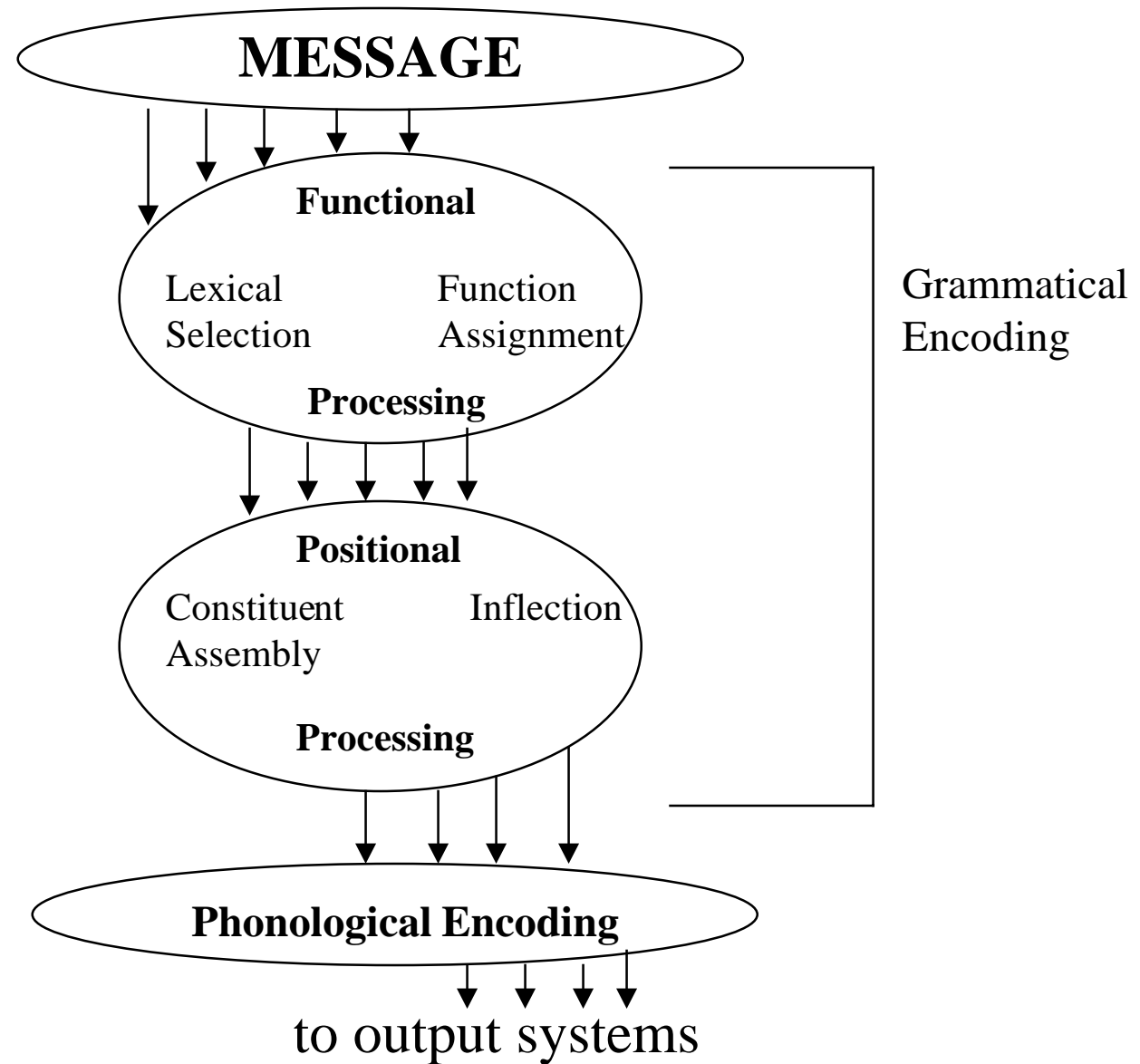# Working Memory and Language Production

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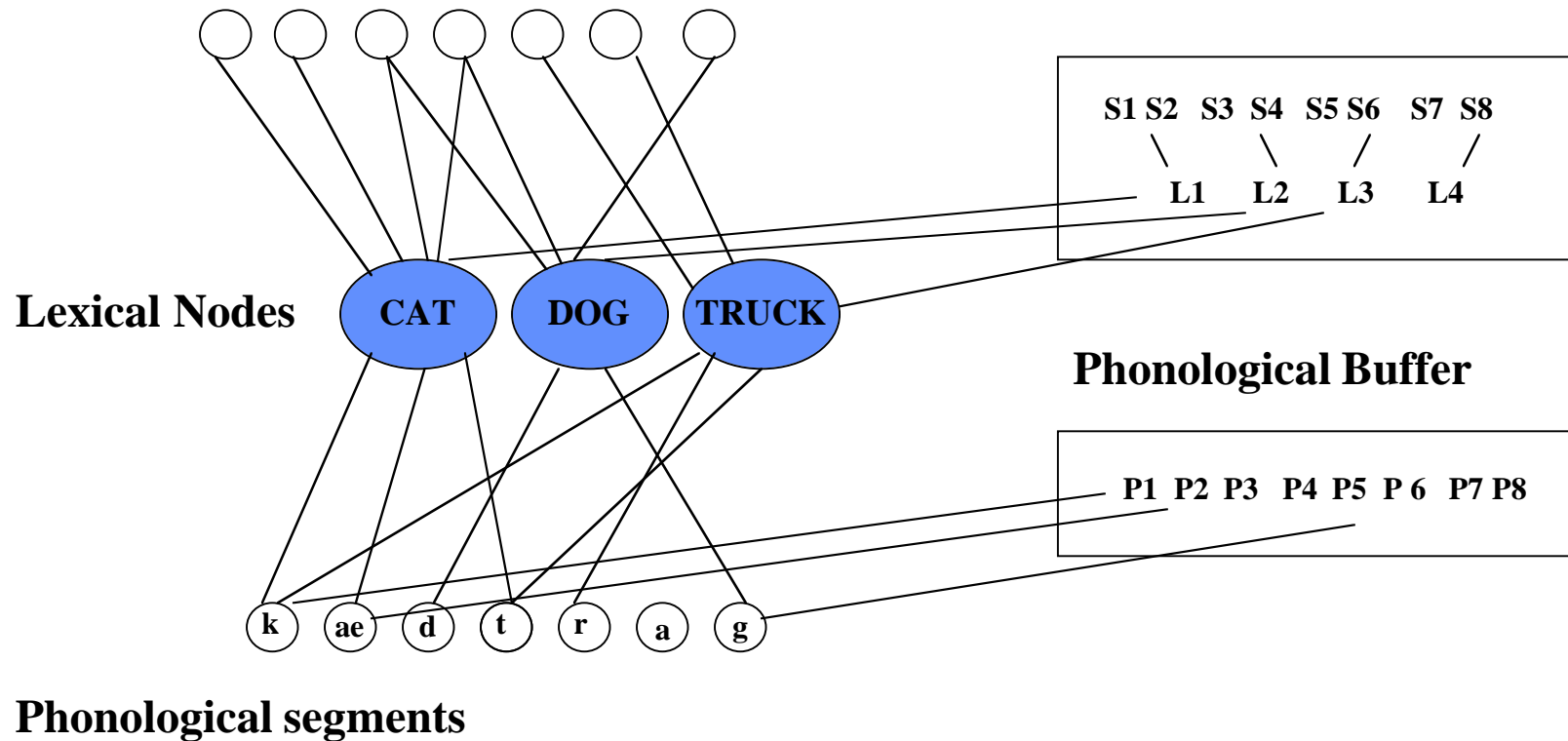# Bock and Levelt (1994) Model of Speech Production

