

Syntactic priming

9.59J; 24.905J

Ted Gibson

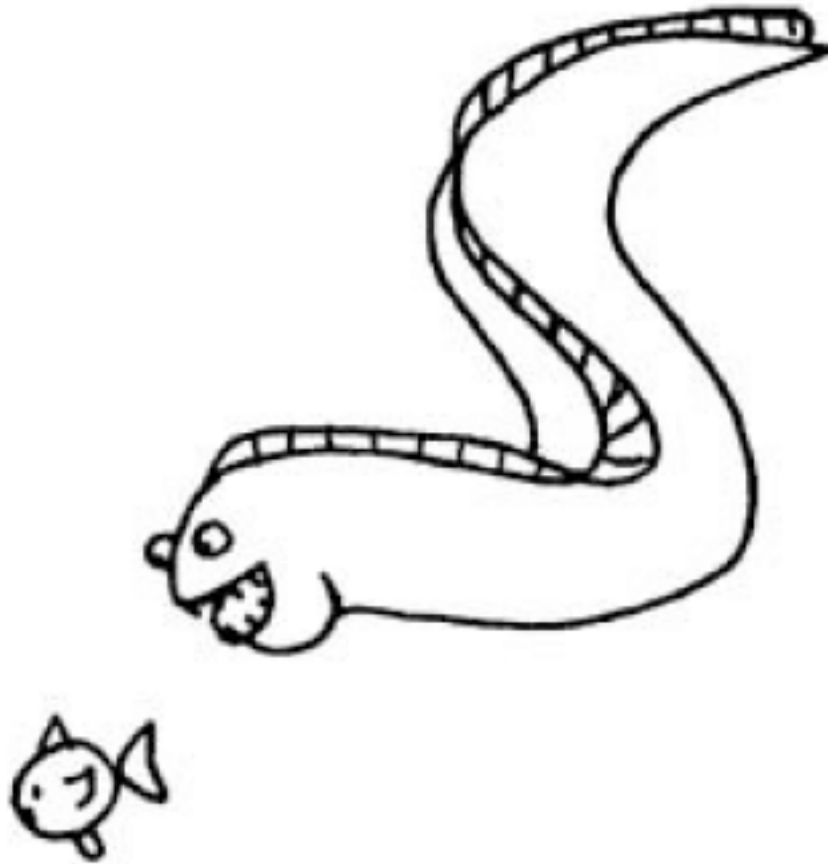
Bock (Cognitive Psychology, 1986)

- Syntactic Priming
 - People are more likely to use a syntactic structure when they used that syntactic structure just before
 - Picture-description task:
 - 1. Read a sentence out loud
 - 2. Describe a picture
- ⇒ The syntactic structure of the sentence (1) will persist in the description of the picture (2)

Task: Read aloud

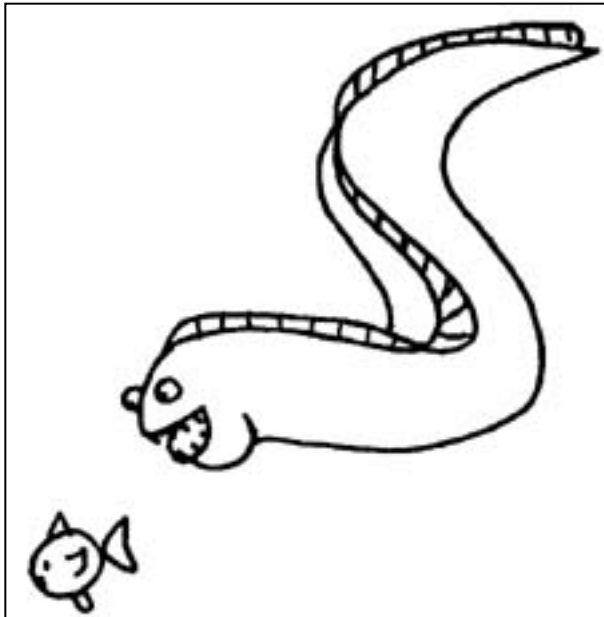
The customer was killed by the bank robber.

Describe the picture



Active vs Passive

- **Active Prime:** *The bank robber killed the customer.*
- **Passive Prime:** *The customer was killed by the bank robber.*



Target

The eel is chasing the little fish.

The little fish is being chased by the eel.

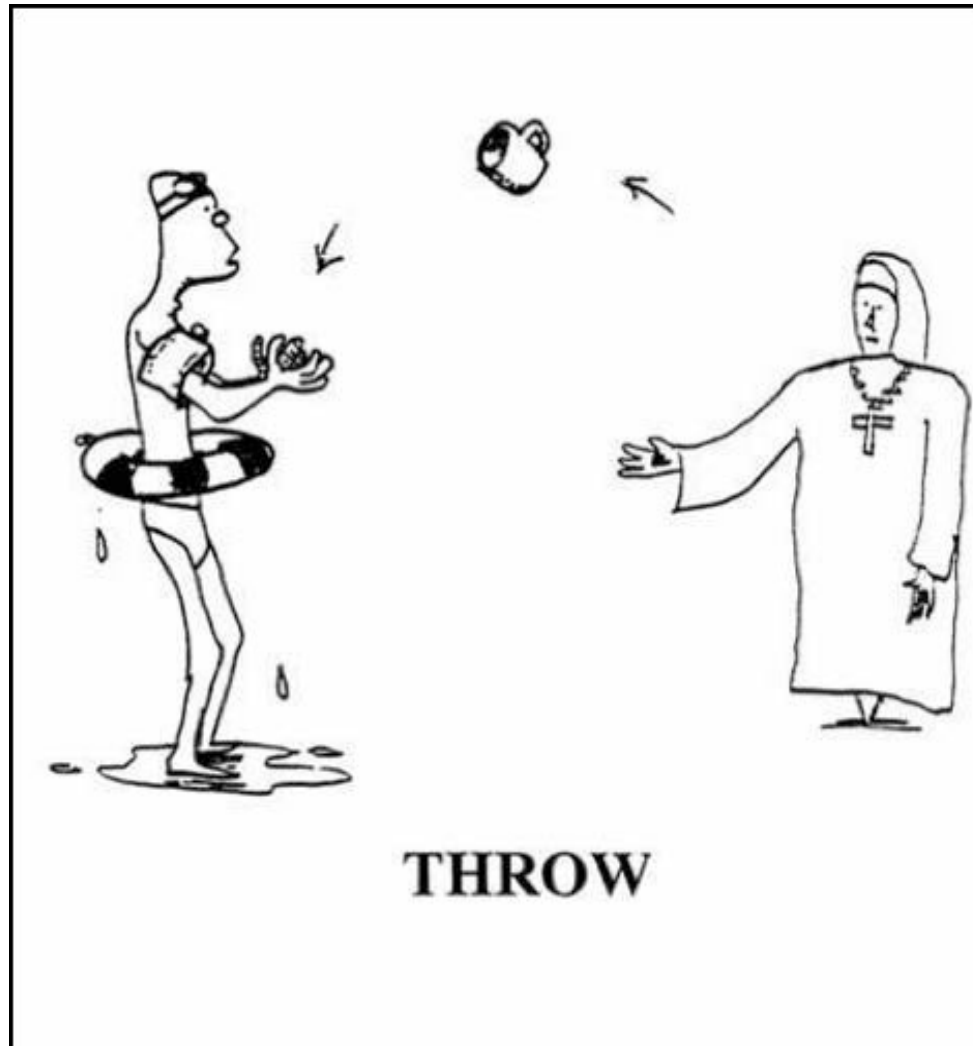
Priming effect:

The active / passive voice in the prime affects how people describe the picture: Passive in the prime leads to more passive descriptions.

Task: Read aloud

The girl gave the man the paintbrush.

Describe the picture



Prepositional Object vs Double Object

- **PO Prime:** *The girl gave the paintbrush to the man.*
- **DO Prime:** *The girl gave the man the paintbrush.*



Target

The nun is throwing the cup to the swimmer.

The nun is throwing the swimmer the cup.

Priming effect:

The PO/DO structure in the prime affects how people describe the picture: e.g., DO in the prime leads to more DO descriptions.

Representational Priming

- Representations that are involved in sentence processing
 - If something can be activated, it must be represented
 - Syntactic ambiguities and complex sentences
- Lexical processing literature
 - Orthographical representations
 - Phonological representations
 - Morphological representations
 - Semantic representations

Syntactic or Lexical Priming?

- Priming of lexical function words
 - *The bank robber killed the customer.*
 - *The customer was killed **by** the bank robber.*

 - *A girl is giving a man a paintbrush.*
 - *A girl is giving a paintbrush **to** a man.*

