FOCAL ATTENTION

AND

THE TIMING OF MEMORY RETRIEVAL

IN LANGUAGE COMPREHENSION

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Our ability to actively attend to and concurrently process information is extremely limited (e.g., Broadbent, 1958).

Nonetheless, component operations in many cognitive skills rely on the products of recent perceptual and cognitive analyses—products displaced from active processing by subsequent operations.

Successful execution of many cognitive skills requires rapid shunting of information between memory and active processing. Retrieval is required to restore past analyses to the focus of attention.

Real-time comprehension routinely requires coordinating linguistic features and constituents over time.

THREE BASIC QUESTIONS

1. How are representations retrieved from memory in real-time comprehension?

3. What factors determine the success of retrieval?

5. When is retrieval from memory required for comprehension?

1. HOW ARE REPRESENTATIONS RETRIEVED IN COMPREHENSION?

✦ Representations formed in comprehension are content-addressable

✦ Representations are retrieved with a cue-driven, direct-access operation

Cues in the retrieval context contact matching memory representations directly, circumventing the need to search through irrelevant representations.

1. HOW ARE REPRESENTATIONS RETRIEVED IN COMPREHENSION?

When retrieval requires a search, retrieval time is determined by the amount of information in memory (e.g., McElree & Dosher, 1993, *JEP:General*)

However, the speed of processing an expression requiring retrieval exhibits the signature pattern of a direct-access operation: It is unaffected by:

- the amount of information interpolated between the to-be-retrieved constituent and the retrieval site

- the amount of information in discourse

1. How are representations retrieved in comprehension?

E.g.,: Speed of interpreting the sentence final verb (*embraced)* does not vary with the distance of its direct object *(the book)*

This is the book that the public embraced _____.

This is the book that the editor claimed the public embraced _____.

This is the book that the editor told the newly appointed writer for the Times the public embraced _____.

Holds across a range of nonadjacent dependancies:

✦ Verb and arguments (McElree, 2000; McElree, Foraker, & Dyer, 2003)

✦ Subject-verb dependancies (McElree, Foraker, & Dyer, 2003)

✦ VP Ellipsis (Martin & McElree, 2008; in press)

✦ Coreference relations (Foraker & McElree, 2007)

2. WHAT FACTORS DETERMINE THE SUCCESS OF

In a cue-driven retrieval operation, success is a function of the degree to which cues uniquely identify the required constituent.

Direct-access retrieval is fast, but it is susceptible to similarity-based interference when retrieval cues overlap with other elements in memory.

Evidence in hand

Both syntactic and semantic/pragmatic cues drive retrieval, with the former gating the latter (Van Dyke & McElree, in prep)

Viz., a competitor sharing semantic/pragmatic properties with a target does <u>not</u> engender interference if in an inappropriate syntactic position

3. When does comprehension require retrieval?

Whenever a required constituent is no longer among those elements that are actively being processed, *viz.* the constituent is outside *focal attention*
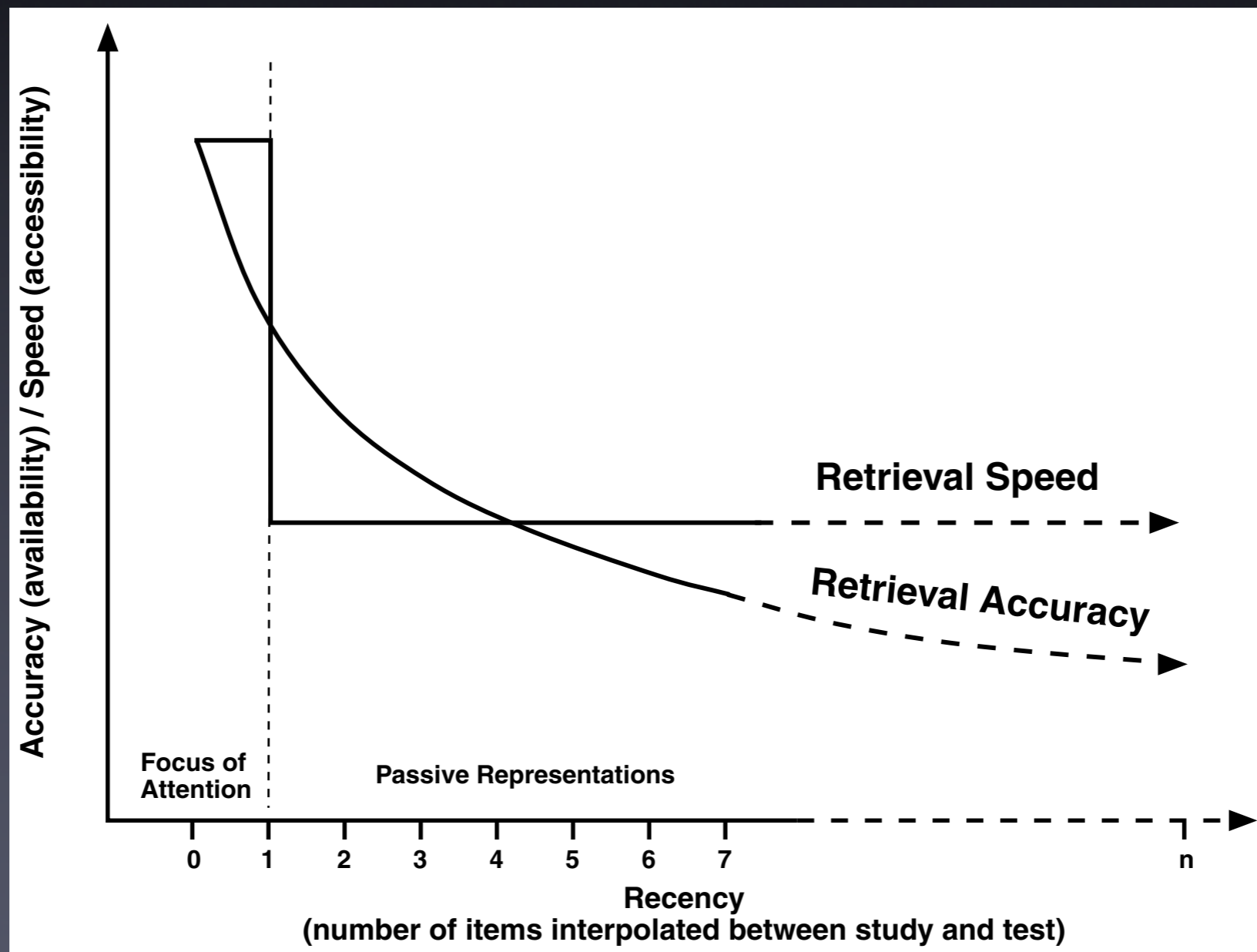
Focal attention is extremely limited: For sequentially-presented information, the capacity of focal attention appears limited to the last "unit" processed (Wickelgren et al., 1980; Garavan, 1998; Cowan, 2001; McElree, 2006; Jonides et al., 2008).