MESSAGE

Functional

Lexical   Function
Selection   Assignment

Processing

Grammatical
Encoding

Positional

Constituent   Inflection
Assembly

Processing

Phonological Encoding

to output systems

Knowledge Representation

Short-term Memory Buffers

Semantic Features

Lexical-Semantic Buffer

S1 S2 S3 S4 S5 S6   S7 S8

L1   L2   L3   L4

Lexical Nodes   CAT   DOG   TRUCK

Phonological Buffer

P1 P2 P3   P4 P5 P 6   P7 P8

k   ae   d   t   r   a   g

Phonological segments

Martin, Lesch & Bartha (1999)

Knowledge Representation

Short-term Memory Buffers

Semantic Features

Lexical-Semantic Buffer

S1 S2   S3 S4   S5 S6   S7 S8

L1   L2   L3   L4

Lexical Nodes   CAT   DOG   TRUCK

Input Phonological Buffer

P1 P2 P3   P4 P5 P 6   P7 P8

k   ae   d   t   r   a   g

Input phonological segments

r   d   u   k   g

Output phonological segments

Output Phonological Buffer

Martin, Lesch & Bartha (1999)

P1 P2 P3   P4 P5 P 6   P7 P8
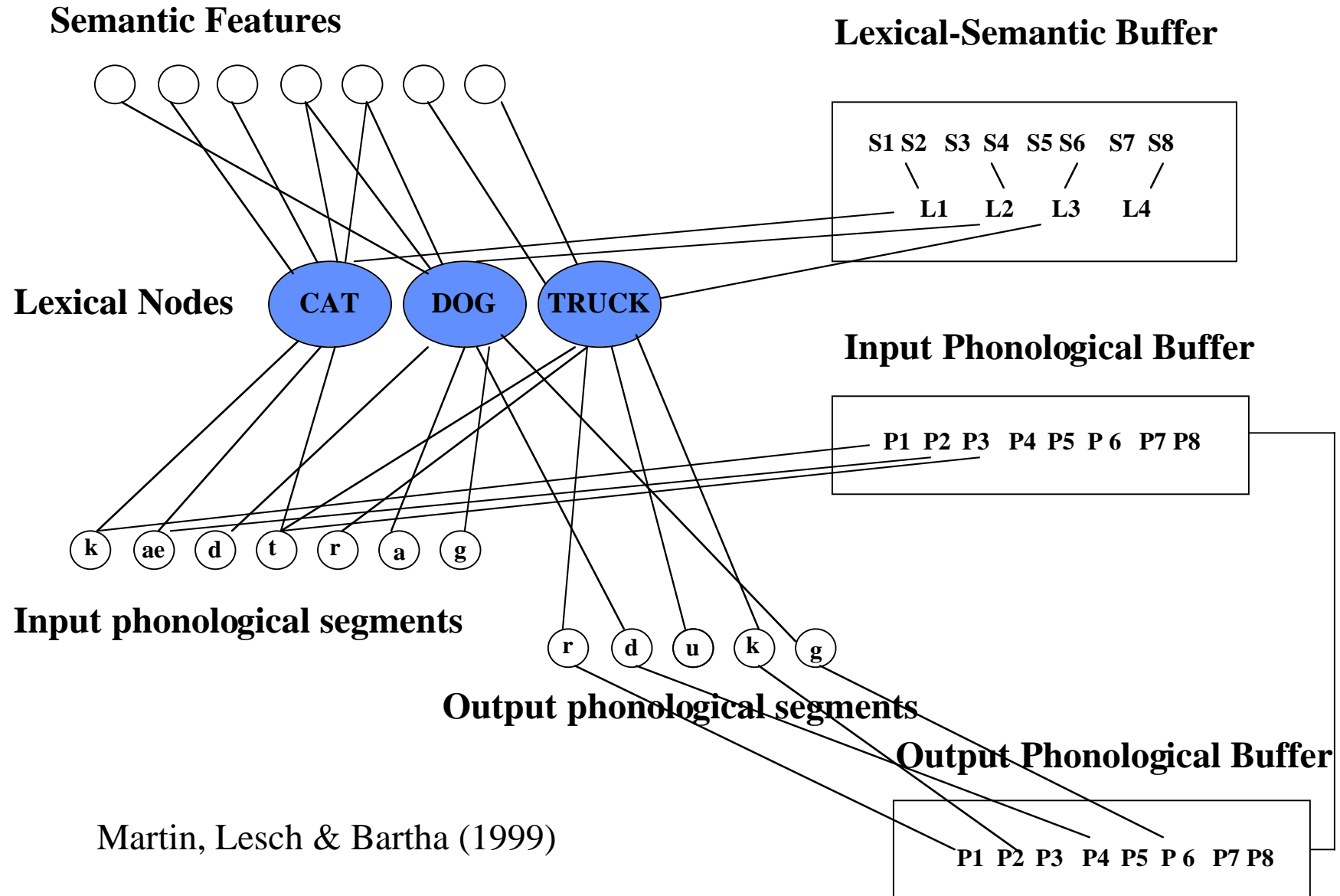
Patient Background

Patient	Age	Education	Lesion Site	Aud. Span	Visual Span
EA	64	College	Temporo-Parietal	1.5	2.5
AB	74	College, Law	Frontal-Parietal	2.5	1.5
ML	60	2 Yrs. College	Frontal-Parietal	2.5	1.5
GR	54	College	Frontal-Parietal-Temporal	3.3	2.2

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

Combined z-scores

- EA (phon)
- AB (sem)
- ML (sem)
- GR (sem)