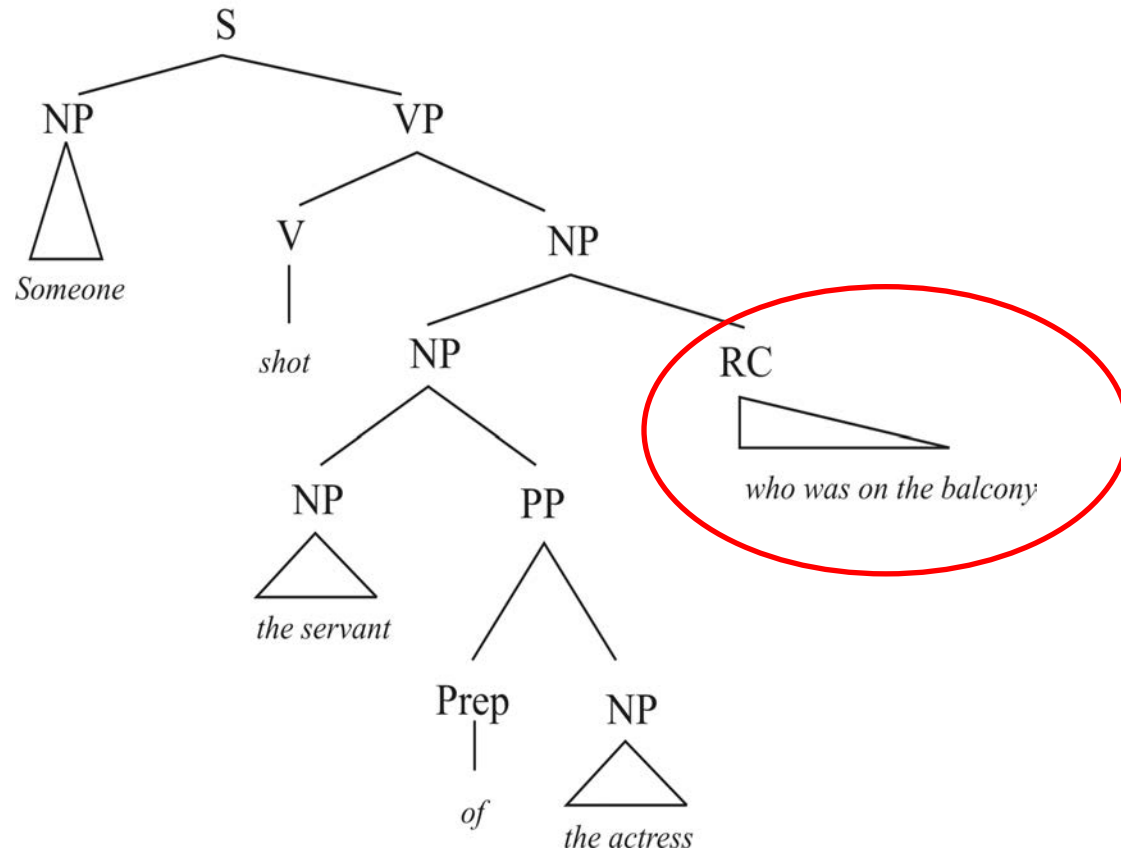
- Priming of verbs: Lexical boost
 - Prime a: *The girl **threw** a paintbrush to the man.*
 - Prime b: *The girl **gave** a paintbrush to the man.*

 - Target: *The nun is **throwing** a cup to the swimmer.*

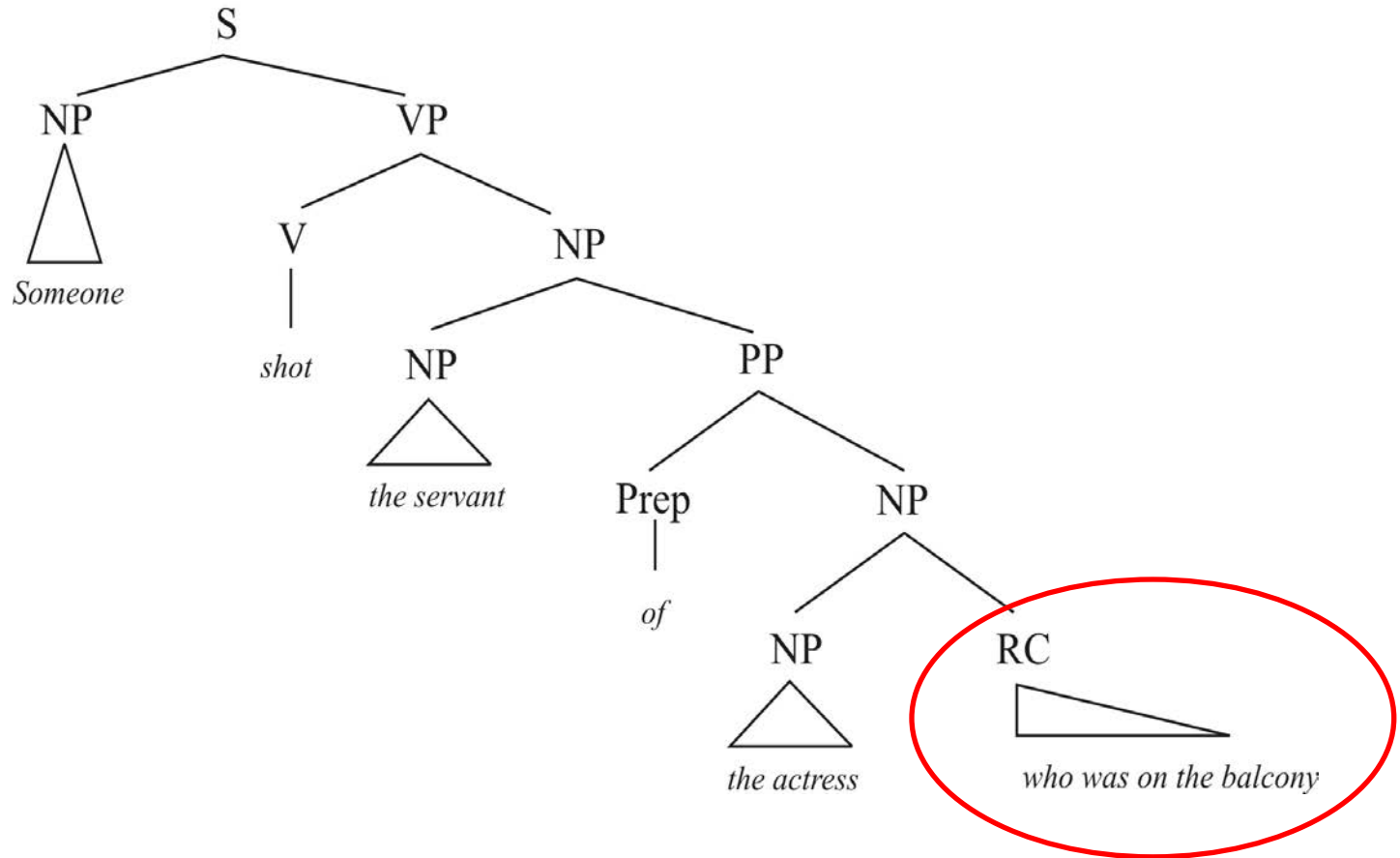
Scheepers (2003)

- Priming of non-lexical syntactic information
- Relative Clause (RC) attachment ambiguity
 - Someone shot *the servant* of *the actress* who was on the balcony.

Non-local / High / NPI Attachment



Local / Low / NP2 Attachment



Aside: Cross-linguistic differences in attachment preferences

Someone shot *the servant* of *the actress* who was on the balcony.

English: Low / local attachment bias (~65%)

Spanish: High / non-local attachment bias (~65%)

Why? Grillo & Costa (2014) suggest that the difference is due the presence / absence of another interpretation of the relative clause, called a Pseudo-relative-clause (PRC), like a small clause

Aside: Cross-linguistic differences in attachment preferences

Grillo & Costa (2014): the presence of a pseudo-relative clause interpretation biases towards high / non-local attachment.

English doesn't allow PRCs, so there is a low attachment bias in English.

Prediction for English: Removing the “that was” from the RC gives the potential for a PRC interpretation, and therefore shifts to high attachment:

Someone shot *the servant of the actress who was eating on the balcony.*

Someone shot *the servant of the actress eating on the balcony.*

Priming of non-lexical syntactic information

- Not priming of lexical function words
 - Both NPI and NP2 attachments contain a relative pronoun
- Not priming of subcategorization info related to lexical items
 - RCs are modifiers
- Not priming of context-free phrase-structure rules
 - Both NPI and NP2 attachments are “NP → NP + RC”
- Only difference between NPI and NP2 attachments is where in the tree the RC attaches

Sentence Continuation Task

- Complete the sentences with the first thing that comes to mind.

The cat didn't like.....

The entrance to the lab was.....

The nurse assisted the child because.....

The supplier knew that.....

The police interrogated the witness of the accident who.....

John met the boss of the employees who.....

The coach talked to the player because.....

The spy thought that.....

The shopper enraged the saleswoman because.....

The mosquito.....

The bread in the supermarket.....

Sentence Continuation Task

- Complete the sentences with the first thing that comes to mind.

The cat didn't like.....

The entrance to the lab was.....

The nurse assisted the child because.....

The supplier knew that.....

The police interrogated the witness of the accident who.....

John met the boss of the employees who.....

The coach talked to the player because.....

The spy thought that.....

The shopper enraged the saleswoman because.....

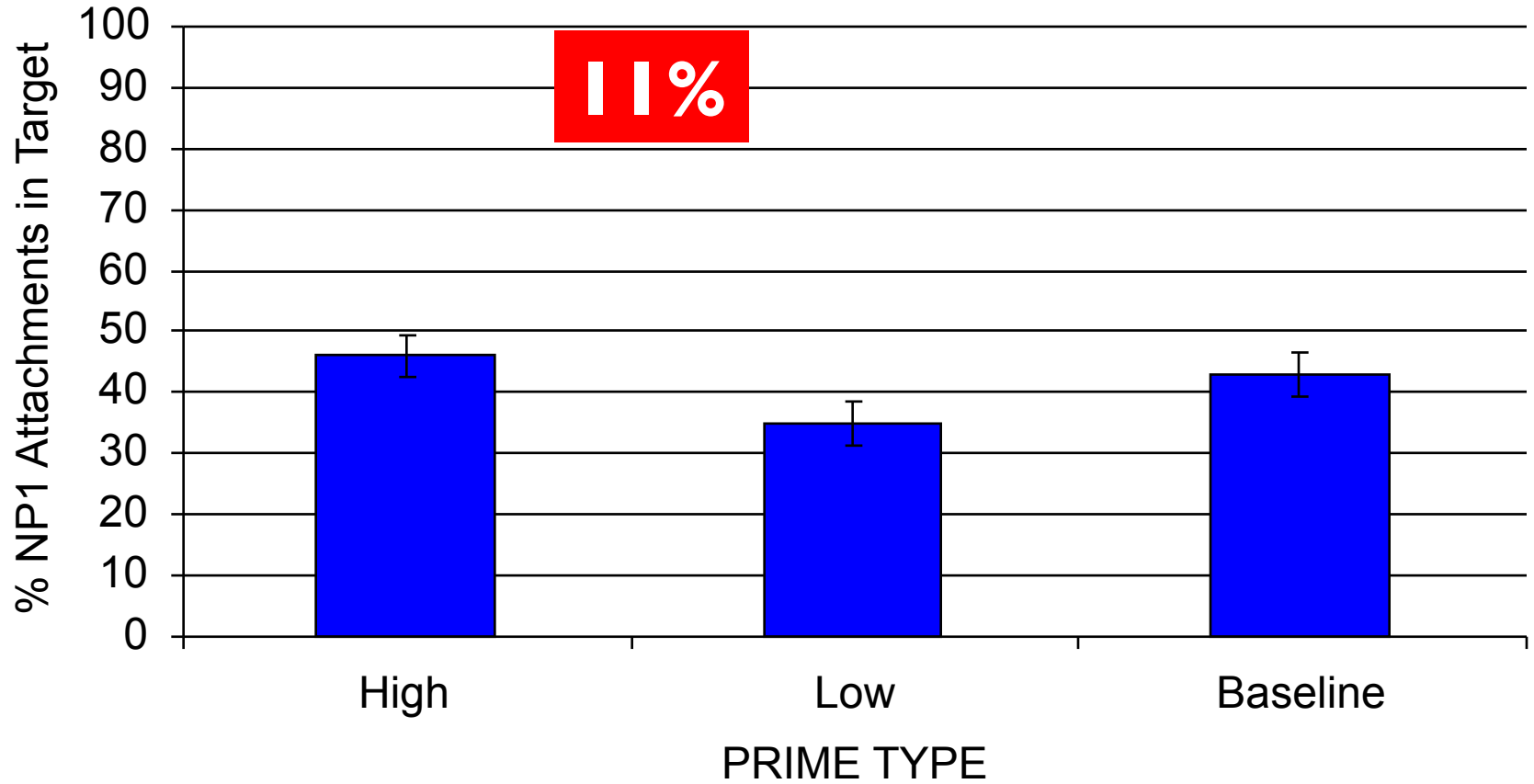
The mosquito.....

