Working Memory in Written Composition

A Progress Report

SigWriting 2012
Porto

Writing Processes

- **Planning conceptual content**: retrieving ideas, organizing ideas, and setting goals.
- **Translating ideas into text:** generating sentences and cohesive links, with motor execution closely linked in time.
- **Reviewing ideas and text**: reading with the purpose of detecting errors at multiple levels of the text.

Working Memory

- Executive Attention
- Short-Term Stores
  - Verbal
  - Visual
  - Spatial

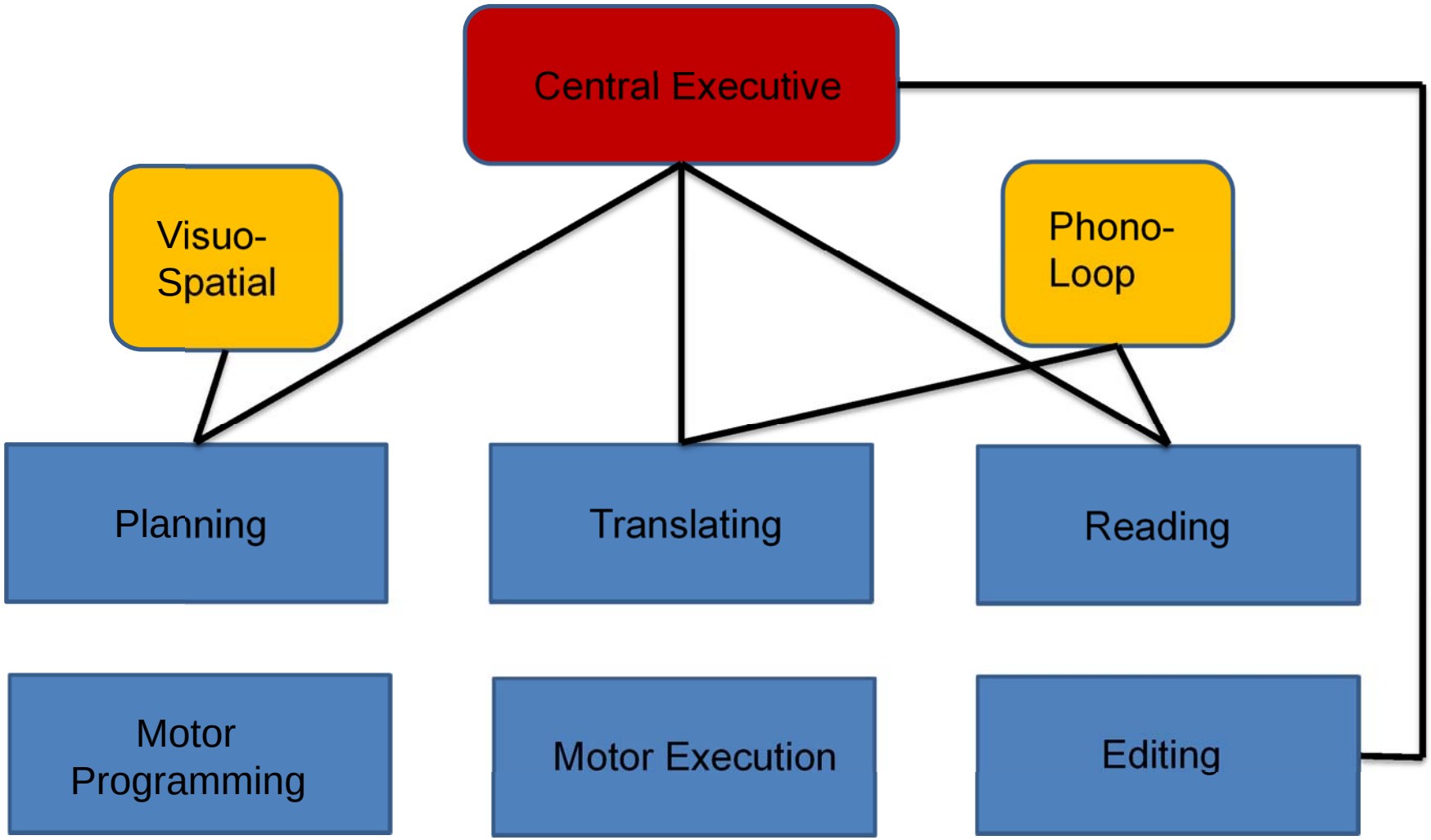
Short-Term Storage Brain Networks

- Verbal—Left frontal, left parietal
- Visual— Different left frontal, left parietal, and left posterior temporal
- Spatial—Right frontal, right parietal