Subject

Legend:
- phon
- semantic
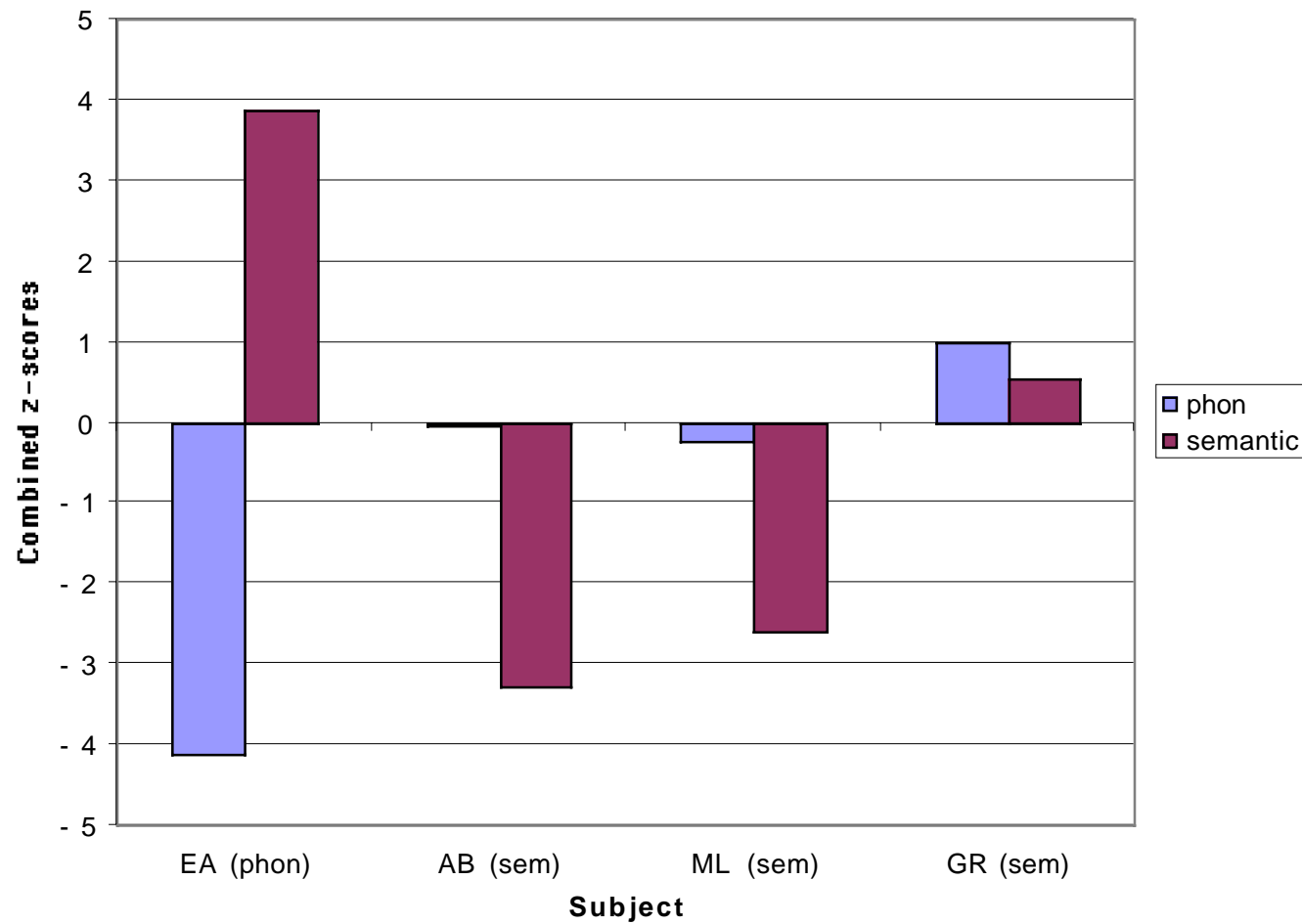
- Sentence comprehension - Sensibility judgments
  - Adjectives before - delayed integration
    - Examples of anomalous sentences

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

The rusty swimsuit was brought to the beach	**Distance 1**

n *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	**Distance 3**

The rug cracked during the move.	**Distance 1**

n *Sentence comprehension*

- *Nouns after - immediate integration*
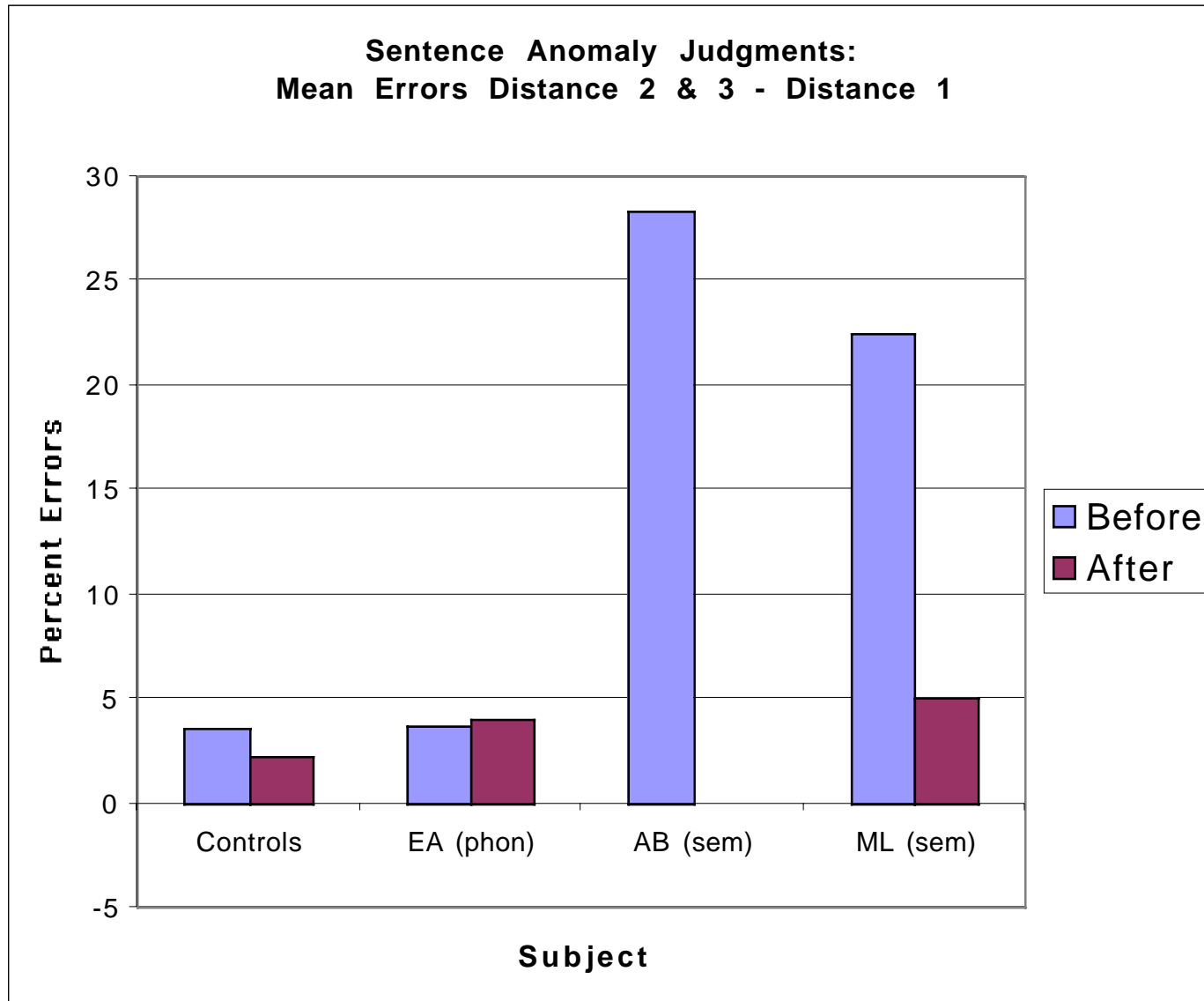 - *Examples of anomalous sentences*

