

Deep and surface anaphora can both prime, but demand different resources

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What is in our syntax?

Null hypothesis: Surfacism

- Words and their parts
- Phrase markers (group of words)
- Constrained relations among these (a system to regulate the combinatorics)

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Non-null hypothesis: “abstract” syntax

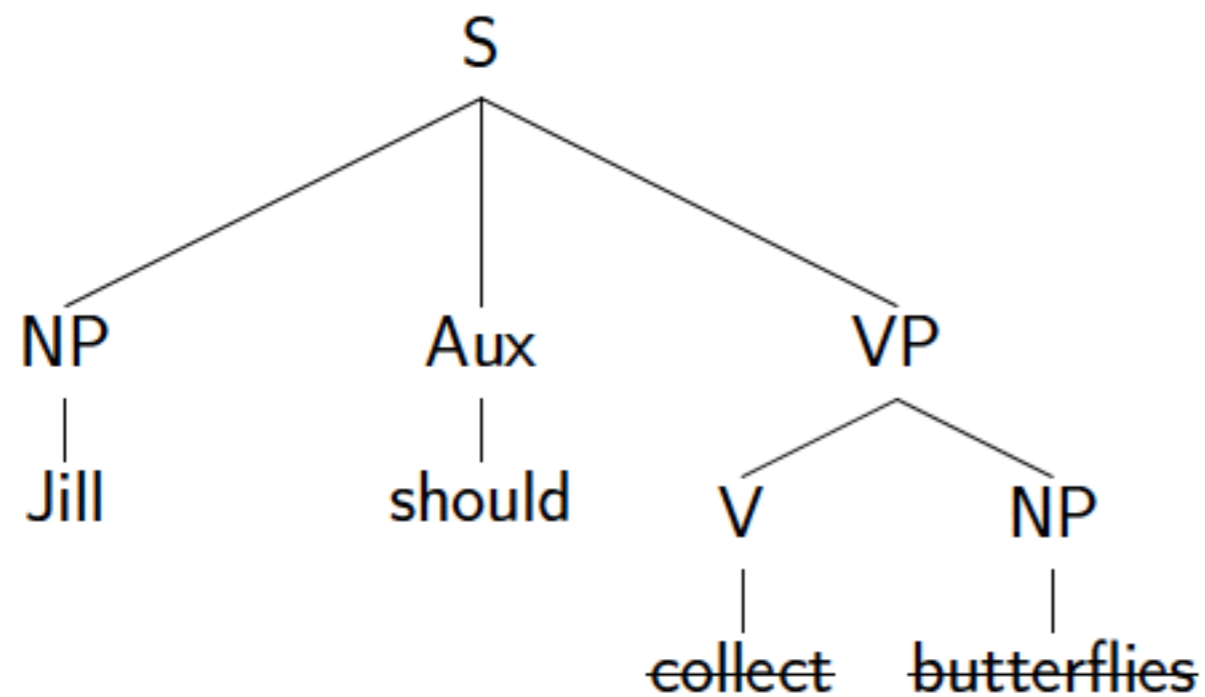
- Phonologically inactive version of the overt syntax

In elliptical constructions, are there unpronounced syntactic structures?

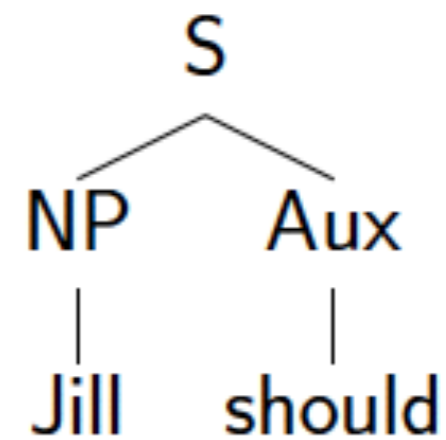
Bill should collect butterflies. Jill should too.

=

Bill should **collect butterflies**. Jill should **collect butterflies** too.



full abstract structure, but some words are not pronounced.



no underlying structure for the unpronounced words (the missing words are truly missing)

There have been a lot of linguistics work discussing this question (Sag 1976; Chung, Ladusaw & McCloskey 1995; Merchant 2001; Hardt 1993; Culicover & Jackendoff 2005; Kehler 2002; Miller and Pullum 2013)

We will focus on the processing aspect of this question:

- What are the processing consequences if there exists a level of “silent” syntax?
- What is a good experimental paradigm to investigate this question?

Our working hypothesis

- **Structural priming effect:** exposure to the structure of one utterance affects the production/comprehension of the structure of the subsequent utterance
- If “silent” syntax exists for ellipsis, we should see comparable structural priming effect for ellipsis and its full-structure counterpart.

What is structural priming effect?

- In production, structural priming refers to the observation that participants tend to produce the same structure they were exposed to previously (see Branigan and Pickering 2016; Pickering and Ferreira 2008; for reviews)
- Bock (1989): exposure to a prepositional dative structure (V NP PP) will prime more production of another prepositional dative structure even without any semantic overlap.

- Bock and Loebell (1990): syntactic category overlap without semantic similarities can prime (“*The foreigner was loitering by the broken traffic light*” primed “*The boy was woken by an alarm clock*”).

observations like this suggest that structure priming is more specifically about phrase structure representations.

What is the mechanism behind priming?

In general, priming happens because the memory representation of a particular representation is strengthened through exposure to the input. Specific accounts may differ:

- **The residual activation account:** the previously used syntactic forms maintain a (short-term) higher activation level, and thus are easier to access (Pickering & Branigan 1998).
- **The implicit learning account:** the learning system adapts to previously used syntactic forms and adjusts its original meaning-form pair associations (Bock & Griffin 2000; Chang et al. 2006).

Experiment 1 Design (Item n=18)

NP NP primes:

First Ralph sang Sheila a song, and then...

