

Does selective reanalysis really play a role in sentence processing? Implications for computational models of eye-movement behaviour.

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Some of the computational models that make numerical predictions about real-time syntactic processing during reading.

- Binder, Duffy & Rayner, 2001; Christiansen and Chater, 1999, 2001; Elman, Hare and McRae, 2004; Ferretti and McRae, 1999; Gibson, 1998; Green and Mitchell, 2006; Grodner and Gibson, 2005; Hale, 2003; Just and Carpenter, 1992; Konieczny and Döring, 2003; Levy 2007; Lewis, 1993; Lewis and Vasishth, 2005; MacDonald and Christiansen, 2002; McRae, Spivey-Knowlton and Tanenhaus, 1998; Narayanan and Jurafsky, 2002; Rohde, 2002; Spivey and Tanenhaus, 1998; Stevenson, 1993, 1998; Tabor, Juliano and Tanenhaus, 1997; Tanenhaus, Spivey-Knowlton & Hanna, 2000; Vasishth, Boston, Patil, Hale and Kliegl, 2007.



We need some steep hills (= data-fitting) to thin out the field!

Empirical challenge for this talk....

- To predict and explain reading/eye-tracking behaviour in the aftermath of reading a disambiguating word.
- All computational models predict increased processing load
- A very long-standing further claim is that an operation dubbed “Selective Reanalysis” is used to direct the eye back to implement various repair processes.

Selective Reanalysis

- A syntactic recovery operation proposed by Frazier and Rayner (1982) that enables the linguistic processor to exploit “whatever information it has available about the type of error it has committed to guide its reanalysis attempts” (F & R, 1982: Abstract).
- Based on this information, the eyes are sent “directly to the ambiguous phrase ... (i.e., the region containing the information that would permit the parser to locate the source of its error)”. (F & R, 1982: p.188)

Theoretical relevance of Selective Reanalysis

- Apart from some of Lewis's models, none of the existing computational models is equipped to account for re-reading and reprocessing phenomena of the kind postulated.
- It follows that if Selective Reanalysis is a real phenomenon then almost all existing models of syntactic processing suffer from severe deficiencies.

Characteristics of Selective Reanalysis

1. Destination of the regressive saccade is determined on the basis of linguistic considerations
2. Saccade destination is assumed to be pre-programmed before regression movement is initiated (a bit like a SatNav system)
3. Targeting is assumed to be precise, efficient and direct.

Time Out – an alternative to Selective Reanalysis

- In the face of difficulty, the parser “buys time” by preventing the eyes from progressing.
- The eye-control system is instructed to programme time-filling refixations or easily-programmed and executed short-range regressions.
- By hypothesis, the fixation position itself is unimportant.
- The eyes are merely “parked” in a convenient place providing the opportunity for covert analysis to run its course.

Time Out: A get-out-of-jail-free card?

- If regressive movements following disambiguation are symptoms of Time Out processing and not of Selective Reanalysis, then most or all existing models might well provide viable accounts of syntactic processing.
- So – quite a lot hangs on the existence or otherwise of Selective Reanalysis.

Past evidence for Selective Reanalysis: What Frazier and Rayner achieved.

Ambiguous Region

Destination for 73.1% of regressions from disamb. region

Since Jay always jogs *a mile and a half* really seems like a short distance to him.

**“Beginning of sentence”
+ “Before ambiguity”**

Landing site for just 7.7% of regressions

Disambiguation Region

Regressions launched from here returned to same region on 19.2% of occasions

Unequivocal support for Selective Reanalysis?

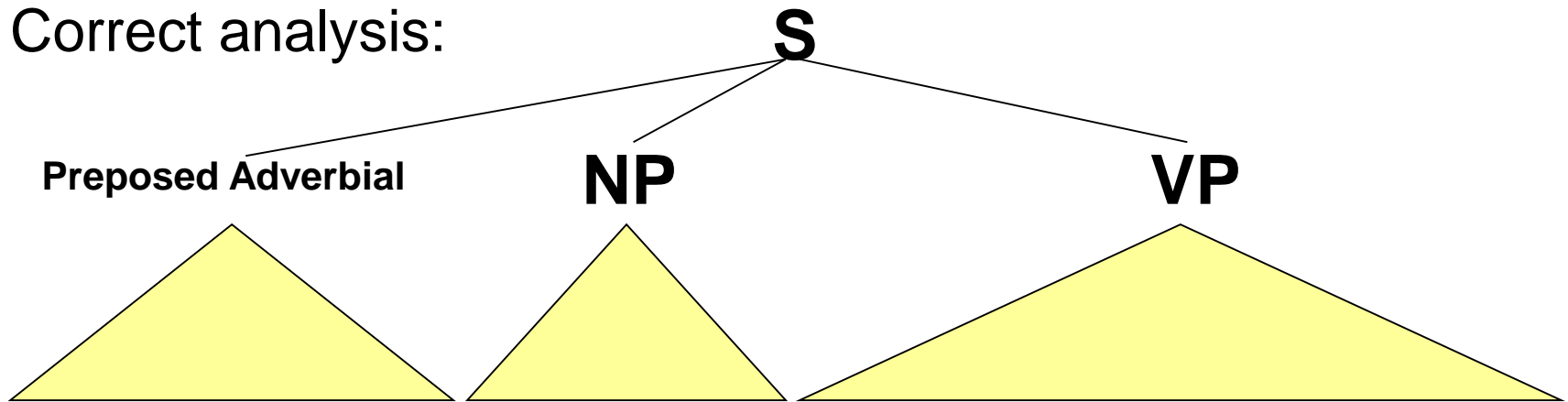
- No! ... because...
- F&R (1982) reported no stats on regression destinations
- F&R (1982) took no account of any role of non-syntactic regressions.
- Contemporary Reanalysis work doesn't necessarily predict returns to the "ambiguous region" (which is what F&R(1982) reported).
- Returns to the ambiguous region don't adjudicate between Selective Reanalysis and Time Out
- Meseguer, Carreiras and Clifton (2002) – also problematic

