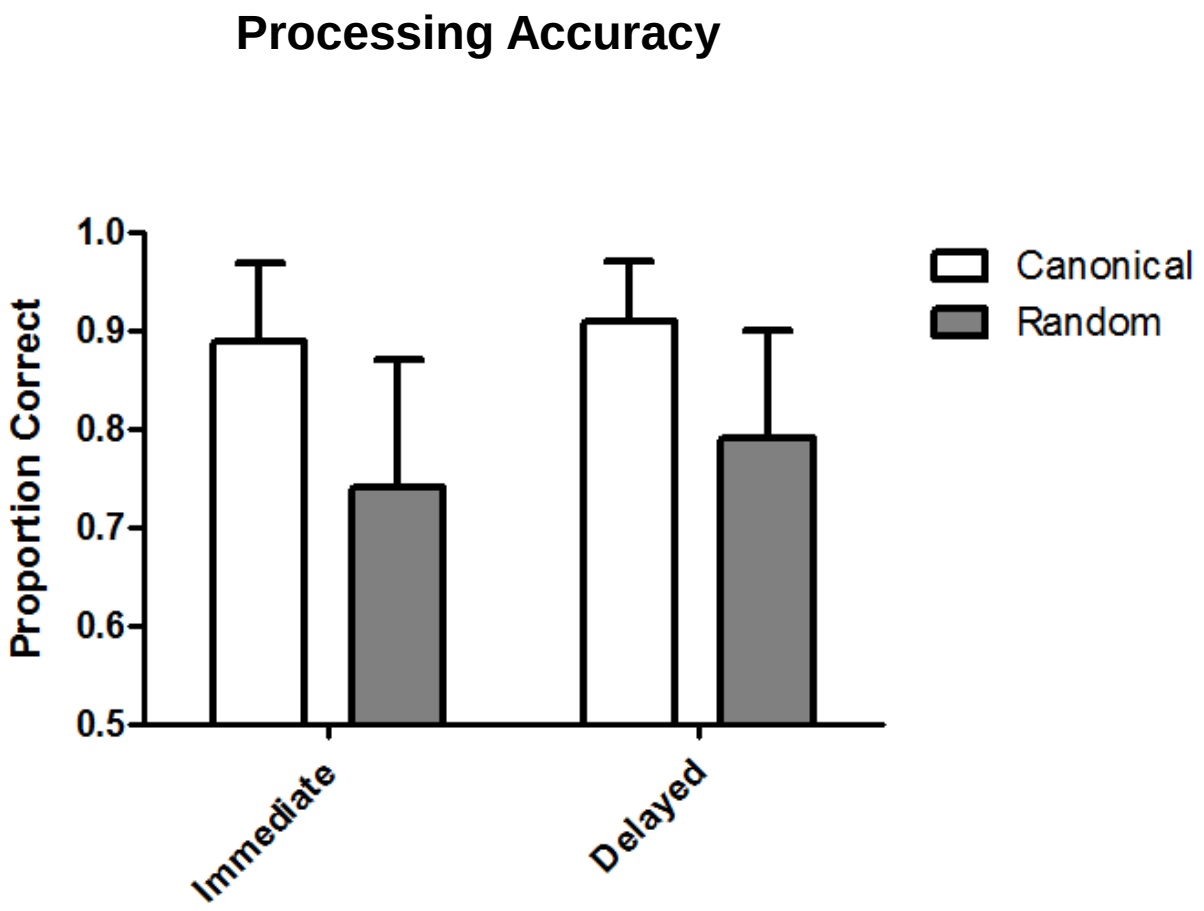
Consolidation and Working Memory



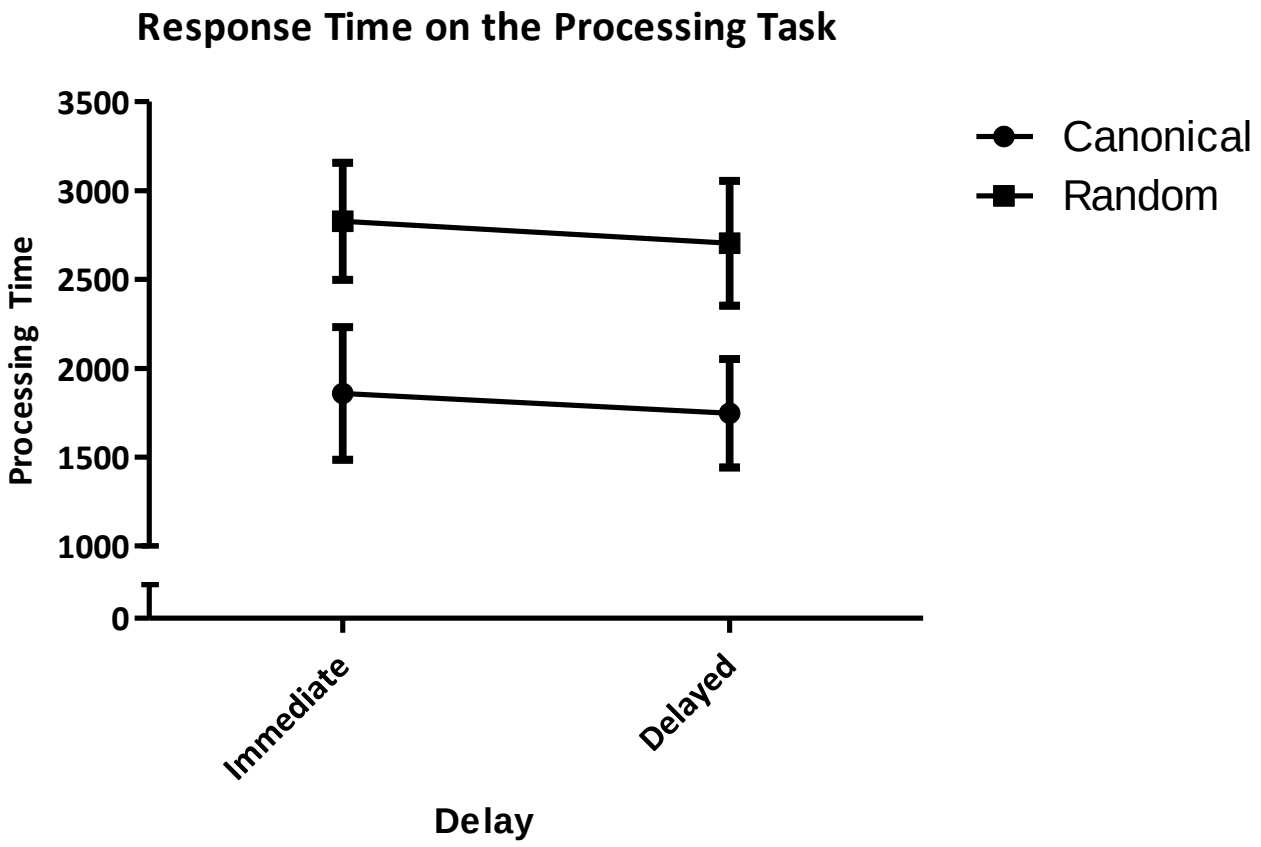