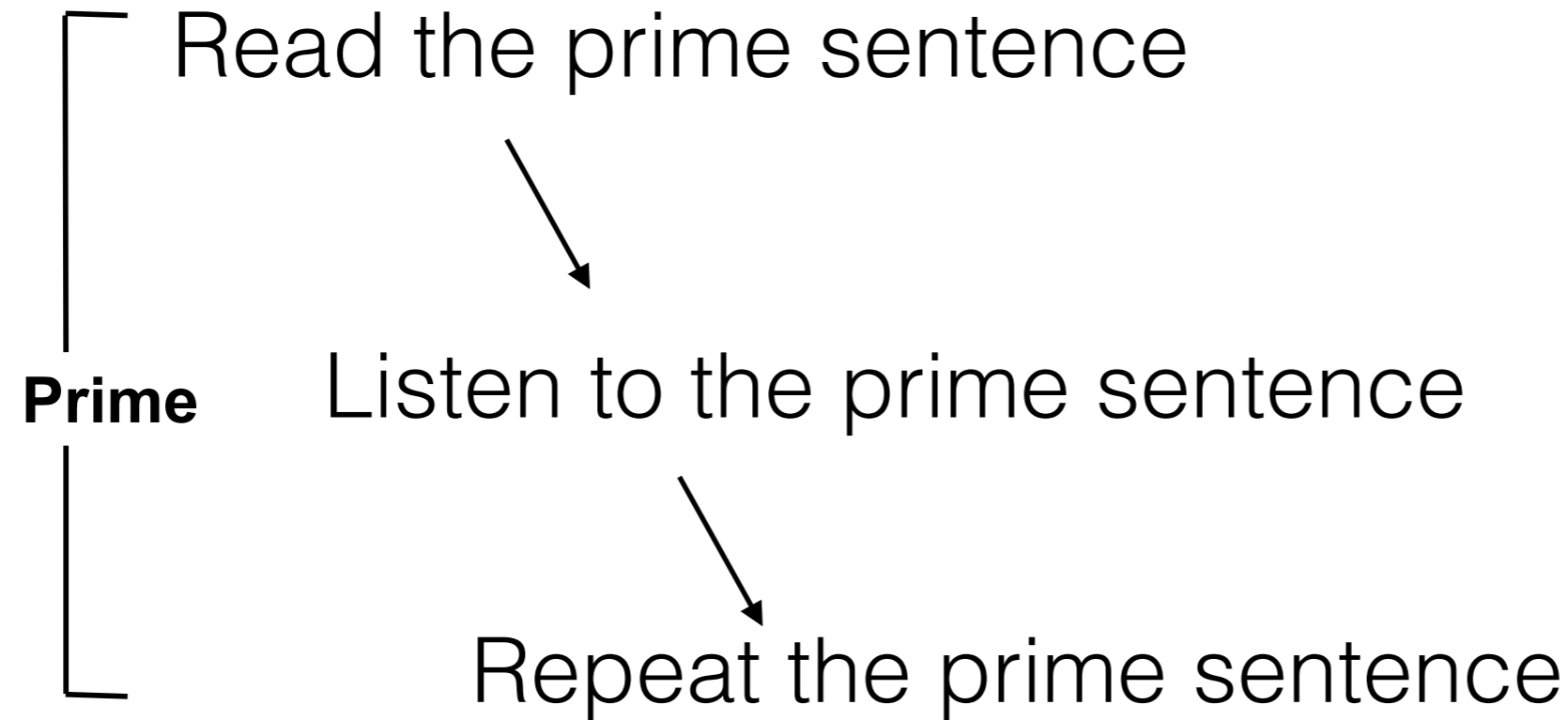
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|--------------------------|------------------|
| (a) Marcus did. | (VP ellipsis) |
| (b) Marcus sang her one. | (Full Structure) |
| (c) Marcus groaned. | (Baseline) |

NP PP primes:

First Ralph sang a song to Sheila, and then...

- | | |
|-----------------------------|------------------|
| (d) Marcus did. | (VP ellipsis) |
| (e) Marcus sang one to her. | (Full Structure) |
| (f) Marcus groaned. | (Baseline) |

Experiment 1 task procedure

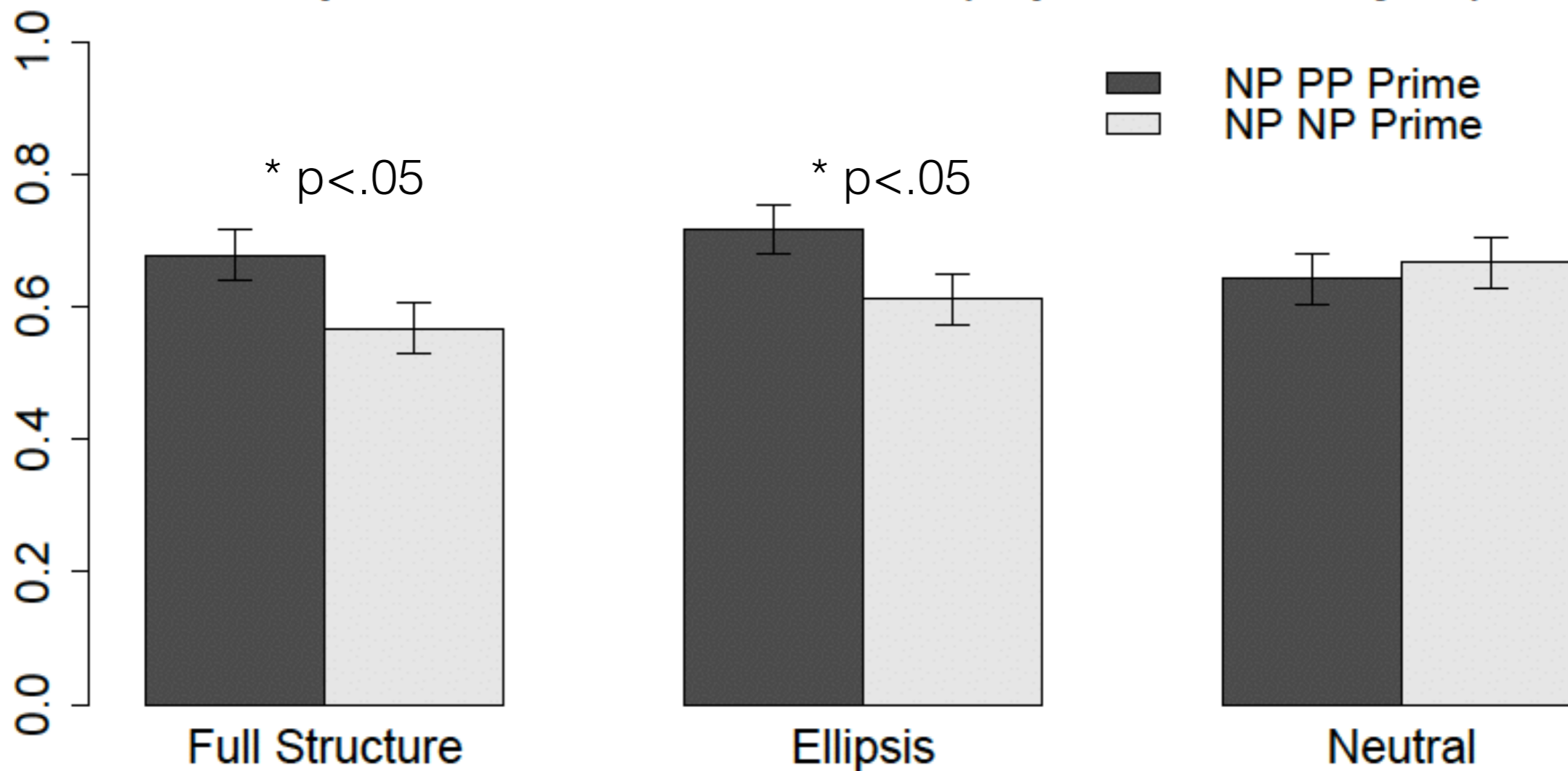


Target:
Describing a
picture



- Structural priming is triggered by the exposure to the structure of the previous utterance.
- If VPE involves a level of abstract syntax, exposure to a VPE construction, like exposure to a Full Structure utterance, involves repeated exposure to the relevant syntactic representation, and therefore both of them should produce larger priming effect than the Baseline control.