Brain Networks of Attention

- Executive attention
  - Anterior cingulate gyrus
  - Lateral prefrontal cortex
- Alerting
  - Frontal and posterior cortical areas
  - Thalamus
- Orienting
  - Parietal cortical areas
  - Pulvinar, superior colliculus, and frontal eye field

The 1996 Model



The Resources of Working Memory Used by the Six Basic Processes of Writing			
	Working Memory Resource		
Basic Process	Visual-Spatial Sketchpad	Central Executive	Phonological Loop
Planning	X	X	
Translating		X	X
Programming		X	
Executing			
Reading		X	X
Editing		X	

Progress Report

- The Kellogg (1996) model is now 16 years old.

  So, how is it faring in adolescence?

Two Limitations on the Relation of Short-Term WM and Writing

- With high degrees of domain-specific knowledge, writers can instead use long-term working memory (McCutchen, 2010).
- Knowledge and skill differences can be as important as WM differences (Bourke & Adams, 2011).
  - Young girls (4-5 years old) write better than young boys because of superior language skill.

The Resources of Working Memory Used by the Six Basic Processes of Writing			
	Working Memory Resource		
Basic Process	Visual-Spatial Sketchpad	Central Executive	Phonological Loop
Planning	X	X	
Translating		X	X
Programming		X	
Executing			
Reading		X	X
Editing		X	

Concurrent Tasks to Divert WM Resources from Written Composition

Ransdell, Levy & Kellogg (2002)

- Irrelevant speech--phonological loop only.
- Decisions about irrelevant speech—Minimal executive attention plus phonological loop.
- Retain 6 random digits—Heavy executive attention plus phonological loop.

Sentence Length in Words

From Ransdell, Levy, & Kellogg (2002)

- Experiment 1
  - Control 14.5
  - Irrelevant Speech 14.1
- Experiment 2
  - Control 14.5
  - Speech Plus 13.0
- Experiment 3
  - Control 14.6
  - Six Digits 11.6

Correlating Writing Performance and Measures of WM components with Hierarchical Regression

Vandenberg & Swanson (2007)

- *Test of Written Language—2 (TOWL-2)* plus an experimental writing prompt assessed writing performance in 160 students in Grade 10.
- Factor analysis of 4 tests of short-term memory and 6 tests of WM yielded Baddeley's three components.
  - Phonological Loop—Recall of non-words, digit span, and word span.
  - Central executive—Sentence span, rhyming, semantic association, and semantic categorization
  - Visuo-spatial sketchpad—Recall of visual matrix, mapping, and directions.

β Values in Simultaneous Multiple Regression

From Vandenberg & Swanson (2007)

- Planning
  - Phonological Loop 0.06
  - Central Executive **0.21***
  - Visuospatial Sketchpad -0.16
- Translating
  - Phonological Loop -0.05
  - Central Executive **0.21***
  - Visuospatial Sketchpad 0.02
- Revision
  - Phonological Loop -0.04
  - Central Executive **0.31***
  - Visuospatial Sketchpad -0.01

*$p < .01$

Translating Demands the Phonological Loop

Chenoweth & Hayes (2003)

- Examined “the inner voice in writing” with a sentence production task using a cartoon picture prompt.
- Compared articulatory suppression (silent repetition of “tap”) with a no load control.

