

Legal Ambiguities: What Can Psycholinguistics Tell Us?

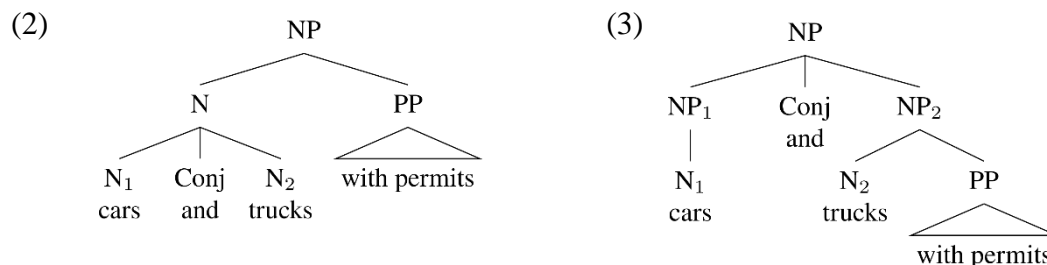
Janet Randall and Lawrence Solan *

I. Introduction

A sign in a parking lot says:

- (1) Only cars and trucks [with permits] are allowed

Are cars without permits allowed? The sentence is ambiguous. The prepositional phrase (PP), [with permits] can have “wide” scope as in (2), where it attaches high in the tree and modifies both [cars] and [trucks], or it can have “narrow” scope, as in (3), where the PP attaches low and modifies only [trucks]. (Note: The trees have been simplified.)



Legal language often poses this kind of ambiguity and judges can disagree on the intended meaning. In *Lockhart v. United States* (2016), the Supreme Court was split on how to apply the boldface phrase in “prior state convictions for crimes relating to [aggravated sexual abuse], [sexual abuse], or [abusive sexual conduct] **involving a minor or ward.**” The majority applied it narrowly, to the last element only, and cited a legal principle, the Rule of the Last Antecedent¹, which requires a modifier to apply with narrow scope, to the element it immediately follows. “Imagine you are the general manager of the Yankees and you are rounding out your 2016

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¹The US Supreme Court first referenced the Last Antecedent Rule in *Sims’ Lessee v. Irvine* in 1799 (Ross 2009), and it was later codified by Jabez Sutherland in *Sutherland on Statutory Construction* in 1891 (See LeClercq 1996, for these and other examples and Ross (2009) for a discussion and some history of the Last Antecedent Rule). According to Goldfarb’s (Oct 27 2015) post in his LAWnLinguistics blog, [Coming to SCOTUS: Battle of the dueling interpretive canons](https://lawnlinguistics.com/2016/09/25/the-rule-of-the-last-antecedent-is-really-old/h), this rule actually goes back to the maxim *ad proximum antecedens fiat relatio nisi impediatur sententia* (“Let reference be to the nearest antecedent, unless the meaning hinders”), which appeared in English case reports as the early 1600s and appears in an earlier case report, “written in law French from 1431: <https://lawnlinguistics.com/2016/09/25/the-rule-of-the-last-antecedent-is-really-old/h>”)

roster,” they wrote. “You tell your scouts to find a defensive catcher, a quick-footed shortstop, or a pitcher from last year’s World Champion Kansas City Royals. It would be natural for your scouts to confine their search for a pitcher to last year’s championship team, but to look more broadly for catchers and shortstops” (p. 4). Returning to (1), under the majority’s interpretation, only trucks need permits. And a narrow-scope interpretation, in fact, has been used more frequently in the courts than a wide-scope interpretation for ambiguous modifiers (Goldfarb 2015, Solan 2018).

But Justice Kagan, writing for the dissenting judges, argued that the baseball example differs crucially from the example in *Lockhart*. In *Lockhart*, the modifier, *involving a minor or ward*, follows “a straightforward, parallel construction of nouns in a series.” For such cases, a different legal principle, the Series-Qualifier Canon,² stipulates that the modifier apply to the entire series. “Suppose a real estate agent promised to find a client ‘a house, condo, or apartment *in New York*.’ Wouldn’t the potential buyer be annoyed if the agent sent him information about condos in Maryland or California?” This, they claim, reflects “the completely ordinary way that people speak and listen, write and read.” (*Lockhart v. U.S.*, 2016, Kagan, J., dissenting, pp. 1-3). In other words, don’t park in that lot without a permit.³

It’s worth noting that debates about the application of legal canons are not new, and that conflicting canons are common and coexist with one another. In his still often-cited classic article from 1950, Karl Llewellyn divides canons into two groups, which he calls “thrust” and “parry,” where “parry” canons exist in response to “thrust” canons, directly contradicting them. This conflict is by design: the canons are not incoherent; they are situational and apply in different contexts. Posner (2003) captures the situation by citing two everyday maxims: If Grandma says, “A stitch in time saves nine” but later says, “Haste makes waste,” we wouldn’t want to call her a hypocrite. And in *Lockhart*, Kagan’s choice of the Series Qualifier Canon over the Last Antecedent Rule was based on linguistic and substantive content, specifically the parallel structure of the conjoined nouns.⁴

With discussions like this occupying courts across the country, legal scholars have launched studies in a new field called “experimental jurisprudence” (Tobia et.al. 2022).⁵ And, as psycholinguists interested in bringing linguistics to bear on important legal issues, we have joined them, in a research program to find evidence for “the way that people speak and listen, write and read,” what the court has called “the ‘natural’ construction of the language,” (*Lockhart* dissent, p. 4). We will report on three empirical studies here.