Consolidation and Working Memory



Consolidation and Working Memory



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

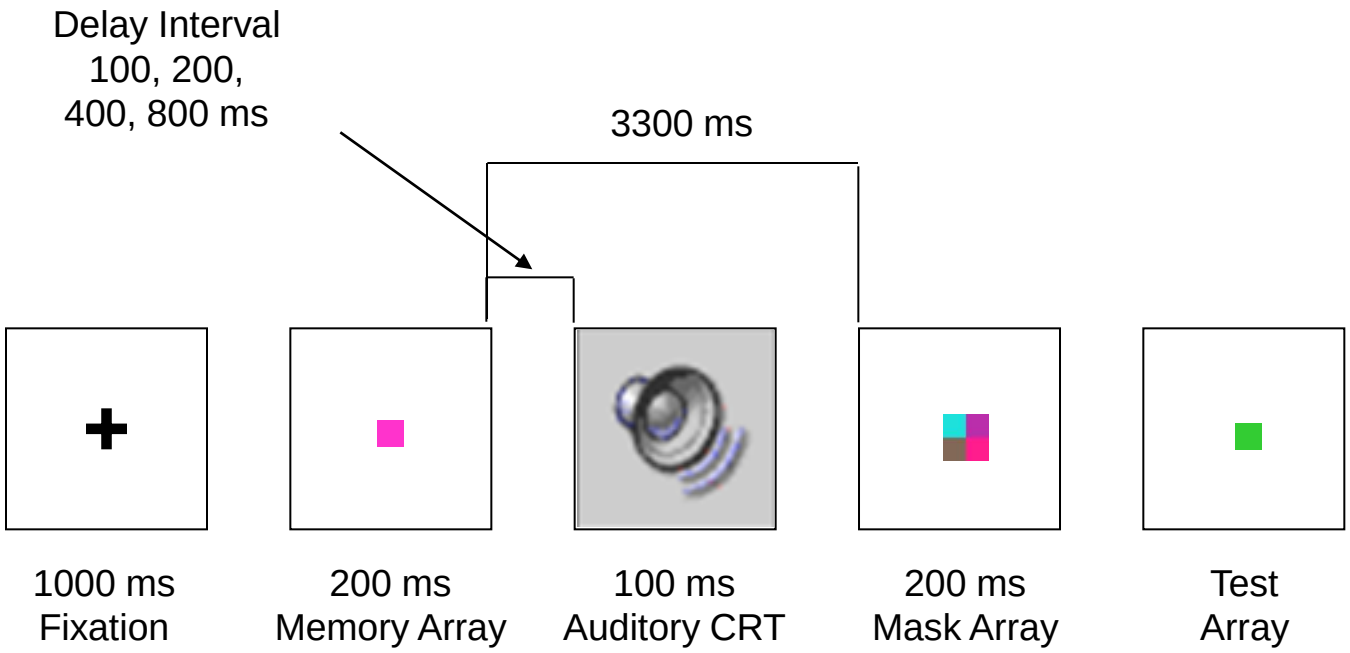
- inserting pauses at syntactic boundaries improves older adults' memory for stories