The Resources of Working Memory Used by the Six Basic Processes of Writing			
	Working Memory Resource		
Basic Process	Visual-Spatial Sketchpad	Central Executive	Phonological Loop
Planning	X	X	
Translating		X	X
Programming		X	
Executing			
Reading		X	X
Editing		X	

P-Burst Length in Words*

From Chenoweth & Hayes (2003)

Condition	No-tap	Foot-tap	Voice-tap
Visible	11	13	8
Invisible	13	13	8

*Rounded to the nearest whole word

The Resources of Working Memory Used by the Six Basic Processes of Writing			
	Working Memory Resource		
Basic Process	Visual-Spatial Sketchpad	Central Executive	Phonological Loop
Planning	X	X	
Translating		X	X
Programming		X	
Executing			
Reading		X	X
Editing		X	

Does Editing Also Demand the Phonological Loop?

Hayes & Chenoweth (2006)

- Examined errors in the transcription of texts, with corrected errors reflecting editing.
- Compared articulatory suppression with a silent control on **uncorrected** errors.

Errors per 100 words

From Hayes & Chenoweth (2006)

- Single Task Control 3.75
- Articulatory Suppression 4.63

The Resources of Working Memory Used by the Six Basic Processes of Writing			
	Working Memory Resource		
Basic Process	Visual-Spatial Sketchpad	Central Executive	Phonological Loop
Planning	X	X	
Translating		X	X
Programming		X	
Executing			
Reading		X	X
Editing		X	

