Short-Term Memory for Serial Order

PSYC201: Cognitive Psychology

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Week 8

Learning Objectives

- Short-Term Memory: The Engine of Cognition
- Benchmark Findings:
  - memory span
  - serial position curve
  - list length effect
  - error patterns
  - grouping effects
  - phonological similarity effect
- Phonological Loop Account of Short-Term Memory
- Summary and Conclusions

Serial Recall Task

- **Serial recall** is the classic method for studying memory for sequentially ordered materials
- Participants study a series of items (e.g., words, letters, or digits)
- Items presented one at a time (visually or aurally) at a rate of 0.5 to 1s per item
- Immediately after the final item (or following a brief delay), participants must recall list in forward order
- Recall may be spoken, typed, or written

Serial Recall Task

Serial Recall Task

+

Serial Recall Task

3

Serial Recall Task

9

Serial Recall Task

5

Serial Recall Task

1

Serial Recall Task

7

Serial Recall Task

4

Serial Recall Task

Recall

Short-Term Memory: The Engine of Cognition

- Serial recall is a deceptively simple task (Hurlstone, 2021)
- Short-term memory for serial order is critical for various acts of higher-level cognition:
  - vocabulary acquisition (Baddeley et al., 1998)
  - speech production (Adams & Gathercole, 1996)
  - mental arithmetic (Furst & Hitch, 2000)
  - predictive of fluid intelligence and reasoning ability (Oberauer et al., 2007)
- Hence, short-term memory is “The Engine of Cognition"
- Understanding short-term memory may be key to solving other puzzles of cognitive functioning

Short-Term Memory: The Engine of Cognition

- Research has focused on characteristics of short-term memory for sequences that differ from long-term memory processes
- One key question is whether short sequences are maintained in a short-term store, and if the store is phonological (i.e., speech-based) in nature
- A second key question is how serial order information is stored and retrieved from short-term memory

Today:

- Review key data on short-term memory for serial order
- Tomorrow: theories of serial order in short-term memory

Short-Term Memory: The Engine of Cognition

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Short-Term Memory Benchmarks

- More than 15,000 papers published on the topic of short-term memory
- Vast amount of data escapes concise summary
- Fortunately, there is agreement on a set of findings that are considered benchmarks:
  1. reproducible
  2. generaliseable
  3. theoretically constraining
- Here, we consider a sub-set of key serial recall benchmarks

Serial Recall and Memory Span: Item Class & Modality

- A defining feature of short-term memory is limited capacity
- **Memory span** is the maximum number of items participants can correctly recall on 50% of trials
- Varies dependent on item classes (e.g., digits vs. words):
  - five words, six letters, seven digits (Cranell & Parish, 1957)
- Memory span higher for auditorily than visually presented lists (Drewnowski & Murdock, 1980)
- Item class and modality only two factors that limit memory span

Serial Recall and Memory Span: Word Length

- Memory span varies with specific features of items
- Memory span depends on word-articulation times (Baddeley et al., 1975):
  - memory span higher for words that can be spoken rapidly (e.g., *sum, wit, hate*) ...
  - ... than for words that take longer to articulate (*opportunity, university, aluminium*)
- Known as the **word-length effect**
- Not due to differences in number of syllables, number of phonemes, or word frequency
- Memory span $\approx$ number of items that can be spoken in 2 sec (Baddeley et al., 1975)

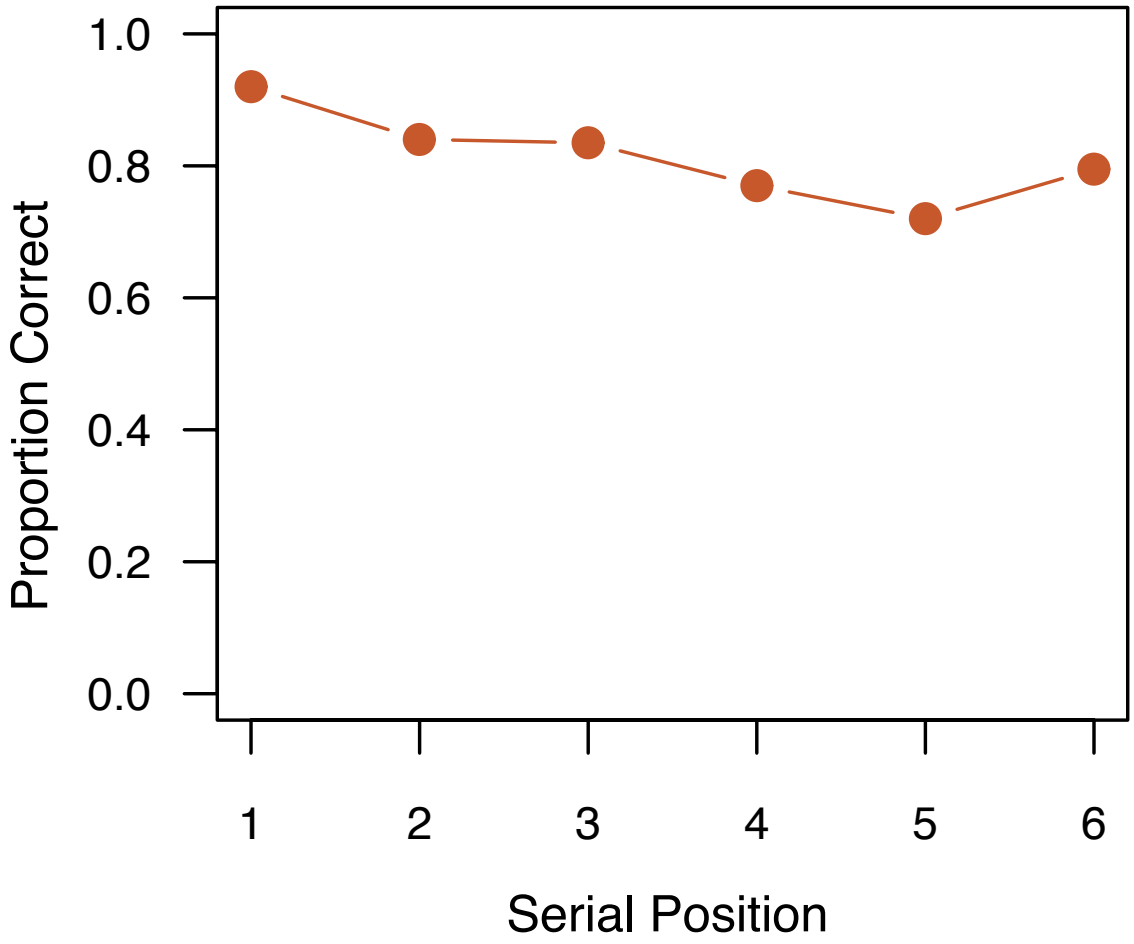
Serial Recall and Memory Span: Word Length