Building structured representations for sequentially-presented input will often require shunting information between memory and focal attention
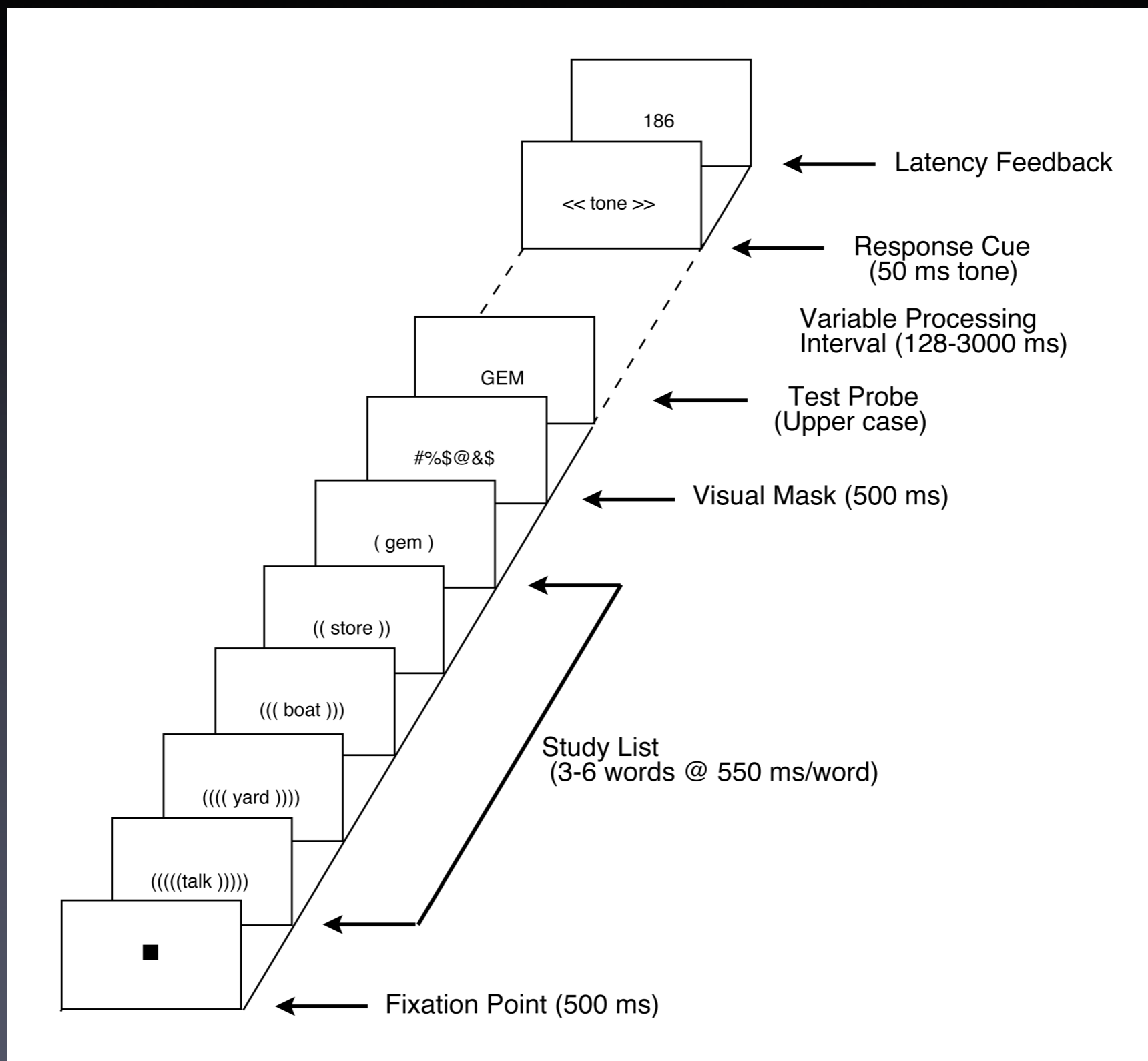
Passive
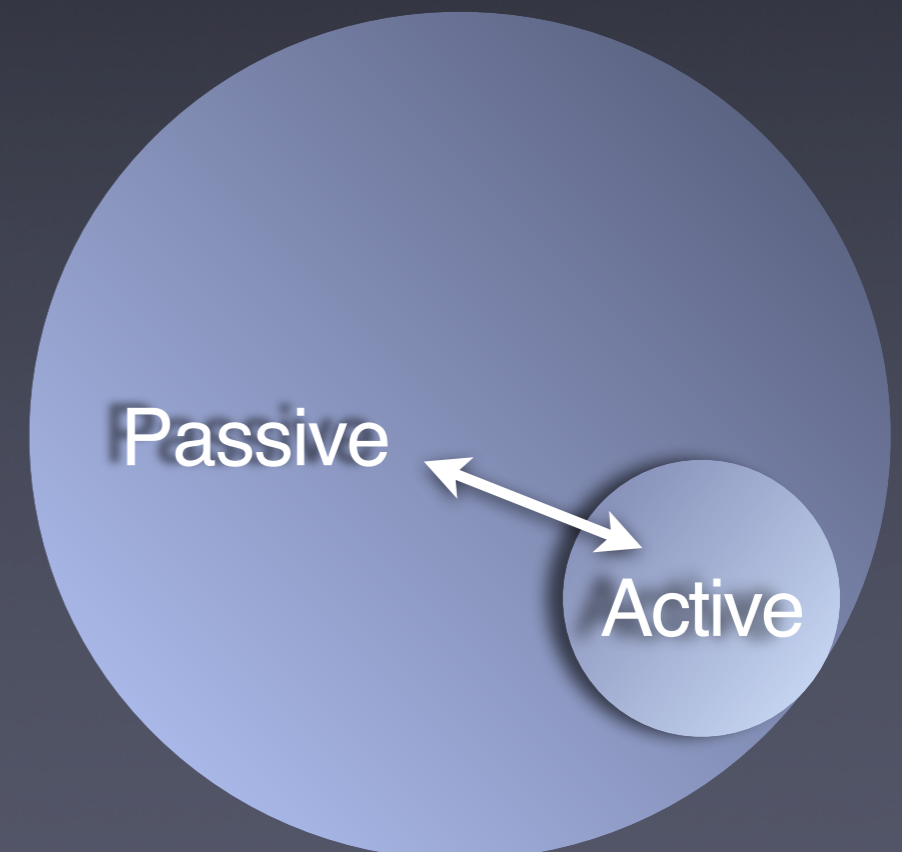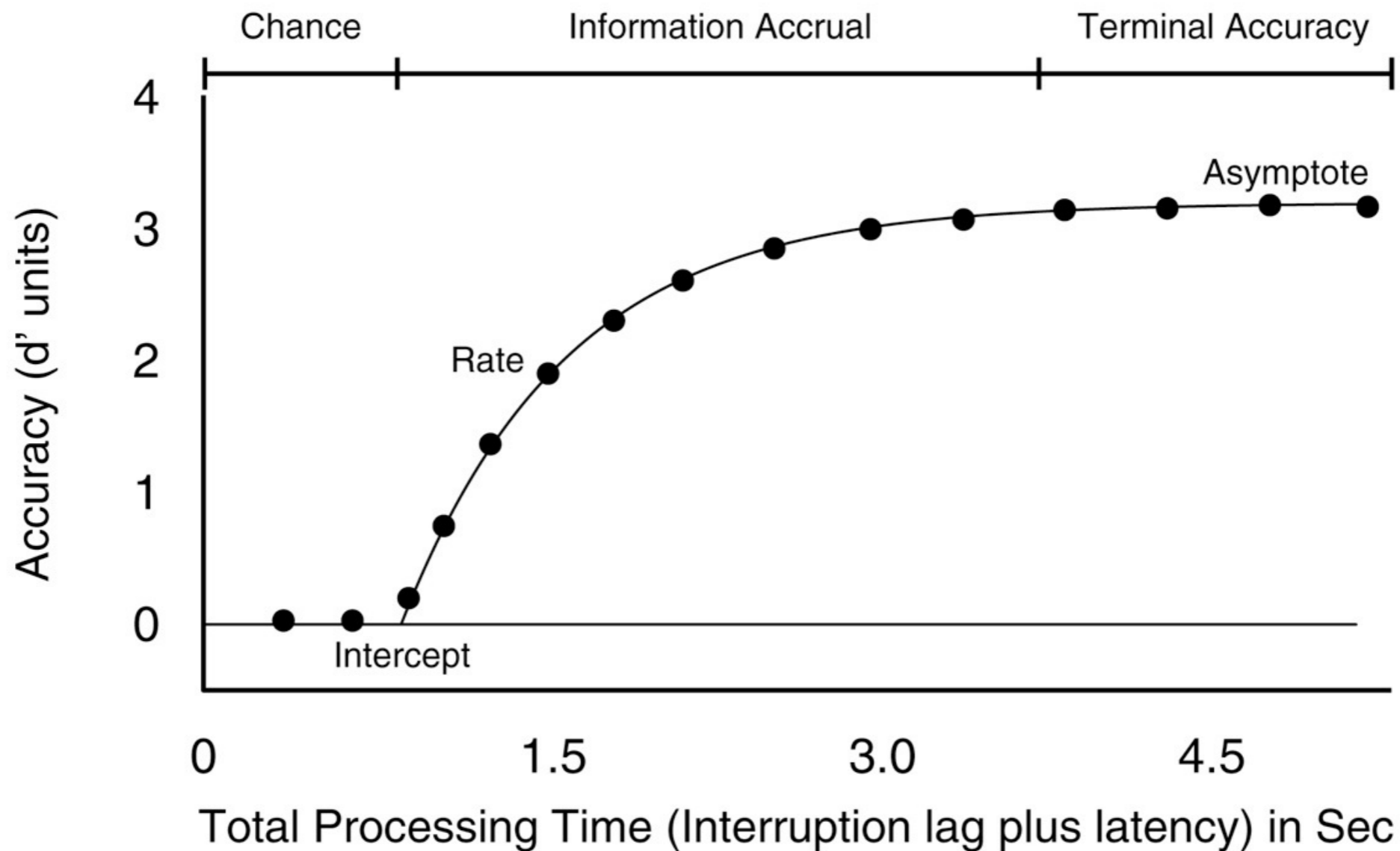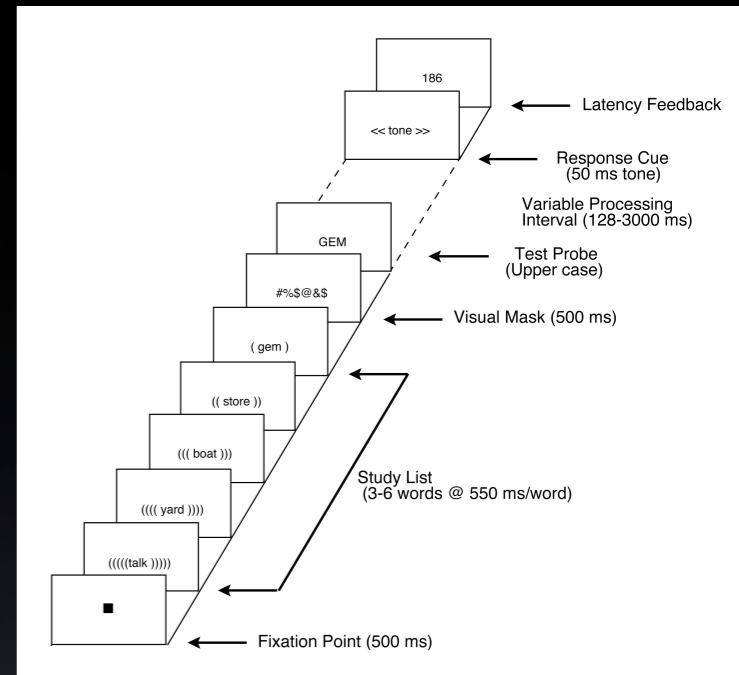
Active

3. WHEN DOES COMPREHENSION REQUIRE RETRIEVAL?

Estimating the capacity of focal attention: Access speed can be used to determine whether a representation is active in focal attention or in memory only (McElree, 2003; 2006).