This talk revisits Selective Reanalysis and compares it with a competing account

- To develop the argument various definitions are required...

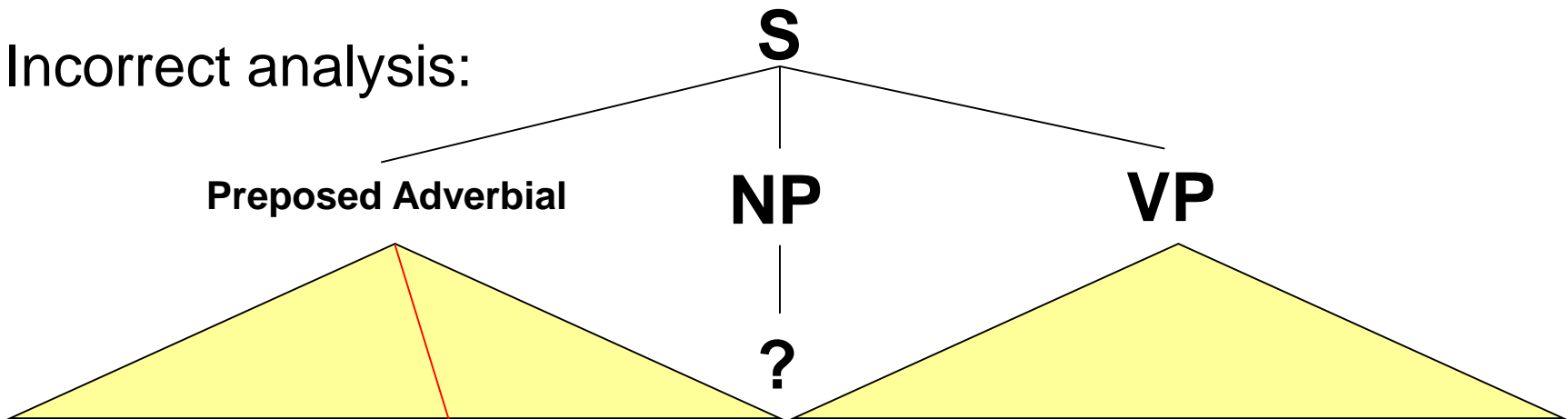
Definition of “Misanalysis area”

Correct analysis:



Since Jay **always jogs** *a mile and a half* really seems like a short distance to him.

Incorrect analysis:



Since Jay **always jogs** *a mile and a half* really seems like a short distance to him.

Misanalysis area

Materials for Experiment 1

Early Misanalysis area:

After the cadet **saluted the major** who was brusque and remote ordered
the sergeant to prepare the ammunition.

Late Misanalysis area:

Same 3-word string embedded

The new NCO recorded that after the cadet **saluted the major** ordered
the sergeant to prepare the ammunition.

Selective Reanalysis predicts
returns to Words 4-6 in
this case

Time Out predicts no
difference in profiles of
returns in Early/Late cases

.. but returns to Words
9-11 here...

Controls for Experiment 1

Early Misanalysis area:

After the cadet saluted, *the major who was brusque and remote* ordered the sergeant to prepare the ammunition.

Late Misanalysis area:

The new NCO recorded that after the cadet saluted, *the major* ordered the sergeant to prepare the ammunition.

Preliminary results and analysis

- Extensive analyses were carried out to confirm that we had reproduced all the standard findings in and after the disambiguation region.
- These showed: (i) reliably longer reading latencies at and beyond Word 12 in the No comma condition; (ii) higher regression rates etc. etc.
- Everything indicated that we had succeeded in reproducing standard and widely replicated disambiguation effects.