² The rule behind the Series Qualifier Canon has been more transparently labeled the “Across the Board Rule” (Solan 1993). Goldfarb discusses both canons beginning with: [Robocalls, legal interpretation, and Bryan Garner \(the first in a series\)](#) and continuing with [The precursors of the Scalia/Garner canons](#) and [The Scalia/Garner canons: Departures from established law](#). According to Baude & Sachs (2017) “as one observer [Steinberg, 2015] noted, ‘nobody proposed [the Series-Qualifier Canon] as a canon until Justice Scalia pioneered it’”.

³ See *Lockhart v. United States*, 136 S.Ct. 958, 965 (2016)

⁴ Goldfarb takes up the linguistics of *Lockhart*, in greater detail than we have room for, in [Coming to SCOTUS: Battle of the dueling interpretive canons. \[Updated\] | LAWnLinguistics](#)

⁵ See Krishnakumar (2014) and Sinclair (2005), (2006), (2008), among others, for discussion.

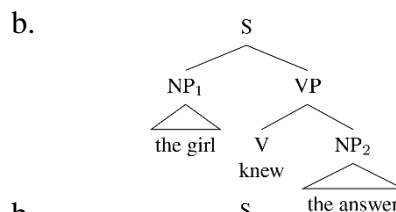
⁶ Other new methods of applied research include corpus linguistics (e.g., Lee & Mouritsen, 2018; <https://lawlinguistics.com/corpora-and-the-second-amendment/> and references cited there), and surveys (Tobia, 2020, Macleod, 2019).

II. Research Question

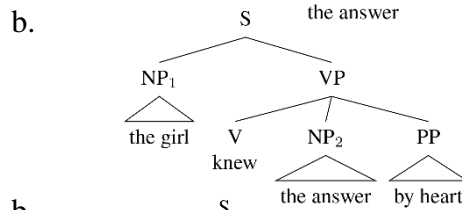
A. Background: Linguistic Principles

The classic psycholinguistic studies (Frazier 1978, Frazier & Fodor 1978) have proposed that two basic principles guide us as we analyze and create a mental representation for an incoming sentence. Our default strategy is to follow a principle of “Minimal Attachment,” attaching new material into the group of words we are currently analyzing, adding as little new structure as possible. Using Minimal Attachment, we start analyzing a string of words like (4a) as in (4b), attaching NP₂ into the VP. This strategy is correct if the sentence continues as in (5a) but not as in (6a), where NP₂ is the first element of a new subordinate clause and a Minimal Attachment parse sends us down a “garden path.” We must now backtrack from (5b), reanalyze, and create the parse in (6b) (Frazier 1987, p. 562).

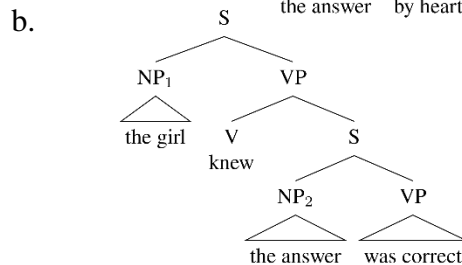
(4) a. The girl knew the answer ...



(5) a. ... by heart



(6) a. ... was correct

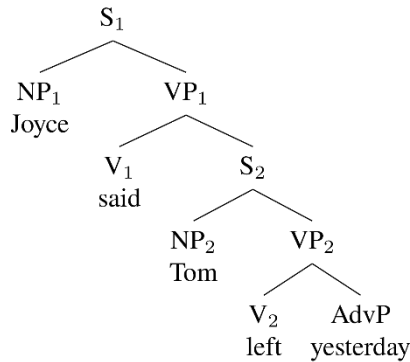


Sometimes Minimal Attachment doesn't choose between two competing analyses, though, because they are equally minimal, so a second principle, “Late Closure,” comes into play. Late Closure says that when we parse new material, we attach it to material that we have most recently analyzed. So in (7), the parser is processing the embedded sentence and has inserted the second verb, [left]. It now has a choice of attaching the Adverb Phrase [yesterday] as its sister, as in (8a) or higher up, in the main clause, as in (8b). Late Closure chooses (8a) and [yesterday] is inserted as sister to V₂.⁶

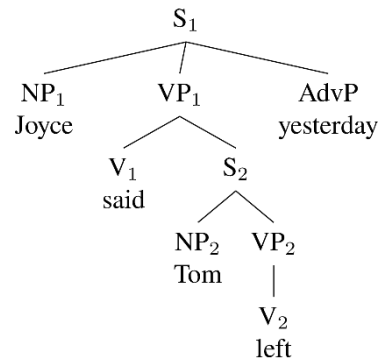
⁶ Other parsing approaches have been proposed (e.g., multiple-constraint satisfaction models and big data analyses) that explain these effects based on “recency” or “locality” rather than syntactic structure, with the relevant parameter being dependency distance. We will not be discussing those models here. See, for example, McRae & Matsuki (2013) and Haitao et al. (2017).

(7) Joyce said Tom left yesterday.

(8) a.



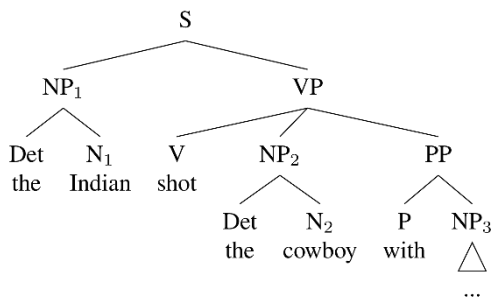
b.