SAT variant of Item Recognition (Sternberg) Task

186

<< tone >> — Latency Feedback

Response Cue
(50 ms tone)

Variable Processing
Interval (128-3000 ms)

GEM — Test Probe
(Upper case)

#%$@&$ — Visual Mask (500 ms)

(gem)

((store))

(((boat)))

((((yard))))

(((((talk)))))

Study List
(3-6 words @ 550 ms/word)

Fixation Point (500 ms)

SAT variant of Item Recognition (Sternberg) Task
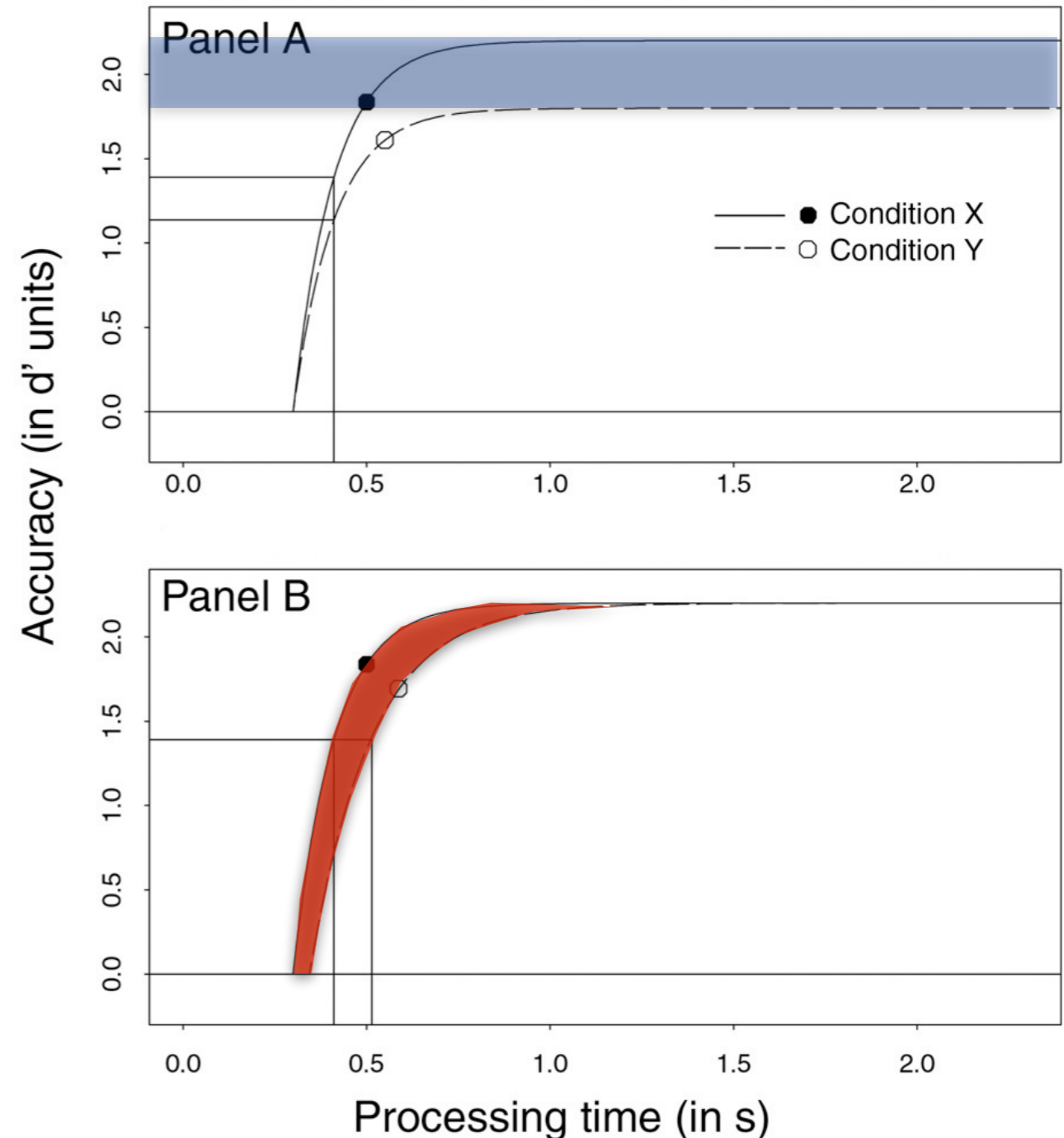
Accuracy (Asymptotic) versus Speed (Dynamics) Effects

A. **Accuracy differences**
   Functions differ in asymptotes (times where performance ceases to improve)
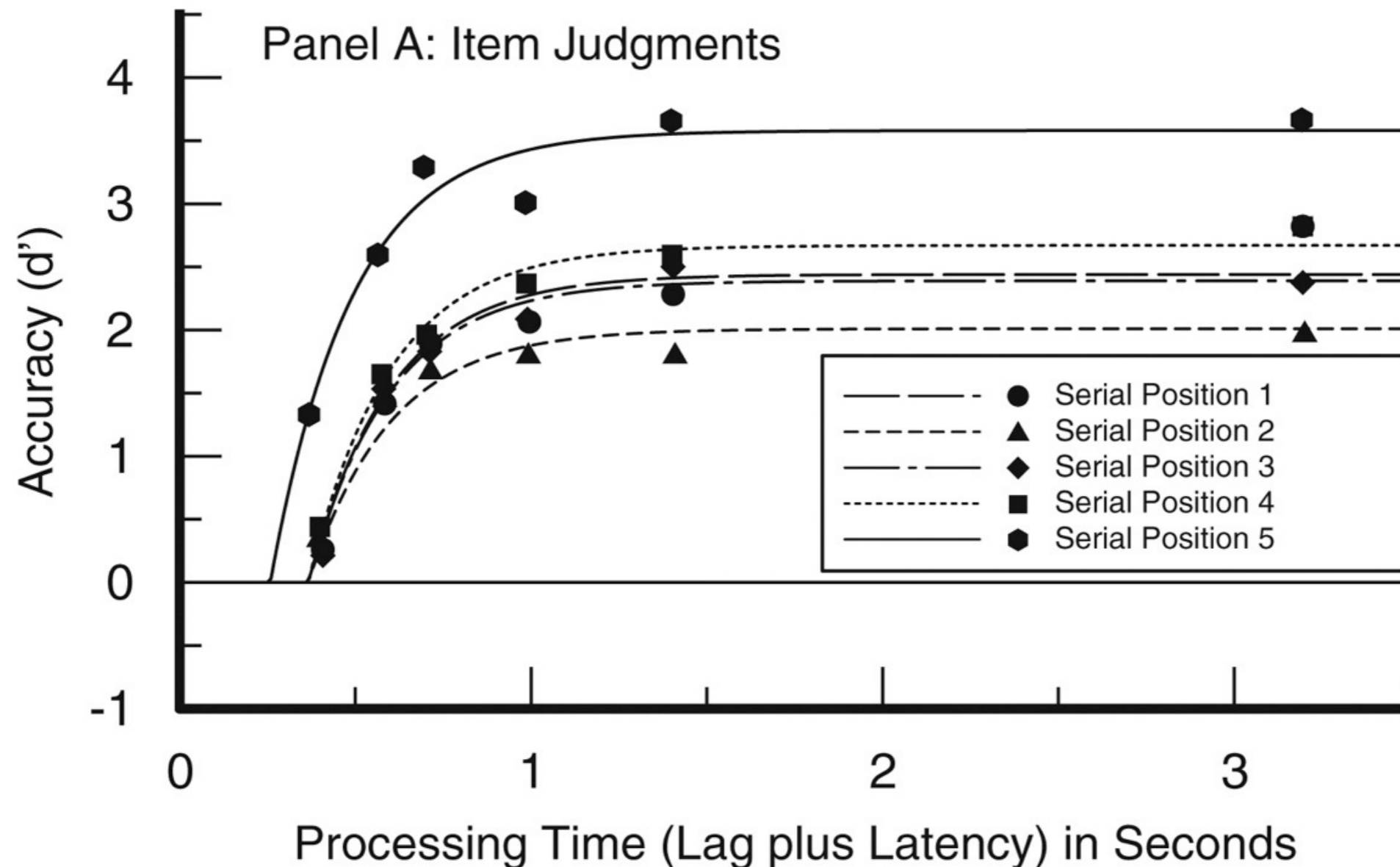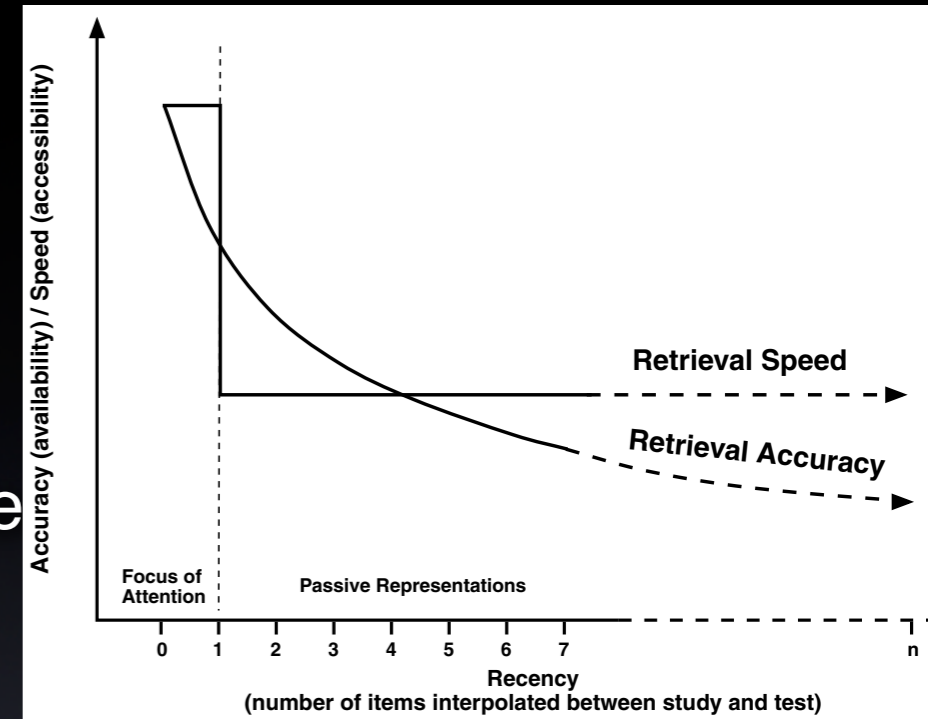
B. **Speed differences**
   Dynamics are disproportional (rate and intercept vary)

Representative findings:
Item Recognition (McElree, 1996, M&C)

Last item studied on the list (SP5) exhibits markedly faster access speed than all other list positions.