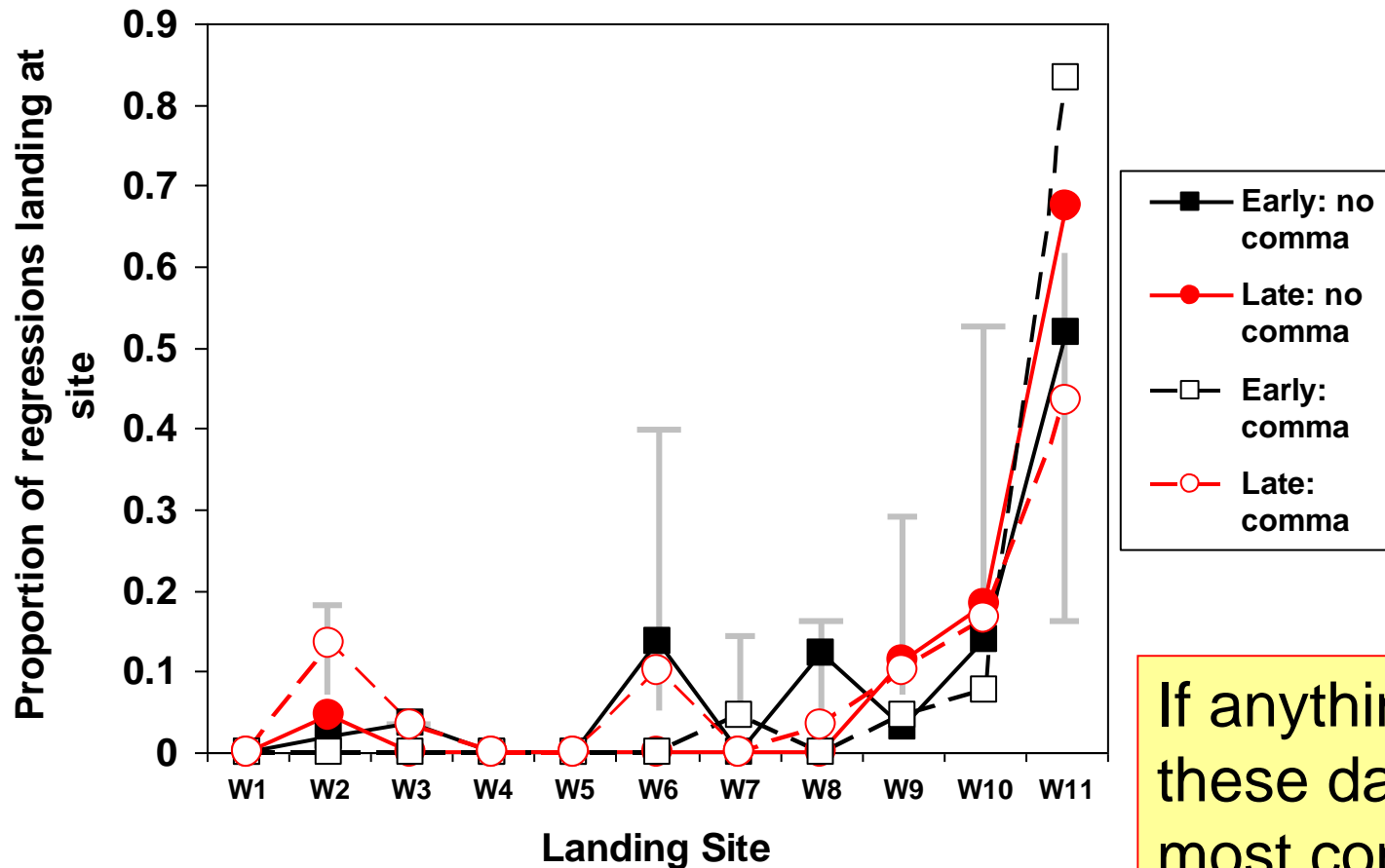
More detailed analysis: Classification of scan-paths starting with the disambiguation word (Word 12)

Single fixation	12	Proceeds to Word 13+													
Dwells before proceeding	12	12	Proceeds...												
	12	12	12	12	Proceeds...										
Local Regressions	12	10	12	Proceeds...											
	12	12	11	12	12	Proceeds...									
	12	12	9	9	9	11	12	12	Proceeds...						
	12	11	12	11	Proceeds...										
Targeted Remote regressions	12	11	10	8	7	6	4	2	4	5	7	10	12	12	Proceeds...
	12	9	7	6	12	Proceeds...									
	12	6	3	4	5	12	12	Proceeds...							
	12	9	10	11	8	7	6	11	12	11	12	Proceeds...			
Other Remote regressions	12	10	7	Proceeds...											
	12	2	Proceeds...												
	12	12	2	12	Proceeds...										
	12	12	2	Proceeds...											