The bread in the supermarket.....

Experiment I: Trial Analyses

- Prime continuation
 - Correct: the intended attachment was followed
 - Incorrect: the intended attachment was not followed
 - Discard incorrect trials (e.g., 9% of the data)
- Target continuation
 - High attachment: RC refers to NPI
 - Low attachment: RC refers to NP2
 - Ambiguous: Attachment is unclear (< 1% in Desmet et al)
 - Dependent measure: high / (high + low)

Desmet & Declercq: Experiment I: Results



Desmet & Declercq (2006)

Cross-linguistic Priming

- Can the effect be replicated between the two languages of bilinguals?
- No overlap between lexical entries whatsoever
- This could tell us something about the syntactic representations of bilinguals
 - Separate-syntax account
 - Shared-syntax account

Experiment 2: Items

High Attachment Prime

De politie ondervroeg de veroorzaakster van het ongeval die...
[The police interrogated the causer of the accident who...]

Low Attachment Prime

De politie ondervroeg de veroorzaakster van het ongeval dat...
[The police interrogated the causer of the accident that...]

Baseline Prime

De politie ondervroeg de veroorzaakster van het ongeval toen...
[The police interrogated the causer of the accident when...]

TARGET

John met the boss of the employees who...

Experiment 2: Sentence Continuation Task

- Complete the sentences with the first thing that comes to mind.

De kat hield niet van.....

The entrance to the lab was.....

The nurse assisted the child because.....

De leverancier wist niet dat.....

De politie ondervroeg de veroorzaker van het ongeval die.....

John met the boss of the employees who.....

The coach talked to the player because.....

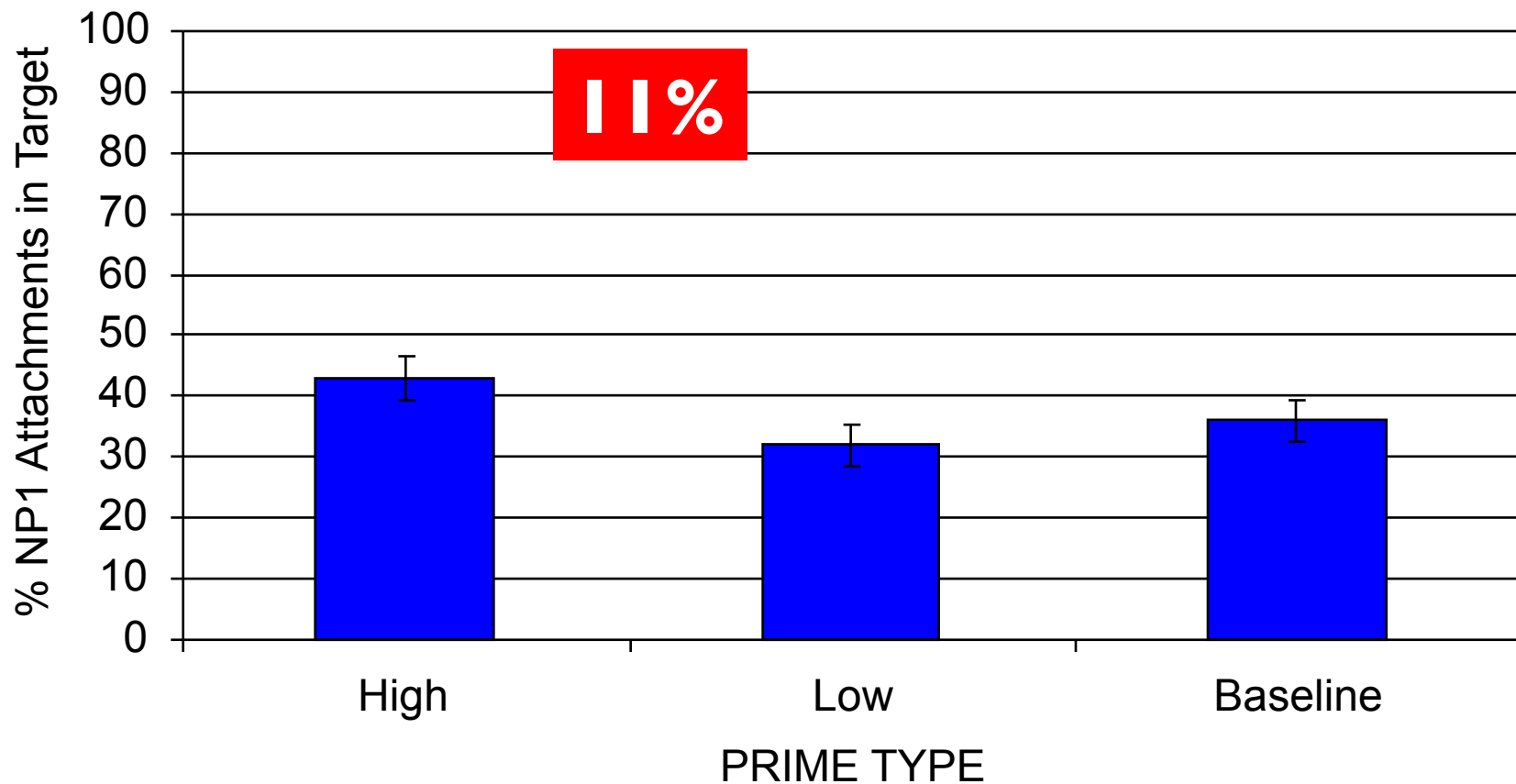
The spy thought that.....

De winkelier was woedend omdat.....

The mosquito.....

The bread in the supermarket.....

Desmet & Declercq: Experiment 2: Results



Summary: Syntactic priming

- People are more likely to use a syntactic structure when they used that syntactic structure just before
- Evidence of syntactic priming:
 - Active / passive priming; double-object / prepositional phrase object priming
But these may be lexical priming
 - Relative clause (RC) attachment priming: not lexical priming
RC attachment priming also works across languages, suggesting a language-independent syntactic priming relationship

Scheepers et al. (2011): Priming RC attachment from arithmetic

- Low attachment arithmetic prime: $80 - 9 + 1 * 5$
- High attachment arithmetic prime: $80 - (9 + 1) * 5$

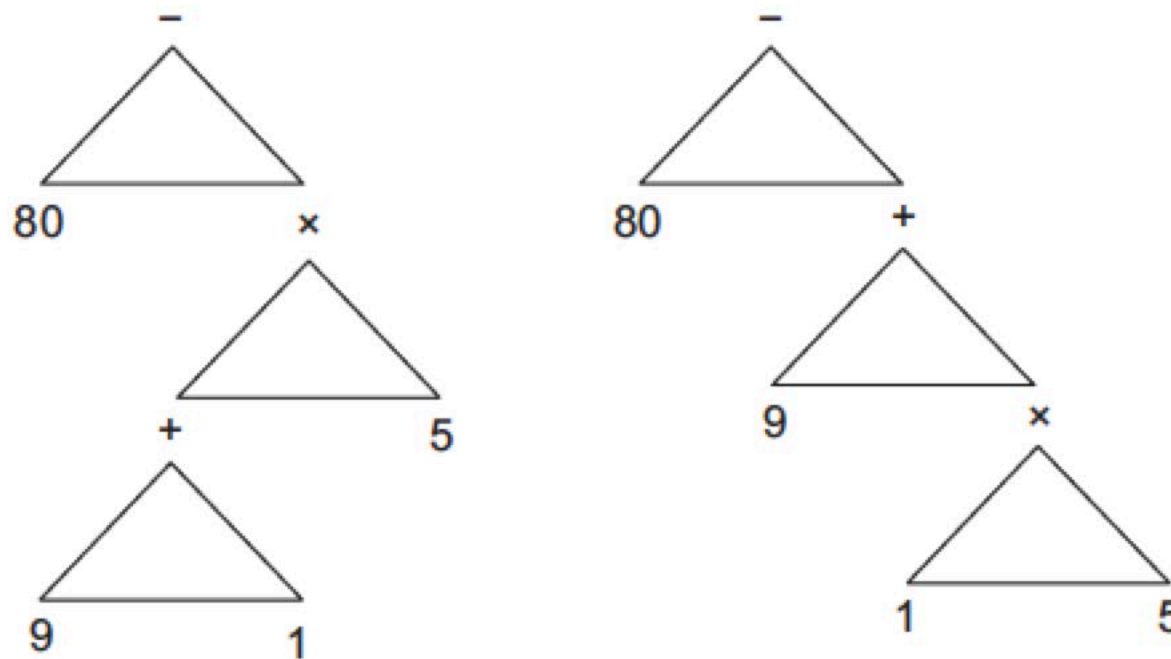


Fig. 2. Hierarchical structure representations of two simple mathematical expressions: $80 - (9 + 1) * 5$ (left) and $80 - 9 + 1 * 5$ (right).