SAT DYNAMICS ADVANTAGE AS A BEHAVIORAL MARKER OF FA

✦ Advantage is not about low-level perception:

  ✦ true of rhyme and synonym judgments

  ✦ speed advantage accrues to chunks, not a single 'item' (McElree 1998; 2006)

✦ Advantage reflects what's currently being processed:

  ✦ not the temporally last item in n-back tasks (McElree, 2001)

  ✦ tracks with covert rehearsal (McElree 2006)

Speed advantage is associated with deactivation in regions implicated in retrieval (e.g., MTL, LIFG)

Öztekin, McElree, Staresina & Davachi (2008) *Journal of Cognitive Neuroscience*.
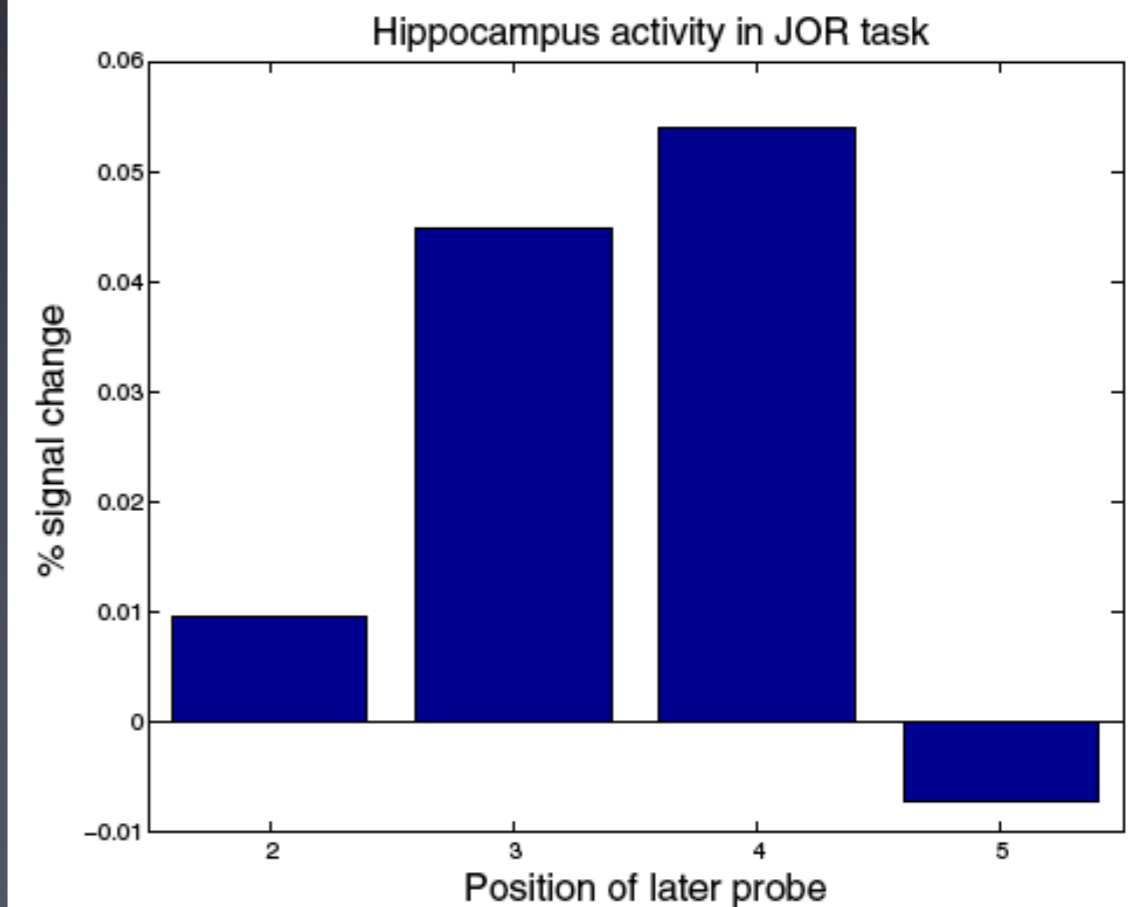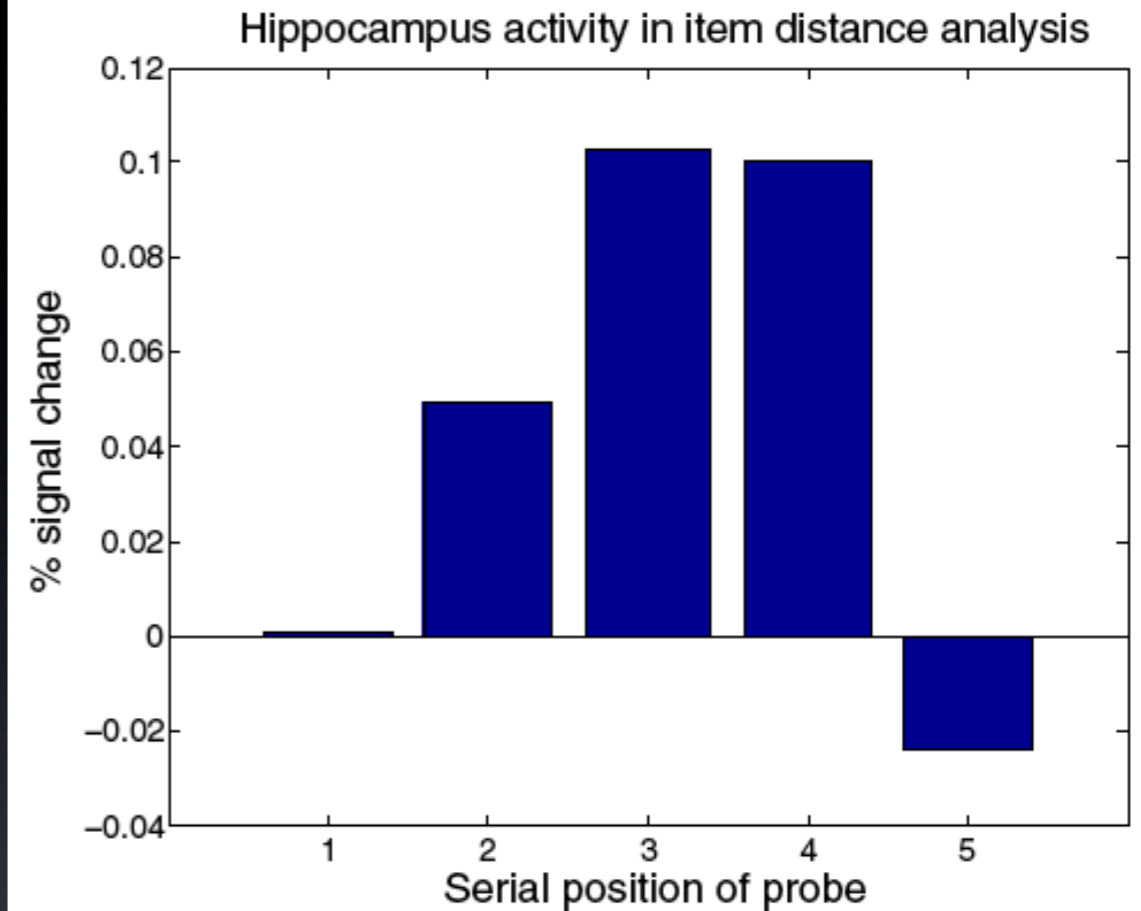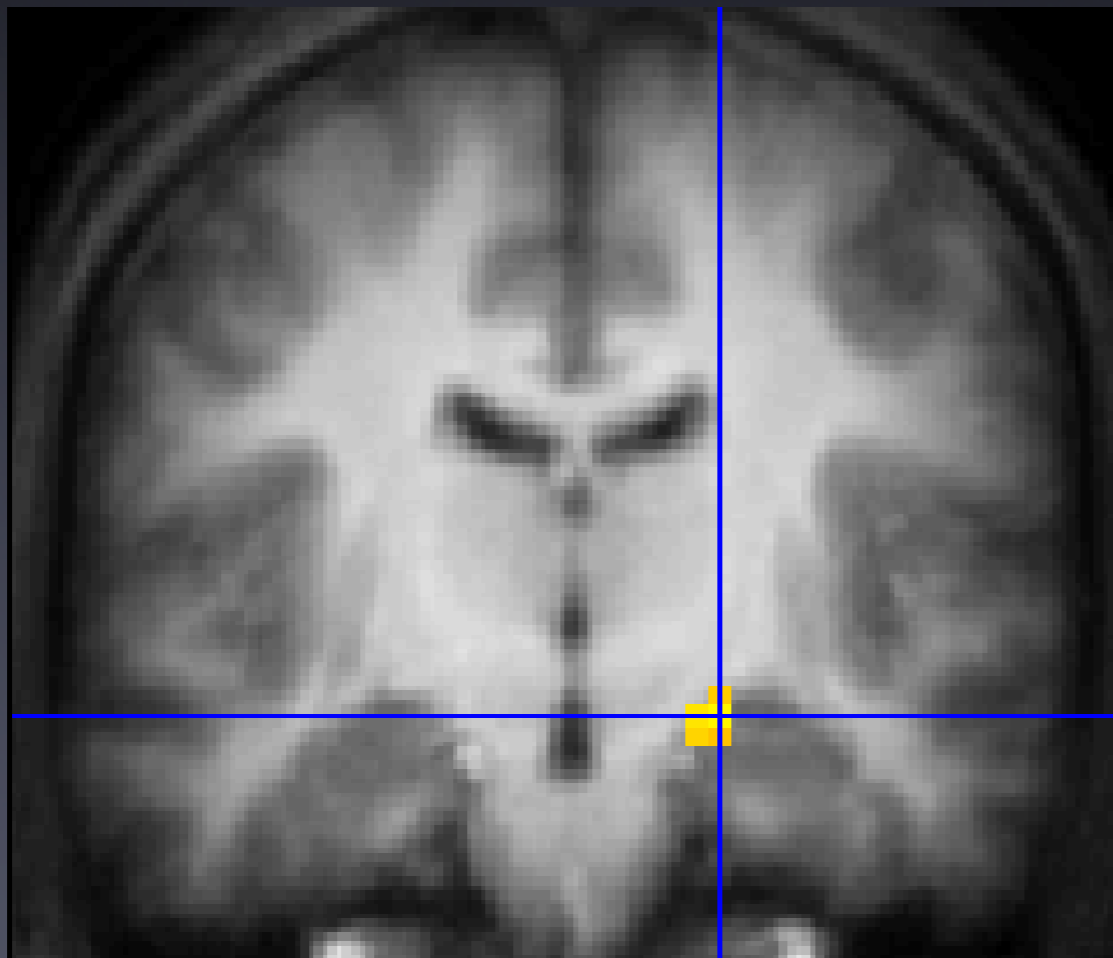
THE SPAN OF FOCAL ATTENTION IN COMPREHENSION

Approach: Determine what types of constituents induce shifts from fast to slower processing when interpolated between two dependent constituents.