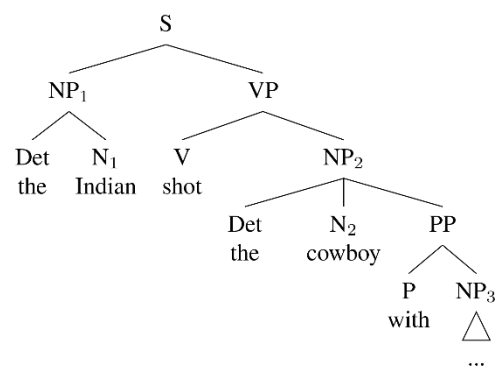
These two strategies, though, while used by the parser across many constructions, do not apply in all contexts. For example, reading time studies have shown that when sentences like (9) are presented in isolation, participants show a general preference for attaching the incoming PP high, to the VP as in (10a), rather than to the NP that it contains (NP₂), as in (10b).

(9) The Arapahoe Indian shot the cowboy [PP with...].

(10) a.



b.



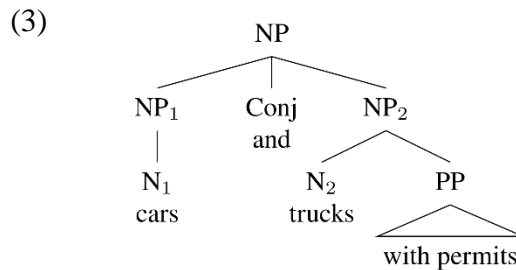
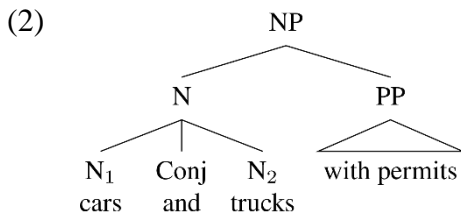
In processing sentences ending as in (11b), where low attachment is required as in (10b), readers showed a slowdown as they got to the PP, as compared with their processing time for (11a), a high-attachment sentence with the structure in (10a). This suggests that the high-attachment tree (10a) is preferred and that our default parsing strategy is to attach ambiguous PPs high.⁷

- (11) a. The Arapahoe Indian shot the cowboy with the bow and arrow.
 b. The Arapahoe Indian shot the cowboy with the leather vest.

Another counterexample to the Late Closure strategy is (1), repeated below. Sentences like this one, containing "a straightforward, parallel construction of nouns in a series," to use Kagan's phrase, have been shown, in a number of studies, to be interpreted as in (2), with the PP attached high, and not as in (3) (Frazier, L., et. al. 2000. Clifton, C., et. al, 2002; Jeon & Yoon, 2012).

⁷ See Spivey-Knowlton & Sedivy, 1995.

(1) Only cars and trucks [with permits] are allowed



One reason for this is discussed in Frazier, Munn, and Clifton (2000), who report that we more easily parse conjoined structures when their conjuncts are internally parallel. For sentence (1), the preferred parse is (2), where the conjuncts are all single words, not (3) with a PP inside the second conjunct and nothing inside the first. So does this mean that a wide-scope reading should be given **whenever** a statute contains conjoined parallel nouns? The answer is no. Though an “initial” parse might show a preference for high attachment, we may settle on a low, narrow-scope reading in the end. The content matters.

B. Content Should Matter

We have seen a case – *Lockhart* – in which the Supreme Court used an unfortunate narrow-scope, or “Last Antecedent,” reading where wide scope was justified. This narrow-scope reading, according to Goldfarb (2015), seems to be the predominant tendency of the court. But there are other cases where the opposite is true – the court applied a modifier with wide scope where narrow-scope makes more sense. In the 1975 case, *Board of Trustees of the Santa Maria Joint Union High School District v. Judge*, a school board attempted to fire one of its teachers, Mr. Theodor Judge, because he had been convicted of a felony for growing a marijuana plant at his home. Judge requested a hearing, and the matter ended up in court. The trial court and the appellate court both held that the board could not fire Mr. Judge because the California statute on firing teachers did not apply. The relevant language is in (12):

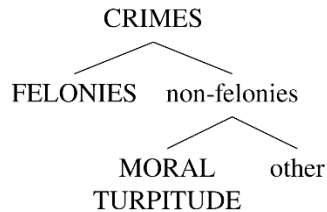
- (12) No permanent employee shall be dismissed except for one or more of the following causes ...
 (h) Conviction of a felony or of any crime **involving moral turpitude.**”

The court held that “involving moral turpitude” has wide scope, attached high to modify both disjuncts (“disjuncts”, rather than “conjuncts” because the connecting word is *or*, not *and*.) It further held that cultivating a marijuana plant, though a felony [at the time] is not a crime of moral turpitude. Because their wide-scope reading required that the crime, whatever type it was, be “of moral turpitude,” Mr. Judge kept his job.

But this wide-scope reading, as Solan (1993) notes, seems wrong here. Why? Consider the logic of the situation, shown in Figure 1. The statute is clearly intended to keep teachers who have committed serious crimes away from schoolchildren. What crimes would those be? Felonies, the most serious of crimes, would certainly qualify, whatever kind of felony it is. Of

the non-felonies, crimes that would endanger schoolchildren are crimes “of moral turpitude.” Logically, then, the phrase should have narrow scope.