© Psychological Science. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <http://ocw.mit.edu/help/faq-fair-use/> Source: Scheepers, Christoph, Patrick Sturt, Catherine J. Martin, Andriy Myachykov, Kay Teevan, and Izabela Viskupova. "Structural priming across cognitive domains: From simple arithmetic to relative-clause attachment." *Psychological Science* 22, no. 10 (2011): 1319-1326.

Scheepers et al. (2011): Priming RC attachment from arithmetic

Experiment 1: 3 groups of participants: Math, Business and Psychology students

Materials:

High attachment prime: $90 - (5 + 15)/5$

Low attachment prime: $90 - 5 + 15/5$ (no parentheses)

Target materials: The tourist guide mentioned the bells of the church that . .

Scheepers et al. (2011): Expt I

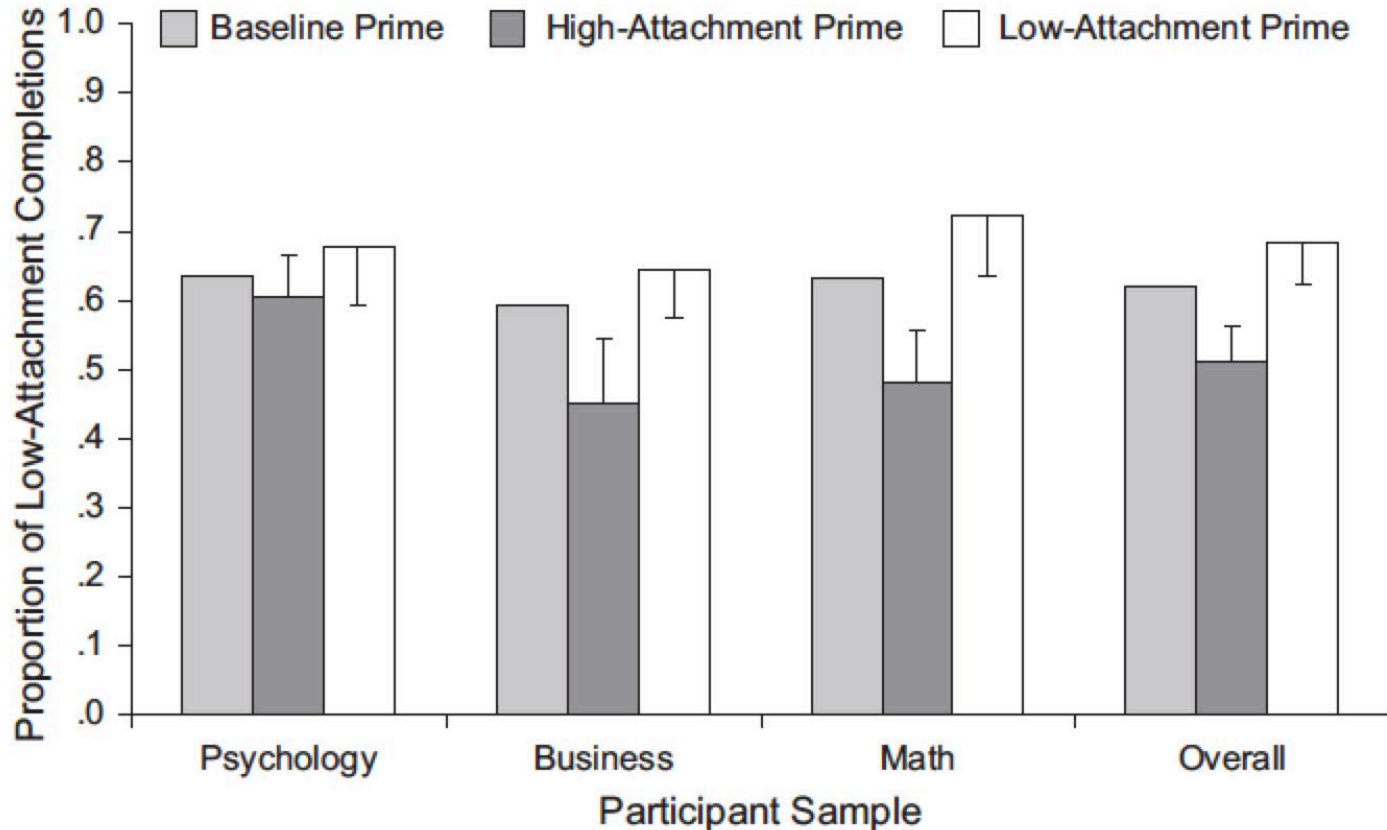


Fig. 3. Results from Experiment I: mean proportion of low-attachment target completions as a function of participant sample and priming condition. Averaged results for the three groups are also shown. Error bars represent by-subjects 95% confidence intervals for contrasts with the baseline priming condition; these intervals were derived from logit binomial generalized-estimating-equation parameters (see the text).

Scheepers et al. (2011): Expt 2

27 psychology students,
with parentheses to
disambiguate the
materials:

High Att: $90 - ((5 + 15)/5)$

Low Att: $90 - 5 + (15/5)$

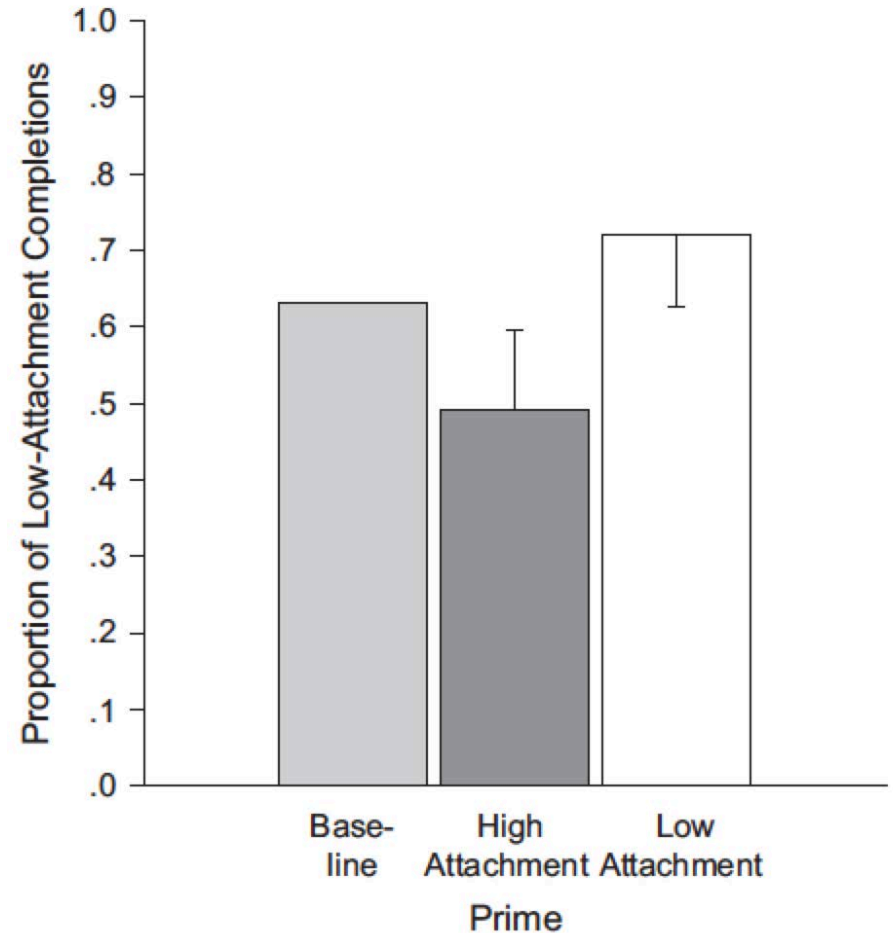


Fig. 4. Results from Experiment 2: mean proportion of low-attachment target completions as a function of priming condition. Error bars represent by-subjects 95% confidence intervals for contrasts with the baseline priming condition; these intervals were derived from logit binomial generalized-estimating-equation parameters (see the text).

Discussion note: The authors discuss how various factors, such as presence of parentheses and participants' majors, influence their priming effect. Do you find their predictions for the effects of these factors natural? Are other predictions possible? If so, what would they be?

- **Nicole M:** While business/math-type majors seemed to understand and solve the equations without trouble, the psychology majors not only struggled to solve the equations but also often didn't seem to understand order of operations.
- **Sarah N:** I find the authors' predictions to be natural. Because STEM and business majors regularly encounter (and are required to interpret) quantitative information, their experience and familiarity with quantitative information are likely to help in generating responses during the arithmetic-priming tasks.
- **Nicole O:** It also makes sense that people's majors would affect their decision in a similar way that expert chess players can better remember the setup of a chess board because they group the pieces differently in their mental representation than others would.
- **Yes, but POST-HOC decisions**

Discussion note: The authors discuss how various factors, such as presence of parentheses and participants' majors, influence their priming effect. Do you find their predictions for the effects of these factors natural? Are other predictions possible? If so, what would they be?

- **Yingtong:** Intuitively I find it hard to believe participants' majors can influence their priming effect, unless psychology major students are biased in some sense
- **Zheng:** ...it's hard for me to believe that people's major can have such a large impact on their cognitive performance.
- **Sarah W:** I really don't find these factors very natural. Math--especially the order of operations-- is highly artificial and has to be explicitly learned
- Also: why did they exclude 60% of the participants and how does that not totally invalidate their claims?

- **Skylar:** The authors suggest that parentheses may increase the priming because they make it clearer and make it so that you don't need as much strategic thinking. But it seems to me like you could also imagine that they'd make less priming occur, because you aren't implicitly processing the tree structures as much, just following the parentheses. Similarly, they suggest that psychology majors, having been reminded of basic math, were more deliberative and so were less primed. But it seems quite possible to imagine the reverse overall effect; they were more deliberative, so they devoted more time and attention, increasing the amount of priming.