Proportion of NP PP Production (Experiment 1, Subj=79)



Effect of Prime Sentence Type $p < .01$
Prime Type x Structure Type $p < .05$

Summary of Experiment 1

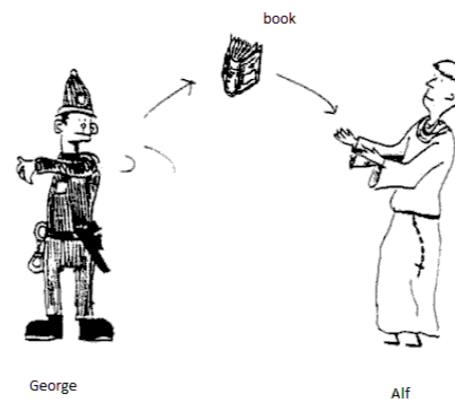
- Ellipsis and the Full Structure conditions produced larger priming effects than the Baseline control condition, providing the initial evidence that abstract structural representations may be generated when ellipsis is being processed.

A replication and extension of Expt 1 in Hall et al. 2015

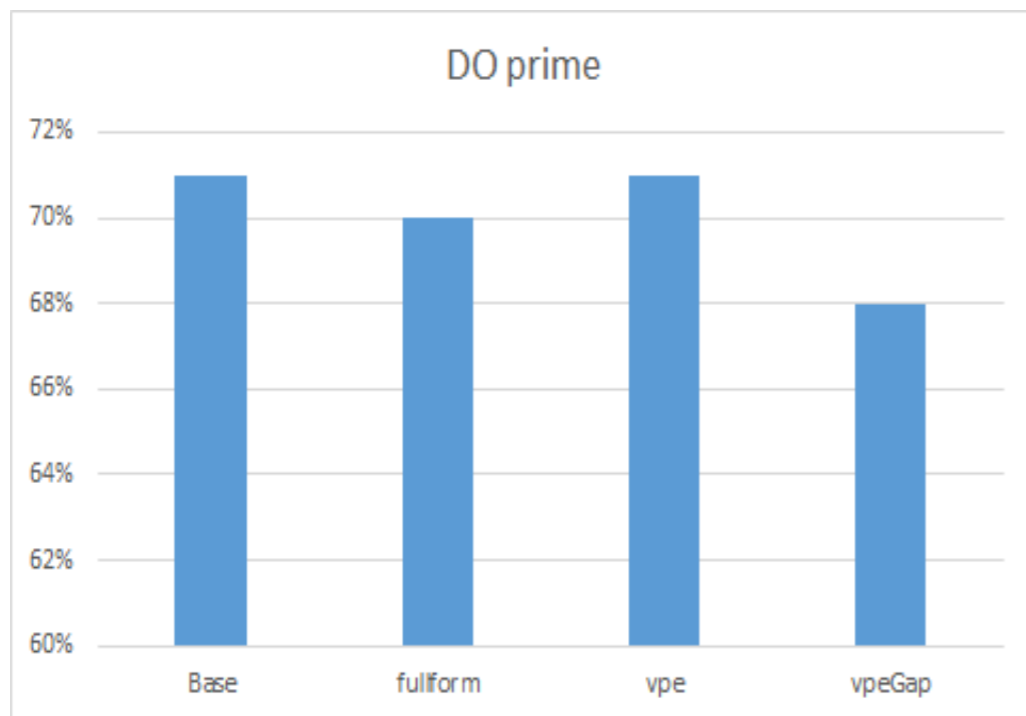
Largely identical design, but with some important changes

- a new condition (“VPE-gap”) was added, in which a clause is inserted before the elliptical clause (e.g. “First Larry threw Jay a banana, because the biology class was so boring, and then Eric did”).
- simplified procedure

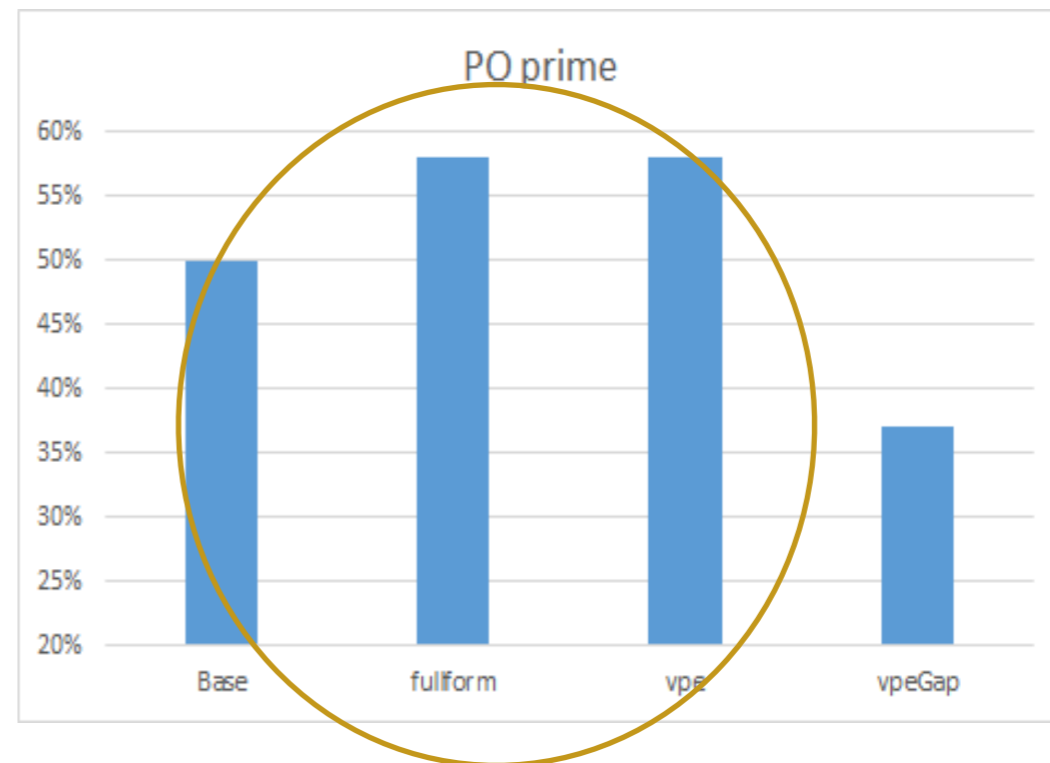
Hear prime, e.g.
“First Larry
threw Jay a
banana and
then Eric did”



Comprehension
question (on 50% of
all items)



DO responses



PO responses

A cautious retake on the structural priming paradigm

- Although there are good evidence that the structural priming paradigm is probing syntactic representations, there are equally good evidence that it is not only syntactic representations that can trigger structural priming effect.
- In particular, thematic role order from the prime sentence can affect the word order of the target sentence as well.