Figure 1: Logic of the “conviction of a felony or of any crime involving moral turpitude” statute



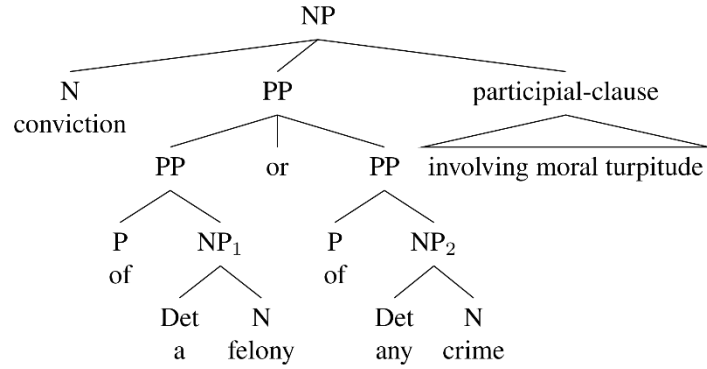
The narrow-scope intent is also clear from the statute’s wording. The statute contains a participial clause, [involving moral turpitude]. Participial clauses are similar to relative clauses starting with *who*, *which* or *that*. They both modify a noun, but as BBC’s “Learning English” website⁸ explains, participial clauses “allow us to say the same thing as relative clauses ..., but with fewer words:” They illustrate with (13)

- (13) At the end of the street there is a **path** a. [that leads to the river]. relative clause
b. [leading to the river]. participial clause

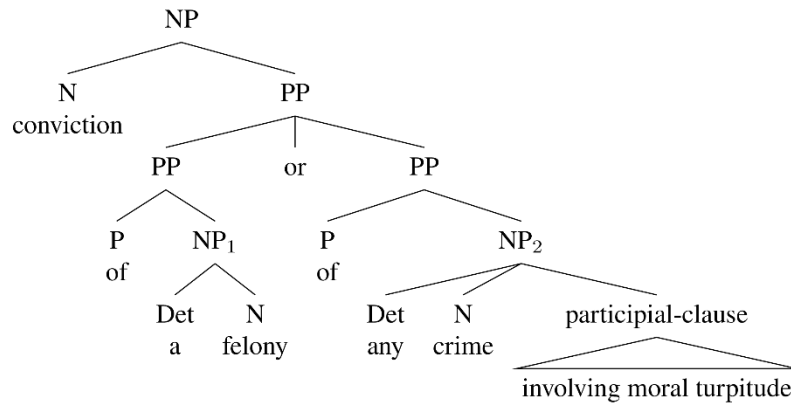
In the statute, the participial clause, [involving moral turpitude] similarly modifies a noun. But **which** noun? There are two possibilities, [conviction] as shown in (14), or [crime] as shown in (15).

⁸ <https://www.bbc.co.uk/worldservice/learningenglish/grammar/learnit/learnitv106.shtml>

(14)



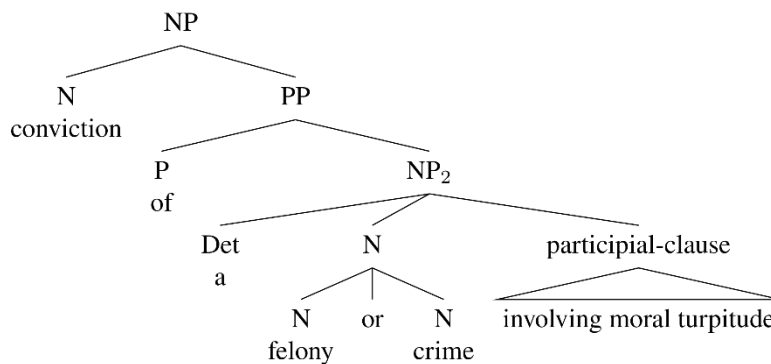
(15)



The first possibility, (14), clearly makes no sense. It's not the conviction that does or doesn't involve moral turpitude, it's the crime. And importantly, the clause modifies **only** crime, not also felony. [Involving moral turpitude] has no relation to [felony]. The only way for this phrase to have a wide-scope reading, modifying both [felony] and [crime], would be if the statute had been phrased as in (16a), with the structure in (16b):

(16) a. [conviction of a [felony or crime] involving moral turpitude]

b.



But that is not the wording. The statute conjoins prepositional phrases containing nouns not nouns by themselves. And participial clauses cannot modify PPs. According to both logic and linguistic structure, then, Mr. Judge’s felony, even though it did not involve moral turpitude, should have sufficed to get him fired. He got off, unjustly, because of a sloppy reading of the statute.

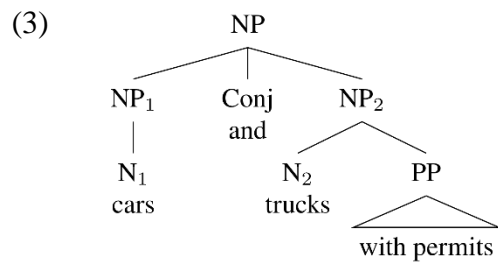
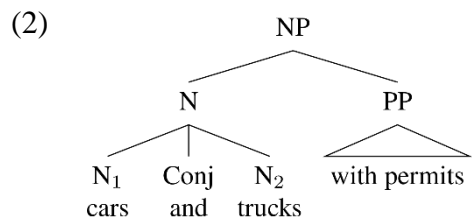
We’ve seen two cases, *Lockhart* and *Judge*, with two different – and we think, misguided – interpretations. In *Lockhart*, the court argued that narrow scope was preferred, using the Rule of the Last Antecedent, but the dissenting judges recognized that a modifier on a series of parallel nouns is most naturally interpreted with wide scope, attached high, as the Series Qualifier Canon dictates. In *Judge*, the court based its ruling on a wide-scope reading, but that interpretation goes against both logic and the wording of the statute. Here only a narrow-scope reading makes sense. If judges are looking for “the way that people speak and listen, write and read,” what the court has called “the ‘natural’ construction of the language,” it’s important to actually investigate what that is, and what linguistic and real-world factors are involved.

