Memory: A two-component model

• The most influential model by Atkinson and Shiffrin (1968)
  • Long-term Memory (LTM)
  • Short-term Memory (STM)

• The flow of information

environment ➔ a temporary short-term storage system ➔ a more durable long-term memory

  also serves as a working memory

• Working memory: a workplace
  • structures and processes used for temporary storage and manipulation of information

• Short-term memory: short-term storage of information
Memory: A two-component model

• Evidence from neuropsychology
  • Damage to the medial temporal lobe
    • Impaired capacity for new learning
    • Performance on STM tasks unaffected
  • Conduction aphasia patients -> a specific deficit in STM

• A Paradox

Problems in STM (functions as a working memory) ➔ Problems in LTM ➔ Problems in a wide range of other complex cognitive tasks
Working Memory: A three component model

- To tackle this paradox ...
  - Divide the unitary WM into three separable components

A visual subsystem for storage and manipulation
An attentional system that controls behavior
A temporary verbal-acoustic storage system
The Visuospatial Sketchpad

• A visual subsystem of working memory
  • Function:
    - Less relevant to language disorders

Visuospatial Sketchpad

Spatial information
Visual information
Kinesthetic information

integration

Unified representation stored and manipulated
• An unexpected role in comprehension
  • Grammatical capacity of people with Williams syndrome
    • Preserved verbal skills
    • Impaired visuospatial processing
  • Subjects: 3 groups
    • WS: Williams Syndrome
    • TD: typically developing children
    • MLD: Minimal Learning Disability
  • Procedure: present sentences
    • with/without spatial term
  • Task: find the corresponding picture from 4
The Central Executive

- The attentional control of working memory
  - Effect on language processing

- Executive Processes determine Working Memory Span
  - Robust predictor for Wide range of complex Cognitive Skills
  - Influence on Reading Comprehension and Learning
The Phonological Loop

• Two subcomponents

<table>
<thead>
<tr>
<th>Phonological loop</th>
<th>Temporary storage system</th>
<th>Subvocal rehearsal system</th>
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Hold memory traces over seconds, decay unless refreshed by ...

Maintain information & Register visual information (item can be named)

• Evidence for subvocal
  • Subvocal -> Retention depend on acoustic phonological characteristics
    • Easy: B, W, Y, K, R, X
    • Hard: T, C, V, D, B, G
    • Easy: pit, day, cow, sup, pen
    • Hard: man, cat, map, cab, can
The Phonological Loop

• Evidence for rehearsal \(<-\) the Word Length effect
  • Present 5-word sequences
  • Require immediate serial recall
    • Number of syllable ↑, Performance ↓
    • Less rehearsal

• Wiped out by utterance of a sequence of irrelevant sounds
  • Output delay held consistent

• Retention through rehearsal blocked
The Phonological Loop

Neuroanatomical basis

• Evidence for separable storage and rehearsal systems

  • Lesions and neuroimaging Studies
    • Brodmann area 44: storage
    • Broca’s area (Brodmann area 6 and 40): subvocal rehearsal
  • Activation principally in the left hemisphere
The Phonological Loop
Functional significance

• What biological function is served by the system?
  • STM deficits -> few problems in daily life

• Hypothesis: facilitate the acquisition of language
  • Subject: patient with pure phonological STM deficit
  • Task:
    • (1) acquisition of the vocabulary of an unfamiliar foreign language
      • 8 items of Russian vocabulary (e.g., rose – svieti)
    • (2) learning to associate pairs of unrelated words in native language
      • e.g., horse - castle
  • Result: normal in (2), but completely failed in (1)
  • Conclusion: A useful aid in learning new words
The Phonological Loop
Functional significance

• What biological function is served by the system?
  • STM deficits -> few problems in daily life

  • Hypothesis: facilitate the acquisition of language
    • Extend the findings:

  • Confined to second language learning
    • Acquisition of native language?

• Variables that impair the phonological loop
  - Disrupt
  - Foreign language learning
  - Paired associate learning in native language
The Phonological Loop
Native language acquisition

• The phonological loop and native language acquisition
  • Follow-up: tests of verbal memory

A group of children with a specific language impairment (SLI)
• Mean age: 8 years
• Nonverbal intelligence: normal
• Language development: delay of 2 years

• A particular deficit in sound mimicry
  • the capacity to hear and repeat nonwords
- The phonological loop and native language acquisition
  - Follow-up: a developed nonword repetition test

A group of normal children
- Mean age: 8 years
- Nonverbal intelligence: matched
- Language development: normal

A group of children with a specific language impairment (SLI)
- Mean age: 8 years
- Nonverbal intelligence: normal
- Language development: delay of 2 years

A group of younger children
- Mean age: 6 years
- Nonverbal intelligence: normal
- Language development: matched

- SLI group: 4 years behind the age & 2 years behind the language development
  - Deficit <- impairment in the phonological storage component
The Phonological Loop
Native language acquisition

- Investigation within normal children
  - Groups of 4 year olds & 5 year olds
    - Measuring ...
      - Nonword repetition
      - Nonverbal intelligence
      - Vocabulary
    - Clear association between nonword repetition and vocabulary
      - Phonological loop facilitates native language acquisition

- Correlation ≠ Causation
  - Rich vocabulary facilitates acquisition of new words?
• Investigation within normal children
  • Evidence for the primacy of phonological storage
    • Cross-lagged correlation
      • Relate vocabulary and nonword repetition between 4 and 5
The Phonological Loop
An alternative view

• An alternative view
  • Phonological storage
    • merely a reflection of deeper phonological processing problems

• A model by Brown and Hulme (1996)
  • No role for phonological storage
  • Emphasize on the role of existing language habits in facilitating vocabulary learning
• Evidence for the alternative view
  • An important study by Gathercole (1995)
    • For any nonword, some sequences are harder than others
      • Easier: resemble English words (e.g., stirple, blonterstaping)
      • Harder: unfamiliar phoneme sequences (e.g., kipser, perplisteronk)
  • Follow-up study
    • Influence of existing language habits on current nonword repetition performance
The Phonological Loop
An alternative view

• One way of explaining this pattern of results ...
  • Phonological loop
    • divided into separate storage and articulatory components
  • Highly appropriate in retrospect
    • If storage dominated by habits ...
      • new items swamped by old items -> new learning hindered by habits
  • Articulatory output impacted by habits
    • enhance repetition of familiar phoneme sequences
The Phonological Loop
An alternative view

• Evidence for the explanation
  • A series of studies by Gathercole et al.
    • Subjects: children who might have articulatory difficulties
    • Procedure: children hear 2 sequences of words or nonwords
      • E.g., *dog, pen, hat, tip* -- *dog, hat, pen, tip*
    • Task: identical or changed
      Performance with word sequences vs. Performance with nonword sequences
  • Result: the lexicality effect disappeared
    • Familiarity of phoneme sequences
  • Conclusion: **Existing language habits** -- impact on output and rehearsal
Conclusion

- **Working Memory ...**
  - A temporary storage system
    - Implications for language processing
    - Disorders impact on language processes
  - Deficits within the phonological loop or other aspects
    - Serious impair language processing

- The interface between working memory and language
  - Continue to be fruitful
Questions

• Word length effect?  
  • Long words take longer to recall?
  • How is the phonological information stored?
  • What’s the unit of phonological information?

• How is the written language processed in working memory exactly?
  • How is the visual information registered by the subvocal rehearsal system utilized?
  • How is stored visual information integrated with phonological information?
  • How does the visuospatial sketchpad integrate with phonological loop?