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

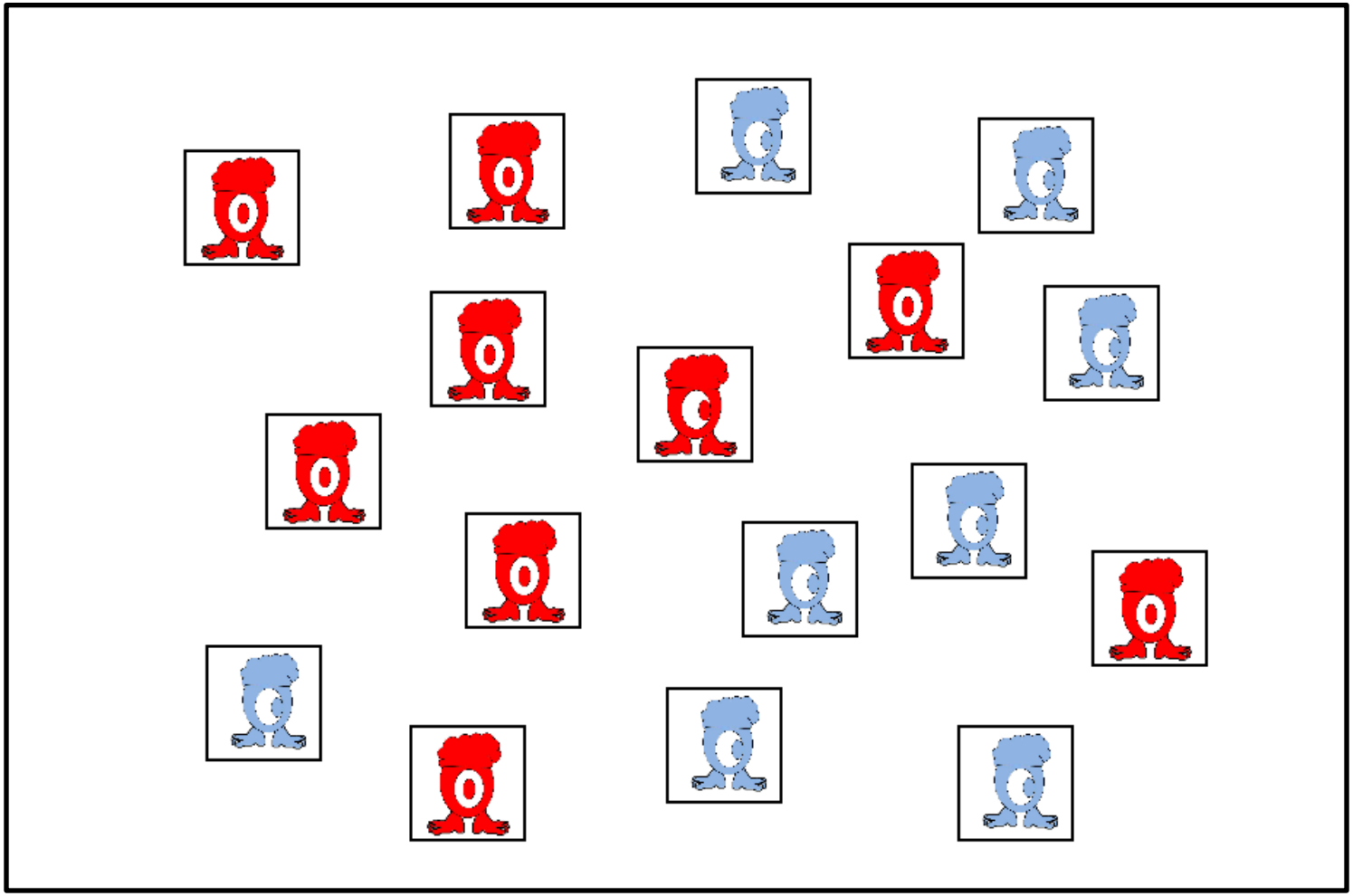
Holland & Fletcher (2000). *Aust. J of Psyc, 52*, 149-154