To examine Selective Reanalysis our first analysis focuses on the very first regressive landing site

After that we look at the regressive scan-paths as a whole

Landing sites of first regressions launched from Word 12 (disamb)

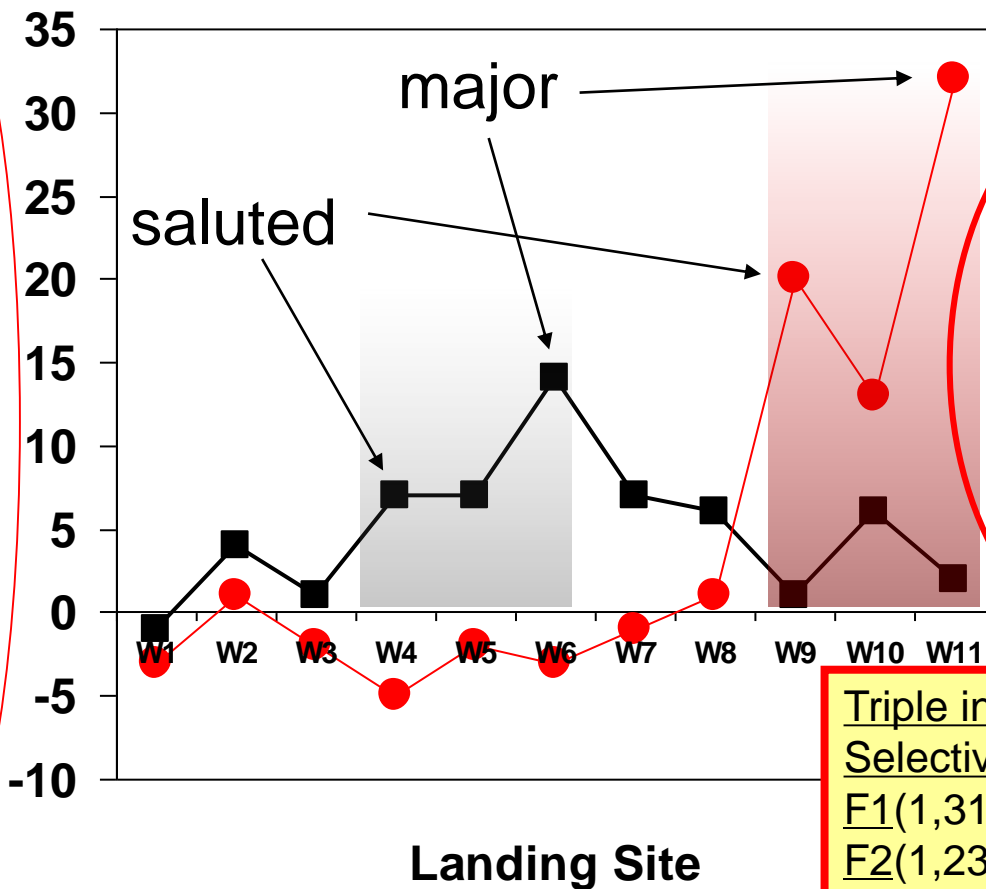


If anything these data are most compatible with Time Out

However, a different
pattern emerged later in
the scan-path....

Where the eyes should make for: Early Misanalysis Area (blue-grey) Late Misanalysis Area (pink)

Unpunctuated minus punctuated number
of regressions landing at site



Sentences with...

■ Early Misanalysis area

● Late Misanalysis area

No surplus visits

Triple interaction contrast supporting
Selective Reanalysis
to Words 1-8

$F_1(1,31) = 11.08, p < 0.01;$
 $F_2(1,23) = 19.66, p < 0.001;$
 $\text{MinF}'(1,53) = 7.07, p = 0.01).$

So – Though we don't see signs of the direct returns predicted by Selective Reanalysis, we do have clear evidence that placements of regressive fixations are somehow influenced by linguistic operations. But, does this rule out a role for less tightly-coupled forms of control – like Time Out?

This is tackled in Expt 2...

Materials for Experiment 2

Disambiguation word (Word 12) appears at end of Line 1:

After the cadet saluted *the major* *who was brusque and remote* ordered

the sergeant to prepare the arm

Word 12 shifted to beginning

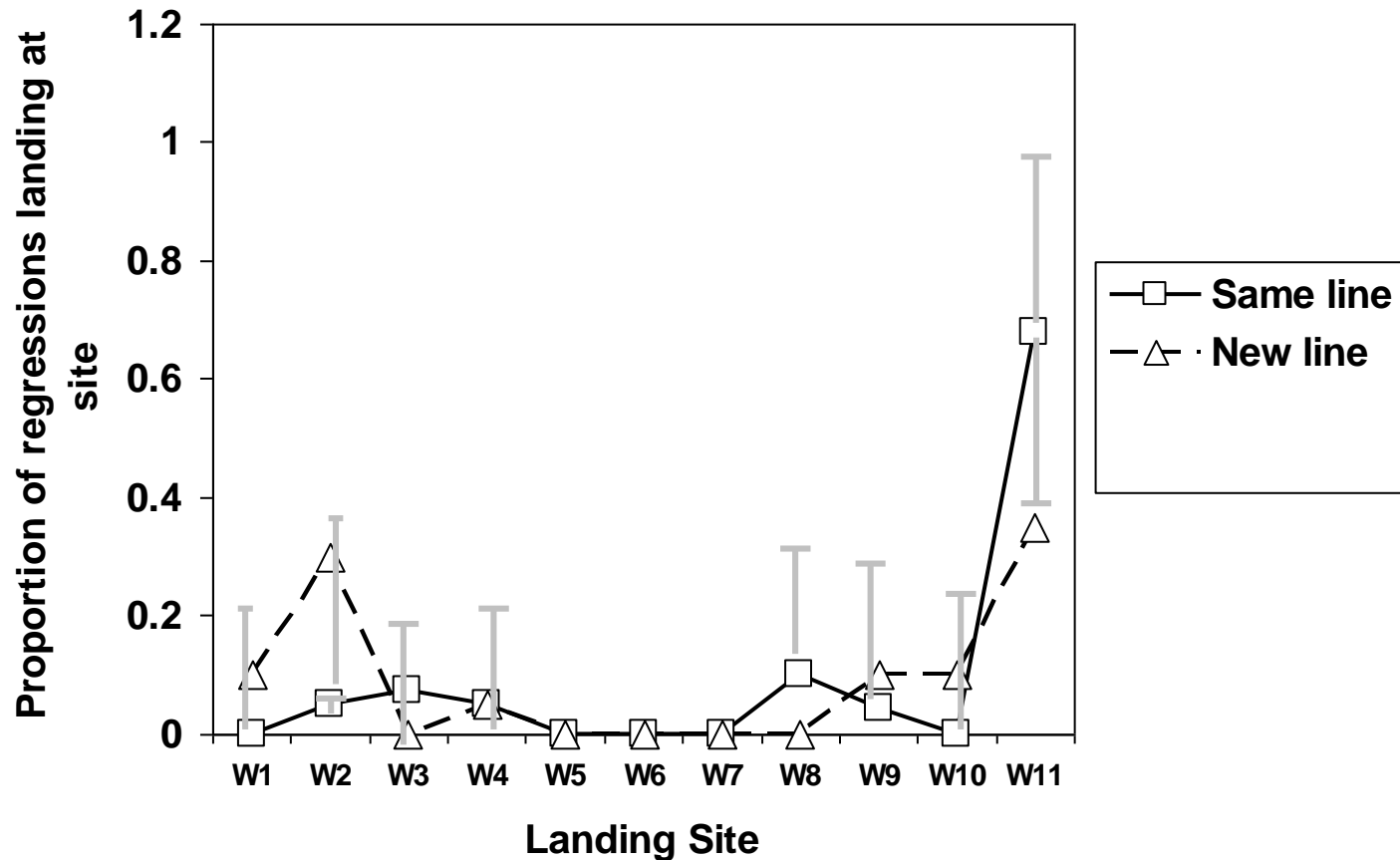
Selective Reanalysis predicts regression landing sites unaffected by position of ordered