- Word length effect is one source of evidence for *phonological coding* in short-term memory
- One view is that serial recall depends on retrieval from a phonological short-term store
- Items in the store are coded in terms of their phonological characteristics, which decay rapidly
- Known as the **phonological loop** because rehearsing items can prevent decay of the phonological trace (Baddeley, 1986)
- Word length effect arises because shorter words can be rehearsed more quickly

Serial Position Curve

- Serial position curve plots recall accuracy as a function of the serial positions of items
- Exhibits two characteristics:
  1. superior performance for early list items (the **primacy effect**)
  2. advantage for terminal items (the **recency effect**)
- The serial position curve is asymmetrical, with stronger primacy than recency

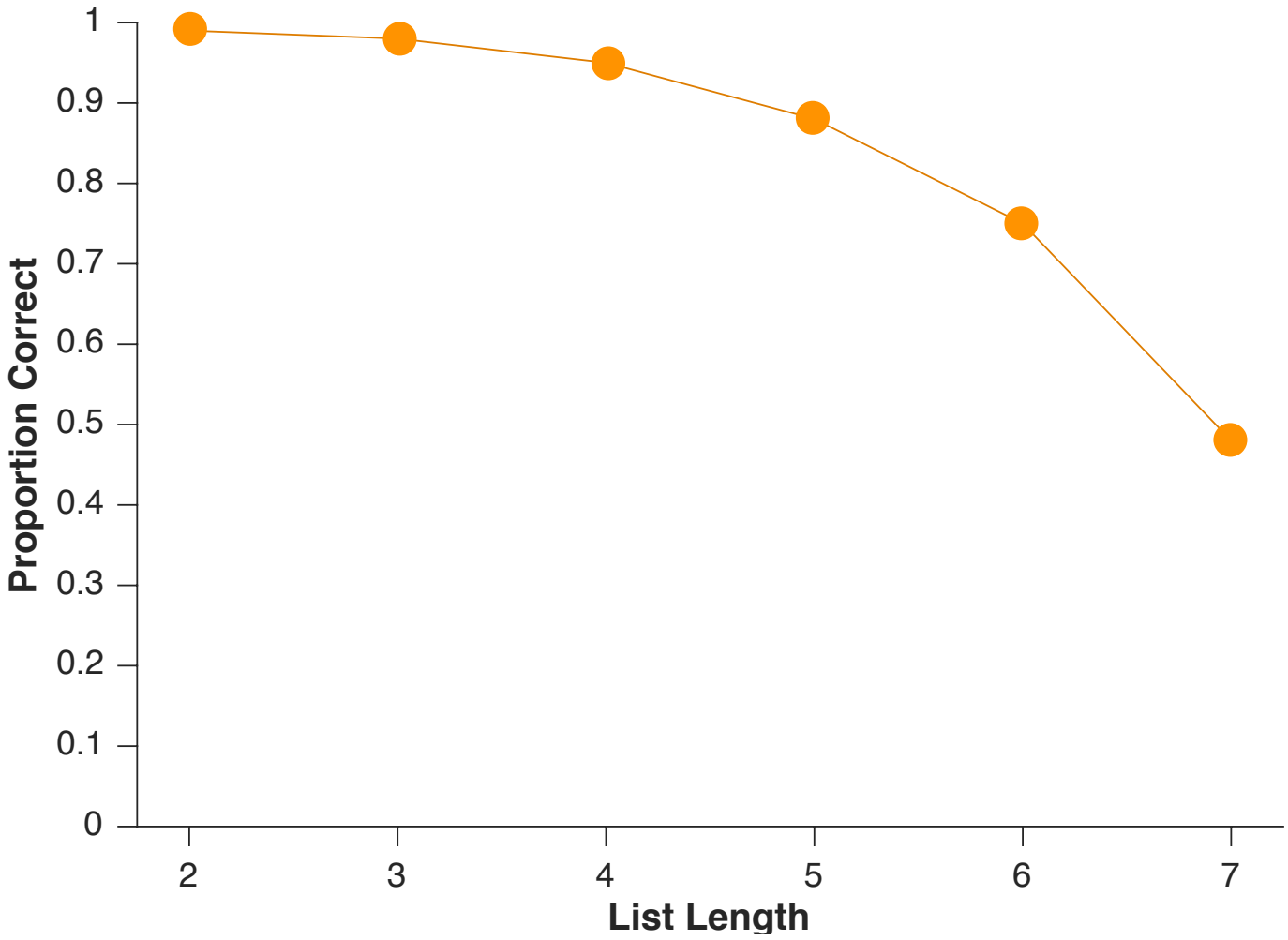
Serial Position Curve (Henson et al., 1996)



List Length Effect

- Serial recall performance decreases as a function of increasing list length (the **list length effect**)

List Length Effect (Unsworth & Engle, 2006)