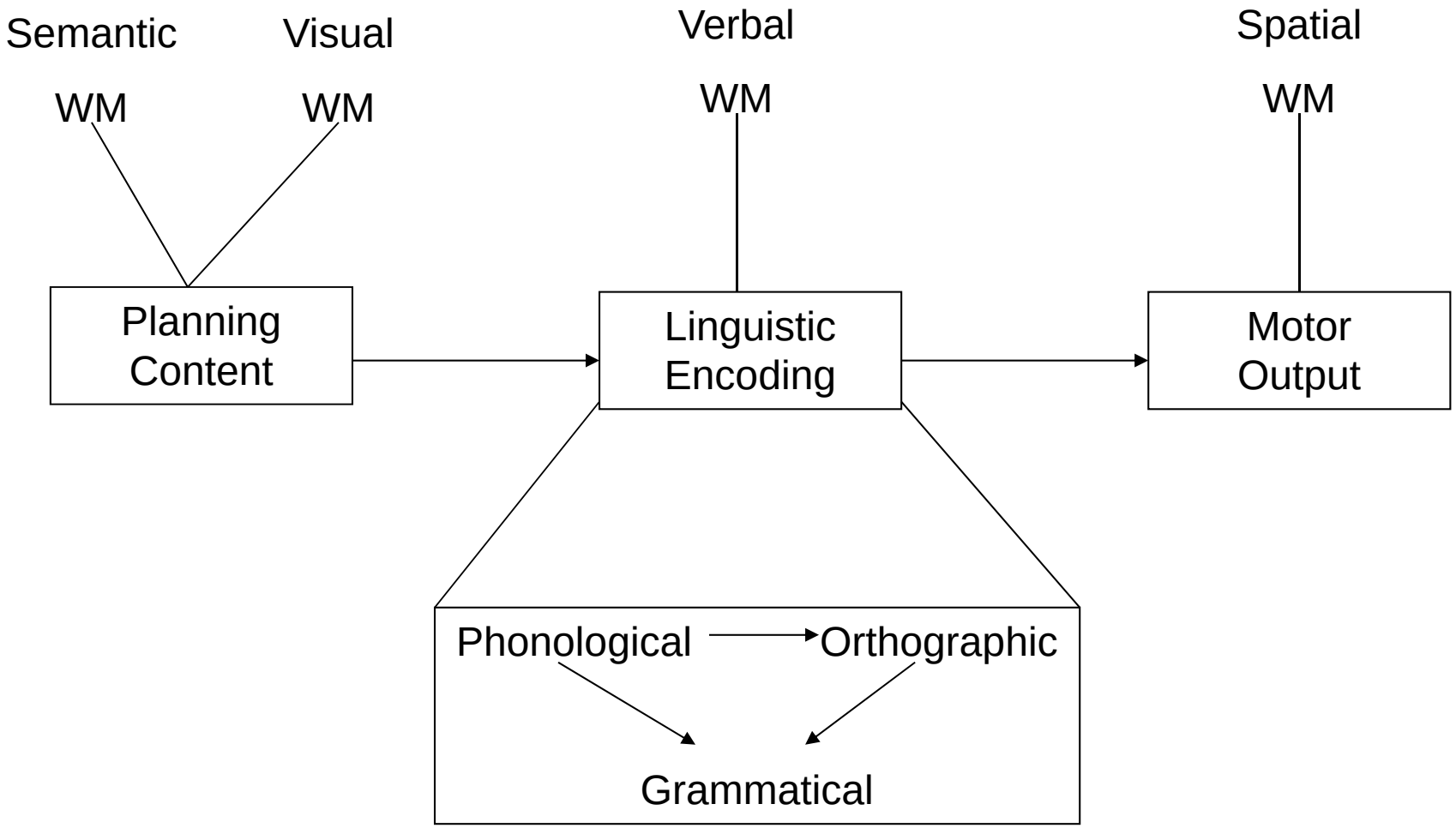


Figure 1. Working Memory Components in Language Production

The Resources of Working Memory Used by the Six Basic Processes of Writing			
	Working Memory Resource		
Basic Process	Visual-Spatial Sketchpad	Central Executive	Phonological Loop
Planning	X	X	
Translating		X	X
Programming		X	
Executing			
Reading		X	X
Editing		X	

1-Back Secondary Task: WM Demands of Written Sentence Production

Kellogg, Olive, & Piolat (2007)