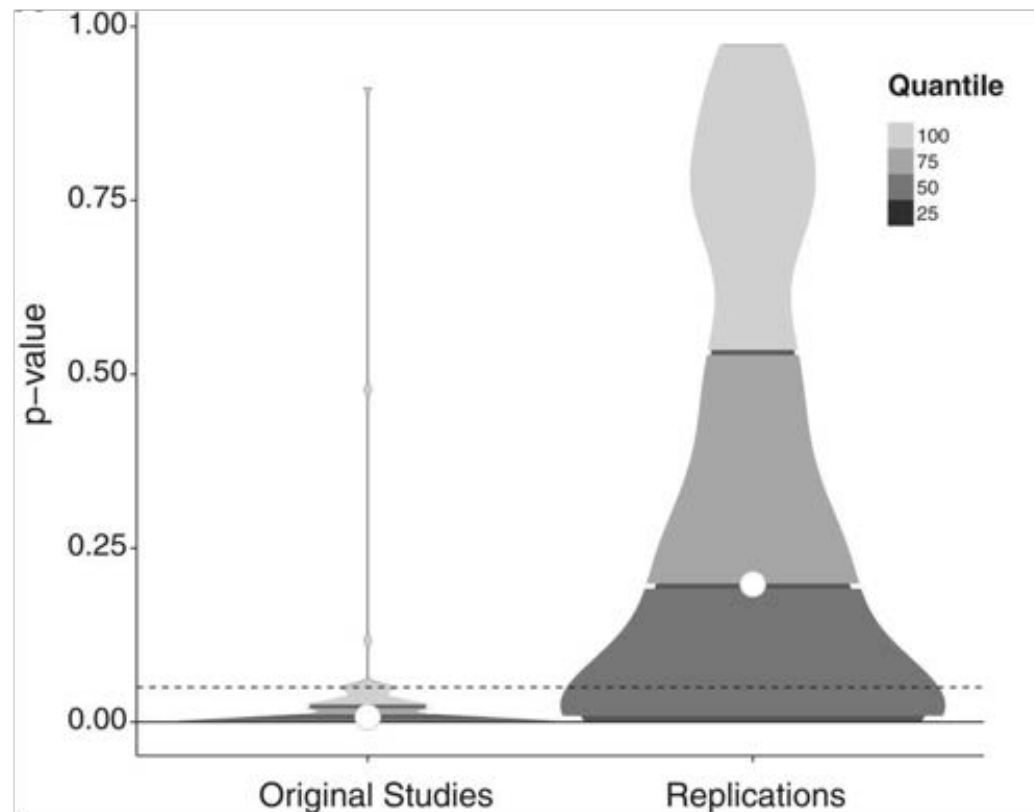
- **Yes, potentially POST-HOC decisions**

Reproducibility problems in psychology

Nosek et al.: Only about 1/3 of psychology studies replicate in large-scale pre-registered replication study.

Button et al.: Experiments in psychology and neuroscience are dramatically underpowered (meaning very little can be concluded from results).

New statistics standards in Psych Science and many other journals.



Nosek et al. (2015): p-values in replications vs original studies

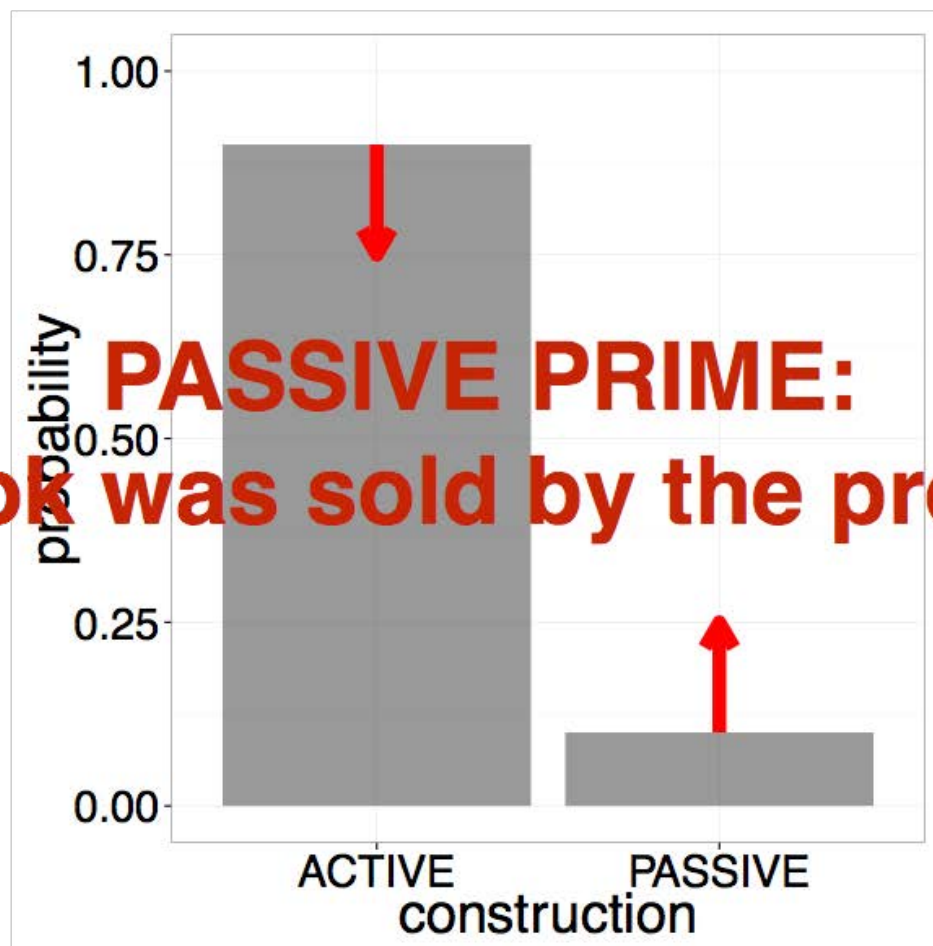
Courtesy of Open Science Collaboration. License CC BY. Source: Open Science Collaboration. "Estimating the reproducibility of psychological science." *Science* 349, no. 6251 (2015): aac4716.

A meta-analysis of syntactic priming in language production

Mahowald, James, Futrell & Gibson, 2016

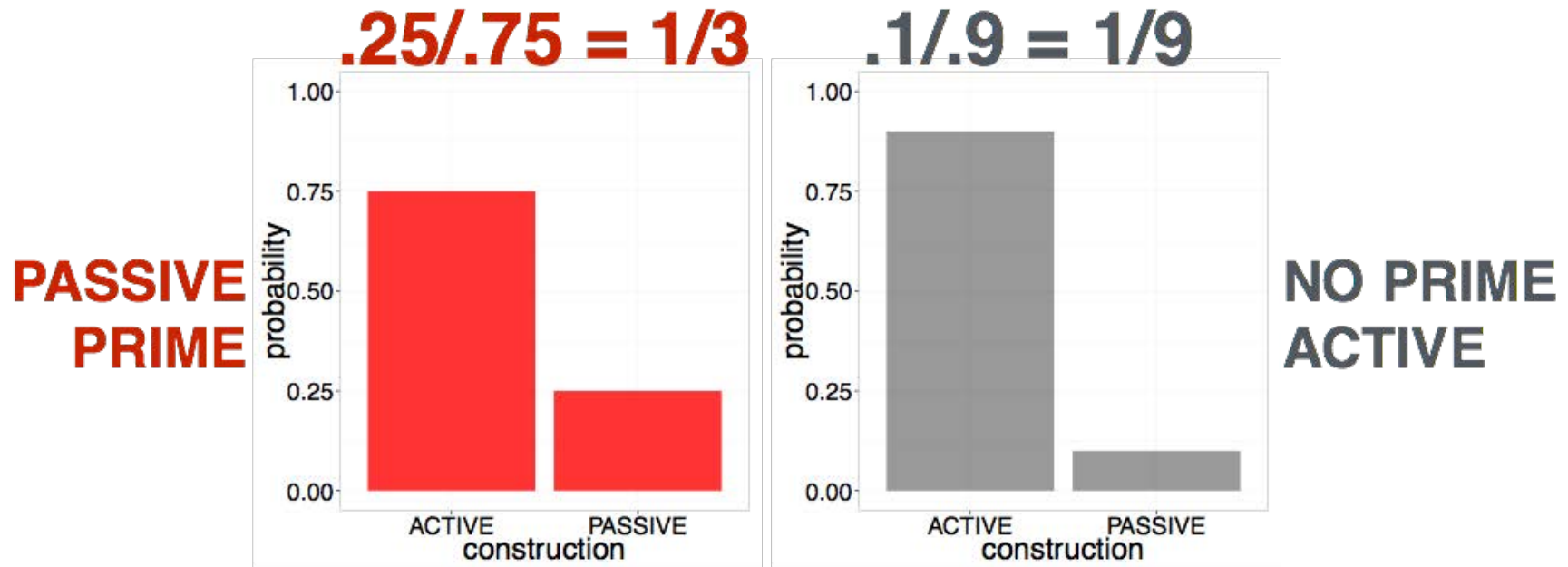
- How are we doing in psycholinguistics? A 73-paper meta-analysis of syntactic priming in production
- **Basic idea:** Combine 73 studies of syntactic priming into one big analysis.
- **Two main goals:**
- 1) What have we learned? Of the many moderators of priming that have been proposed, which are the biggest contributors and how do they compare? How big is the priming effect itself?
- 2) Have we amassed a stable and consistent body of evidence? Is there publication bias?

Basic claim of syntactic priming



PASSIVE PRIME:
The book was sold by the proprietor.