Error Patterns

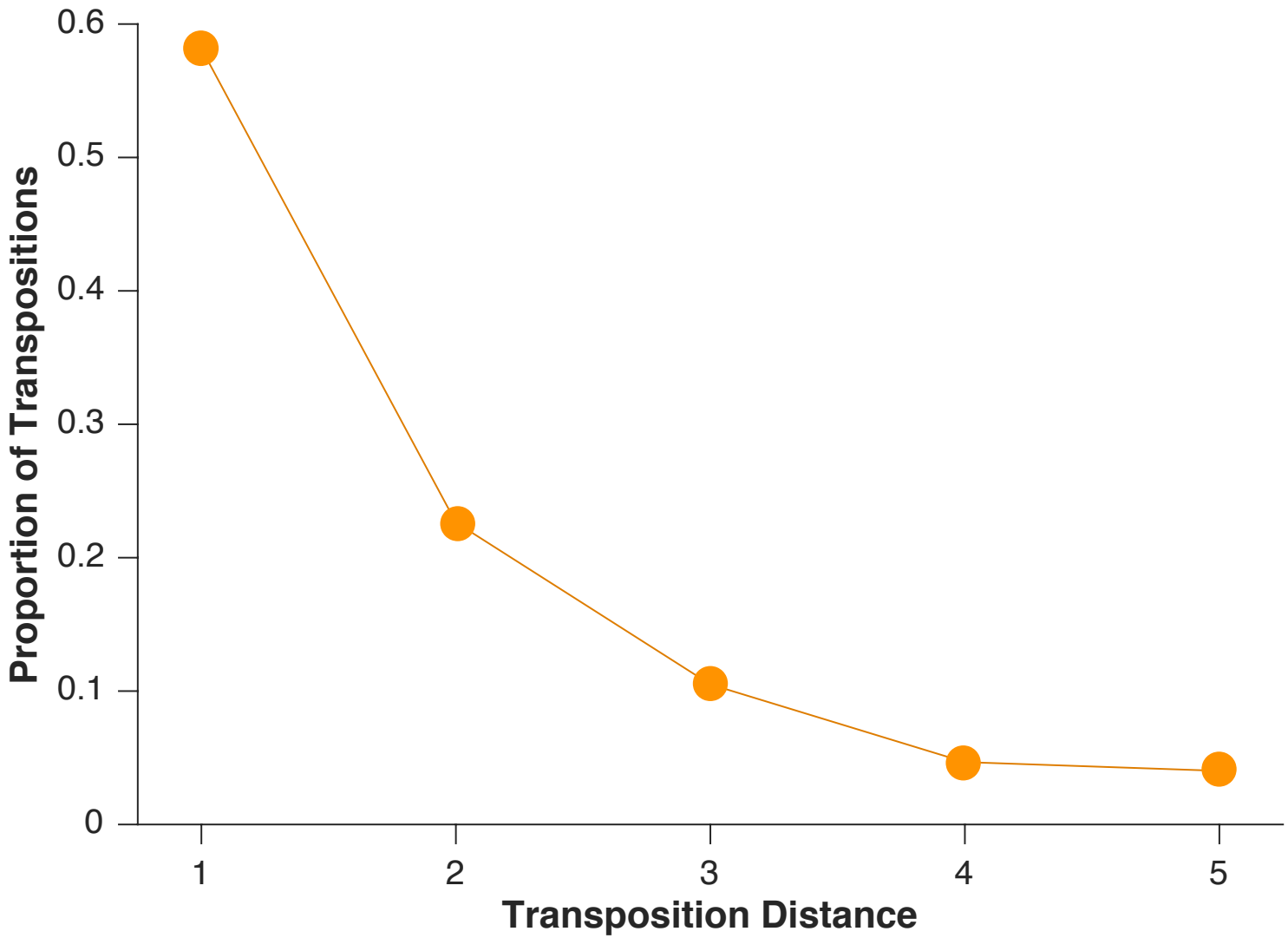
- Error analysis is “the royal road to memory” (Reuben Conrad; A. D. Baddeley, personal communication, 2008)
- Patterns of errors are useful in discriminating between different mechanisms for generating serial order
- In serial recall, there are two broad classes of errors:
  1. transposition (or order) errors
  2. item errors
- The frequency and distribution of these errors is highly systematic and predictable

Reuben Conrad

Transposition Errors

- A transposition error occurs when a list item is recalled in an incorrect position
  - recalling R M Q **H** **J** V in response to R M Q **J** **H** V
- Most transpositions involve neighbouring list positions, such that the third item might be recalled in the second or fourth position (rather than the first or seventh)
- This property of transpositions is known as the **locality constraint** (Henson et al., 1996)
  - frequency of transpositions decreases with increasing distance from correct position

Transposition Errors: Locality Constraint (Henson et al., 1996)