- In a 1-back WM task, the participant decide if the stimulus is identical to one presented 15 seconds or so before.
- Depending on the stimulus, it requires verbal, visual, or spatial WM plus executive attention to update the contents of WM with each new stimulus.

Verbal Task

ba

da *target*

da

ba *target*

da *target*

da

ba *target*

Exp. 1 RT Interference (ms)

From Kellogg, Olive, & Piolat (2007)

Condition	Concrete	Abstract
Verbal	150	180
Visual	304	58

Exp. 2 RT Interference (ms)

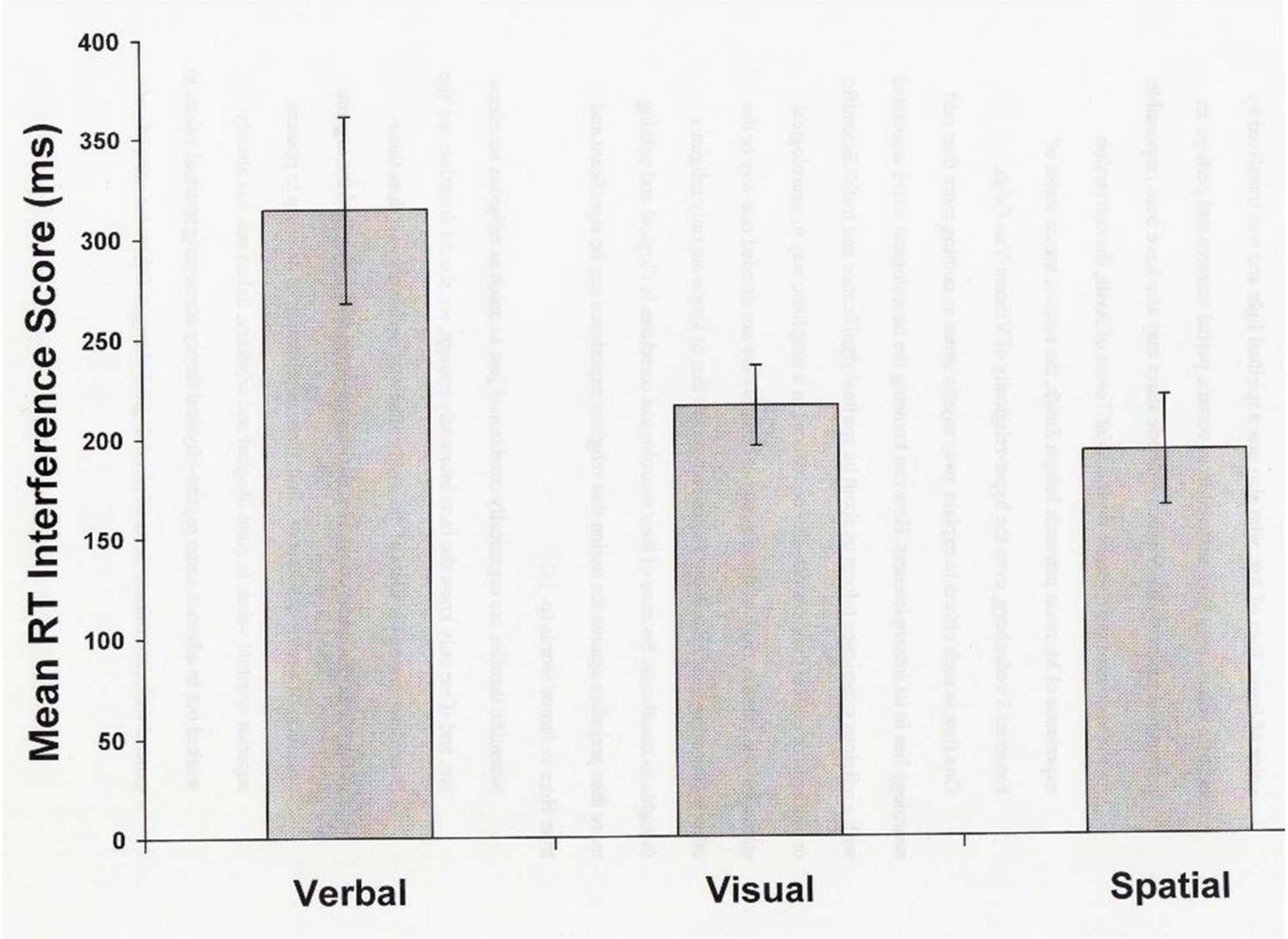
From Kellogg, Olive, & Piolat (2007)