The effect of thematic role order in structural priming

- The effect of thematic role order was reported in a number of earlier studies (Hare & Goldberg, 1999; Chang, Bock and Goldberg, 2003)

	Prime type	Examples	
a	<i>ditransitive</i>	His editor offered Bob the hot story.	V NP NP (recipient, theme)
b	<i>dative</i>	His editor promised the hot story to Bob.	V NP PP (theme, recipient)
c	<i>provide-with</i>	His editor credited Bob with the hot story.	V NP PP (recipient, theme)
d	<i>intransitive</i>	Sasha always dawdles over lunch.	The priming effect of (c) is similar to (a), but not (b)
	Target Picture	<i>A man hands a woman a box of candy.</i>	

- If thematic role order could prime as well, the structural priming effect from Experiment 1 does not necessarily lead to the conclusion that the ellipsis site contains silent syntactic phrase markers.
- A semantic representation in the ellipsis site that maintains the thematic role order information is sufficient to trigger the priming result in Expt 1
- Even the priming effect in the Full Structure condition could be triggered by thematic role order information, not necessarily syntax structure

A second try: compare VPE and NCA constructions

- Null complement anaphora (NCA)

We asked Anna to review these five films, and she **agreed** (to review them).

* We need to know which films Anna refused to review, and which ones she **agreed**.

- VP ellipsis (VPE)

We asked Anna to review these five films, and she **agreed to** (review them).

We need to know which films Anna refused to review, and which ones she **agreed to**.

Experiment 2 Design (Item n=32)

NP NP primes:

Daniel planned to send his mother a note, but after work ...

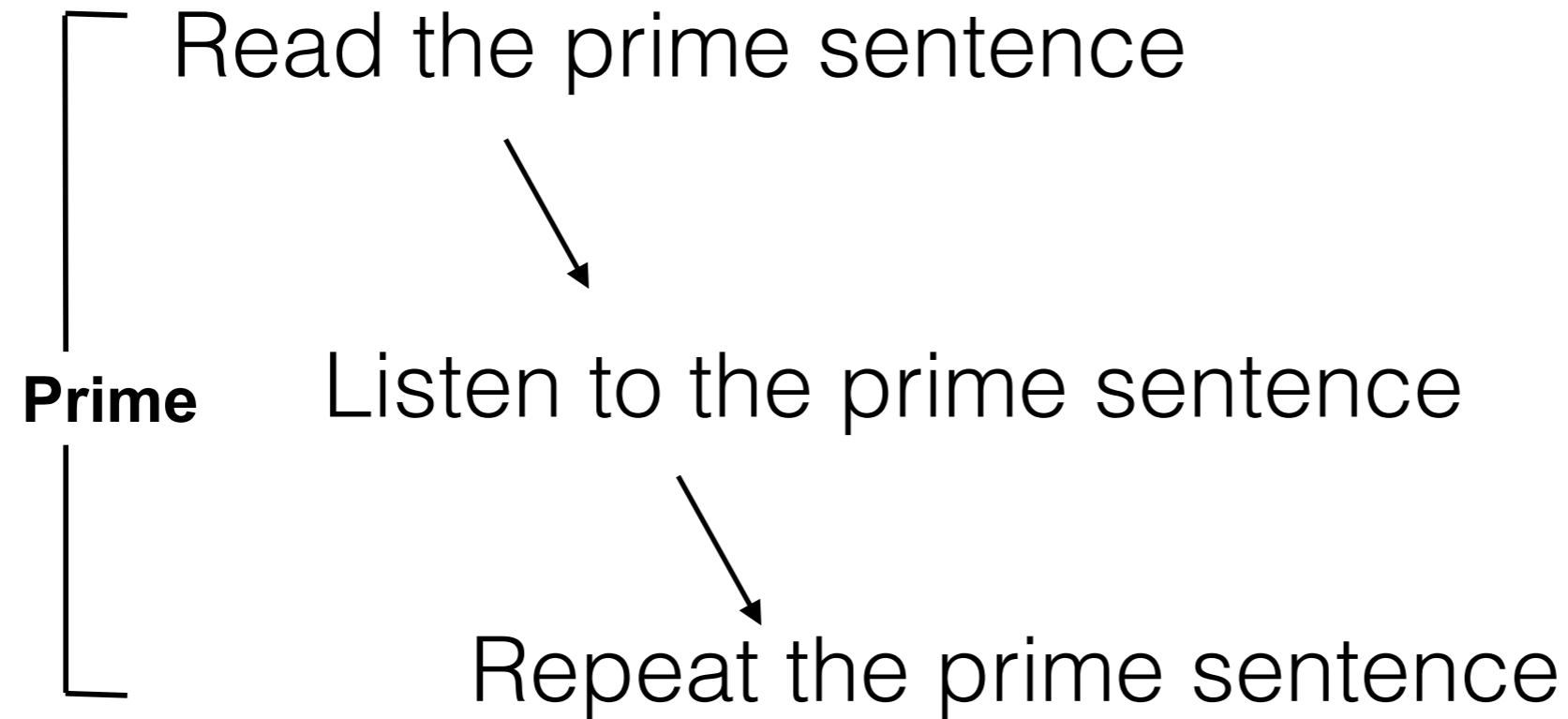
- | | |
|--|------------------|
| (a) he was too tired to. | (VP ellipsis) |
| (b) he was too tired. | (NCA) |
| (c) he was too tired to send her anything. | (Full structure) |
| (d) he slept. | (Baseline) |

NP PP primes:

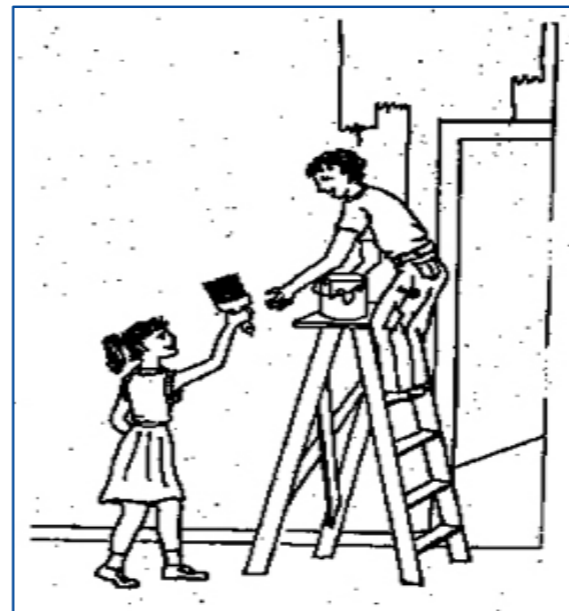
Daniel planned to send his mother a note, but after work ...