Consolidation and Educational Achievement

Visual Change-Detection Task

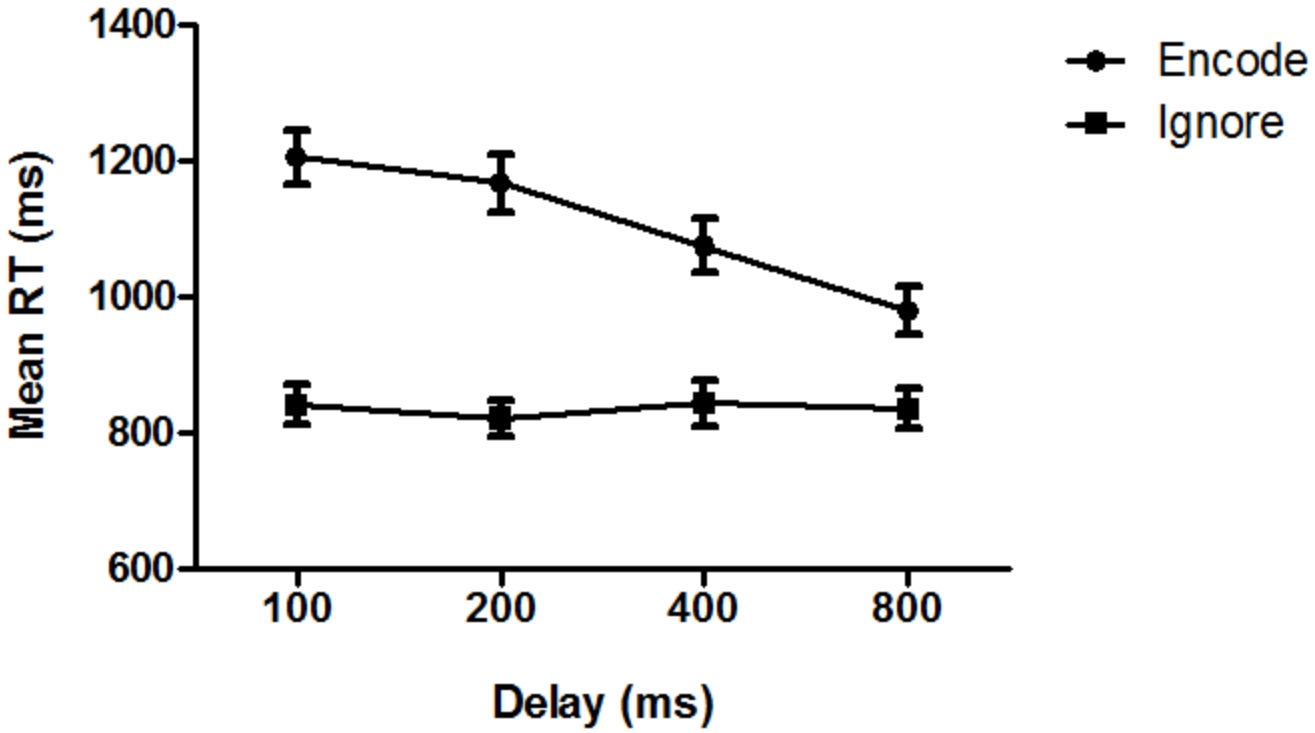


Consolidation and Educational Achievement



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

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Australian Government