The point at which processing speed shifts indicates when the constituent required to resolve the dependancy has been displaced from focal attention.

SAT Procedure
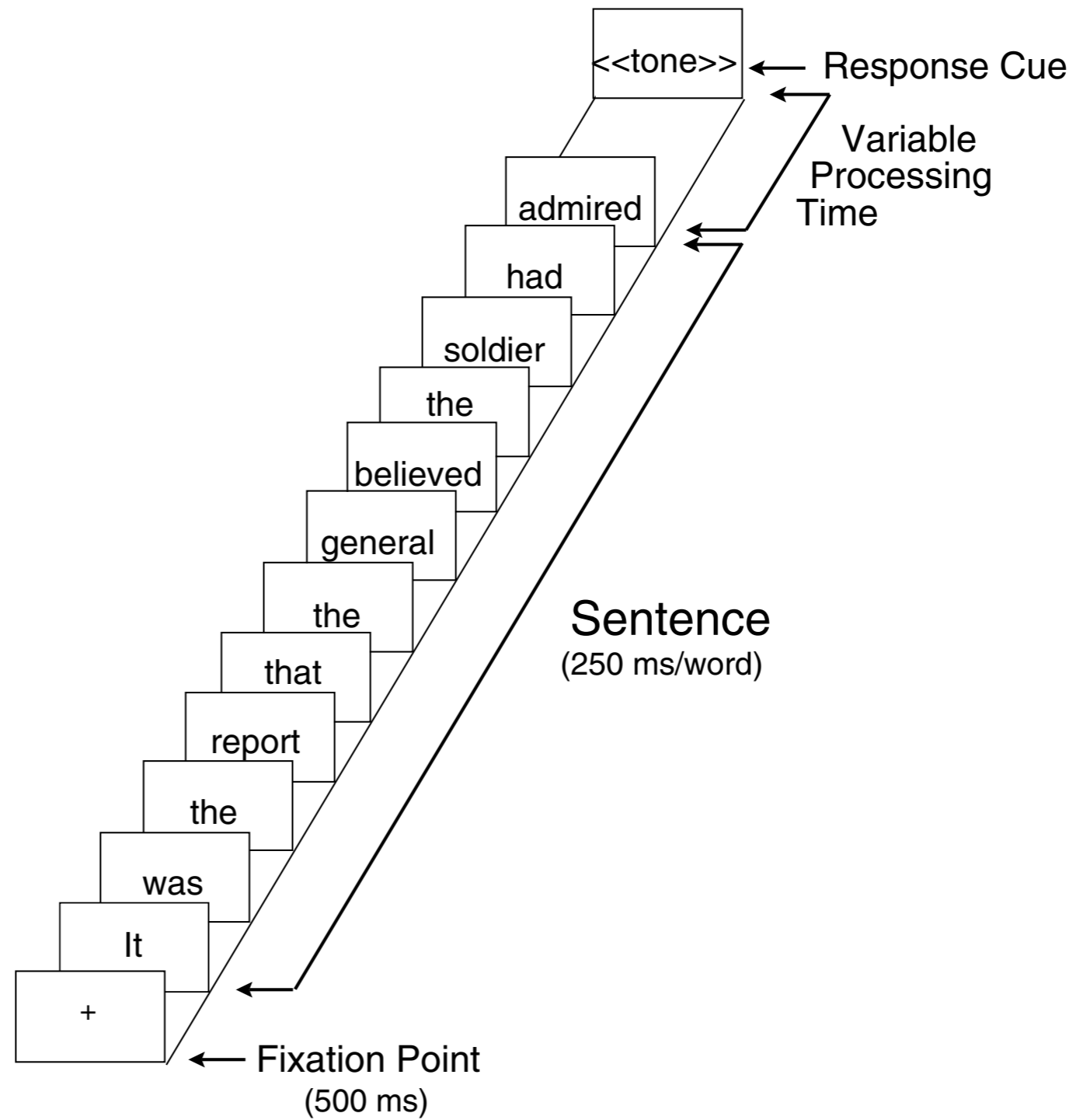
McElree, Foraker, & Dyer (JML, 2003)

1. *The editor laughed.*

   (....*ripped.)

2. *The editor that the book amused laughed.*

3. *The editor from the prestigious press that the book amused laughed.*

4. *The editor that the book that won the award amused laughed.*

5. *The editor that the book that the journalist wrote amused laughed.*
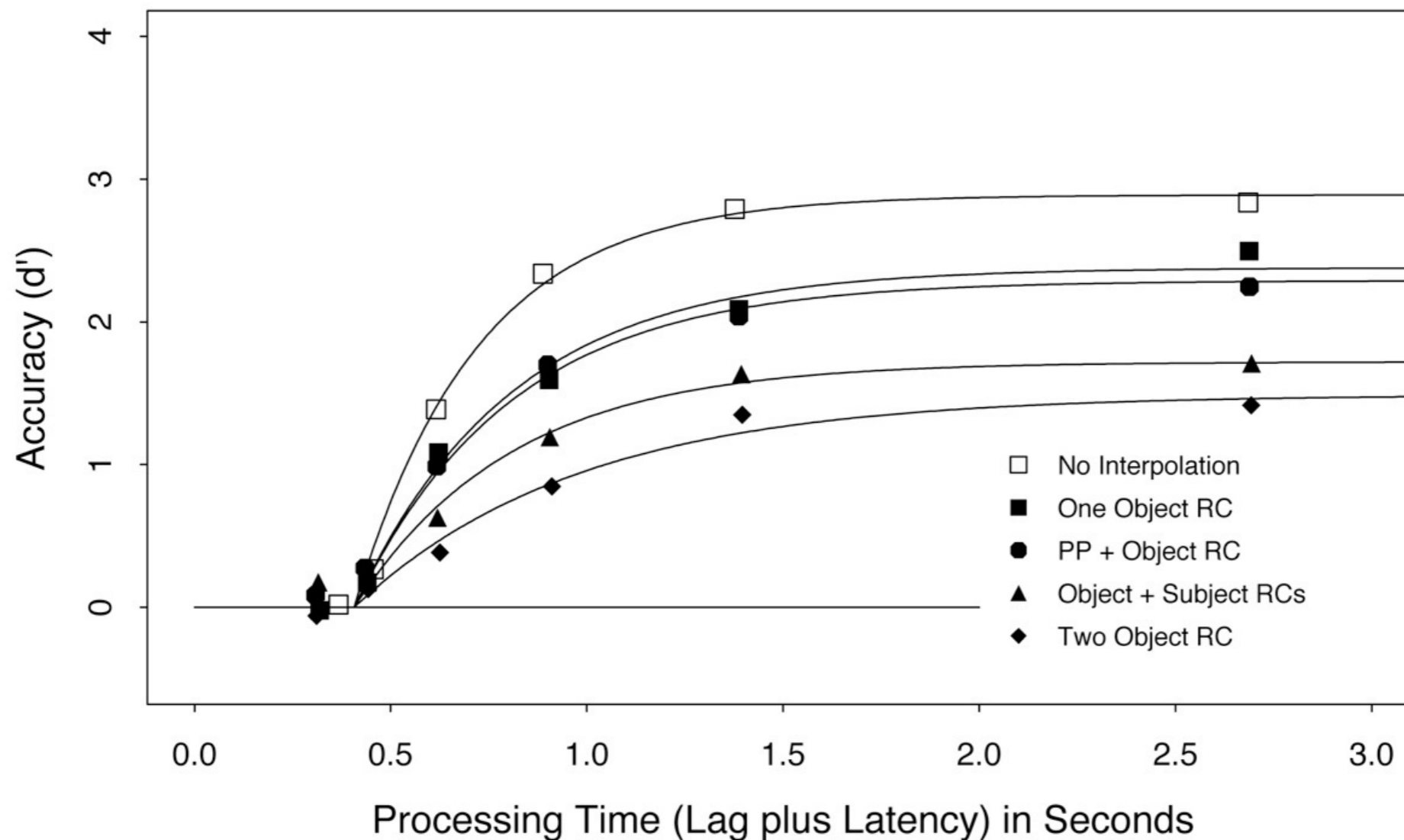
New Experiment

When is the embedded subject (*the driver*) displaced from focal attention, so that it must be retrieved at the verb (*fainted*)?

Adjacent

The officer was informed that the driver fainted.   *...*drained.*

Adverb

The officer was informed that the driver abruptly fainted.

Preposition Phrase (PP modifying the subject)

The officer was informed that the driver of the ambulance fainted.

Subject Relative Clause

The officer was informed that the driver who wrecked the ambulance fainted.