Condition	Concrete	Abstract
Visual	318	95
Spatial	48	56

RT Interference (ms)

From Raulerson, Donovan, Whiteford, & Kellogg (2010)

	High Frequency	Low Frequency
Verbal	308	321
Visual	173	179


Mean RT Interference Score (ms)
400
350
300
250
200
150
100
50
0
Verbal
Visual
Spatial

Conflicting Results for Spatial WM

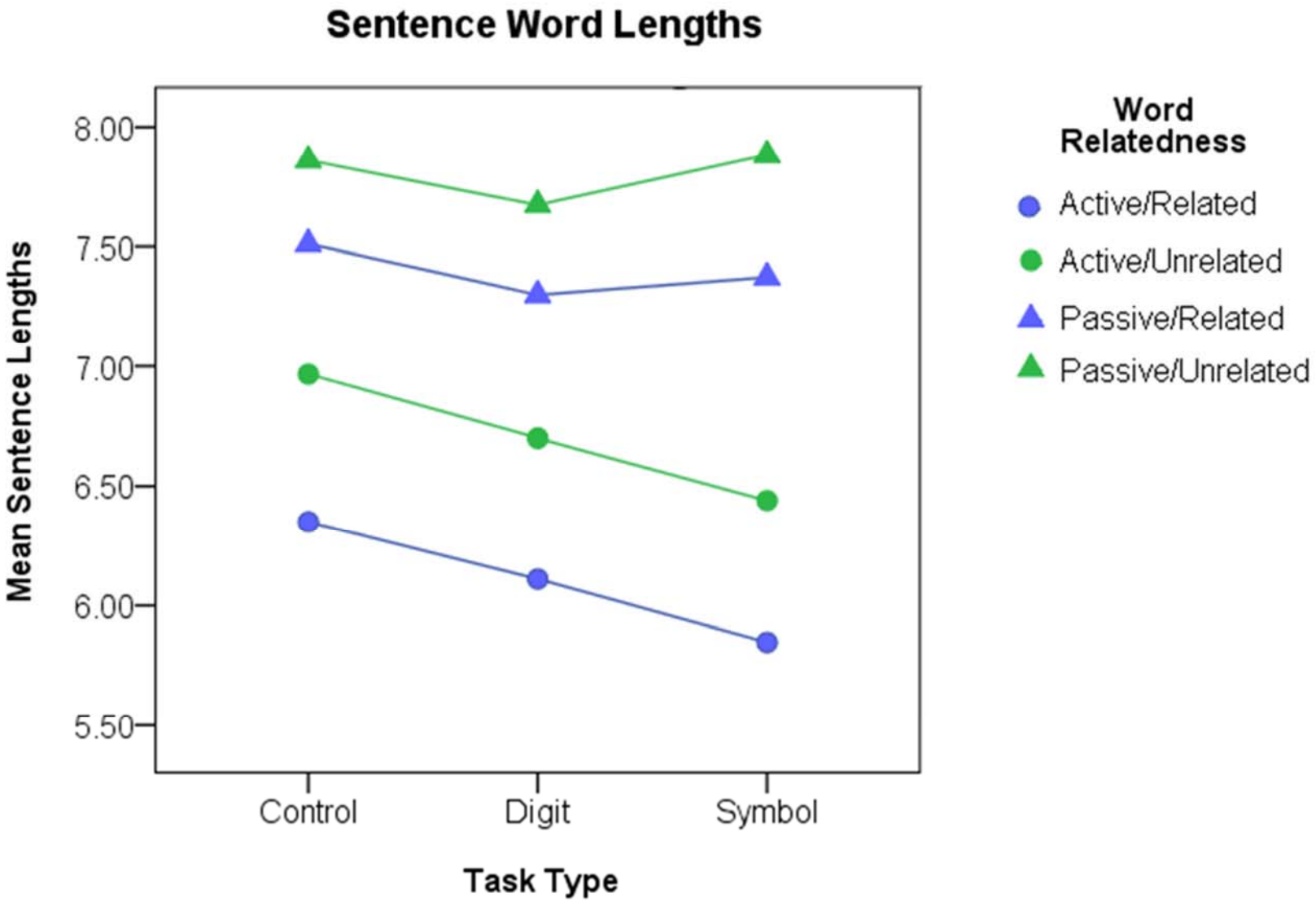
- Reported measurable demands of spatial WM for:
  - written sentence production (Raulerson et al., 2010)
  - text composition (Galbraith, Ford, Walker, & Ford, 2005)
- Reported null results for:
  - written sentence production (Kellogg et al., 2007)
  - text composition (Olive, Kellogg, & Piolat, 2008).
- Possibly the specific kinds of planning required by the writing task are critical as proposed by Passerault and Dinet (2000).