After the cadet saluted *the major* *who was brusque and remote*

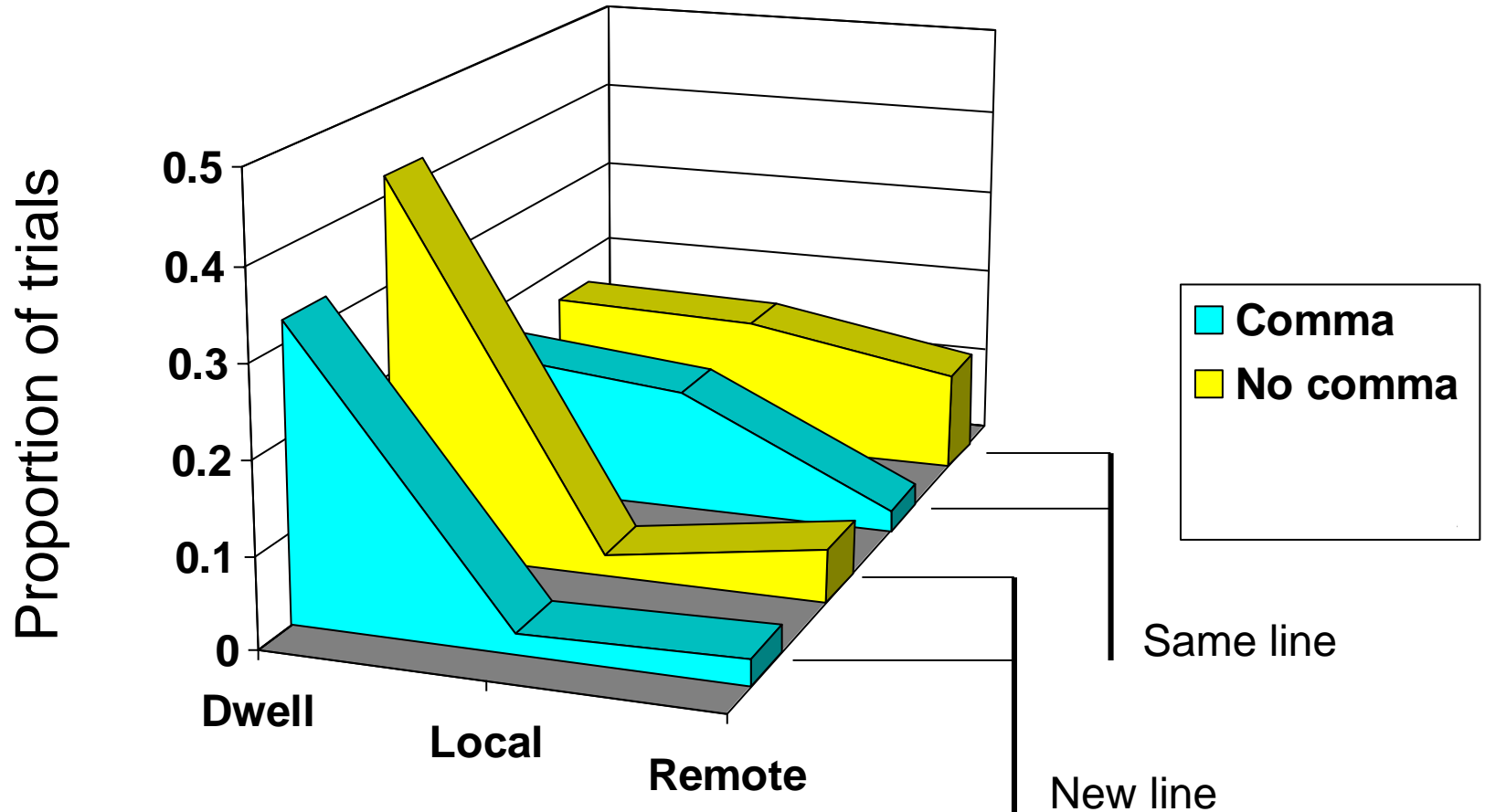
ordered the sergeant to prepare

Time Out predicts regression landing sites will cluster around position of ordered

Landing sites of regressions launched from Word 12 in its Line 1 & Line 2 locations



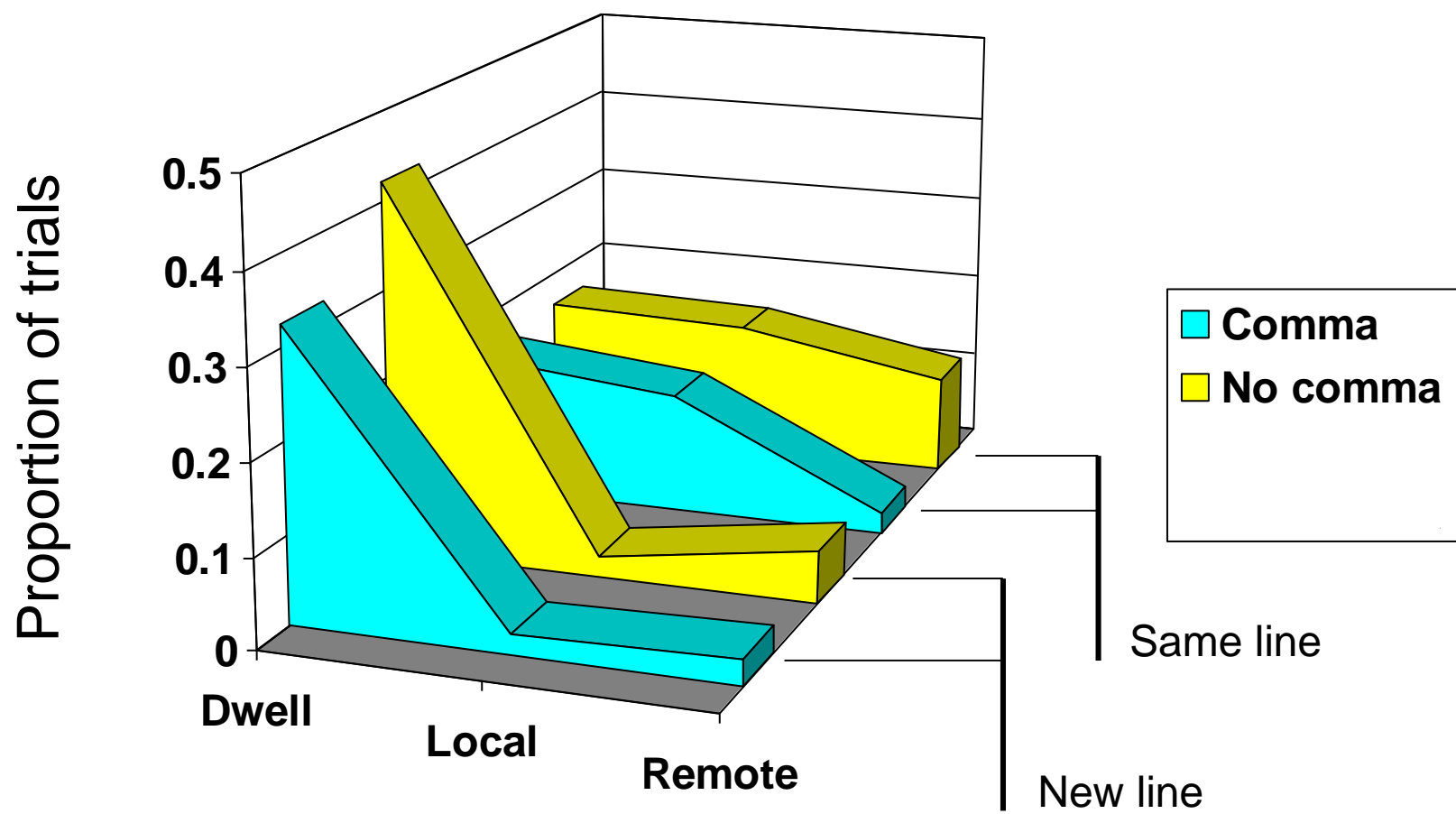
Classification of trials for which there are 2+ fixations before progression beyond Word 12