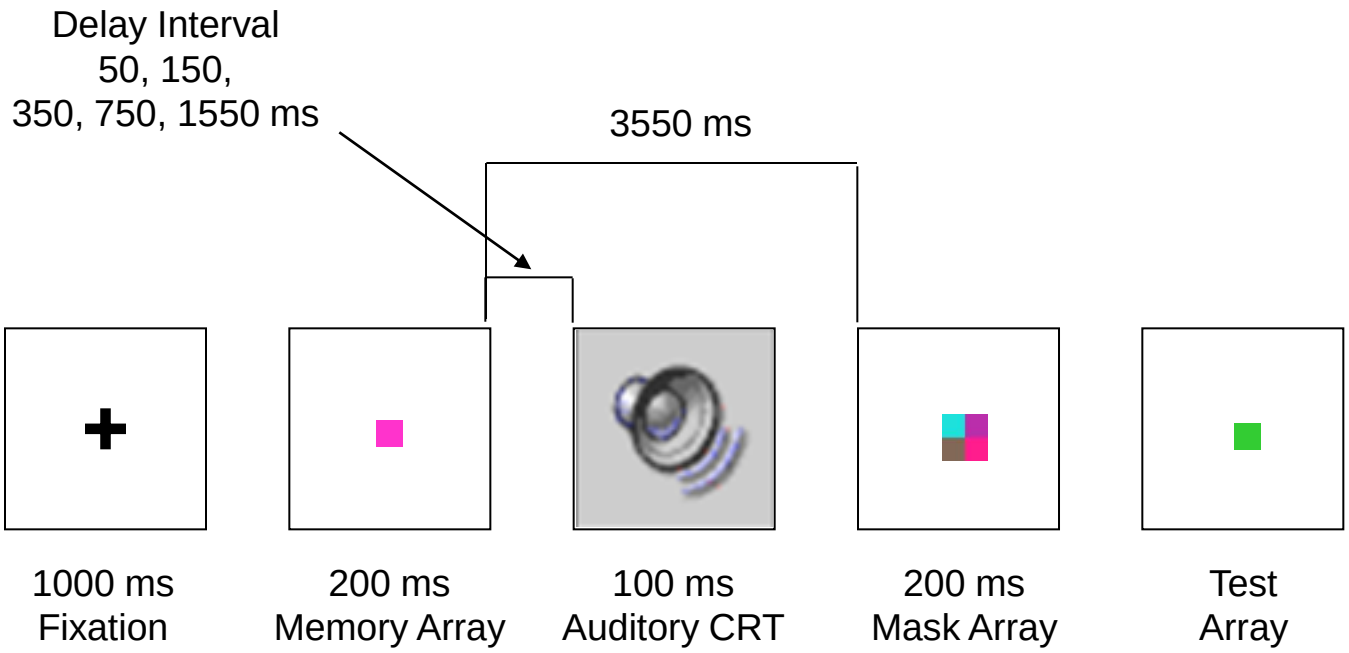
Australian Research Council

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

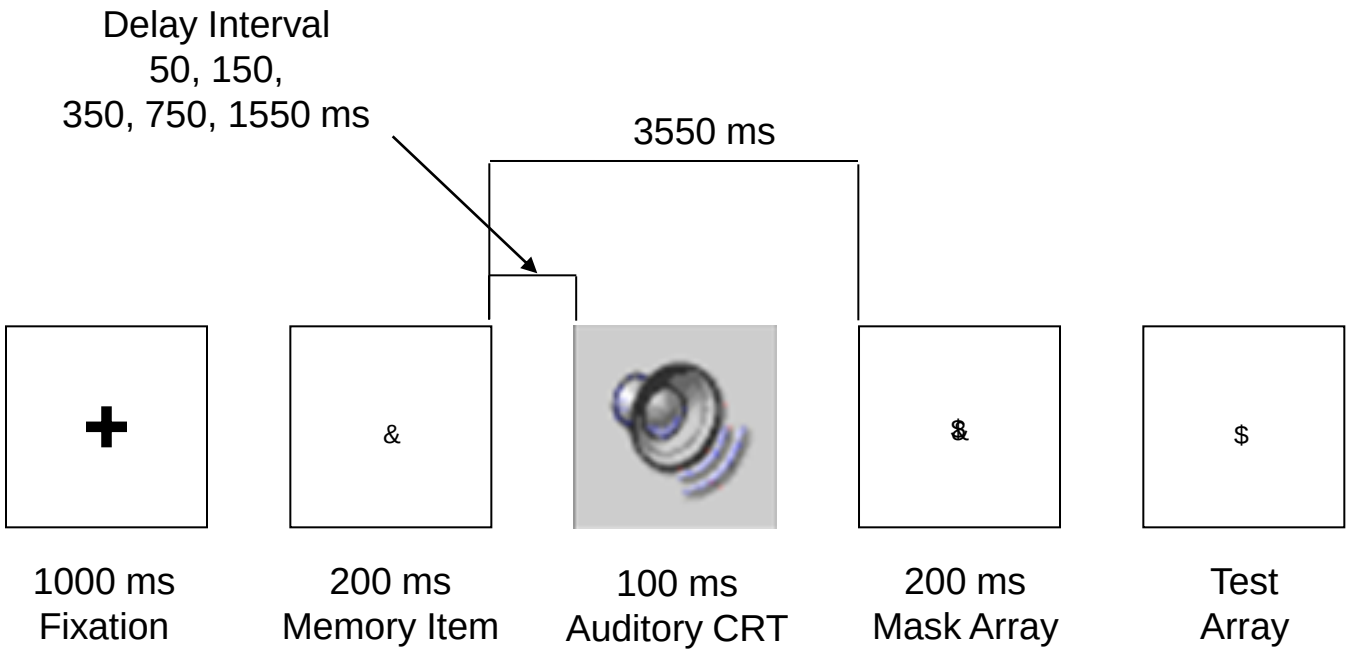
Experiment 2

Visual Change-Detection Task (colours)