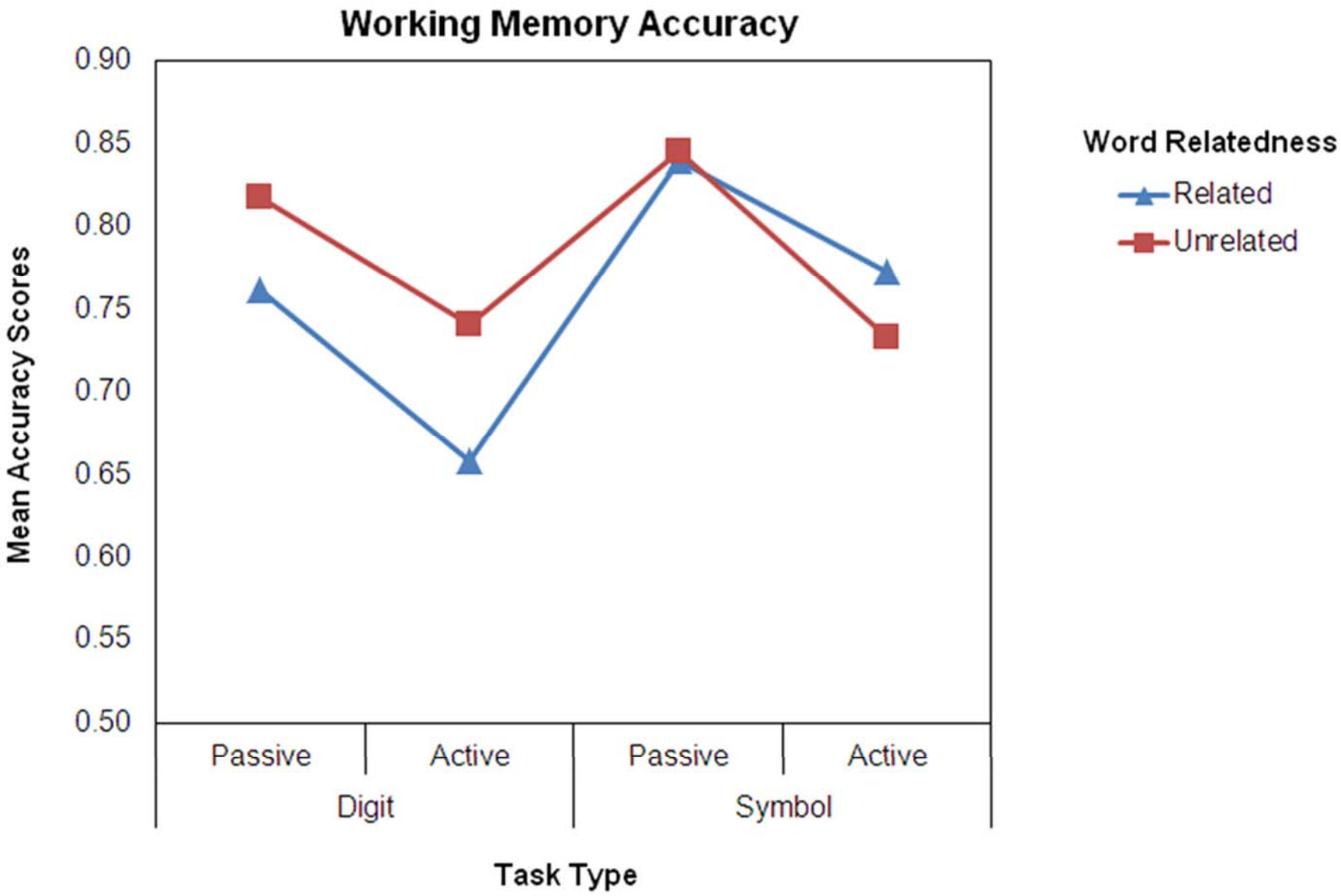
Digit vs. Symbol Recognition: WM Demands of Written Sentence Production

- Participants wrote a sentence linking two nouns presented as prompts.
  - Unrelated (bride-eagle) compared with related (table-chair) should affect planning difficulty and visual WM.
  - Passive grammatical constructions compared with active sentences should affect grammatical encoding and verbal WM.

Experimental Design

- 2 (sentence type) X 2 (prompt relatedness) X 2 (WM task); N = 46 with half active and half passive.
- All noun prompts were concrete and rated high in imagability.
- Retained 6 digits or 6 symbols while writing to load verbal versus visual-spatial WM.


Sentence Word Lengths
Mean Sentence Lengths
8.00
7.50
7.00
6.50
6.00
5.50
Control
Digit
Symbol
Task Type
Word Relatedness
Active/Related
Active/Unrelated
Passive/Related
Passive/Unrelated