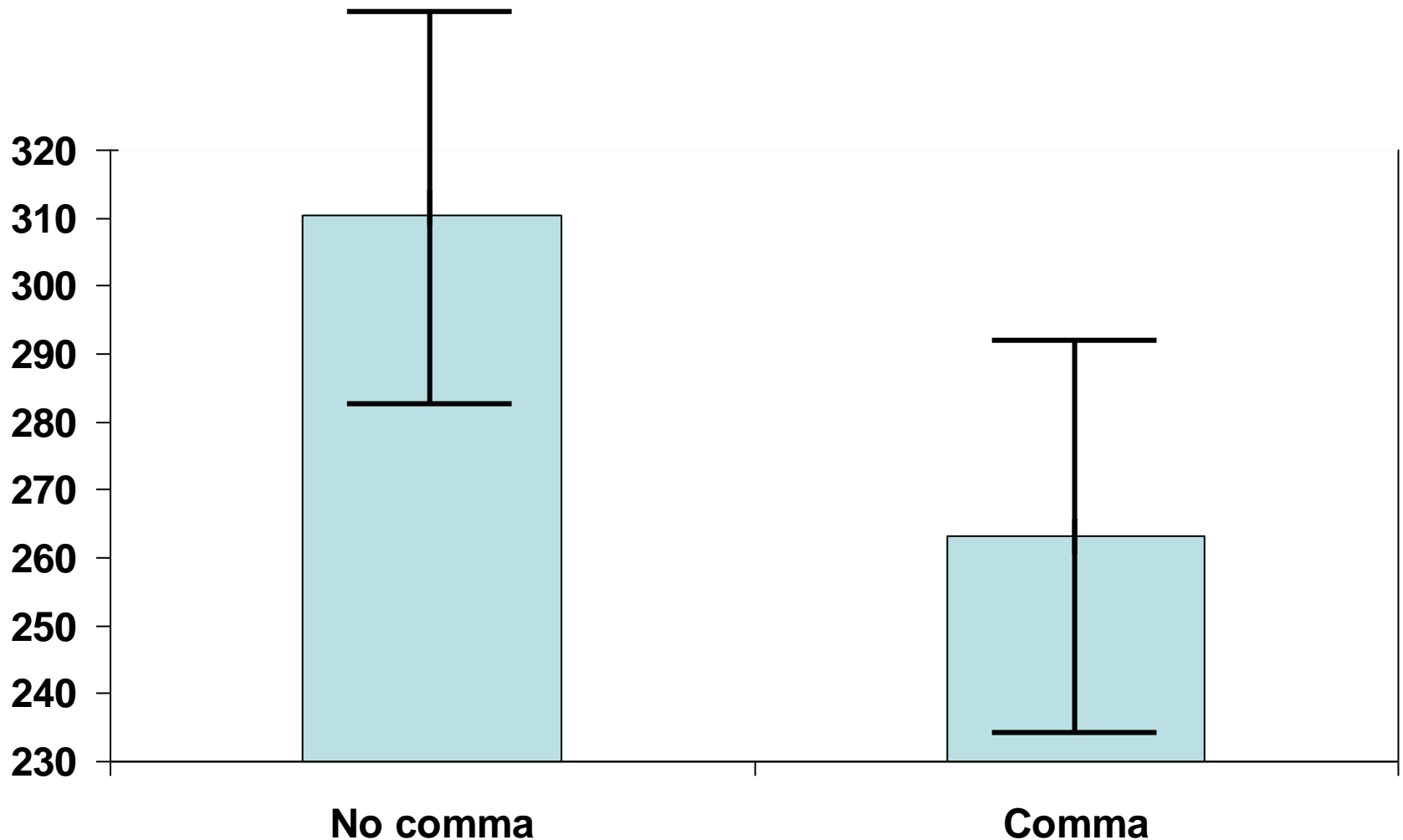
Definitions of Local and Remote regressions plus “dwells”