Odds ratio



$$\frac{1/3}{1/9} = 3 = \text{size of priming effect}$$

For each study, we extract:

odds ratio (the size of the priming effect)

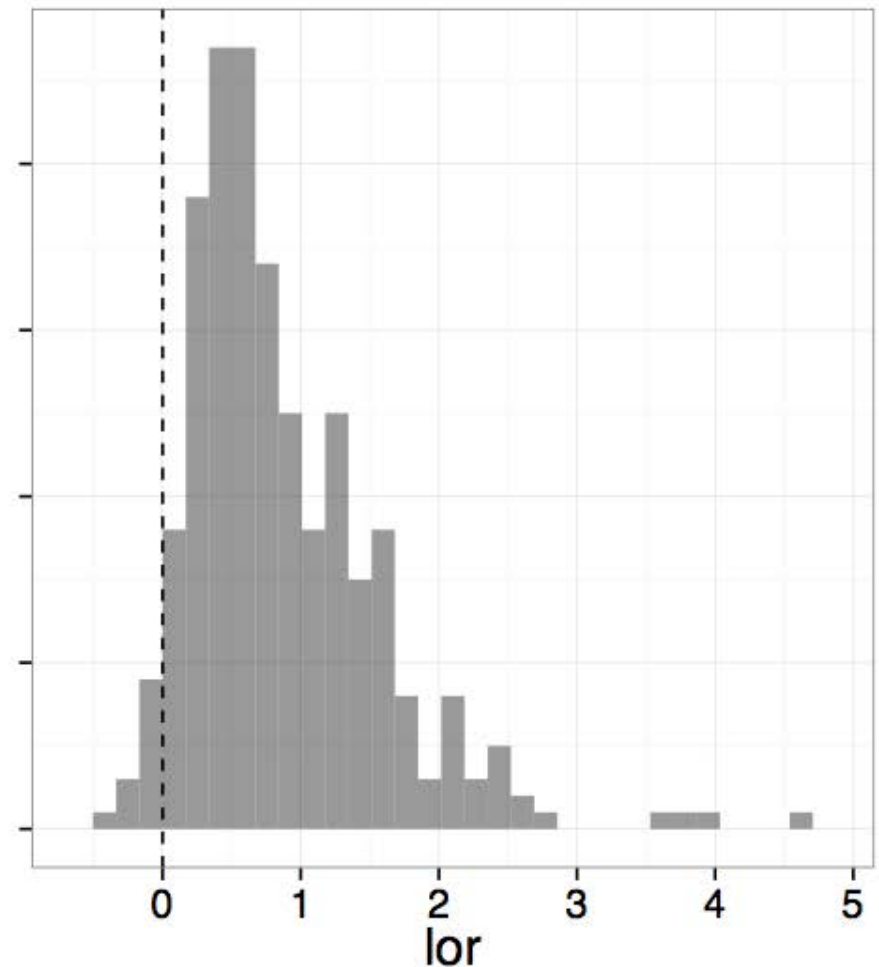
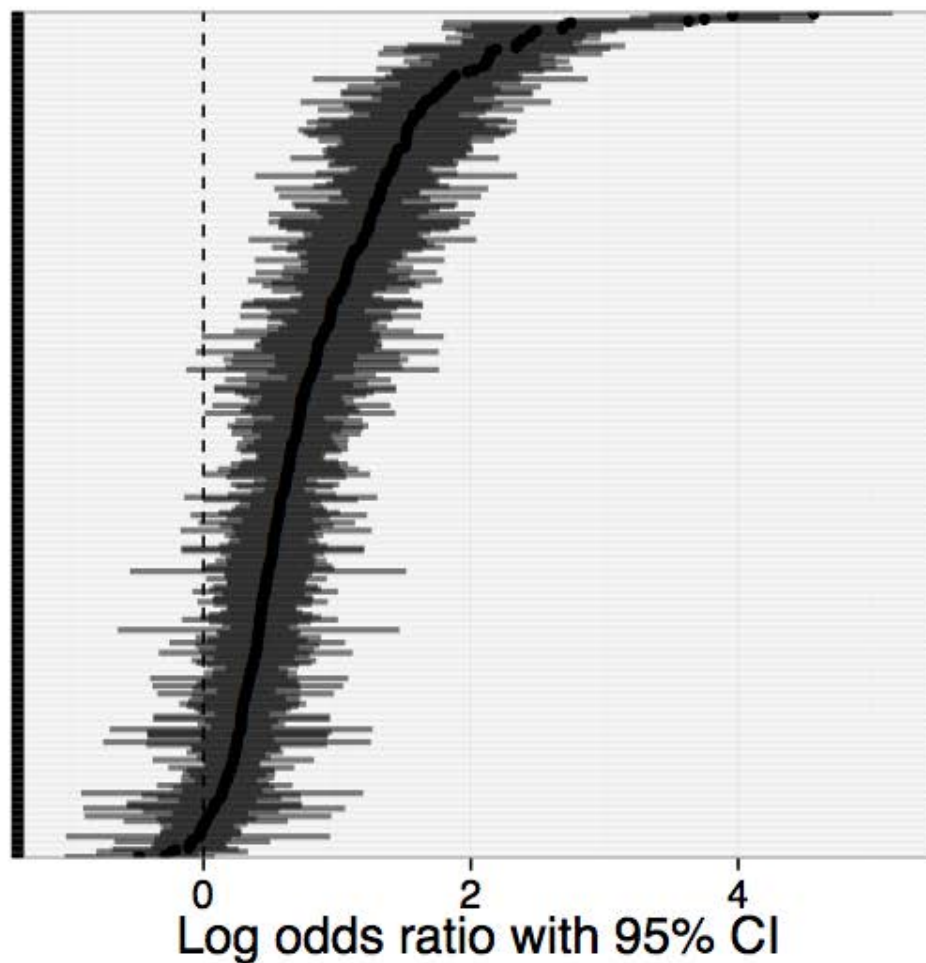
number of participants and number of items per cell

standard error on the log odds ratio:

$$SE = \sqrt{\frac{1}{n_{\text{Prime}X}} + \frac{1}{n_{\text{NoPrime}X}} + \frac{1}{n_{\text{Prime}Y}} + \frac{1}{n_{\text{NoPrime}Y}}}$$

list of moderators

All studies (one data point per condition)



Results: weighted mean

average weighted odds ratio: 1.67 when there is no lexical overlap. Cohen's $d = .28$. 3.26 when there is lexical overlap. Cohen's $d = .65$.

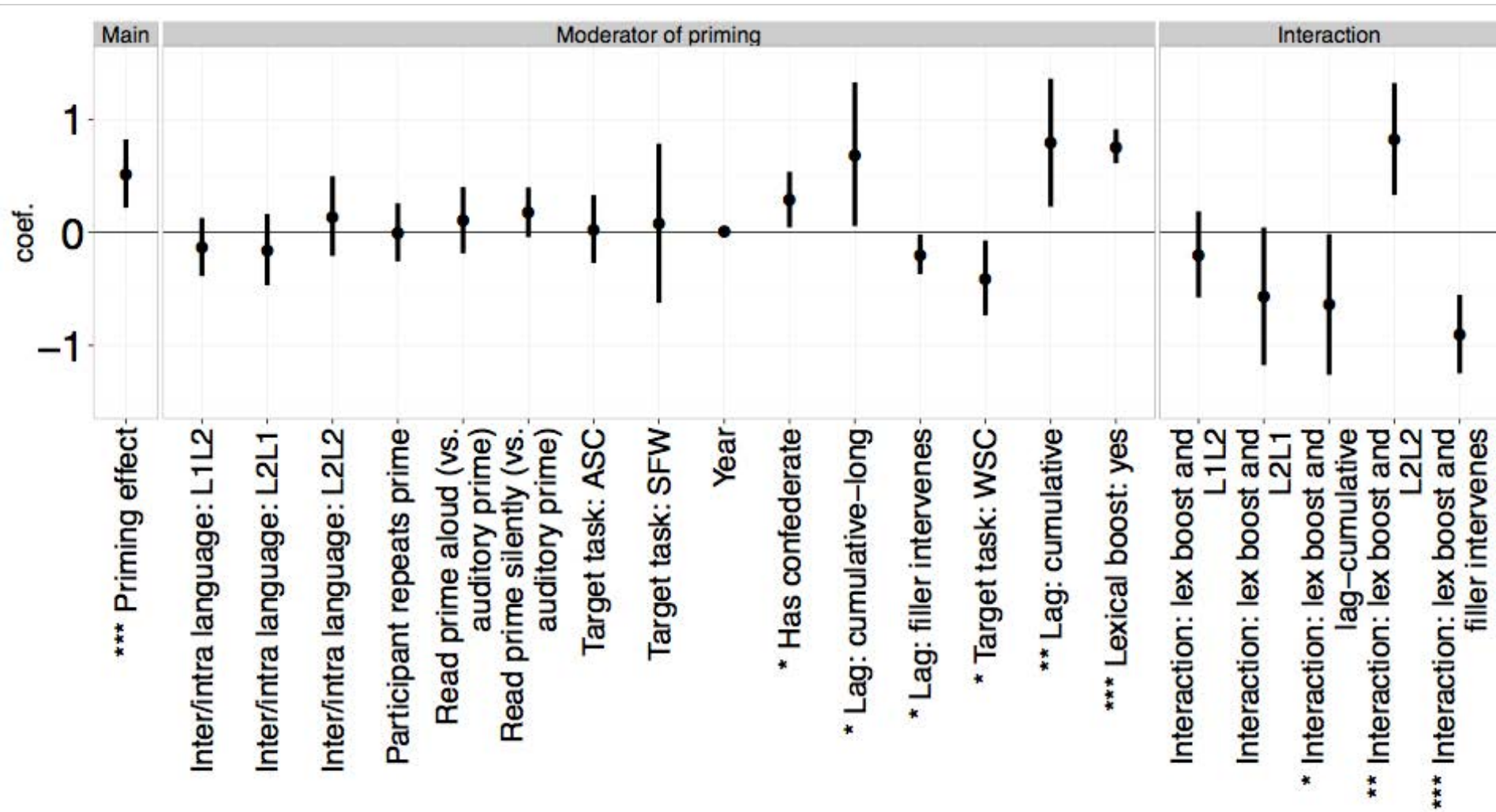
A construction X which occurs 50% of the time in the absence of priming would occur 63% if primed without lexical repetition and 77% of the time if primed with lexical repetition.

Meta-regression

Same idea as standard regression with mixed effects (moderators treated as either fixed or random effects).

Data is weighted by the standard error.