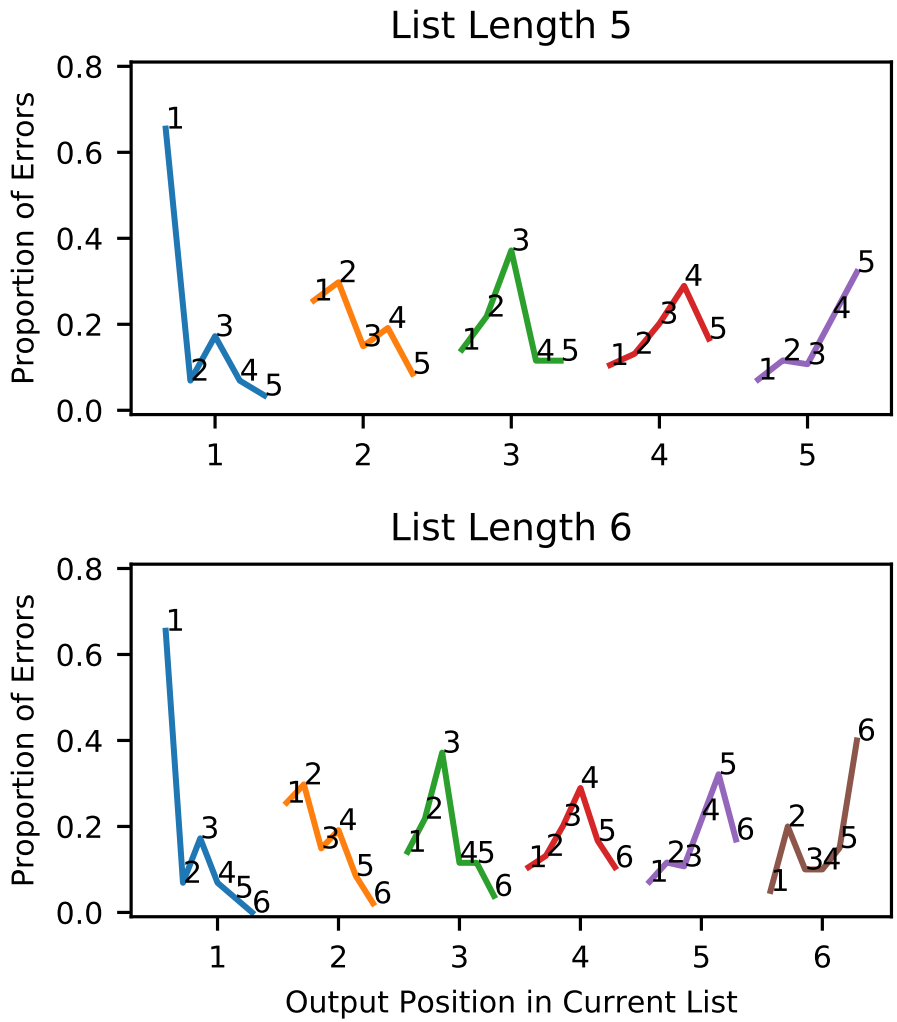
Transposition Errors: Sequential Dependencies (Farrell et al., 2013)

- Closer examination of transpositions reveals a pattern of sequential dependency
- Suppose an item is recalled one position before its correct position (i.e., recalling B ... in response to the list A B C D)
- What happens at the position following the initial error?
  1. the error can be followed by report of the first item (i.e., B A ...), an error known as a **fill-in**, or
  2. it can be followed by report of the third item (i.e., B C ...), an error known as **infill**
- Fill-in errors are known to be roughly twice as frequent as infill errors (Farrell et al., 2013)

Item Errors: Intrusion Errors

- Sometimes people will mistakenly introduce an extra-list item into their recall
- These **intrusions** frequently involve items from the immediately preceding list
- Such errors are known as **protrusions** and tend to occur at the same position as on the original list
- For example, recalling R M **Y** J **Z** V after the list R M **Q** J **H** V when the prior list was F P **Y** K **Z** W
- The frequency of intrusions increases with serial position

Protrusion Errors (Osth & Dennis, 2015)



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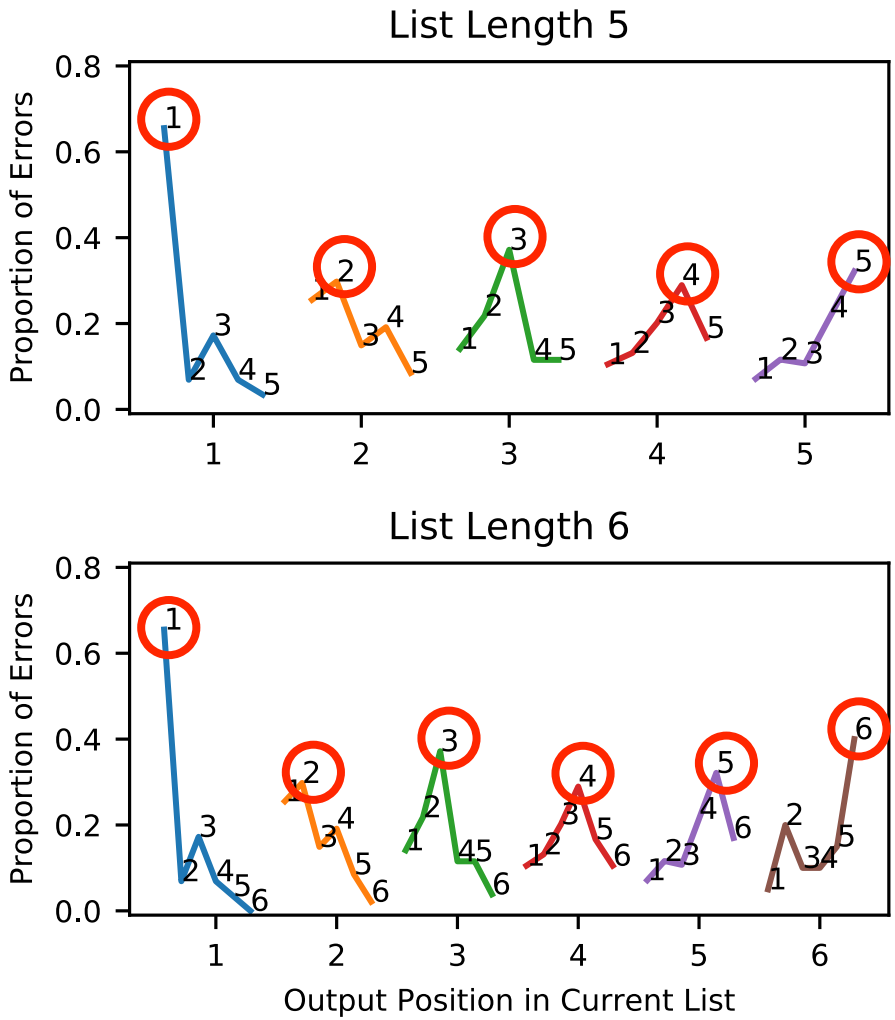


Item Errors: Omission Errors

- Sometimes people will “skip” items during recall
- The resulting errors are known as **omissions** and their frequency increases with serial position
- For example, recalling R M Q J _ _ after the list R M Q J **H V**