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

The movers cracked the rug.	**Distance 1**

Martin & Romani (1994); Martin & He (2000)

Sentence Anomaly Judgments:
Mean Errors Distance 2 & 3 - Distance 1

**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

Short-term Memory Buffers

Semantic Features

Lexical-Semantic Buffer

S1 S2 S3 S4 S5 S6 S7 S8

L1   L2   L3   L4

Lexical Nodes   CAT   DOG   TRUCK

Input Phonological Buffer

P1 P2 P3   P4 P5 P 6   P7 P8

k   ae   d   t   r   a   g

Input phonological segments

r   d   u   k   g

Output phonological segments

Output Phonological Buffer

Martin, Lesch & Bartha (1999)

P1 P2 P3   P4 P5 P 6   P7 P8
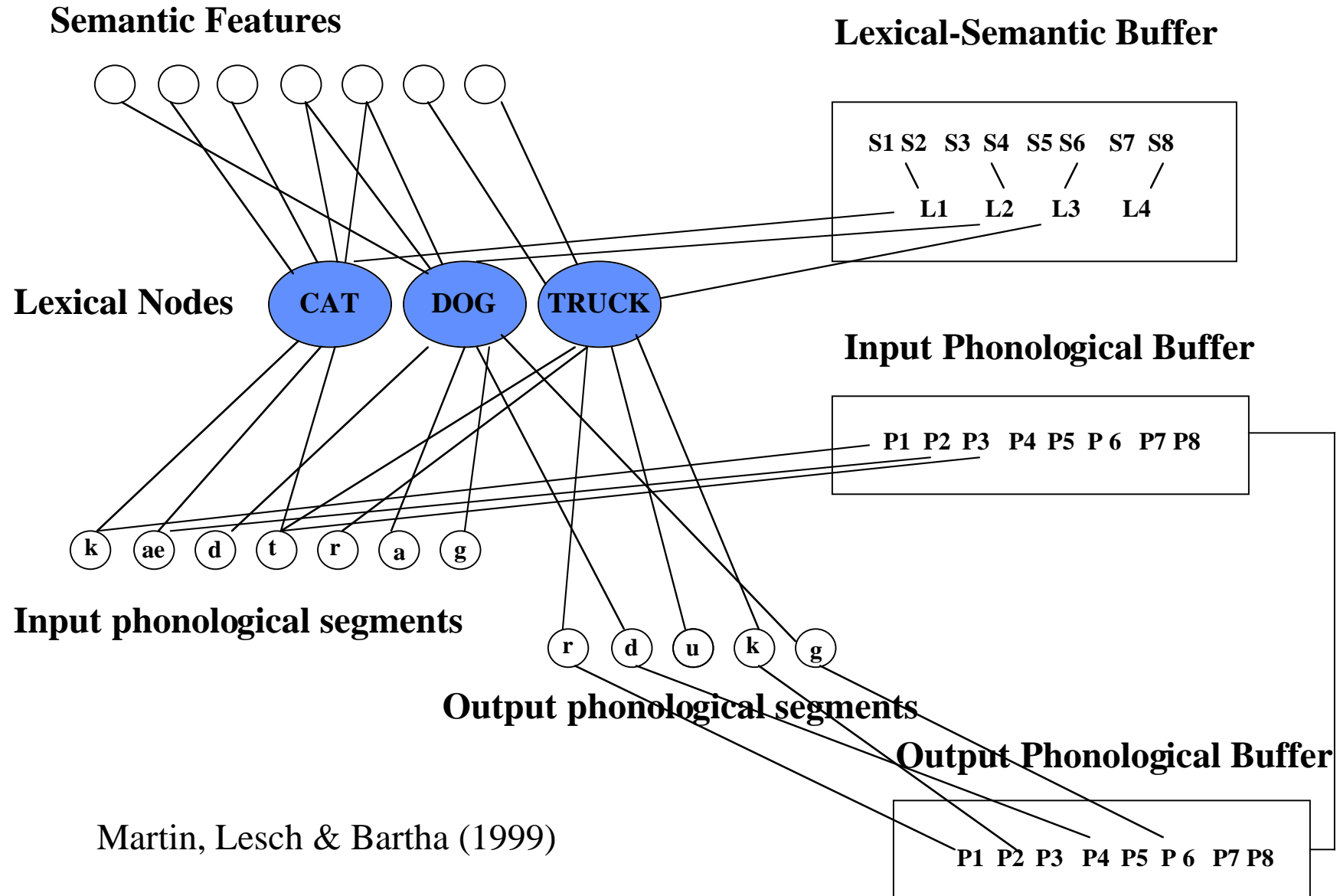
Same semantic capacity for input and output?

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")

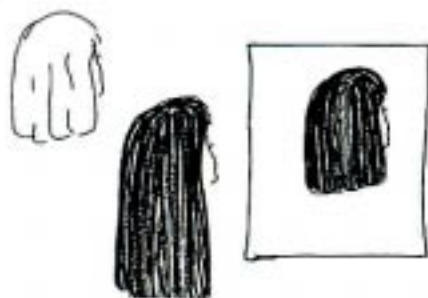**Adjective-Adjective Noun Phrase (e.g., "small green leaf")**

A

B

C

Percent Correct on Preliminary Noun Phrase Production Task
(numbers in parentheses are percent correct after self-correction)

	Adj.	N.	Adj N	AAN
Controls	100	88	92	77
(n=6)		(93)	(97)	(82)
Phonological STM				
EA	100	90	90	70
		(90)	(100)	(80)
Semantic STM				
AB	100	100	30	0
			(30)	(0)
ML	100	100	20	10
			(80)	(40)