C. One More Factor: Semantics and Pragmatic “Real-world” Knowledge

Our parking lot sign in (1) led us to ask,

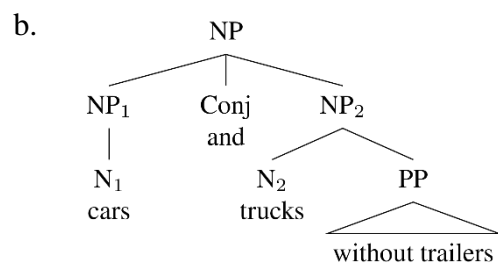
(1) Only cars and trucks [with permits] are allowed

How do native speakers interpret the PP modifier here? Let’s return to that case and delve a bit deeper.



Based on the literature, the interpretation of (1) is clearcut. The two conjuncts, N₁ [cars] and N₂ [trucks] are parallel, so tree (2) should be preferred over tree (3); both cars and trucks need permits. But now consider (17):

(17) a. Only cars and **trucks** [PP without trailers] are allowed

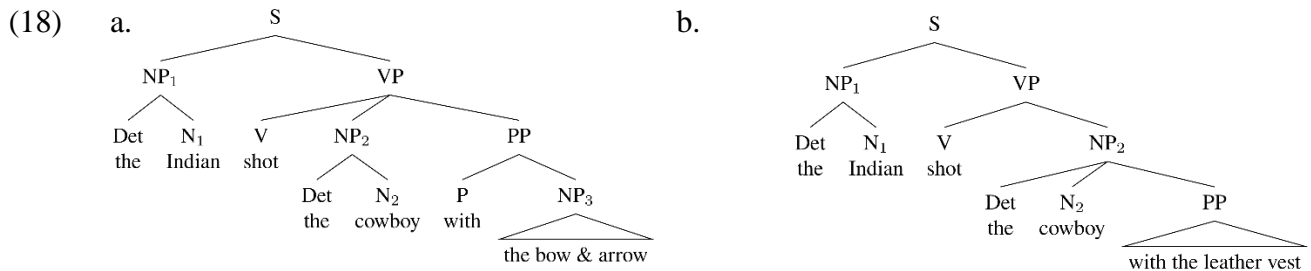


In (17a), the PP relates more closely to trucks than to cars because trailers are more often attached to trucks than to cars. If our initial preference for high-attachment can be influenced by

that semantic difference, then N2-biased cases should elicit more low attachments like (17b) as compared to unbiased cases like (1).

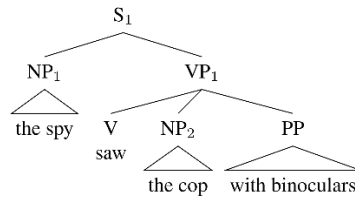
Research backs this up. We already discussed the difference in reading times of the PPs in (11) (repeated here). When the last NP is encountered, the semantics forces the parser to take the time to reanalyze its first preference and assign it the semantically-compatible parse in (18b) (Spivey-Knowlton & Sedivy, 1995).

- (11) a. The Arapahoe Indian shot the cowboy [with the bow and arrow].
 b. The Arapahoe Indian shot the cowboy [with the leather vest].

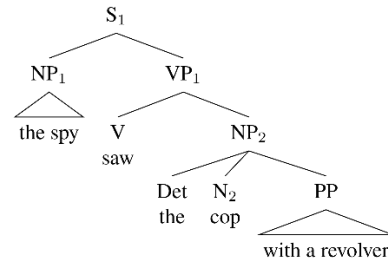


In another reading-time study, Rayner et. al. (1983) also showed the effect of lexical bias on sentence interpretation on, comparing the reading times of sentences like (19a) and (20a) where the two different PPs are most compatible with different attachments. In (19), the PP is attached high, into the VP; in (20), it is attached low, modifying the N.

- (19) a. the spy saw the cop [with **binoculars**] b.



- (20) a. the spy saw the cop [with a **revolver**] b.



Low-attachment cases like (20) showed significantly longer reading times than high-attachment cases like (19), confirming that our default parsing preference is high-attachment. The parser goes with its initial, preferred, parse, so it must then backtrack and assign a new structure that works for the semantics.

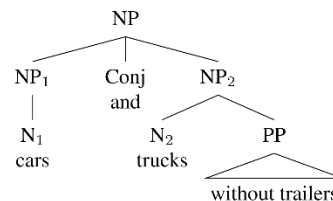
Further evidence that semantic bias affects our wide-scope default analysis comes from a study by Jeon & Yoon (2012) showing significant differences in pronunciation (duration and pitch contour) of phrases like (21a), where the PP was equally compatible with both nouns, and (21b) where it is biased toward the last noun. (Semantic bias was established in a lexical-bias pretest.)

- (21) a. Athletes and painters [with their **gear**] gathered in the park.
 b. Athletes and **painters** [with their **sketchbooks**] gathered in the park.

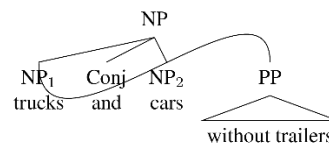
D. Limits on Semantics: Syntactic Constraints

But there are limits on semantics. Syntactic principles constrain how attachments are made, and the No Crossing Branches Principle, a tenet of tree-construction, prevents a PP from relating to the first of the two conjuncts but not also to the second. Compare (17a) and its tree in (17b), repeated here, where the PP is biased toward N2, with (22a), where the nouns are reversed and the bias is toward N1.

- (17) a. cars and **trucks** [without trailers] b.