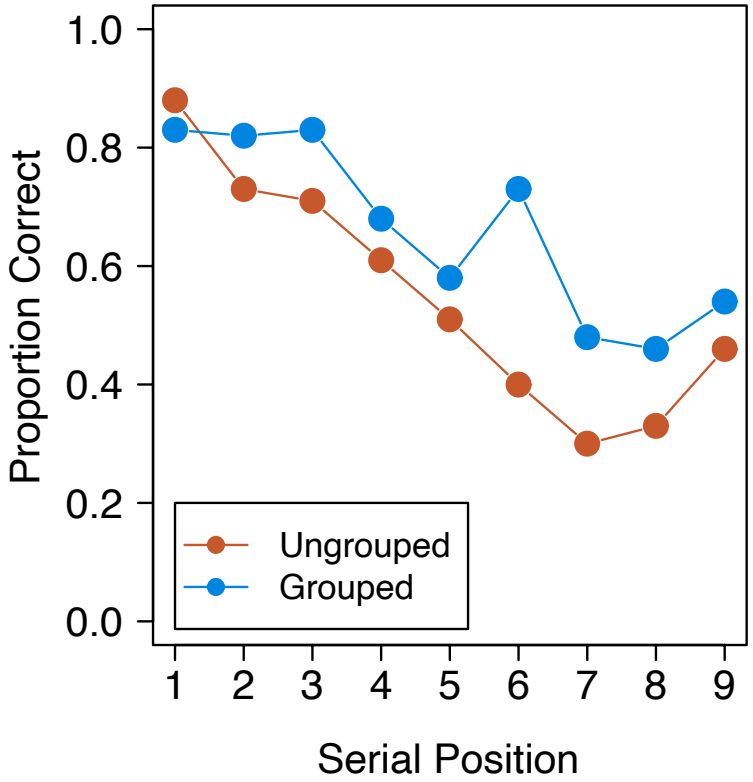
Item Errors: Repetition Errors

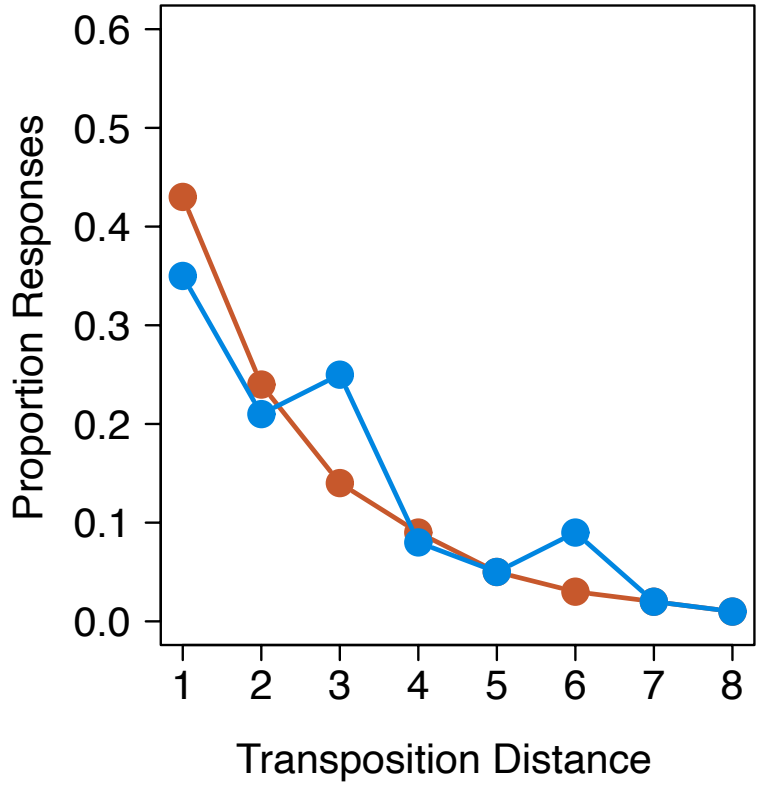
- A **repetition** occurs when an item is recalled on more than a single occasion despite being presented only once in the study list
- For example, recalling R M Q **R** H **M** in response to the list **R** **M** Q **J** H **V**
- Repetitions are extremely rare accounting for approximately 2% to 5% of all responses (Vousden & Brown, 1998)
- Most repetitions are early list items reported a second time late in recall
- In consequence, repetitions are typically separated by 3 or 4 serial positions

Grouping Effects

- **Temporal grouping** involves organising a list into sub-groups by inserting extended temporal pauses after every few items (i.e., H N Q ... L F Y ... R J S)
- Produces several reliable effects on serial recall
- Compared to ungrouped lists:
  1. grouping enhances recall accuracy
  2. causes primacy and recency effects within groups, as well as the list as a whole
  3. reduces frequency of transpositions overall, but increases frequency of **interpositions**; transpositions between groups that preserve their position within groups (i.e., H **F** Q ... L **N** Y ... R J S)

Grouping Effects (Hurlstone, 2019)