Coefficients from meta-regression



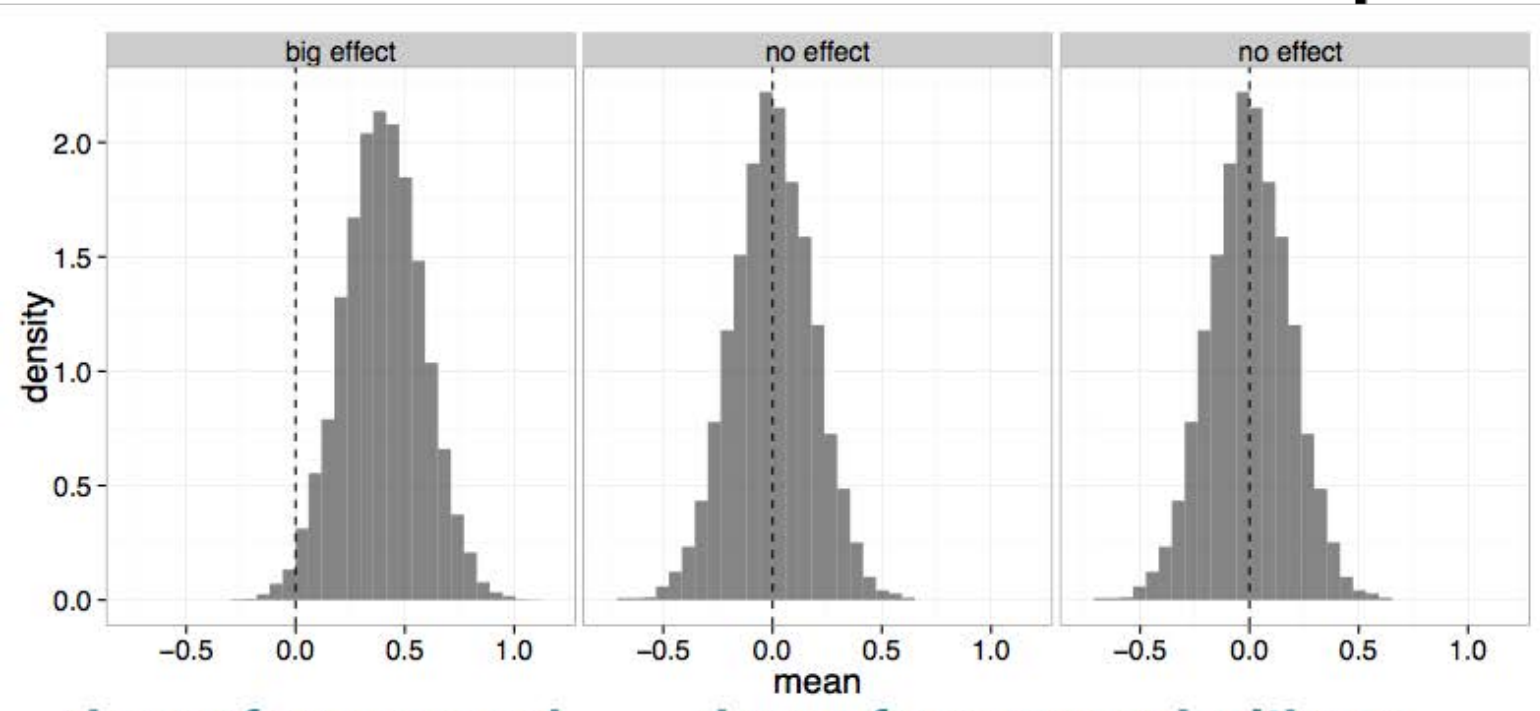
How much bias is there? What is the power?

Publication bias, p-hacking, selective reporting of results, questionable research practices, low power.

How likely is it that these are real results?

P-curve (tool designed by Simonsohn, et al. for assessing publication bias, power, and p-hacking)