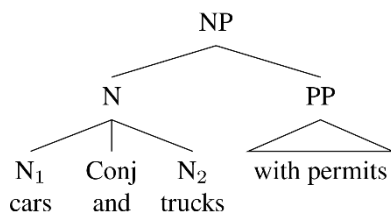


- (22) a. **trucks** and cars [without trailers] b.



Given the No Crossing Branches requirement, though the PP relates more to the first noun, the tree in (22b) is impossible. The only way to associate the PP with N1 legally is to attach it high, as in (23) (repeated here from (2)), with wide scope.

(23)



Thus, sentences biased towards N1 like (22a) should have the same rate of wide-scope readings as unbiased sentences like (1). Syntactic constraints will override semantic bias.

We have seen that the interpretation of modifiers is not always clear-cut but is sometimes semantically biased in one direction or the other. This bias does not operate on its own, though. It is constrained by syntactic principles, specifically, the No Crossing Branches prohibition. In the following section, we will present experimental evidence supporting these claims, and then discuss another syntactic fact that influences interpretation.

III. Three Experiments to Test “The Way That People Speak and Listen, Write and Read”

We designed a series of experiments to look for evidence (to quote Justice Kagan,) “about the way that people speak and listen, write and read”. Are the courts correct when they use the Rule of the Last Antecedent as their default? (Goldfarb, 2015).

Our first two experiments focus on PPs that follow, “a straightforward, parallel construction of nouns in a series,” as in Justice Kagan’s example: ‘a house, condo, or apartment *in New York.*’ We asked three questions: (1) Is wide-scope the default parsing strategy? (2) Does semantic bias have an effect? And, if so (3) Do syntactic principles limit that effect? We formulated these questions as three hypotheses:

Hypothesis I: The preferred PP reading is wide-scope (high attachment) over narrow-scope (low attachment)

Hypothesis II: Semantic bias can weaken the default wide-scope preference

Hypothesis III: Syntactic constraints override semantic biases

A. Experiment 1: Unbiased vs. semantically-biased PPs (with no syntax violation)

Experiment 1 tested Hypothesis I and Hypothesis II by comparing the interpretation of PPs after a series of conjoined nouns when the nouns and PPs are either semantically unrelated or semantically related.⁹ In the unrelated, “unbiased” condition, the PP was equally compatible with N1 and N2, as in (24a). In the related, “biased” condition, the PP was more compatible with N2, as in (24b). We predict that (i) in the unbiased condition, PPs will be given predominantly wide-scope readings, and that (ii) in the biased condition, PPs (biased toward N2) will have a lower rate of wide-scope readings

⁹ We used sentences from Jeon & Yoon (2012)’s Lexical Bias pretest, which rated 91 sentences high-, equal-, or low-attachment biased.

Subjects

113 subjects, all US citizens over 18, matching the demographics of the US census data, were recruited through Lucid¹⁰, a subject-recruitment and survey-distribution service. We limited participation to US citizens over 18, requirements for serving on a jury. Out of these, 50 participants were disqualified for incomplete responses or not following instructions, leaving 63 subjects who completed the survey.

Materials, Design and Procedure

Subjects saw a total of 24 sentences, 12 test sentences and 12 distractor sentences, intermingled and presented in different randomized orders. The test sentences were of the form [N1 and N2 PP VP], as in (24).

- (24) a. unbiased: Athletes and photographers [with their **gear**] waited by the van.
b. biased: Athletes and **photographers** [with their **cameras**] waited by the van.

Each subject saw each test sentence in one version, with the PP (a) unbiased or (b) semantically biased toward N2, the last noun in the series. So subjects saw 6 unbiased sentences and 6 biased sentences. Following each sentence was a multiple-choice question with four answers, [N1], [N2], [N1 and N2] and [none of the above], randomly ordered, as in (25).

- (25) Who had **their gear/their cameras**?
A. the athletes B. the photographers C. the athletes and the photographers
D. none of the above

There were two types of distractor items, largely adapted from Frazier & Rayner (1982). They all started with a dependent clause containing either a transitive verb, as in (26a) or an intransitive verb as in (26b), which caused a “garden-path” effect, because the subject of the main clause (here, *the clock*) was first parsed as the object of the embedded verb (*dusting*). Following each item was a multiple-choice question with two choices, randomly ordered, followed by a third choice, *I don't know*. For the transitive verb cases like (26a) the two choices were the two postverbal nouns; for the intransitive verb cases like (26b) they were the one postverbal noun and a semantically related noun. To be included in the study, subjects had to correctly answer all of the distractor questions. (Acceptable answers are in **boldface**.) In addition, they had to take longer than 3.5 seconds to answer the test questions, averaged across all 12. This was to ensure that they were spending enough time to process the sentences before choosing an answer.

- (26) a. While Grandma was knitting the sweater the yarn fell off her lap.
What was Grandma knitting?
A. **the sweater** B. the yarn C. I don't know
b. While Mary was dusting the clock started to chime.
What was Mary dusting?
A. **the clock** B. the dust cloth C. **I don't know**

¹⁰ For an extensive description of the Lucid Survey Platform, see Tobia, et. al. (2021) p. 24, footnote 164.

To acclimate subjects to the format of the questions, the survey began with two practice questions: one that mimicked a test question, the other that mimicked a distractor question. No subjects were excluded for incorrect answers on these practice questions. After answering all of the survey questions, subjects saw a slide explaining the purpose of the study and instructions for how to contact the experimenters, followed by a Thank-you page.