- | | |
|---|------------------|
| (e) he was too tired to. | (VP ellipsis) |
| (f) he was too tired. | (NCA) |
| (g) he was too tired to send anything to her. | (Full structure) |
| (h) he slept. | (Baseline) |

Experiment 2 task procedure is identical to Experiment 1



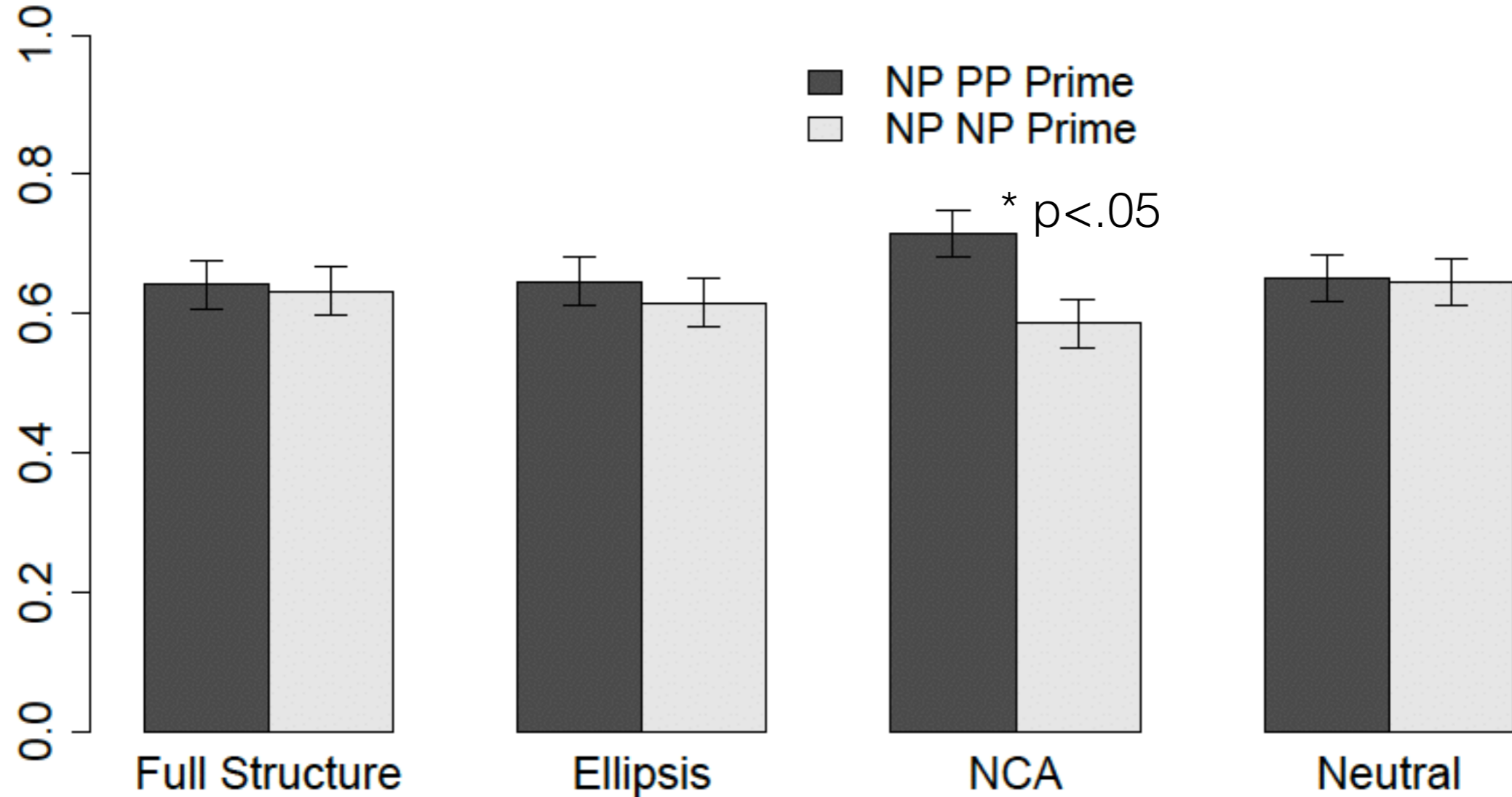
Target:
Describing a
picture



Predictions

- Replicate the findings on the Full Structure, Ellipsis and Baseline conditions from Expt 1
- If thematic role order leads to priming effect, we should see priming effect on the NCA condition as well. The critical question, then, is whether the priming effects on the Full and Ellipsis conditions go above and beyond the priming effect on the NCA condition.

Proportion of NP PP Production (Experiment 2, subj=83)



Effect of Prime Sentence Type $p=.06$
no significant interaction

- There is indeed priming effect from NCA primes, supporting a more refined view on the mechanism of structural priming.

- But there is no priming at all on the Full Structure and the Ellipsis conditions!
- On the one hand, this suggests VPE and NCA have different representations, but on the other hand, the lack of priming effect on VPE and Full Structure conditions is puzzling.
- What is the difference between Experiment 1 and 2?

One consideration:

The prime sentences in Experiment 2 are longer and more complicated than Experiment 1

Prime sentence Recall Accuracy	Full Structure	VPE	NCA	Baseline
NP NP Prime	Expt 1 87%	97%	na	94%
	Expt 2 69%	93%	95%	96%
NP PP Prime	Expt 1 79%	96%	na	95%
	Expt 2 71%	93%	96%	98%

participants with overall recall accuracy less than 70% were removed from the calculation

An augmented hypothesis

- Structural priming (or priming in general) is the effect of strengthened representations in memory.
- Memory representations decay over time, and therefore repeated exposures lead to larger chance of priming than single exposure
- Full Structure, Ellipsis, and NCA conditions all involve repeated exposure to a particular representation (either syntax or thematic role representations), and therefore in principle should produce larger priming effect than the Baseline control.