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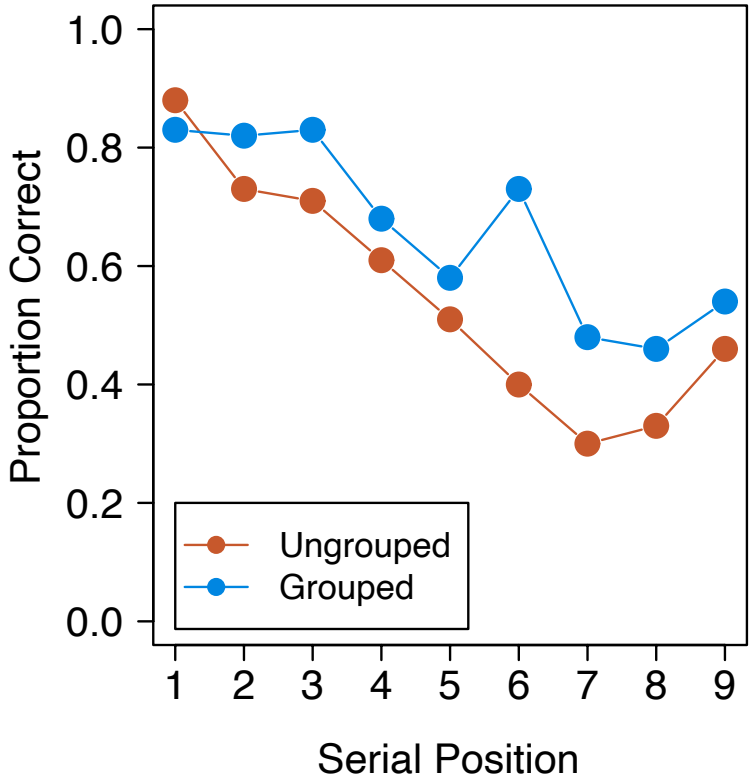
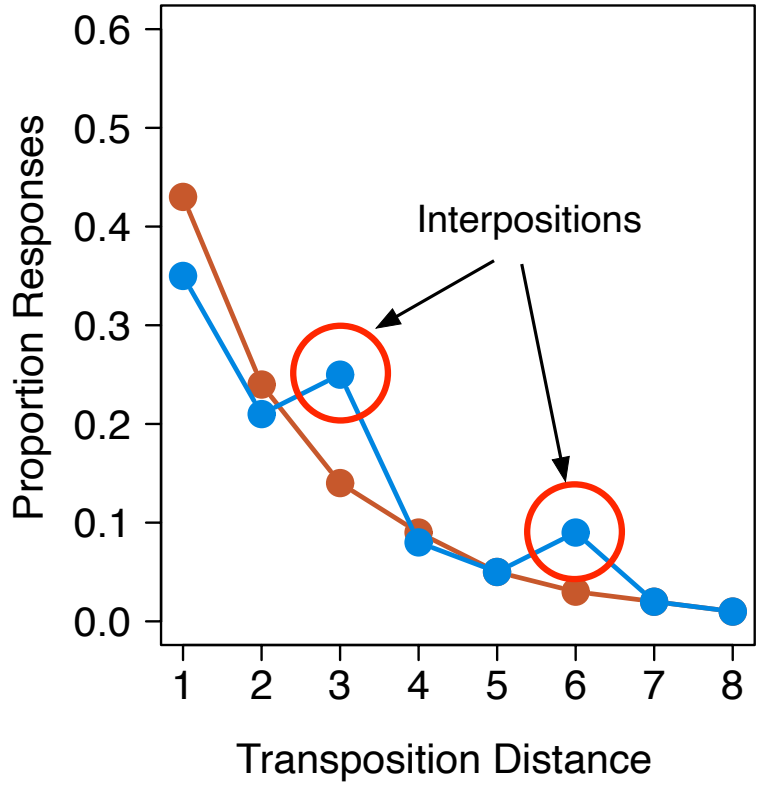
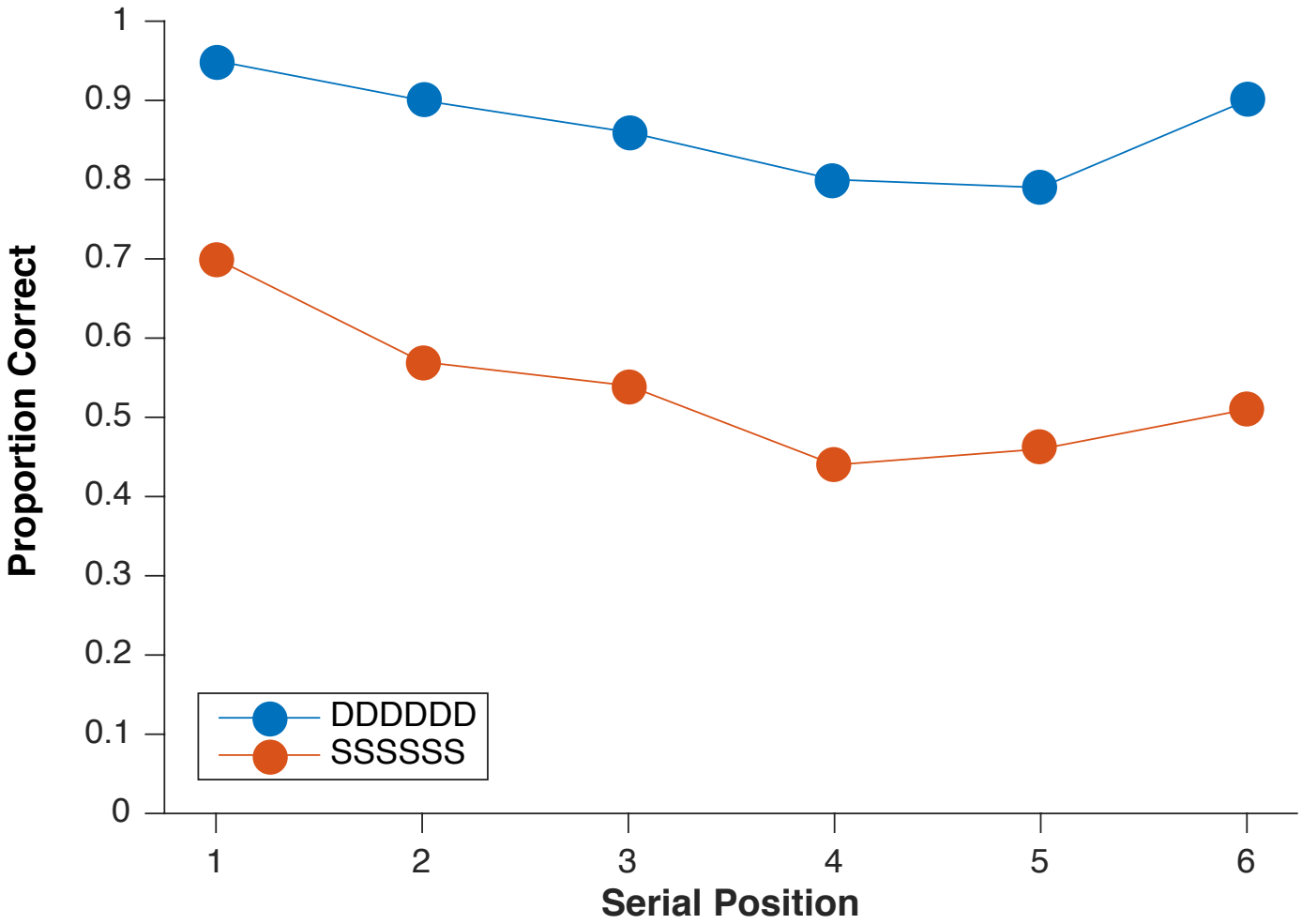