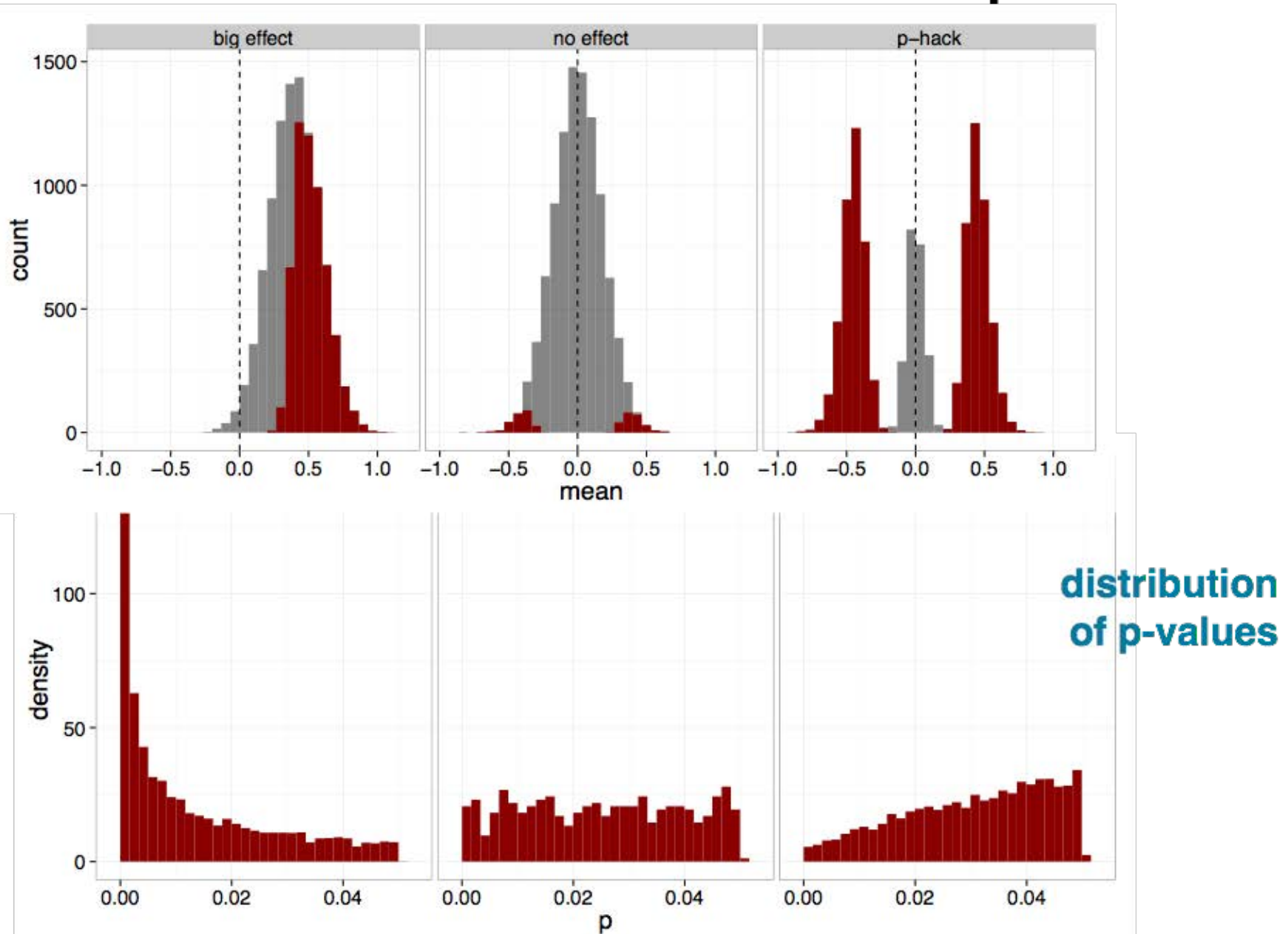
Publication bias and power



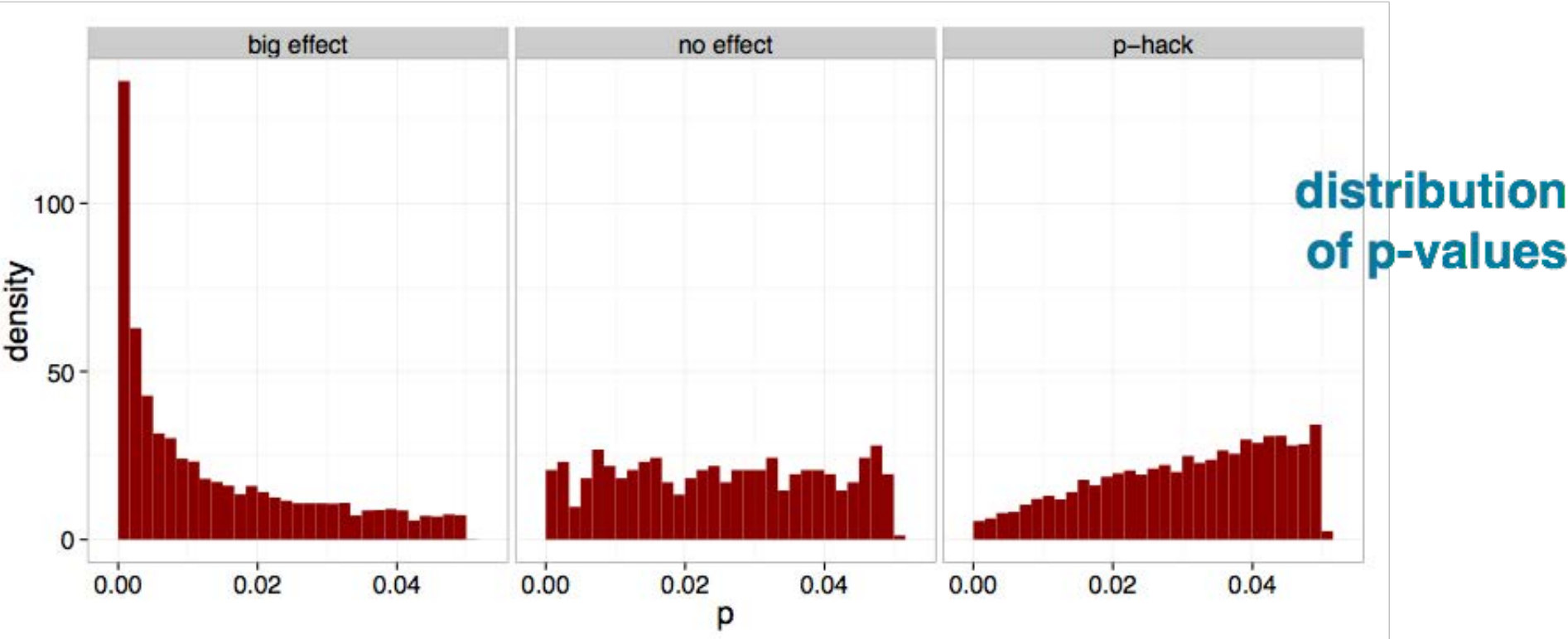
**draws from normal
with effect**

**draws from normal with no
effect**

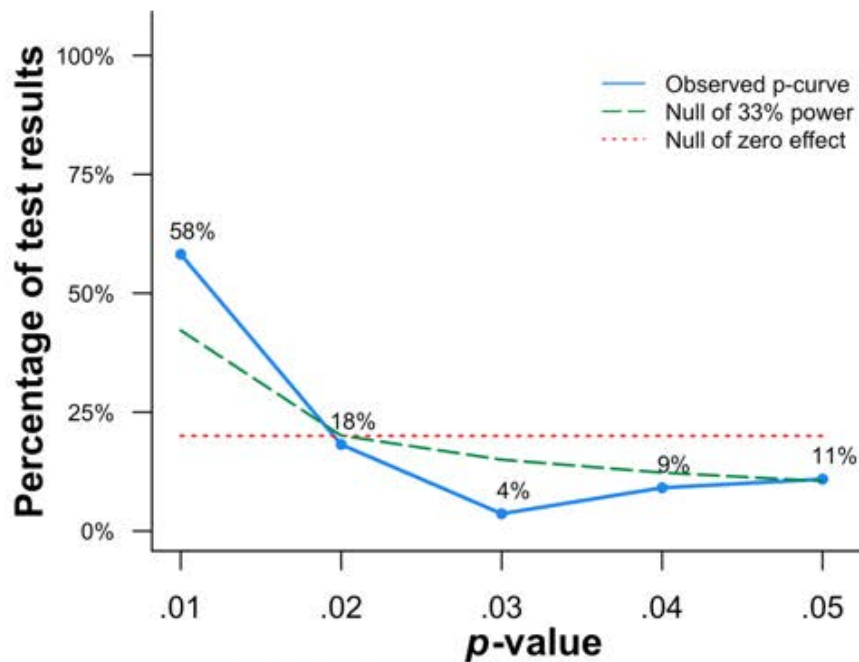
Publication bias and power



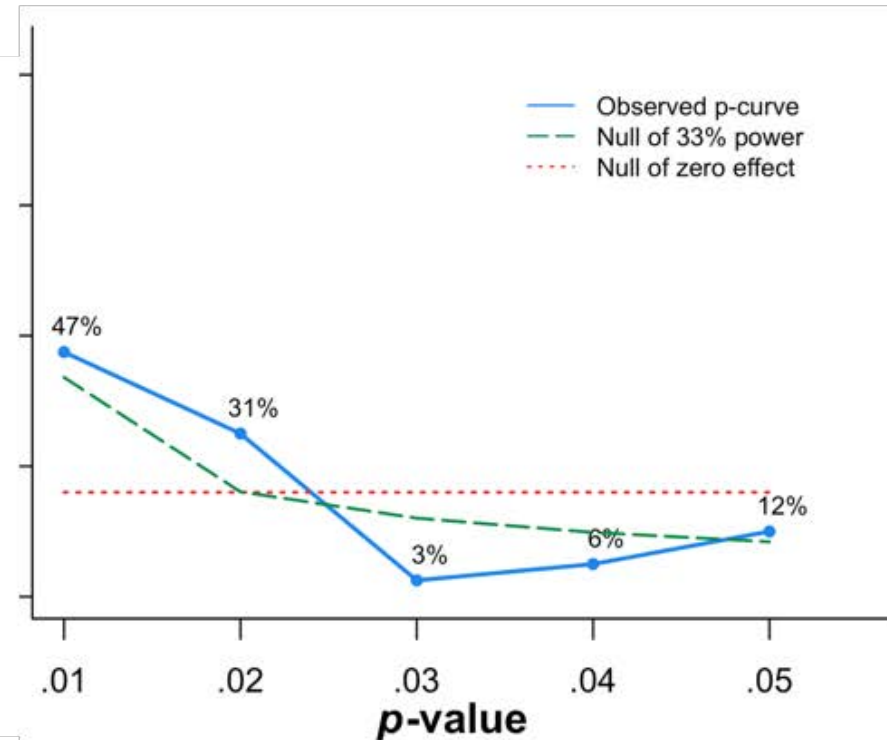
Which of these do priming studies look like?



P-curve: priming studies asking “does priming exist?”



82% power
All priming



57% power
No lexical overlap

Conclusions

No evidence of intense p-hacking in priming studies.

Lexical boost effect is very robust. Several other moderators discussed in the literature show clear effects across papers.

Studies are underpowered when there is no lexical boost or when experimenters are testing for effects of moderators.

Scheepers et al. (2011): Priming RC attachment from arithmetic

Odds ratio: about $(.7)/(.3) / (.5):(.5) = 2.3$

Average weighted odds ratio in Mahowald et al: 1.67

And there is a penalty of ~ 1 for Written sentence completion in Mahowald et al.

So this effect is much too big! Almost certainly exaggerated.

Our attempts to replicate on M Turk have all failed. We have only succeeded in replicating simple priming, DO-PO, and it's a small effect on M Turk.

Troyer et al. (2011)

- 2 experiments investigating relative clause (RC) priming: subject- vs. object-extracted RC priming.

- Old result: ORCs harder than SRCs:

ORC: The reporter that the senator attacked admitted the error

SRC: The reporter that attacked the senator admitted the error

- Reali & Christiansen (2007): SRCs are more frequent than ORCs with a definite NP in subject position

- But pronominal ORCs are more frequent than pronominal SRCs:

The consultant that you called / called you emphasized the need...

Here ORCs are read *faster* than matched pronominal SRCs

Troyer et al. (2011)

Troyer et al: examined frequent vs. infrequent types of ORCs to investigate whether common lexical items may be stored directly with abstract structures: pronouns (I, you, we) in subject position of ORCs

- Part 1 (*who* as the relative pronoun): 111 participants
- Part 2 (*that* as the relative pronoun): 109 participants
- Experiments run on Amazon.com's Mechanical Turk
- Sentence completion task; prime-target pairs interleaved with fillers

Troyer et al. (2011)

Prime types:

Definite-NP baseline

The...

Pronominal baseline

You/I...

Definite-NP complement clause

The screenwriter said that the...

Pronominal complement clause

The screenwriter said that you / I...

Definite NP ORC

The screenwriter who the...

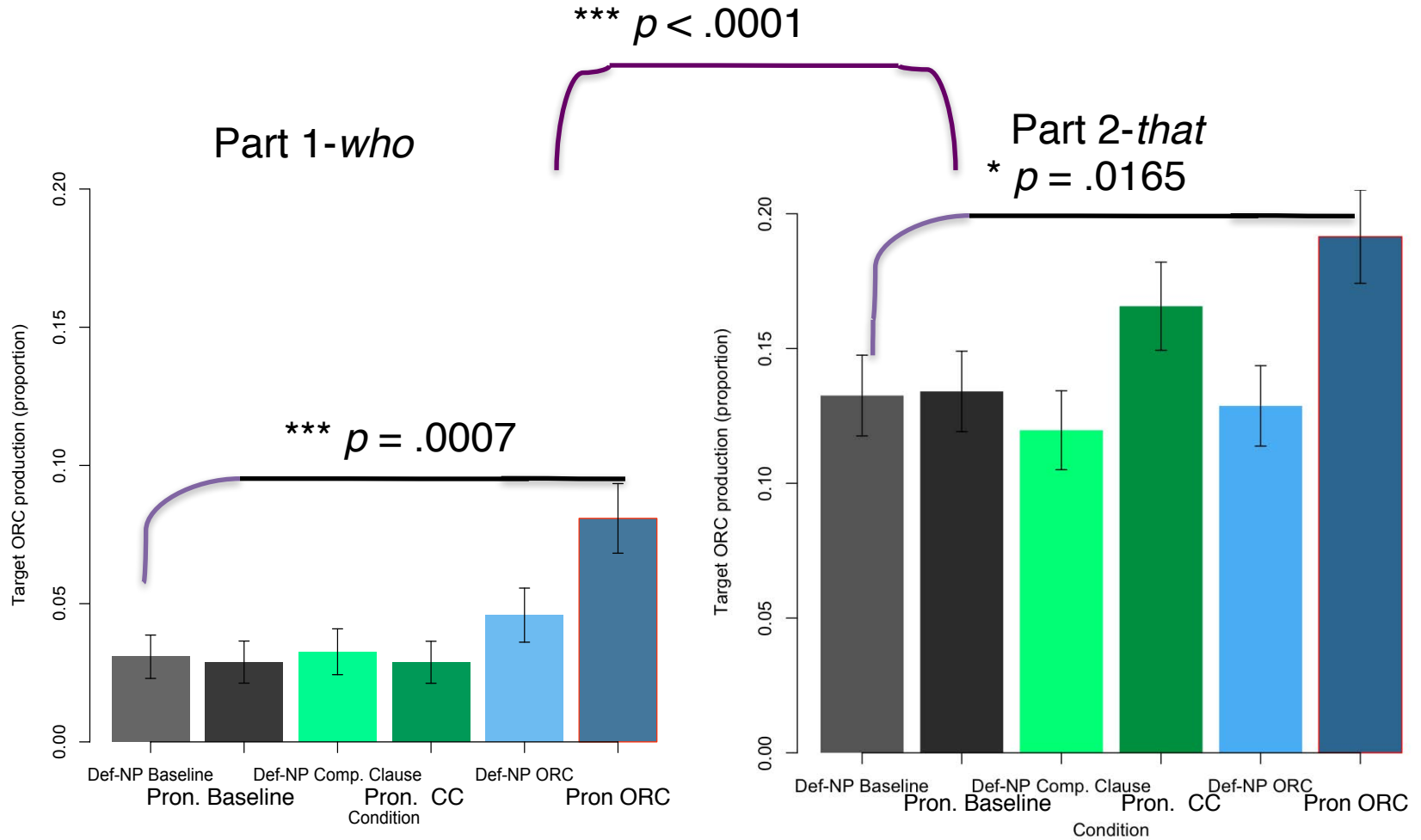
Pronominal ORC

The screenwriter who you / I...

TARGET:

The marine who...

Troyer et al. (2011)



Courtesy of Melissa Troyer, Timothy O'Donnell, Evelina Fedorenko and Edward Gibson. License CC BY-NC. Source: Troyer, Melissa, Timothy J. O'Donnell, Evelina Fedorenko, and Edward Gibson. "Storage and computation in syntax: Evidence from relative clause priming." In Proceedings of the Cognitive Science Society, vol. 33, no. 33. 2011.

9.59J/24.905J Lab in Psycholinguistics
Spring 2017

For information about citing these materials or our Terms of Use, visit: <https://ocw.mit.edu/terms>.