Object Relative Clause

The officer was informed that the driver who the ambulance hit fainted.

Multi-response SAT

✦ 17 subjects made Yes-No acceptability judgments at each response-tone (18/ trial)
  e.g., *the driver fainted/ *drained.*

✦ 40 item sets (10 conditions)

... the driver fainted.

18 response tones
at 350 ms intervals

✦ Hierarchical model fitting performed on subjects' SAT functions (d' as a function of processing time) to isolated differences in accuracy (SAT asymptote) and speed (SAT intercept or rate).

ADJACENT

    The officer was informed that the driver fainted.   *...*drained.*

ADVERB

    The officer was informed that the driver abruptly fainted.

PREPOSITION PHRASE (PP MODIFYING THE SUBJECT)

    The officer was informed that the driver of the ambulance fainted.

SUBJECT RELATIVE CLAUSE

    The officer was informed that the driver who wrecked the ambulance fainted.
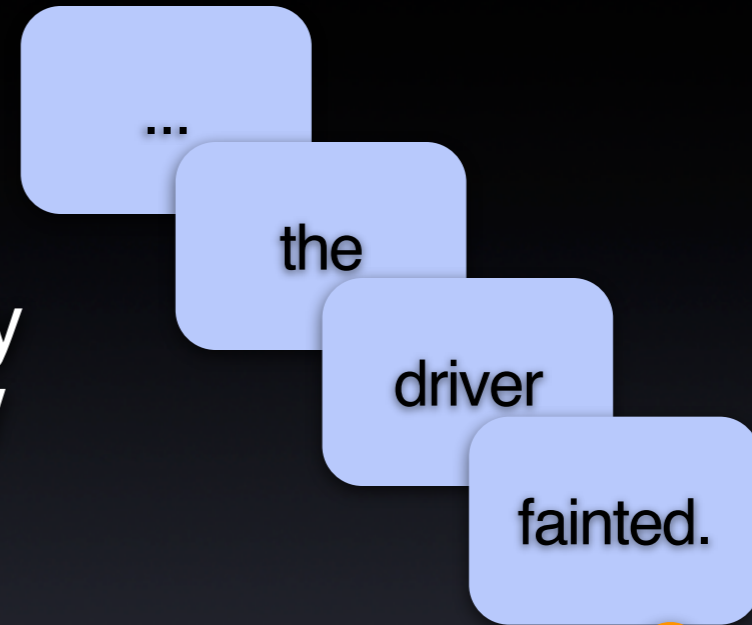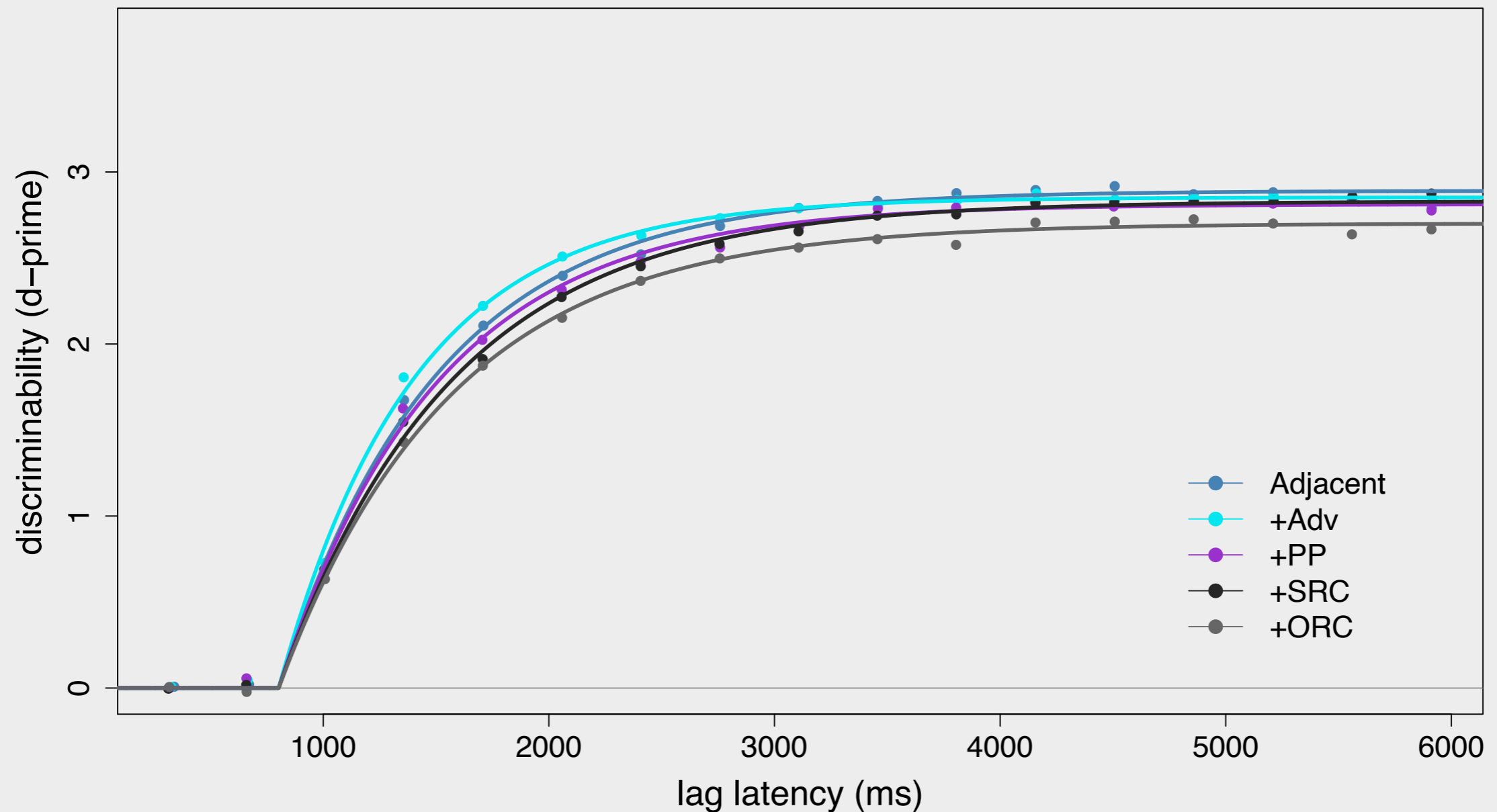
OBJECT RELATIVE CLAUSE

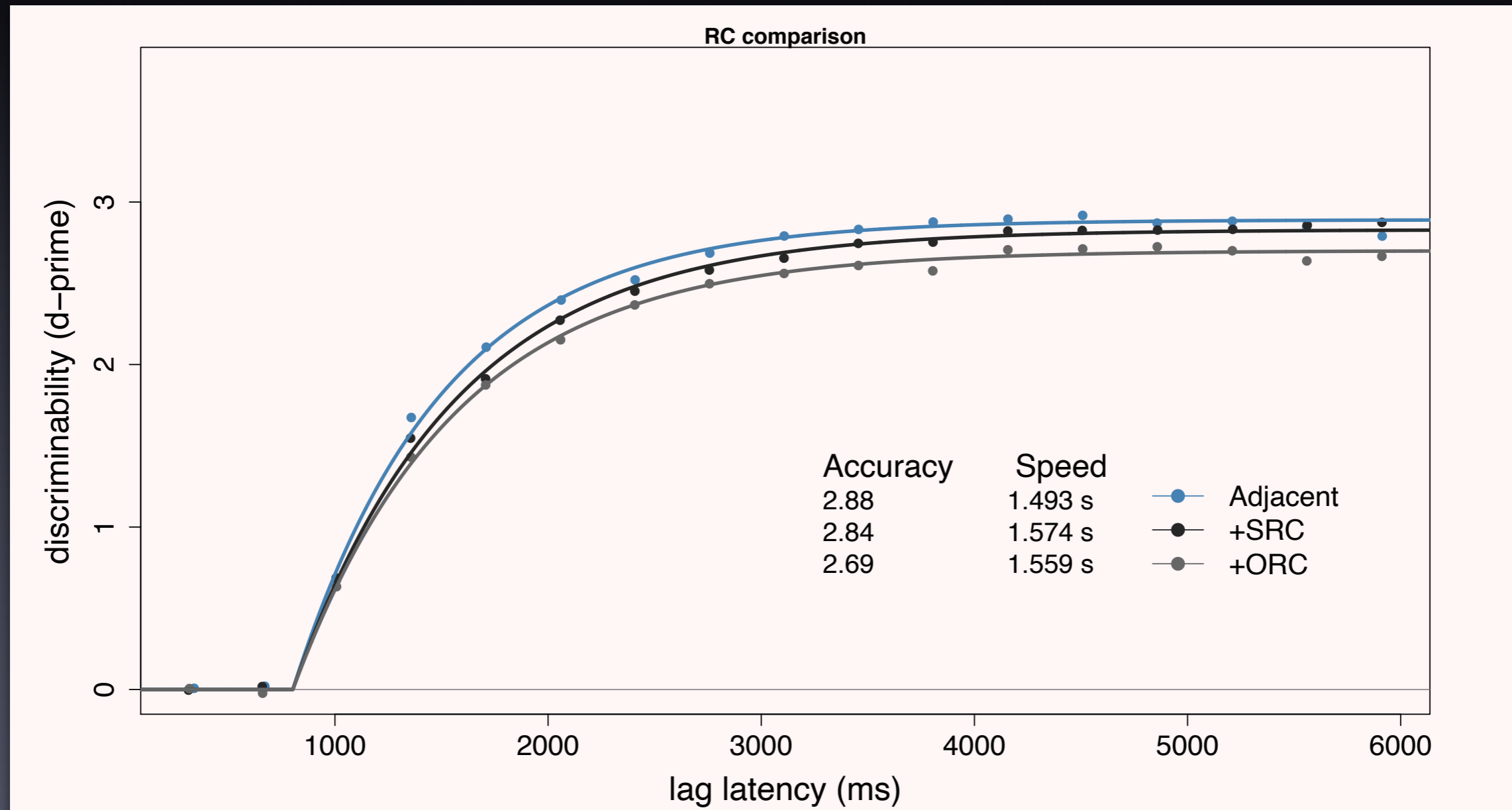   *The officer was informed that the driver who the ambulance hit fainted.*

ADJACENT
The officer was informed that the driver fainted.
SUBJECT RELATIVE CLAUSE
The officer was informed that the driver who wrecked the ambulance hit fainted.
OBJECT RELATIVE CLAUSE
The officer was informed that the driver who the ambulance hit fainted.