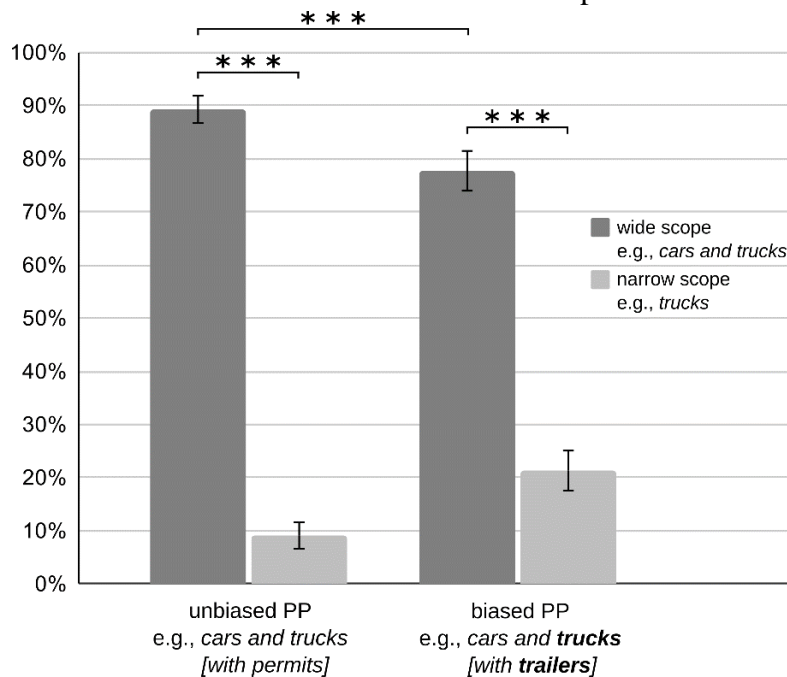
Results

As Table 1 and Figure 2 show, the results confirm Hypothesis 1. In *unbiased* sentences, subjects overwhelmingly interpreted the PPs with wide scope (on N1 & N2), not narrow scope (on N2), 89.4%, vs 8.99%. This difference is highly significant, according to a paired-samples t-test ($t(62) = 15.96, p < .001$). In Figure 2, the two bars on the left show this contrast.

Table 1. Experiment 1: PP Attachment Rules

	Wide scope (N1 & N2)	Narrow scope (N2 only)	N1 only (Illegal)
Unbiased	89.4%	8.99%	0.794%
N2-biased	77.8%	21.2%	0.794%

Figure 2: Rates of wide- & narrow scope interpretations for unbiased & biased PPs in Experiment 1.



Hypothesis I was also confirmed by the data for *biased* sentences. Despite the semantic bias between the PP and N2, subjects still overwhelmingly preferred a wide-scope reading, 77.8% vs. 21.2%, according to a paired-samples t-test ($t(62) = 7.57, p < .001$). In Figure 2, the two bars on the right show this contrast. However, confirming Hypothesis II, this wide-scope preference was slightly (but significantly) weaker, 89.4% vs. 77.8%, according to a paired-samples t-test ($t(62) = 4.73, p < .001$). A tiny fraction of “error responses”, under 1% in both conditions, illegally assigned the PP to N1.

B. Experiment 2: Unbiased vs. semantically-biased PPs (with a syntactic violation)

To test Hypothesis III, that syntactic constraints limit the effect of semantic bias, Experiment 2 compared the interpretations of PPs after a series of conjoined nouns when the nouns and PPs are either semantically unrelated (the “unbiased” condition or semantically related (the “biased” condition”) but here the bias was not to N2, but to N1, which is in a syntactically inaccessible position, as we saw above, in (22a). For the unbiased sentences, the results should reconfirm Experiment 1’s default wide-scope preference. For the biased sentences, though, because attaching the PP to N1 would result in crossing branches, the preference should **also** be wide scope.

Subjects

Subjects were drawn from the same Lucid subject pool as in Experiment 1. Out of a total of 110 subjects recruited, 57 were disqualified, leaving a total pool of 53 who completed the survey.

Materials, Design and Procedure

Experiment 2 used the same procedure and distractor sentences and questions as Experiment 1. It also used the same test sentences – but with the nouns reversed. (24a) and (24b) now appear as (27a) and (27b). For the unbiased cases (24a)/(27a), this makes no difference, but for the biased cases like (24b) – now (27b) – the bias now illegally relates the PP to N1.

- (27) unbiased: a. Photographers and athletes [with their **gear**] waited by the van. (=24a)
illegal biased: b. **Photographers** and athletes [with their **cameras**] waited by the van.

Again, following each sentence was the same multiple-choice question as in Experiment 1, with the answers, again, randomly ordered:

- (28) Who had **their gear/their cameras**?
A. the photographers B. the athletes C. the photographers and the athletes
D. none of the above

The complete list of test sentences and distractor sentences for Experiment 2 appears in Appendix 2.

