Working Memory and Language Production

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Bock and Levelt (1994) Model of Speech Production

MESSAGE

- Functional
  - Lexical Selection
  - Function Assignment

- Positional
  - Constituent Assembly
  - Inflection

- Processing

- Phonological Encoding
  - to output systems

Grammatical Encoding
Knowledge Representation

Semantic Features

Lexical Nodes

CAT  DOG  TRUCK

Phonological segments

k  ae  d  t  r  a  g

Short-term Memory Buffers

Lexical-Semantic Buffer

S1 S2 S3 S4 S5 S6 S7 S8
\  \  \  /  /  /  /  /
L1  L2  L3  L4

Phonological Buffer

P1 P2 P3 P4 P5 P6 P7 P8

Martin, Lesch & Bartha (1999)
Knowledge Representation

Semantic Features

Lexical Nodes

Input phonological segments

Output phonological segments

Short-term Memory Buffers

Lexical-Semantic Buffer

Input Phonological Buffer

Output Phonological Buffer

Martin, Lesch & Bartha (1999)
## Patient Background

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Education</th>
<th>Lesion Site</th>
<th>Aud. Span</th>
<th>Visual Span</th>
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</thead>
<tbody>
<tr>
<td>EA</td>
<td>64</td>
<td>College</td>
<td>Temporo-Parietal</td>
<td>1.5</td>
<td>2.5</td>
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<tr>
<td>AB</td>
<td>74</td>
<td>College, Law</td>
<td>Frontal-Parietal</td>
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<td>1.5</td>
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<td>ML</td>
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<td>2 Yrs. College</td>
<td>Frontal-Parietal</td>
<td>2.5</td>
<td>1.5</td>
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<td>GR</td>
<td>54</td>
<td>College</td>
<td>Frontal-Parietal-Temporal</td>
<td>3.3</td>
<td>2.2</td>
</tr>
</tbody>
</table>
Patient Background (cont).

All show normal performance on:

1. picture naming (BNT)
2. single word comprehension (PPVT)
Composite STM Scores
(Freedman, 1998)

Phonological
1. Immediate vs. delayed phoneme discrimination
2. Nonword repetition - 1 & 2 syllable vs. 3 & 4 syllable
3. Rhyme probe

Semantic
1. Category probe
2. Word-nonword
3. 2 choice vs. 3 choice relatedness judgments
4. Attribute judgments
Phonological vs. Semantic Composite STM Scores

Subject

<table>
<thead>
<tr>
<th>Subject</th>
<th>Phon (EA)</th>
<th>Semantic (AB)</th>
<th>Semantic (ML)</th>
<th>Semantic (GR)</th>
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<tbody>
<tr>
<td>EA</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>1</td>
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<tr>
<td>AB</td>
<td>0</td>
<td>-1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>ML</td>
<td>0</td>
<td>0</td>
<td>-1</td>
<td>0</td>
</tr>
<tr>
<td>GR</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Combined Z-scores

-5 -4 -3 -2 -1 0 1 2 3 4 5
• Sentence comprehension - Sensibility judgments
  – Adjectives before - delayed integration
  • Examples of anomalous sentences

  The rusty old red swimsuit was brought to the beach
  Distance 3

  The rusty swimsuit was brought to the beach
  Distance 1
Sentence comprehension

• Adjectives after - immediate integration
  – examples

The swimsuit that was old, red, and rusty was lying on the back seat.

Distance 3

The swimsuit that was rusty was lying on the back seat

Distance 1
• Sentence comprehension - Sensibility judgments
  – Nouns before - delayed integration
  • Examples of anomalous sentences

  The rug, the vase, and the mirror cracked during the move
  
  The rug cracked during the move.
Sentence comprehension

• Nouns after - immediate integration
  – Examples of anomalous sentences

  The movers cracked the mirror, the vase and the rug.
  Distance 3

  The movers cracked the rug.
  Distance 1
Sentence Anomaly Judgments:
Mean Errors Distance 2 & 3 - Distance 1

Subject

Controls  EA (phon)  AB (sem)  ML (sem)

Percent Errors

Before  After

Martin & Romani (1994); Martin & He (2000)
Relation between Working Memory Capacities in Comprehension and Production

Dissociations between input and output phonological capacity:

1) Martin, Lesch & Bartha (1999). Preserved input, disrupted output capacity

2) Shallice & Butterworth (1977), Martin, Shelton & Yaffee (1994) Disrupted input, preserved output capacity
Knowledge Representation

Semantic Features

Lexical Nodes

Lexical-Semantic Buffer

S1 S2 S3 S4 S5 S6 S7 S8
\ / \ /持ち\ /持ち\ /持ち\ /持ち
L1 L2 L3 L4

Input Phonological Buffer

Output Phonological Buffer

Input phonological segments

Output phonological segments

Martin, Lesch & Bartha (1999)
Same semantic capacity for input and output?