RC comparison

discriminability (d–prime)

	Accuracy	Speed
Adjacent	2.88	1.493 s
+SRC	2.84	1.574 s
+ORC	2.69	1.559 s

lag latency (ms)

✴Findings replicate McElree et al (2003):
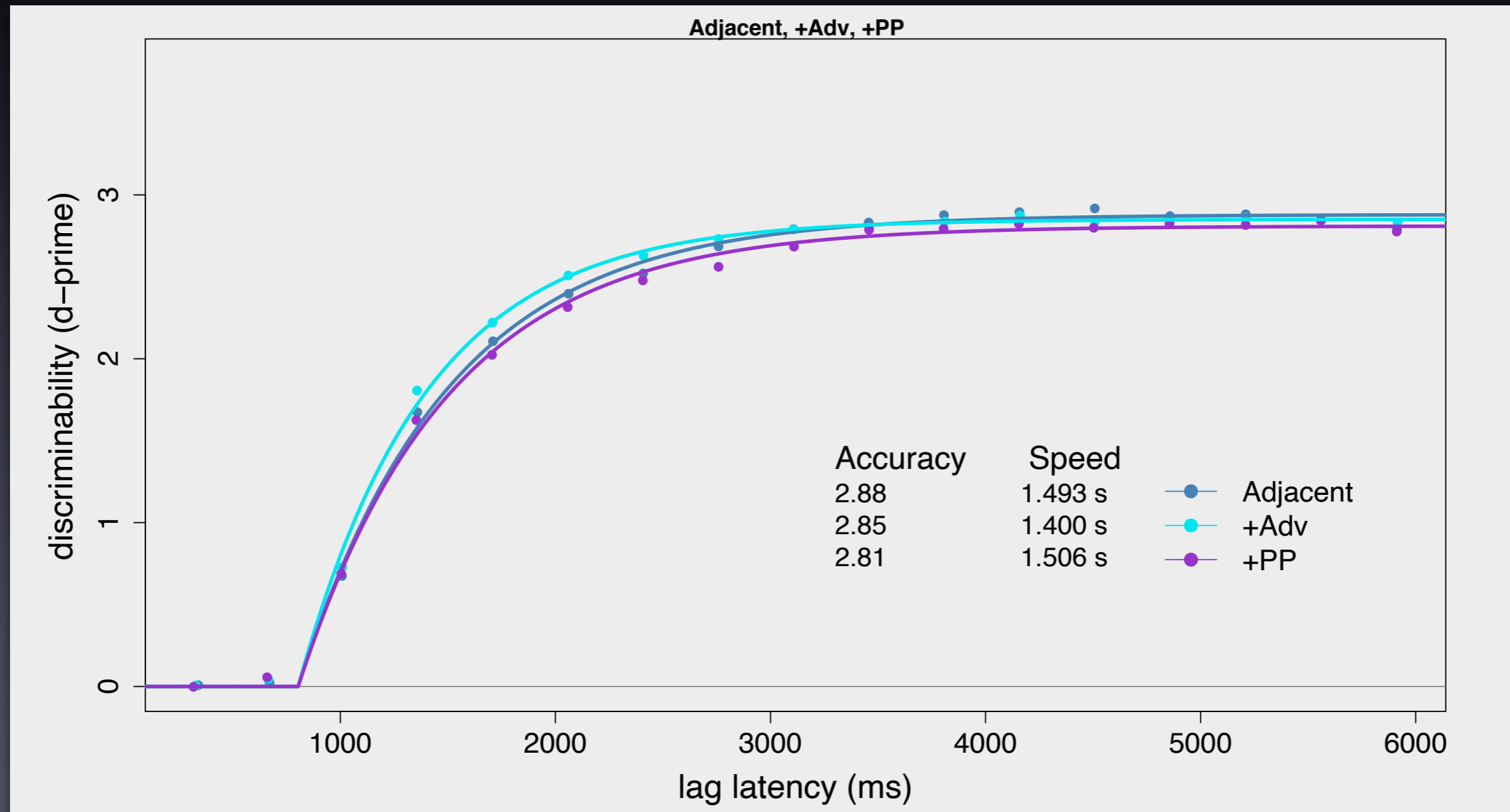   Relative clauses displace subject from focal attention

ADJACENT

The officer was informed that the driver fainted.

ADVERB

The officer was informed that the driver abruptly fainted.

PREPOSITION PHRASE (PP MODIFYING THE SUBJECT)

The officer was informed that the driver of the ambulance fainted.

✳PP modifying the subject keeps the subject active in focal attention
✳ Adverb? Processing speed was significantly faster than Adjacent

Adverbs such as *abruptly* in our Adverb condition modified the VP. Preverbal modifiers strongly—if not unequivocally—signal the presence of a VP.

The officer was informed that the driver abruptly fainted.

The speed advantage for the Adverb condition may reflect this "headstart" on VP processing.

EXPERIMENT 2: VP VS SENTENTIAL ADVERBS

ADJACENT
The officer was informed that the driver fainted.   *...*drained.*

ADVERB/VP
The officer was informed that the driver abruptly fainted.

✳ADVERB/S
The officer was informed that the driver evidently fainted.

PREPOSITION PHRASE (PP MODIFYING THE SUBJECT)
The officer was informed that the driver of the ambulance fainted.
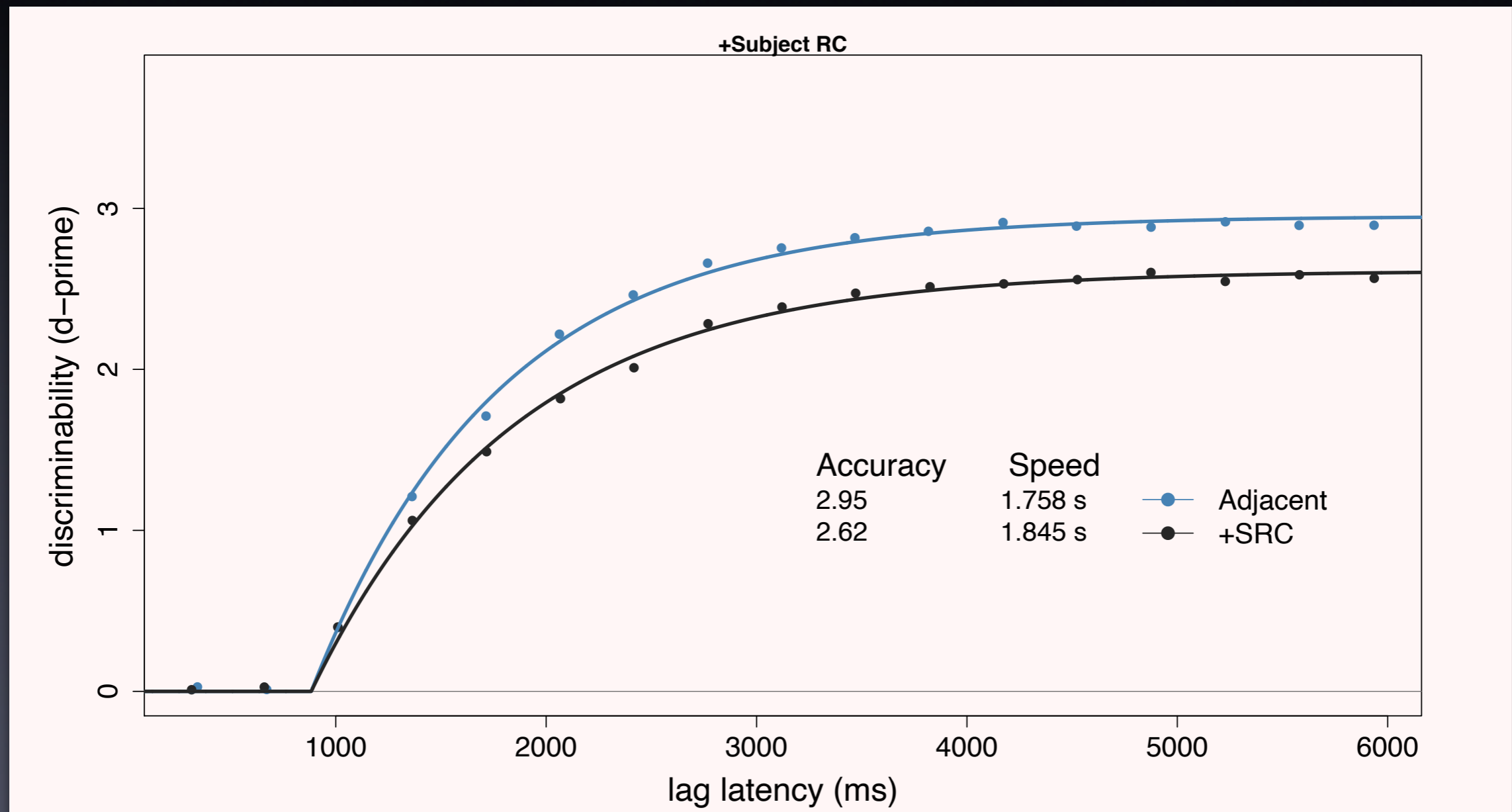
SUBJECT RELATIVE CLAUSE
The officer was informed that the driver who wrecked the ambulance fainted.