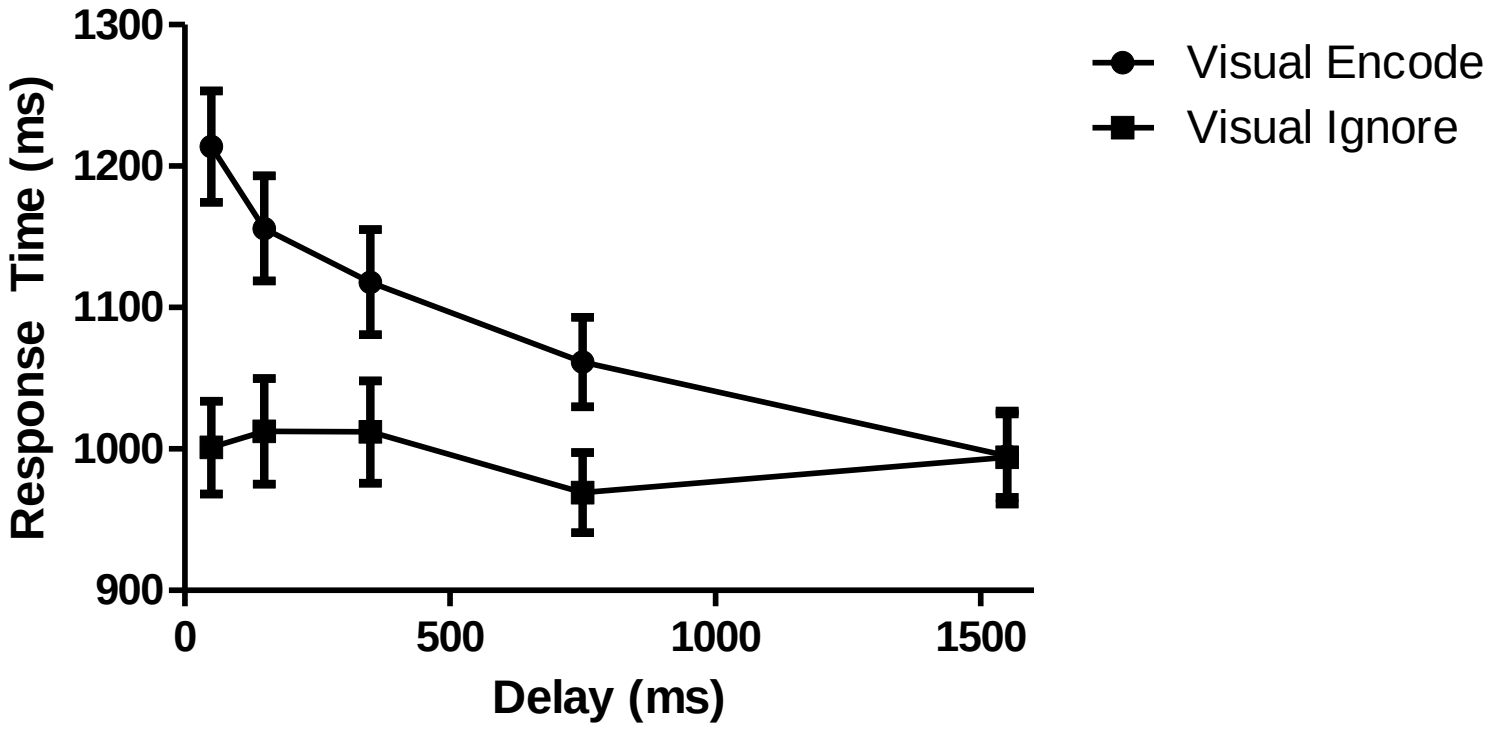
Experiment 2

Visual Change-Detection Task (symbols)