Phonological Similarity Effect

- Lists of phonologically similar sounding items (e.g., *B D G P T V*) are recalled less accurately than lists of phonologically dissimilar sounding items (e.g., *F K L R X Y*; Baddeley, 1968; Conrad, 1964)
- This **phonological similarity effect** is a major source of evidence for phonological coding in verbal short-term memory
- The effect is a cornerstone of the phonological loop theory (Baddeley, 1986)
- Hugely influential finding for theorising about verbal short-term memory

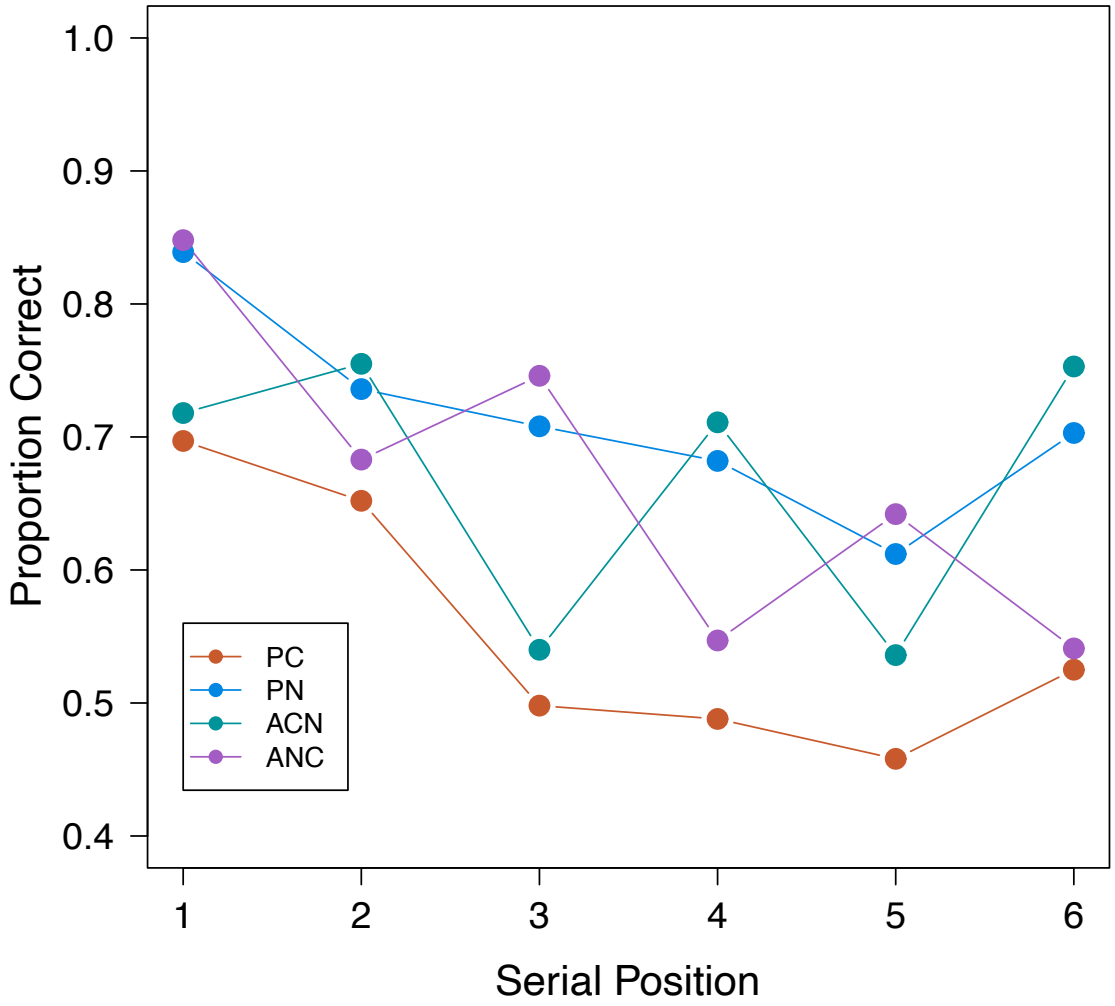
Phonological Similarity Effect (Farrell & Lewandowsky, 2003)



Mixed-List Phonological Similarity Effect

- The phonological similarity effect is also observed when lists are constructed by alternating phonologically dissimilar and similar items (e.g., *F B K G R T*)
- Such mixed lists create a saw-toothed accuracy serial position curve, with peaks corresponding to recall of dissimilar items and troughs corresponding to recall of similar items (Baddeley, 1968)
- This mixed-list phonological similarity effect has been influential in distinguishing theoretical accounts of serial order in short-term memory

Mixed-List Phonological Similarity Effect (Page et al., 2007)