An augmented hypothesis

- However, maintaining a particular representation to the activation level that is sufficient to trigger priming effect demands working memory resources, but the memory recall task is consuming and therefore competing for the limited memory resources.
- The low recall accuracy on the Full Structure condition is a partial reflection of the task demand on memory.

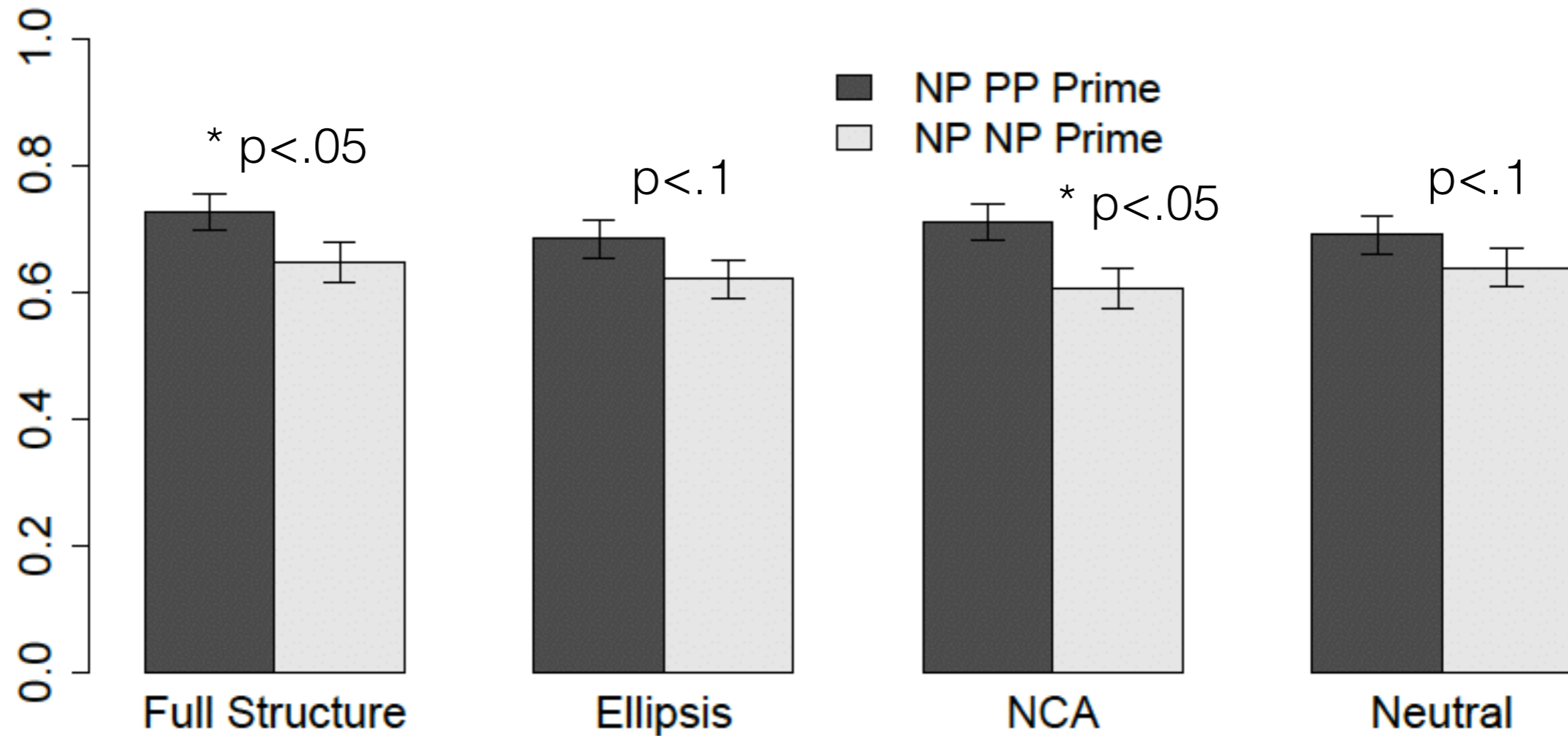
An augmented hypothesis

- VPE patterned with the Full Structure condition in terms of the absence of a priming effect, but its verbatim recall accuracy is high. This possibly suggests more “abstract” structural representations for VPEs compared to the NCA. Abstract syntactic representations require memory maintenance, but do not affect verbatim recall.
- The difference between VPE and NCA could also lie in the memory retrieval process (instead of memory maintenance). If the representations that need to be recovered/retrieved for VPE are more complex than NCA, it may require more working memory support for successful retrieval. Insufficient WM (due to task demands) may increase the chance of misretrieval, hence dampening the structure priming effect.

Experiment 3: reducing the task complexity

- The experiment is identical to Experiment 2, except that the step in which participants repeated the prime sentence was removed

Proportion of NP PP Production (Experiment 3, Subj=95)



Effect of Prime Sentence Type $p < .01$
No significant interaction

Summary of Experiment 3

- Reducing the task complexity and the demand on working memory boosted priming effect across the board, suggesting that structure priming is indeed sensitive to the limitation on working memory resources.

Interim summary

- Under different tasks and stimuli, VPE appears to pattern more like the Full Structure condition than NCA or the baseline control.
- But the specific conclusions are clouded by the fact that the priming mechanism itself is more nuanced than previously thought: (i) it is not specific to syntactic representations; (ii) it is sensitive to working memory demands