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:
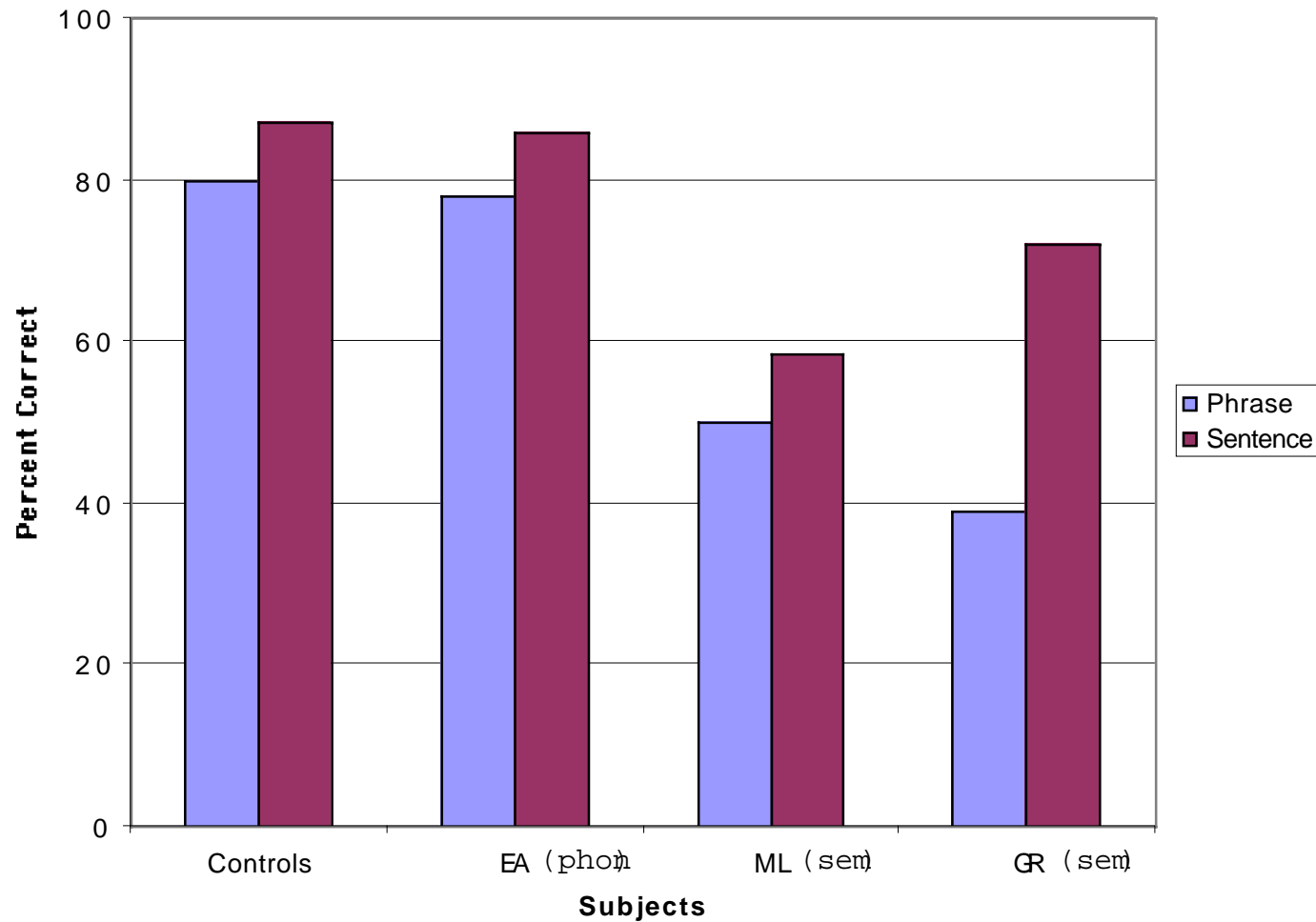
    the old pail   the old red pail
    det-adj-N   det-adj-adj-N

N is adj:

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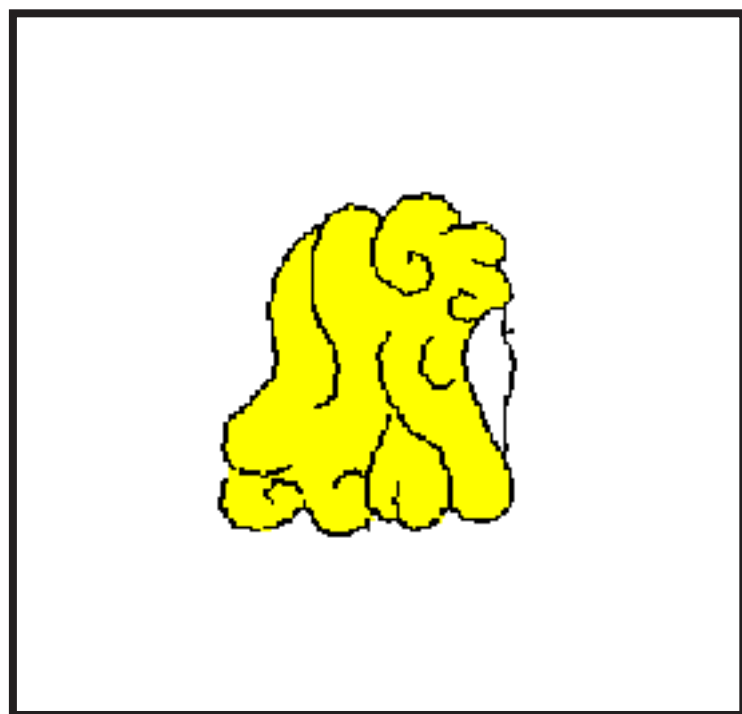
**Phrase vs. Sentence Production
AN and AAN Combined**