Patients AB and ML:

1) slow speech rate

2) reduced NP & VP complexity

3) grammatically correct speech for AB, mild impairment on function words and grammatical markers for ML
Noun Phrase Production

Single Noun (e.g., “leaf”)

Single Adjective (e.g., “green”)

Adjective Noun Phrase (e.g., “green leaf”)

Adjective-Adjective Noun Phrase (e.g., “small green leaf”)
## Percent Correct on Preliminary Noun Phrase Production Task
(numbers in parentheses are percent correct after self-correction)

<table>
<thead>
<tr>
<th></th>
<th>Adj.</th>
<th>N.</th>
<th>Adj N</th>
<th>AAN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Controls</strong></td>
<td>100</td>
<td>88</td>
<td>92</td>
<td>77</td>
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<tr>
<td>(n=6)</td>
<td></td>
<td></td>
<td>(93)</td>
<td>(97)</td>
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<tr>
<td></td>
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<td>(82)</td>
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</tr>
<tr>
<td><strong>Phonological STM</strong></td>
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<tr>
<td>EA</td>
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<td>(90)</td>
<td>(100)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(80)</td>
<td></td>
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<tr>
<td><strong>Semantic STM</strong></td>
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<td></td>
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<tr>
<td>AB</td>
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<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(30)</td>
<td>(0)</td>
</tr>
<tr>
<td>ML</td>
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<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(80)</td>
<td>(40)</td>
</tr>
</tbody>
</table>
Examples

A.B.

(short hair) Well.. that’s hair. It’s short. That’s short.... I can’t get it.

(small green leaf) That’s brown. No, br.. br.. green. I know it’s a leaf. It’s a green leaf and it’s big.

M.L.

(closed curtain) black curtain....gathered and closed ....closed curtain, closed curtain

(small, rough leaf) small...small...rough, rough leaf ....small, rough leaf

(large, smooth leaf) big....big,big...small, large ... big leaf
Production via Phrasal Fragments  
(Dell & Lapointe, 1989; de Smedt, 1990)

1) Phrase fragments activated differentially

2) Production begins before entire clause is planned

3) Phonological access waits on retrieval of lemma of lexical head of phrase and lemmas for all preceding content words (lexical head principle)

4) Minimal planning unit at lemma level is lexical head and lemmas for preceding words in the same phrase
Noun Phrase vs. Sentence Production

“The blonde hair” vs. “The hair is blonde”

“The curly blonde hair” vs. “The hair is blonde and curly”
Adj-N phrase:

the old pail
det-adj-N

the old red pail
det-adj-adj-N

N is adj:

the pail is old
(det-N) ((V) (adj))

the pail is old and red
(det N) ((V) (adj & adj))
Phrase vs. Sentence Production
AN and AAN Combined

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Controls</th>
<th>EA (phon)</th>
<th>ML (sem)</th>
<th>GR (sem)</th>
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</thead>
<tbody>
<tr>
<td>Percent Correct</td>
<td>80</td>
<td>70</td>
<td>60</td>
<td>40</td>
</tr>
</tbody>
</table>

Legend:
- Phrase
- Sentence
Onset Latencies

Subjects:
- Controls
- EA
- ML (sentence)
- CR (sentence)

Phrases vs. Sentences:
- Phrases (light blue bars)
- Sentences (dark red bars)

Y-axis: Seconds

X-axis: Subjects
Compound Noun Phrase Production

```
NP
│  conj  │  NP
│       │       │
│ NP    │ conj   │ NP
│       │       │
│ Det   │ N      │ Det   │ N
│       │ ball   │       │ the   │ block
│ The   │       │       │       │
```

Moving Picture Descriptions:  
Compound Noun Phrase Production  
(based on Smith and Wheeldon, 1999)

Simple-complex

The cup moves above the finger and the cross.  
The tie moves below the candle and the foot.

Complex-simple

The cup and the finger move above the cross.  
The tie and the candle move below the foot.
Smith and Wheeldon (1999)  
(young normal subjects)  
Onset latencies in ms

Simple-complex  962
Complex-simple  1039
Difference  77
Subjects

EA (phonological STM deficit)

ML (semantic STM deficit)

Age-matched controls: n=6
Experimental Design

128 experimental trials:
  64 simple-complex
  64 complex-simple

128 filler trials:
  32 all move left
  32 all move right
  32 all move up
  32 all move down
Procedure

Pre-testing: Subjects asked to name all pictures - provided with correct answer if incorrect

Practice: 32 practice trials sampling from all Experimental and control sentence types
Trial Sequence

Subject views 3 stationary objects and names each

Experimenter initiates object movement

Subject describes movement of objects from left to right

Picture removed 500 ms after movement onset
Scoring

Responses were digitized for patients and controls
Latencies measured to onset of first noun

Responses scored as errors:
  a. incorrect noun used
  b. noun omitted
  c. initiation of incorrect noun (e.g., “ki….finger”)
Moving Pictures Errors

Controls

EA

ML

Patient

Percent Errors

simple-complex

complex-simple

p < .05

NS
Error types for EA and ML

![Error types for EA and ML](chart.png)

**Error type**
- Omit final word
- Switch order
- Wrong prep
- Miscellaneous

**Percent of total trials**
- EA
- ML
Onset Latencies for Complex-Simple Minus Simple-Complex

Latency Difference

Subject

Controls  EA  ML
Summary of Moving Picture Experiment Results

A patient with a phonological retention deficit showed a normal latency effect for initial noun phrase complexity.

A patient with a semantic retention deficit showed a greatly exaggerated latency effect for initial noun phrase complexity.
Syntactic Complexity?

One clause sentences:

Simple active: The dog chased the cat.
Simple passive: The dog was chased by the cat.

Cleft sentences:

Active: That’s the dog that chased the cat.
Passive: That’s the dog that was chased by the cat.

Procedure: act out with animals, indicate which animal should be mentioned first
Production of frames with 3 content words

Patient

Percent Correct (last)

ML (sem)  GR (sem)  EA (phon)

AAN
One Clause Active-Passive
Cleft Active/Passive
Conclusions

1) Production proceeds on a phrase-by-phrase basis

2) The same lexical-semantic retention buffer is used in comprehension and production.

3) Different phonological capacities are involved in perception and production.