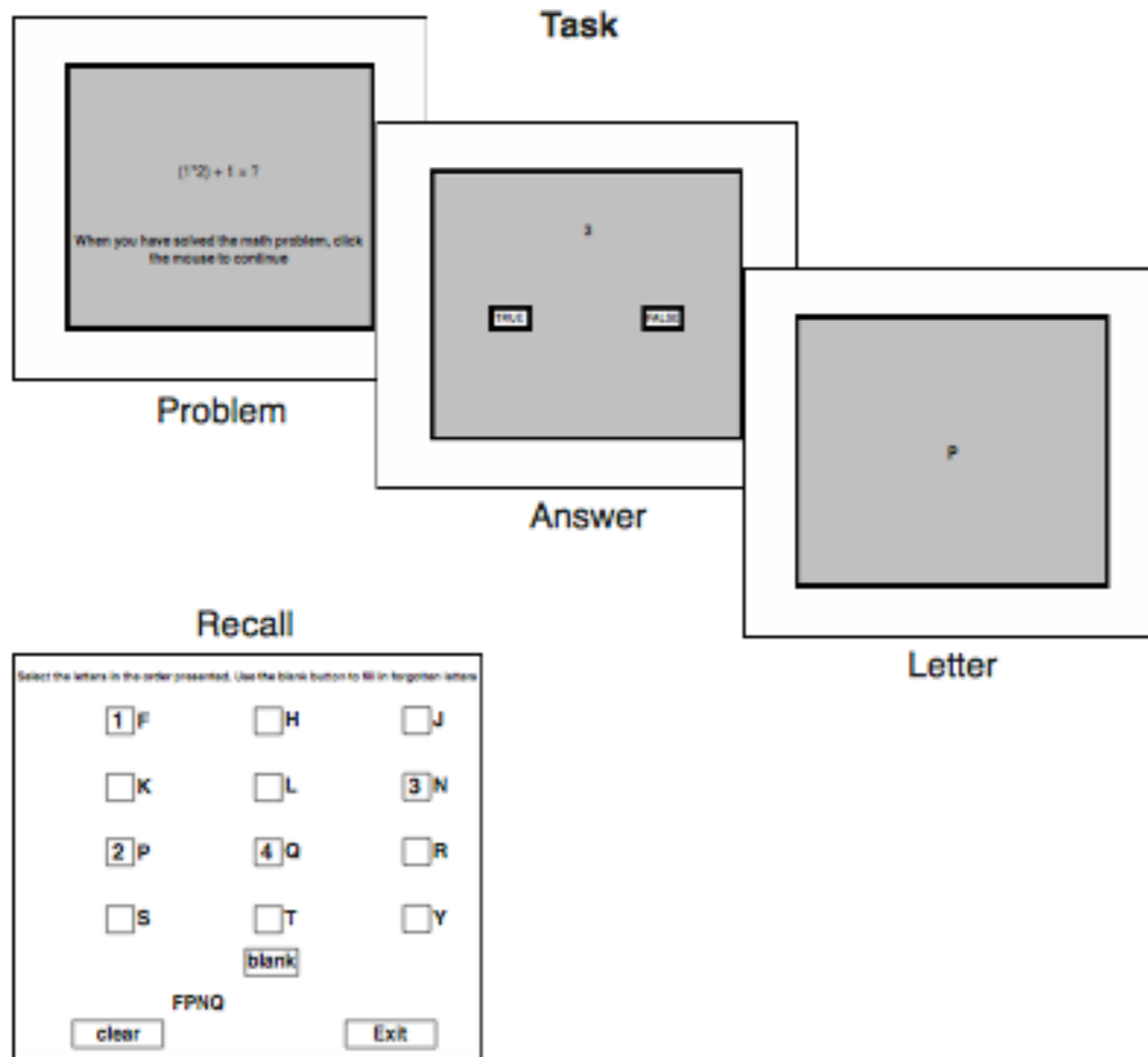
Experiment 4 (exploratory): individual differences in working memory

Maximally reduced task complexity

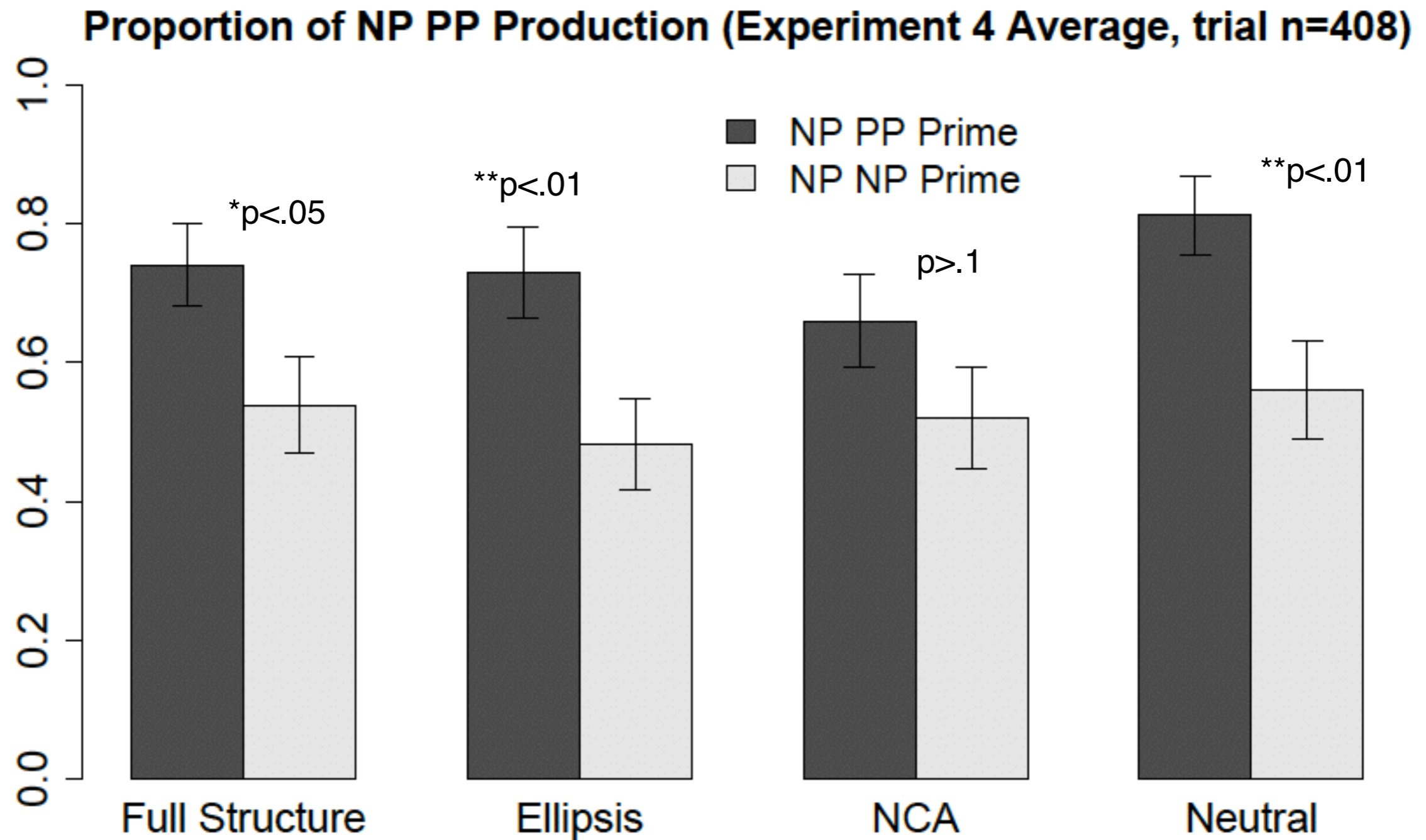
- each participant only did one trial
- there was no recall component in the procedure
- a verb cue is given (the “lexical boost” effect, e.g. Branigan et al. 2000; Pickering and Branigan 1998)

e.g. read and listen to a prime sentence that has the verb “offer”, and then was asked to describe a picture with the verb “offer”.