Percent Correct

100

80

60

40

20

0

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

Subjects

☐ Phrase
■ Sentence

Onset Latencies

Seconds

14
12
10
8
6
4
2
0

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

Subjects

■ Phrases
■ Sentences

Compound Noun Phrase Production

```
                              NP
                     /        |        \
                   NP        conj        NP
                  /  \        |         /  \
               Det    N      and     Det    N
                |     |               |     |
               The  ball             the  block
```
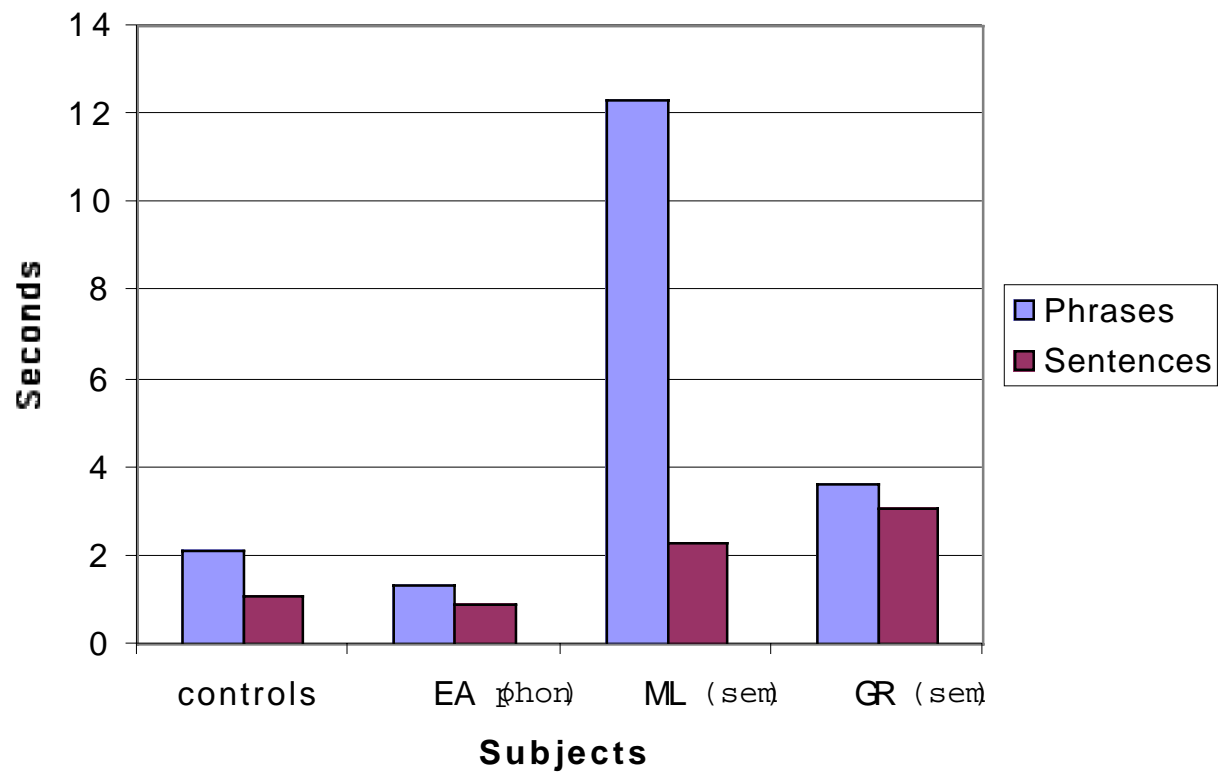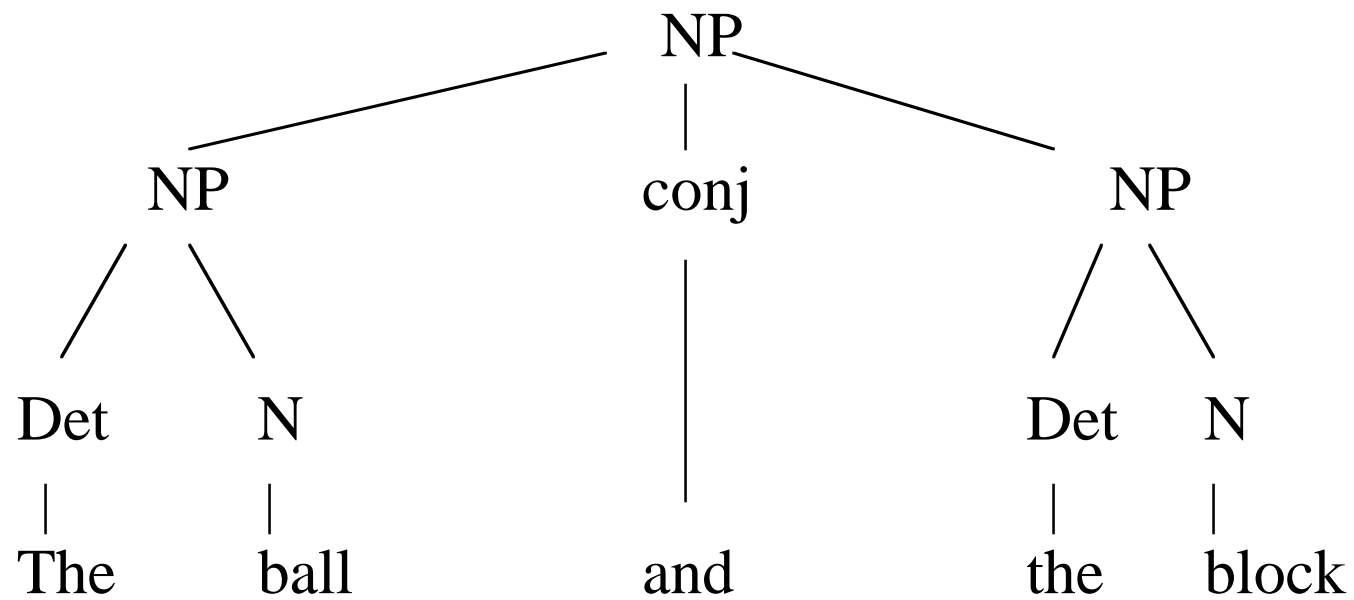
Moving Picture Descriptions: Compound Noun Phrase Production (based on Smith and Wheeldon, 1999)