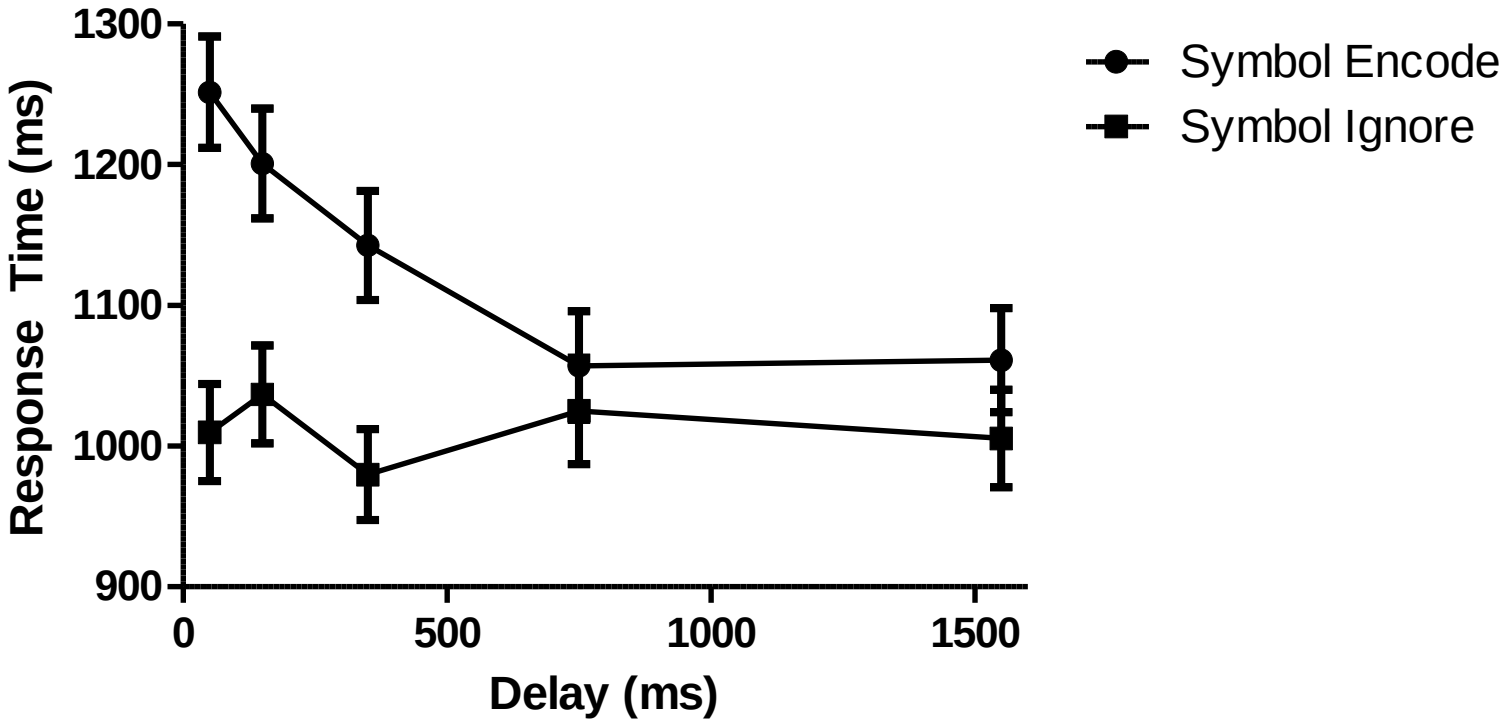
Experiment 1

- Visual Colours (*N=36*)



Experiment 1

- Visual Symbols (*N=36*)



Experiment 2 (*N*=22)

	Symbol 50ms	Symbol 150ms	Symbol 350ms	Symbol 750ms	Symbol 1550ms	Visual 50ms	Visual 150ms	Visual 350ms	Visual 750ms	Visual 1550ms
Symbol 50ms	1	.816**	.726**	.304	.260	.530**	.210	.214	.404	.010
Symbol 150ms		1	.725**	.542**	.415	.380	.089	.138	.326	.061
Symbol 350ms			1	.522*	.301	.347	.183	-.018	.348	.290
Symbol 750ms				1	.535*	-.108	-.292	-.076	.144	.166
Symbol 1550ms					1	-.043	-.431*	-.435*	-.261	.303
Visual 50ms						1	.652**	.589**	.586**	.345
Visual 150ms							1	.588**	.778**	.211
Visual 350ms								1	.690**	.076
Visual 750ms									1	.380
Visual 1550ms										1

Consolidation of STM

- Woodman & Vogel (2005)