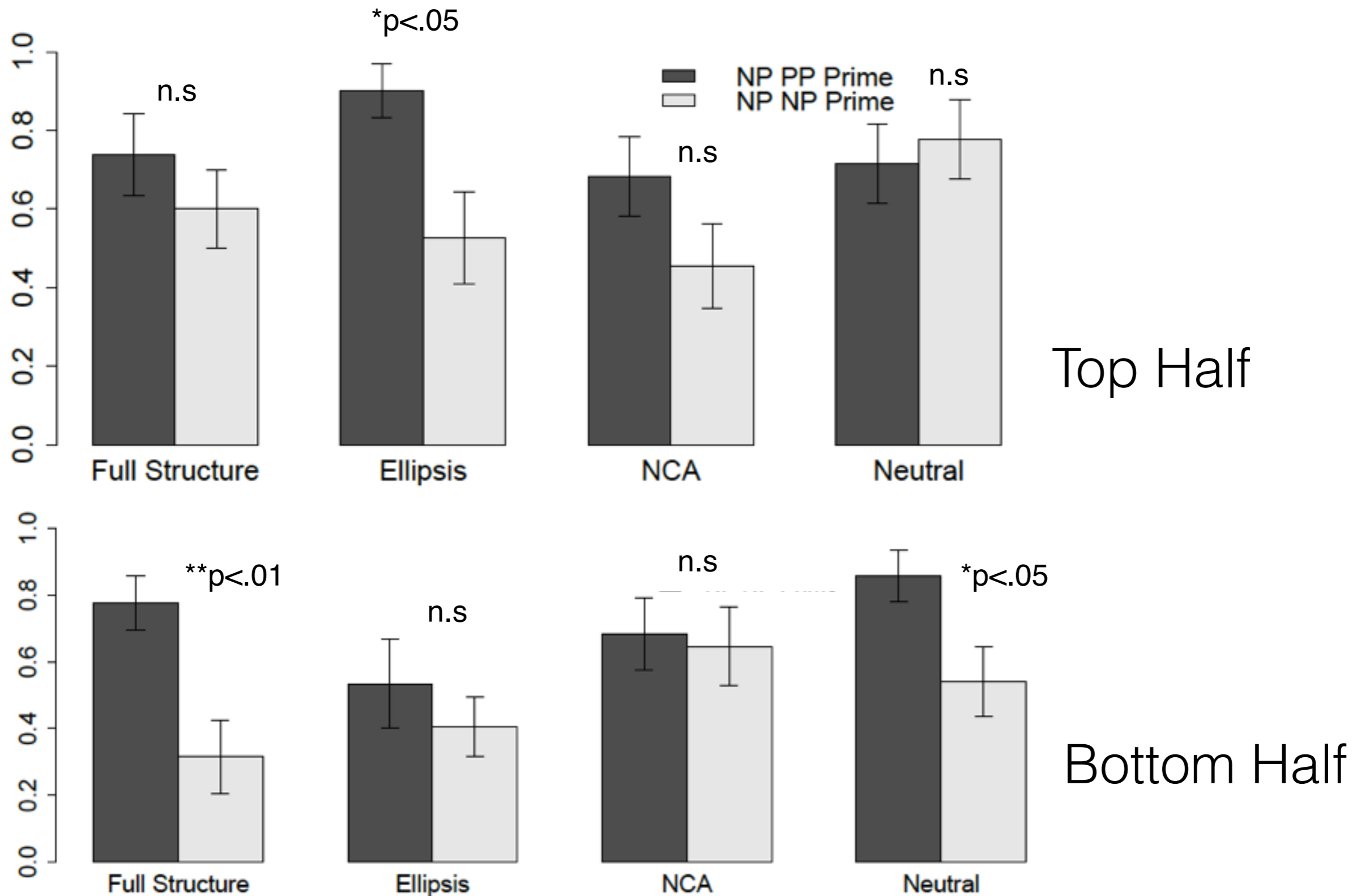
Experiment 4: the OSPAN task



Averaged results



Results for High WM and Low WM groups



Summary of Experiment 4

- Maximally reducing the task complexity and introducing overlapping lexical representations did help to boost the priming effect on average
- But working memory appears to modulate priming effect in interesting ways

Summary of Experiment 4

- Low WM group showed priming effect for only the Full Structure condition and the Baseline control condition, with the effect larger in the Full Structure condition
- High WM group showed priming effect for only the Ellipsis and NCA conditions, with the effect larger in the Ellipsis condition

A few (speculative) thoughts to put everything together

- The current study turned out to be as much about abstract syntactic representations as about processing mechanisms, especially the mechanisms for priming.
- A good take-home lesson is that it is very hard to talk about representations without understanding the mechanisms that process them.

Different language processing operations compete for a limited pool of working memory resources. We consider the following processes that all require WM support:

- Maintaining previously processed representations requires WM support. More complex representations may demand more WM support.
- Memory representations decay over time, unless more WM is allocated to them.
- Memory retrieval also requires WM support. Retrieving complex representations may require more WM support than retrieving simpler representations, either because there are “more stuff” that need to be retrieved, or because the likelihood of retrieval errors increases with high complexity and/or insufficient WM.

For the low WM group:

- Both the Ellipsis and NCA involve retrieval (recovery) of the antecedent information. The retrieval process itself consumes the already limited WM resources. As a result, there isn't sufficient WM to maintain the representations from the antecedent clause for the priming effect. Insufficient WM may also have led to lower retrieval accuracy of the antecedent representations, further dampening the structural priming effect.
- No memory retrieval for the Full Structure and the Baseline condition. The former has larger priming effect than the latter, because of repeated exposure to the relevant structural representation.

For the high WM group:

- There are enough WM support to more accurately retrieve the antecedent representation in the Ellipsis and NCA conditions. The Ellipsis condition had larger priming effect than the NCA condition, possibly because the ellipsis site recovered not only the thematic role information, but the actual syntactic structure information as well, providing multiple converging representations for the priming effect.

For the high WM group:

- Why did the priming effect disappear for the Full and Baseline conditions for the high WM group?
- We speculate that high WM participants have surplus WM that are not needed for parsing the Full and Baseline sentences (e.g. there is no additional memory retrieval demand). The high WM participants may entertain the alternative structures that can express the same message, generating alternative representations that would neutralize the priming effect.

Conclusions

- To explain the results from different sentence stimuli and tasks, it seems most coherent to postulate abstract structural representations for the processing of VP ellipsis constructions. The minimal pair comparison between VP ellipsis and NCA suggests critical differences in representations.
- But these conclusions are only as good as our understanding of the processing mechanisms, especially the structure priming mechanism, that support the construction of the relevant representations.

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