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

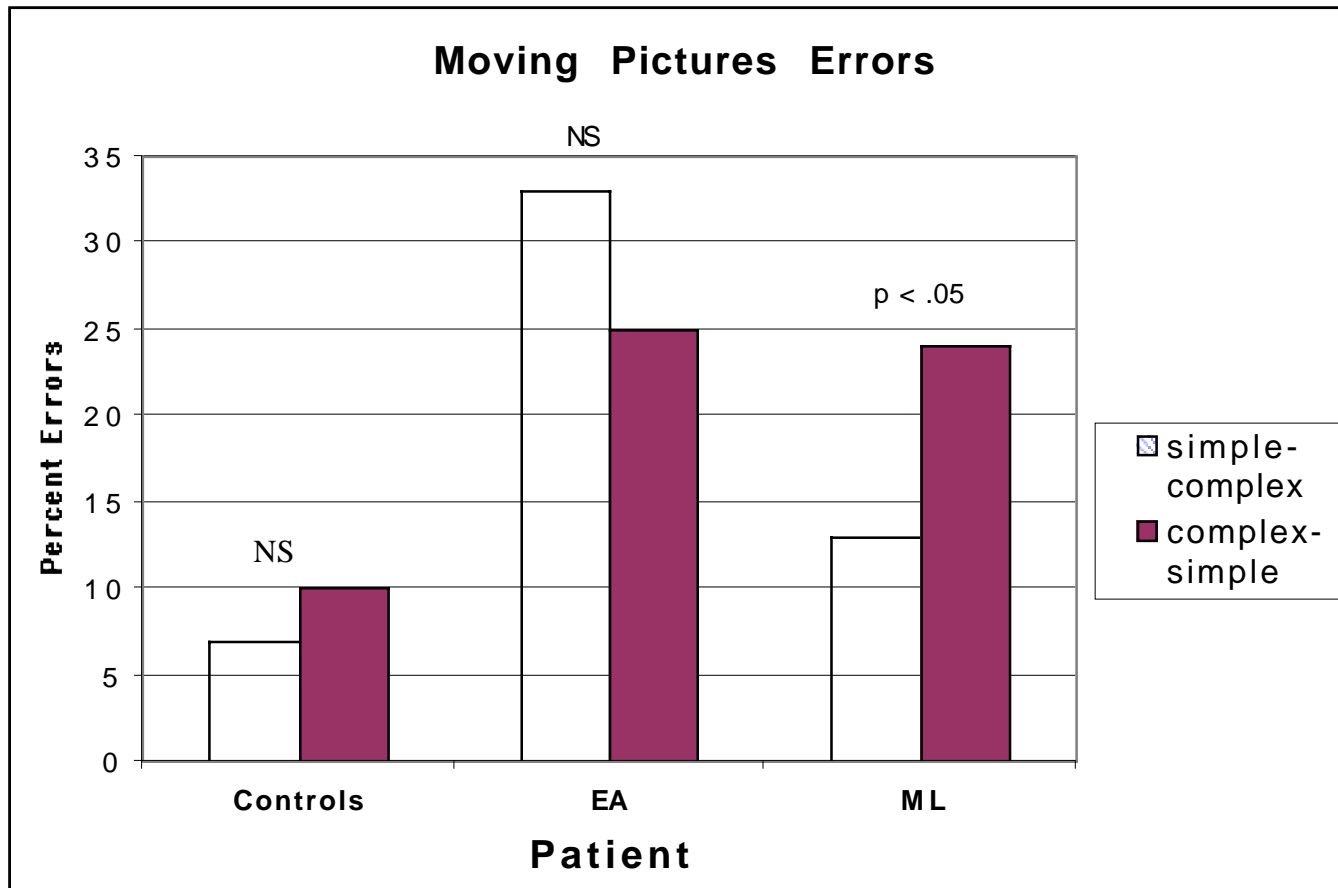Picture removed 500 ms after movement onset
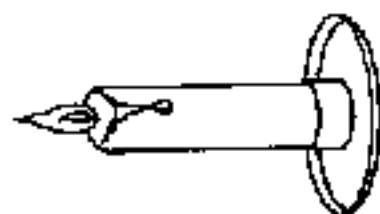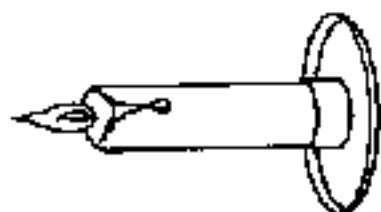
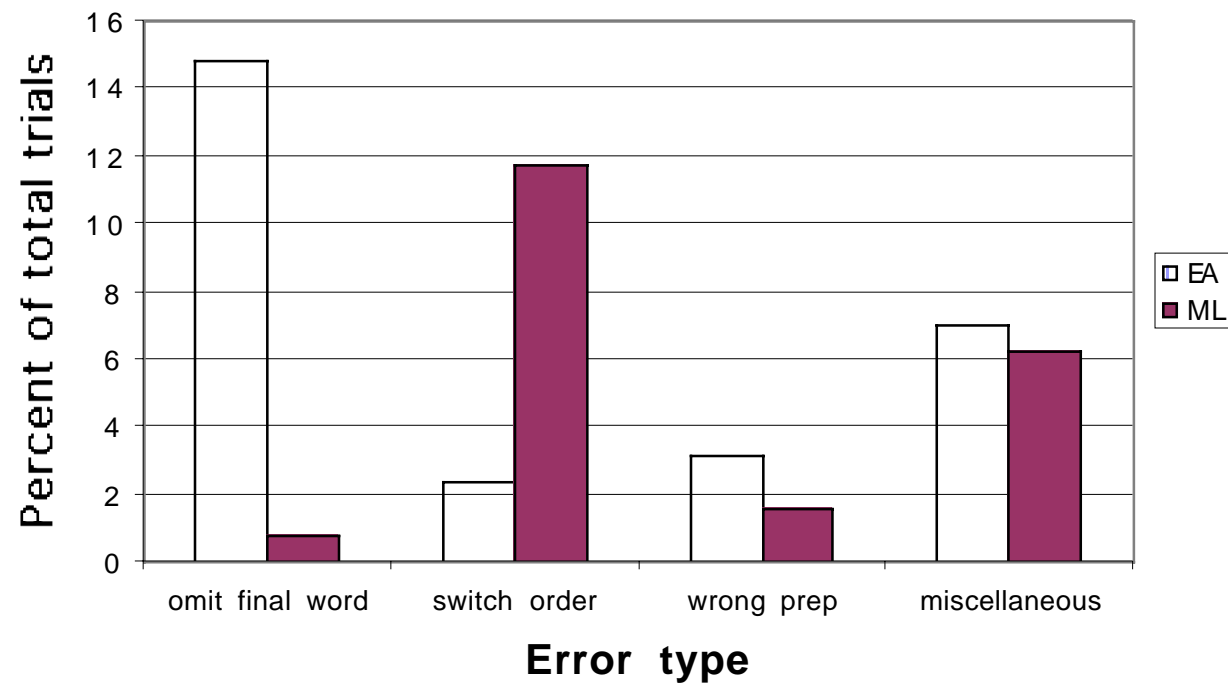# Scoring

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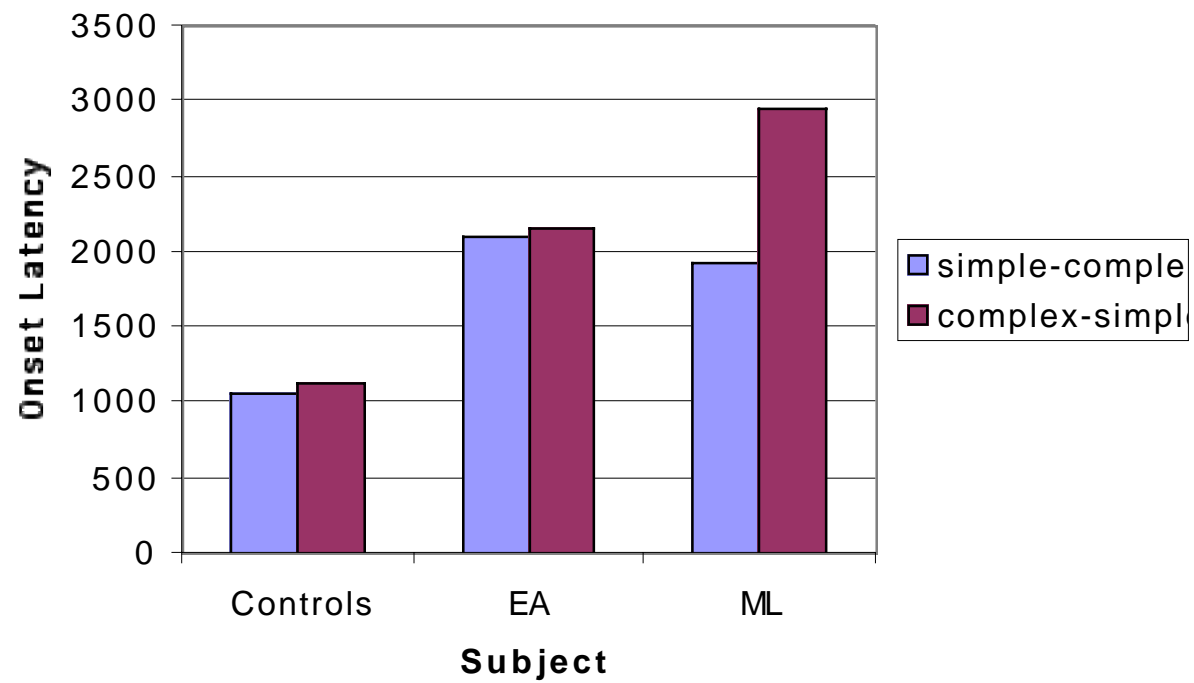Latencies measured to onset of first noun