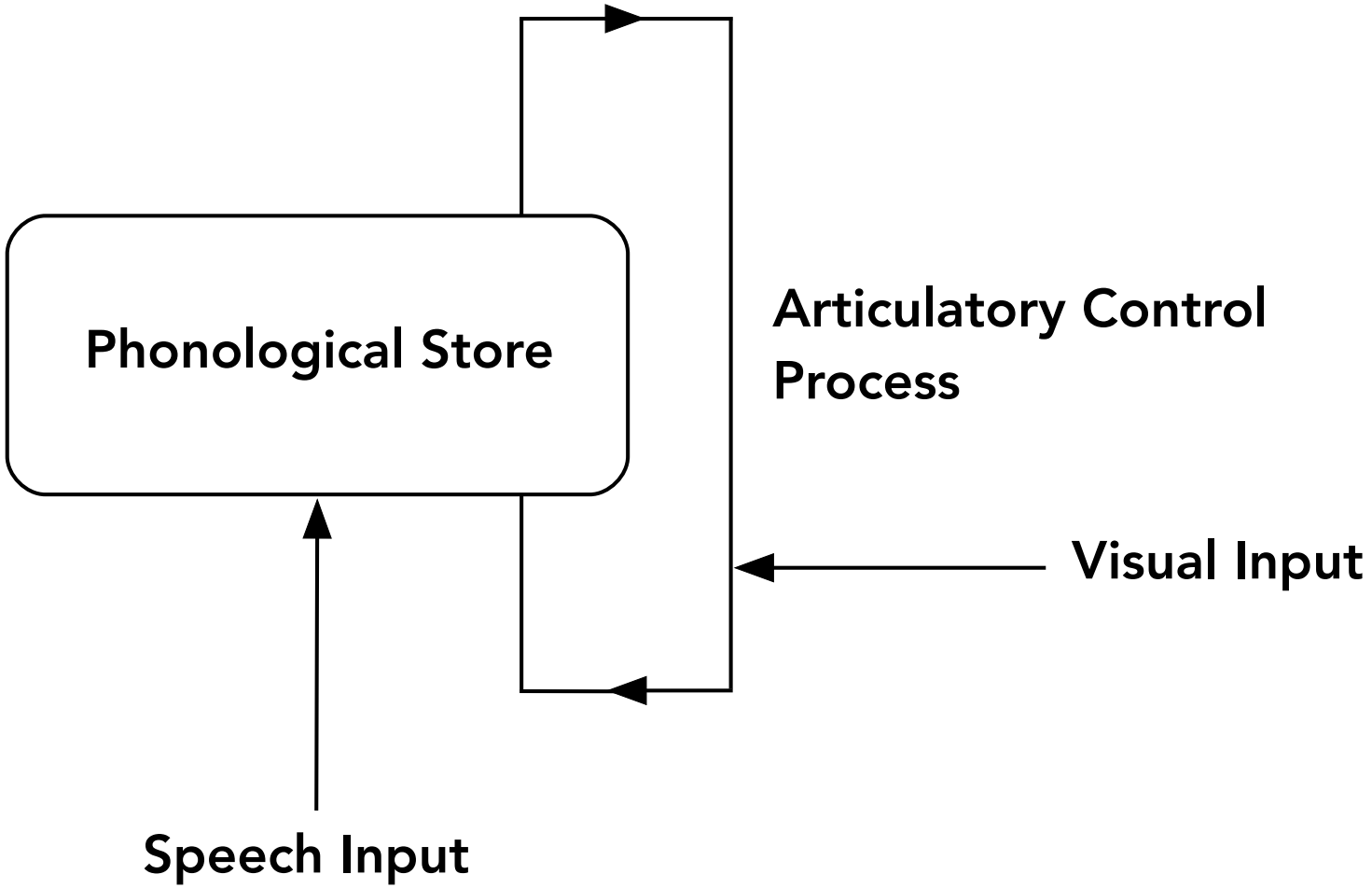


Phonological Loop Account (Baddeley, 1986)

- The phonological loop comprises two components:
  1. a **phonological store** which holds phonological representations of verbal items that are subject to loss due to decay
  2. an **articulatory control process** (subvocal speech) that can be used to refresh the contents of the store
- For auditory input, entry into the phonological store is automatic and obligatory
- For visual input, entry depends on visual-verbal information being converted into phonological form via the articulatory control process

Alan Baddeley

Phonological Loop Account (Baddeley, 1986)



Phonological Loop Account (Baddeley, 1986)

- The articulatory control process can be disrupted via *articulatory suppression*
- This involves the repeated utterance of an irrelevant verbal token (e.g., *'the', 'the', 'the'*)
- This prevents the articulatory control process from refreshing the decay-prone contents of the phonological store
- It also prevents visual-verbal input from being converted into phonological form to enter the phonological store

Phonological loop evidenced by interplay of four variables:

- Phonological similarity, word length, presentation modality (auditory vs. visual), and articulatory suppression

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Phonological loop evidenced by interplay of four variables:

- Phonological similarity, word length, presentation modality (auditory vs. visual), and articulatory suppression

Phonological Loop Account (Baddeley, 1986)

- The main empirical signature of the phonological loop is the phonological similarity effect
- Arises due to confusions between similar phonological representations when retrieving items from phonological store
- The effect with auditory input should survive under articulatory suppression (auditory input gains automatic access to the phonological store)
- With visual input the effect should disappear (articulatory control process is needed to recode visual-verbal information into phonological form)
- These predictions have been empirically confirmed (e.g., Baddeley et al., 1984)

Phonological Loop Account (Baddeley, 1986)

- The word length effect is another empirical signature of the phonological loop
- Arises because shorter words can be rehearsed more quickly, providing more opportunity to offset forgetting due to decay
- Regardless of presentation modality (auditory vs. visual), the effect should disappear under articulatory suppression
- Articulatory suppression blocks use of the articulatory control process, the mechanism by which the word length effect is generated
- These predictions have been empirically confirmed (Baddeley, et al., 1975)

Phonological Loop Account (Baddeley, 1986)

- Hugely influential account of verbal short-term memory
- Provides a parsimonious explanation of the effect of several key variables
- But, most aspects of the model have been questioned (e.g., Jones et al., 2006)
- *A serious shortcoming is that it does not specify the mechanism by which serial order is maintained*

Tomorrow:

- Focus on theories of serial order in short-term memory

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Recommended Reading

Hurlstone, M. J. (2021, in press). Serial recall. Invited book chapter contribution to Kahana, M., and Wagner, A. *The Oxford Handbook of Human Memory* (Oxford University Press). `https://mark-hurlstone.github.io/H.21.OHHM.pdf`

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