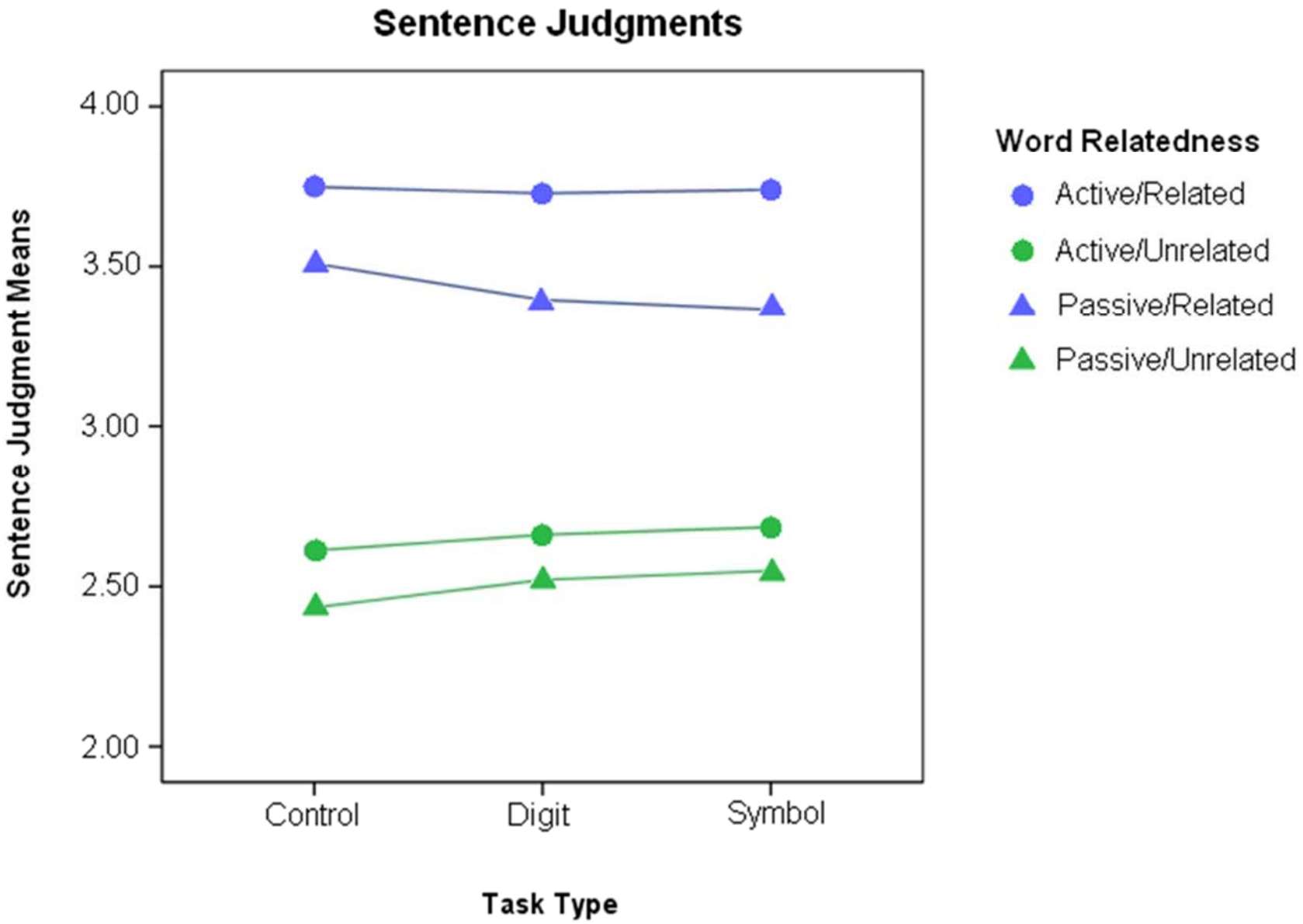

Working Memory Accuracy
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
Mean Accuracy Scores
Passive
Active
Passive
Active
Digit
Symbol
Task Type
Word Relatedness
Related
Unrelated

Experiment 2
Sentence Judgments

- "To what degree are the words in this sentence integrated into one mental image or idea?”

  (1 = not at all; 5 = highly)

- A total of 92 college students were recruited to provide two ratings the passive (*n* = 23) and active conditions (*n* = 23).
  - The mean agreement between pairs of judges was reliable (*r* = .32, $p < .01$, one-tailed test).
  - The active *(r* = .33) and passive *(r* = .31) conditions were equally reliable.


Sentence Judgments
Sentence Judgment Means
4.00
3.50
3.00
2.50
2.00
Control
Digit
Symbol
Task Type
Word Relatedness
Active/Related
Active/Unrelated
Passive/Related
Passive/Unrelated

Conclusion 1

- Two related nouns are forwarded for grammatical encoding in a single, integrated representation rather than encoded sequentially one after the other.
- Thus, prompt relatedness can impact verbal WM rather than visual WM.

Conclusion 2

- Active sentences demand more WM resources to produce as well as to comprehend.
- Active sentences interfered more with visual as well as verbal WM tasks (or possibly demanded more executive attention) compared with passive sentences.

Progress Report

- The 1996 model, like many adolescents, stands chastened by outcomes.
- While right about some matters, it was wrong about others.
- Progress has been made, especially in developing the methods needed for testing alternative models.
- Attaining maturity in our understanding WM in writing remains distant but attainable.