Responses scored as errors:
a. incorrect noun used
b. noun omitted
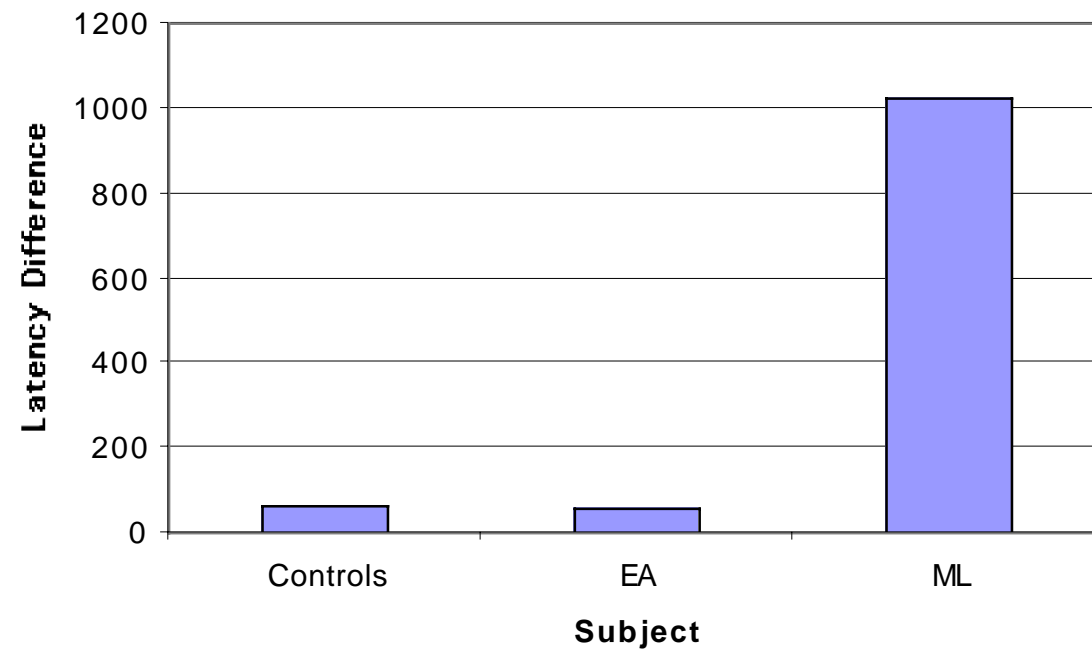c. initiation of incorrect noun (e.g., "ki….finger")

Moving Pictures Errors

Error types for EA and ML

Percent of total trials

16
14
12
10
8
6
4
2
0

omit final word   switch order   wrong prep   miscellaneous

Error type

EA
ML

Moving Picture Descriptions

Onset Latencies for Complex-Simple Minus Simple-Complex

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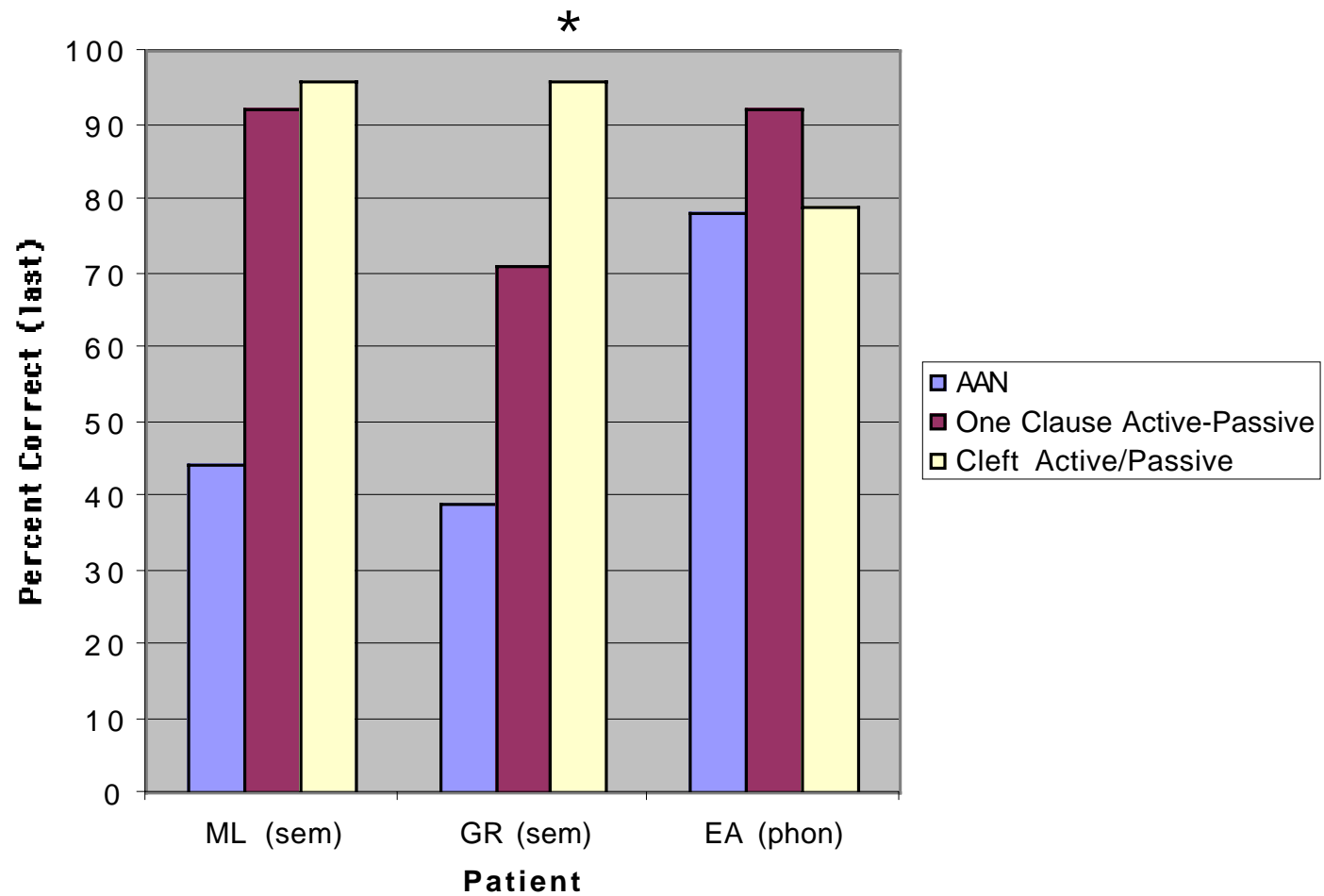Simple passive: The dog was chased by the cat.

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

*

Percent Correct (last)

Patient

Legend:
- 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.