Single fixation	12	Proceeds to Word 13+													
Dwells before proceeding	12	12	Proceeds...												
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Classification of trials for which there are 2+ fixations before progression beyond Word 12



Dwell times on Word 12 for non-regression trials (Expts 1 & 2 combined: Same line only)



Empirical conclusions re: eye-tracking responses to disambiguation

- Confirmation that (some form of) Selective Reanalysis is a real phenomenon.
- However, in our experiments the overt returns to the Misanalysis area were not “direct”. Instead, they were faltering, staged and rather inefficient.
- On trials where regressions do not occur, there is an increased pause on the disambiguating word
- Presumably additional pause time is used for covert reanalysis

Theoretical implications for modelling disambiguation operations

- Most current computational models are compromised in that they offer no account of regression trajectories, and therefore have no way of explaining selective returns.
- Our final slide summarises the current standing of the main theories of syntactic processing...

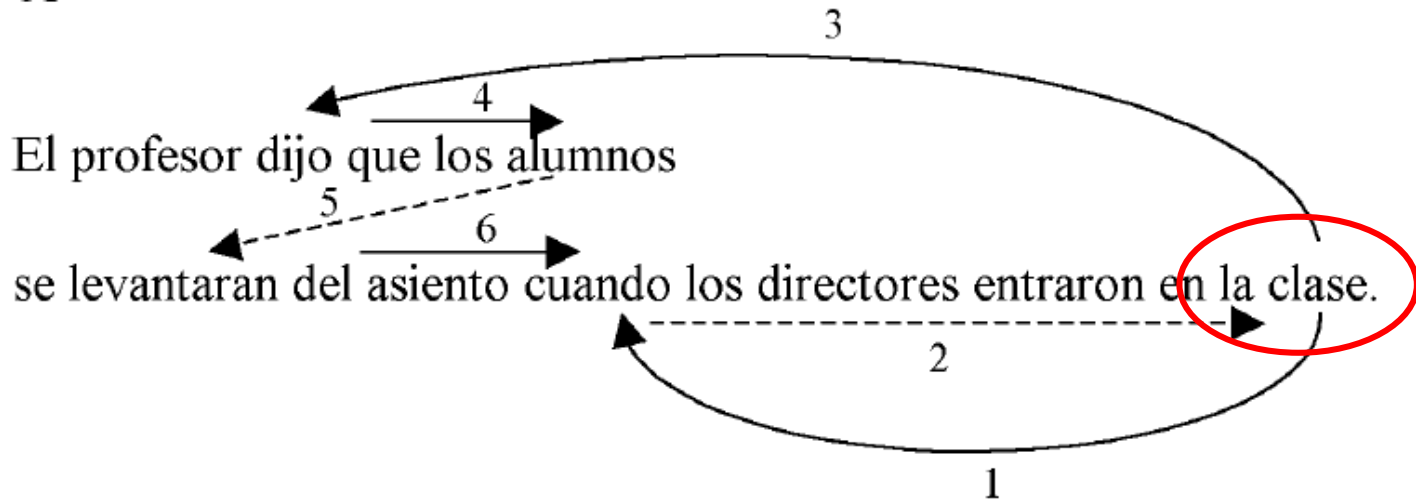


t was sturdy and nimble
semen hunted the moose
was furious and bitter
hilda's phoned the coach
o was grouchy and aloof
maid dressed the queen
was drunken and drowsy
awoke awoke her father
was brusque and remote
cadet saluted the major
was dynamic and astute
diva married her agent
was nervous and scared
crowd heckled the comic
t was divided and weary
reps lobbied the union

After the cadet saluted the major who was brusque and remote ordered the sergeant to prepare the ammunition.

Launch sites used in Mesequer, Carreiras & Clifton (2004) study

A



B