ADJACENT
The officer was informed that the driver fainted.
SUBJECT RELATIVE CLAUSE
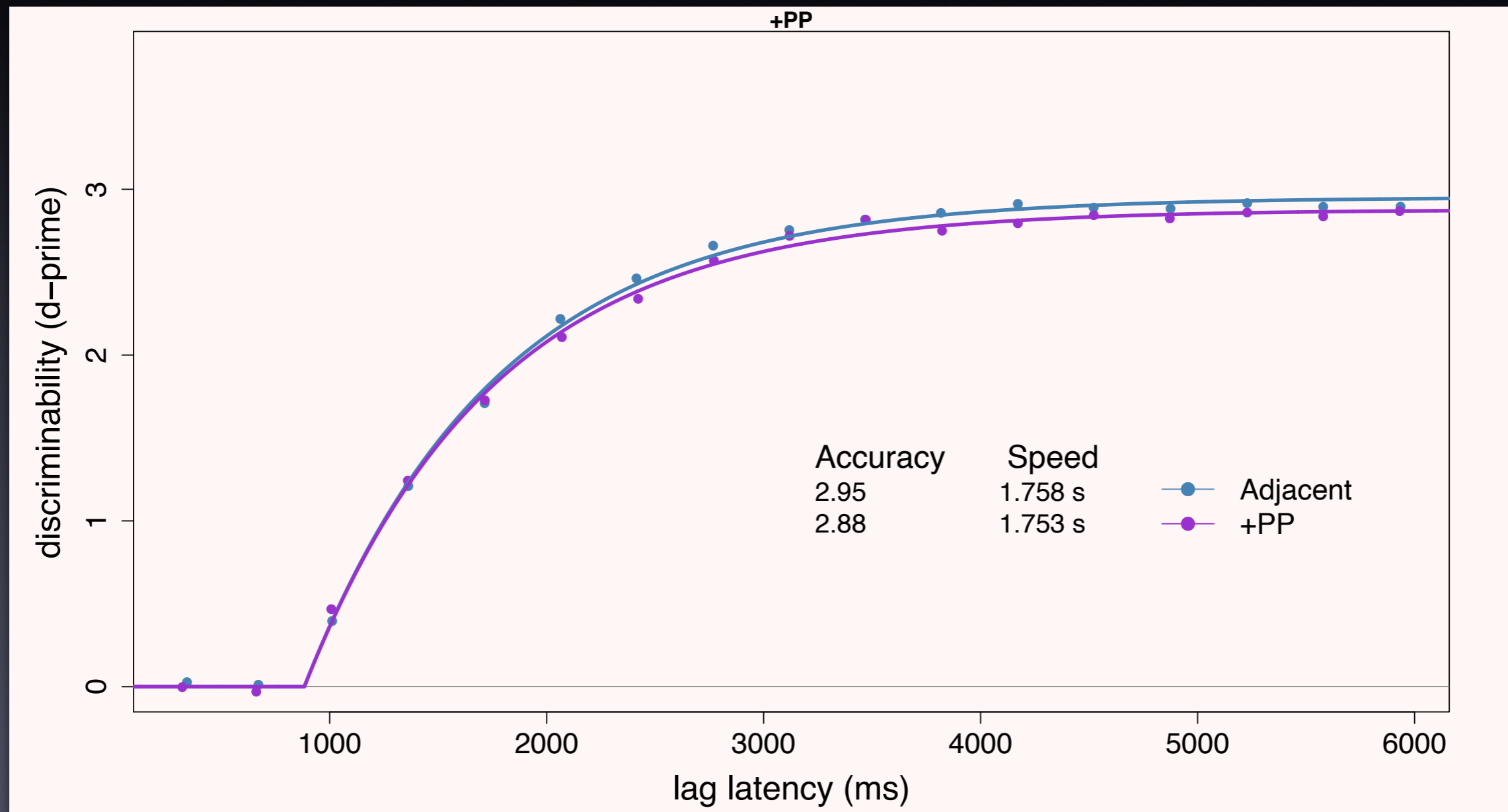*The officer was informed that the driver who wrecked the ambulance hit fainted.*

✳ As in past studies, a relative clause displaces subject from focal attention.

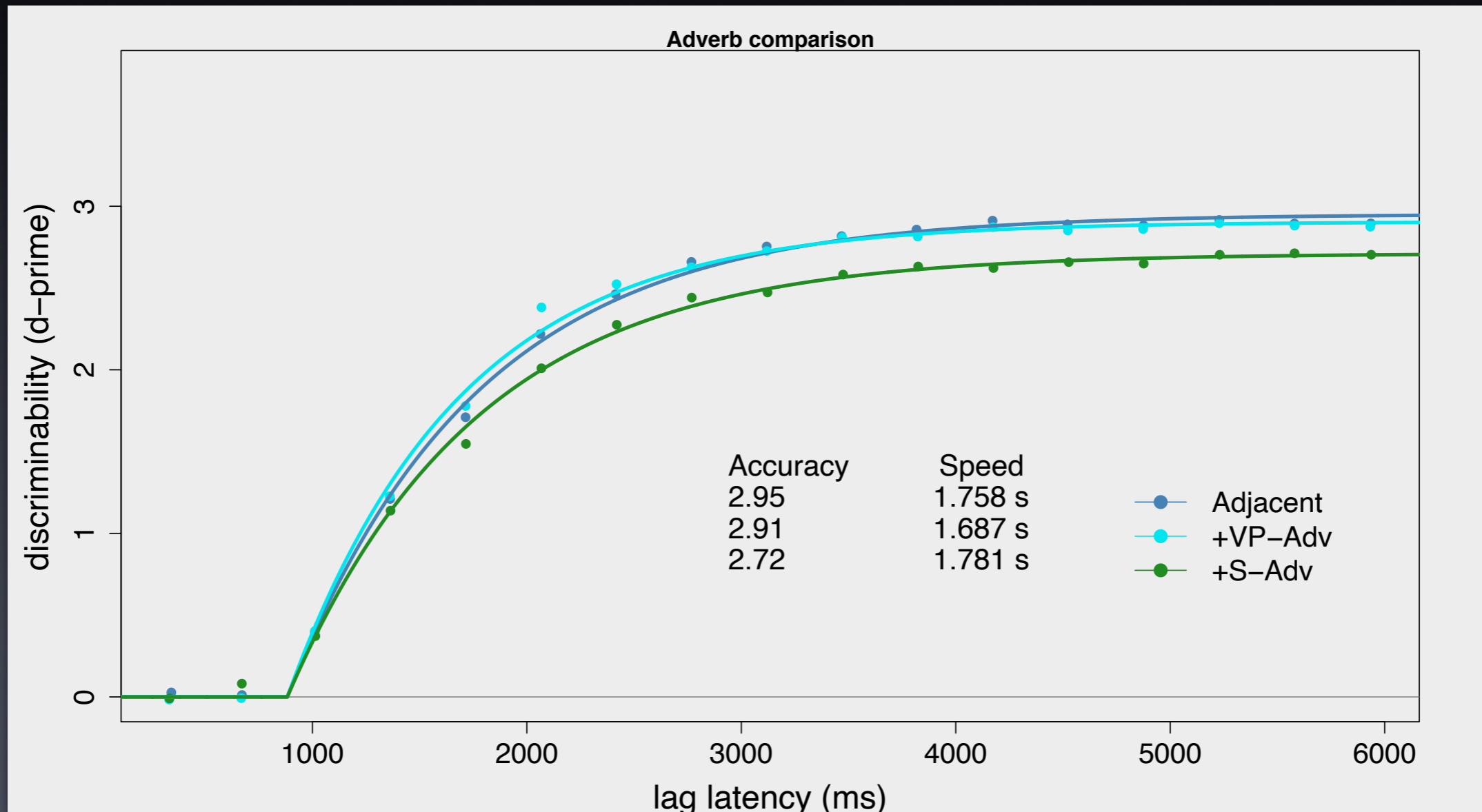Again, a PP does <u>not</u> displace the subject from focal attention.

ADJACENT
The officer was informed that the driver fainted.

ADVERB/VP
The officer was informed that the driver abruptly fainted.

ADVERB/S
The officer was informed that the driver evidently fainted.

Adverb comparison

Accuracy	Speed
2.95	1.758 s
2.91	1.687 s
2.72	1.781 s

Adjacent
+VP−Adv
+S−Adv

discriminability (d−prime)

lag latency (ms)

✳ A high-attaching adverb does <u>not</u> show the 'prep-processing' advantage of VP-modifying adverb, nor does it displace the subject from focal attention.

THE SPAN OF FOCAL ATTENTION IN COMPREHENSION

Our comprehension results converge with those from basic memory research—using a wide range of 'memory' tasks (see McElree, 2006*) —indicating that focal attention is extremely limited, perhaps limited to a single chunk (processing unit).

In comprehension, our results suggest that only the last major constituent (e.g,. subject-NP) processed is maintained in focal attention, and hence does not require retrieval to be restored

Even so, not all information about such a constituent may active within focal attention.

* McElree, B. (2006). Accessing recent events. In B. H. Ross (Ed.), *The psychology of learning and motivation*, Vol. 46. San Diego: Academic Press.

WAGERS & MCELREE (IN PREP; CUNY '09 TALK)

Availability of a plurality feature throughout the building of an NP.

MARKED FEATURE   **NO FOCAL/NONFOCAL BREAK**

...those
monkeys.   *...*monkey*
...those face-making monkeys.
...those mischievous, face-making monkeys.

UNMARKED FEATURE   **ADJACENT FASTER THAN +1 AND +2**
MODIFIERS

...that monkey.   *...*monkeys*
...that face-making monkey.
...that mischievous, face-making monkey.

An unmarked feature of the determiner does not appear to be maintained in focal attention throughout processing of the NP.

GENERAL CONCLUSION

Memory operations may be more ubiquitous in comprehension than previously supposed.

Even simple expressions may require shunting information between memory and focal attention.