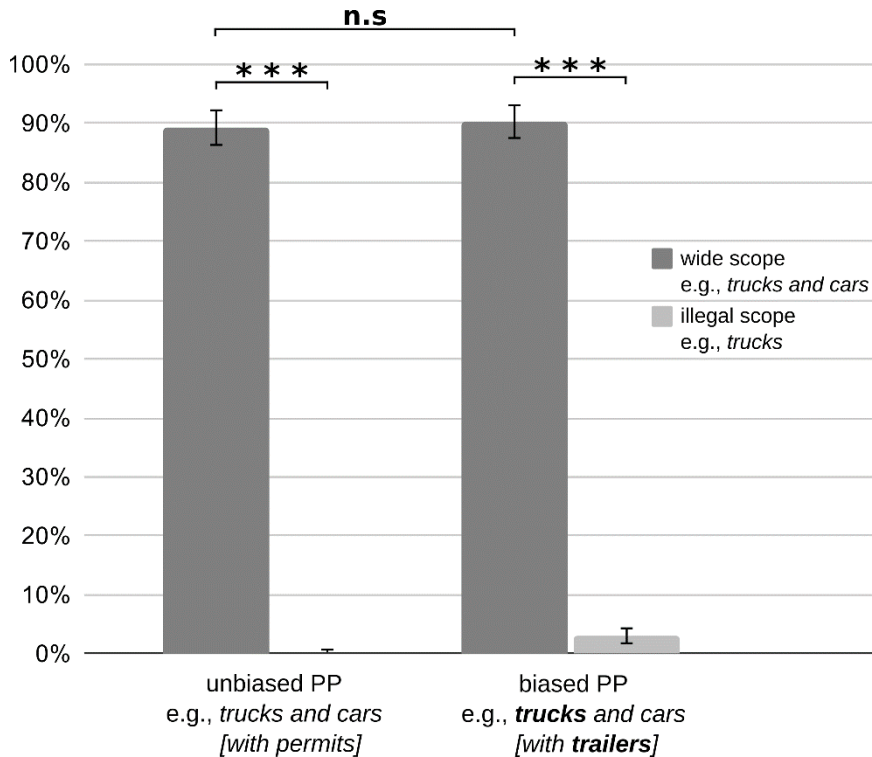
Results

As Table 2 and Figure 3 show, for the *unbiased* sentences, the results again confirmed Hypothesis I: subjects still overwhelmingly interpreted the PPs widely, as applying to both N1 and N2, not just to N2. The wide-scope preference 89.3% vs. 10.1%, is highly significant, according to a paired-samples t-test ($t(52) = 13.62, p < .001$), and is nearly identical to the preference in Experiment 1 (89.4%).

Table 2. Experiment 2: PP Attachment Rates

	Wide scope (N1 & N2)	Narrow scope (N2 only)	N1 only (Illegal)
Unbiased	89.3%	10.1%	0.629%
N1-biased	90.3%	6.60%	3.14 %

Figure 3. Rates of wide- & narrow-scope interpretations for unbiased & biased PPs in Experiment 2.



For *biased* sentences, however, as predicted by Hypothesis III, the bias had **no** effect. In contrast to the findings of Experiment 1, here, subjects did **not** interpret the PP as applying to the semantically-related *but syntactically inaccessible* N1. They again showed a wide-scope preference and the rate was not significantly different from the wide-scope preference in the unbiased sentences, according to a paired-samples t-test (90.3% vs 89.3%, $t(52) = -0.45$, $p > .05$). This is shown by the similarity of the two dark grey bars in Figure 3.

Thus, as predicted, when the biased PP refers to N1, in a syntactically unavailable position, the bias has no effect. Syntax wins.

C. The Plot Thickens

To summarize the results of Experiments 1 and 2, we have evidence for all three of our hypotheses:

Hypothesis I: The preferred PP reading is wide-scope (high attachment) over narrow-scope (low-attachment)

Hypothesis II: Semantic bias will weaken the default wide-scope preference

Hypothesis III: Syntactic constraints override semantic biases

Hypothesis I: In the neutral default case (athletes and photographers [with their **gear**]), the PP is nearly always understood as having wide scope, modifying both conjuncts, [athletes and photographers] rather than just the last conjunct (89.4% vs. 8.99%, $p < .001$). Hypothesis II: When the PP is biased towards the last conjunct (athletes and **photographers** [with their **cameras**]), wide scope is still the favored reading but, predictably, semantic bias slightly weakens that preference (77.8% vs. 21.2%, $p < .001$). Hypothesis III: Syntactic constraints override the semantic bias when the PP is biased to the first conjunct, N1, because it is syntactically inaccessible (**photographers** and athletes [with their **cameras**]). Now, the semantic bias has **no effect** (89.3% vs. 90.3%, $p > .05$). Subjects obey the syntactic No-Crossing Branches Constraint.

Notice that the items in the cases that we have been discussing — [[cars] and [trucks]], [[aggravated sexual abuse], [sexual abuse], or [abusive sexual conduct]], [a [house], [condo], or [apartment]], and even the non-parallel baseball case –[a defensive catcher, a quick-footed shortstop, or a pitcher from last year’s World Champion Kansas City Royals] are all series of noun phrases. For this kind of ambiguity, our experiments found strong evidence for a wide-scope preference, consistent with the Series Quantifier Canon: “*when there is a straightforward parallel construction that involves all nouns or verbs in a series, a prepositive or postpositive modifier normally applies to the entire series.*”

Tobia, Slocum & Nourse (2022) report a finding that they claim was similar. They tested how people interpret sentences related to a number of interpretive canons. One of their questions, shown in (28), was intended to focus on the Series Qualifier Canon:

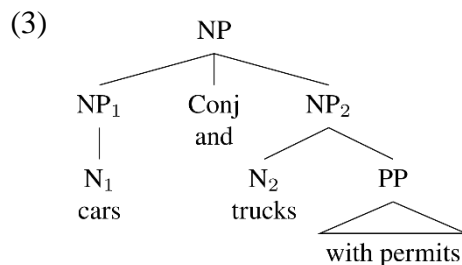
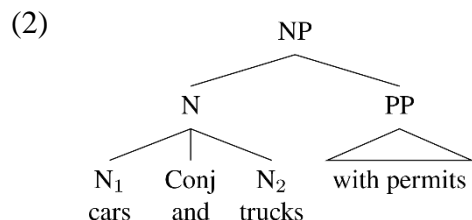
(28) Imagine that there is a law. Part of that law states that “**In parking area A, people may park cars, mopeds, and trucks on weekends.**” Does this part of the law mean:

- (a) In parking area A, people may park cars on any day, mopeds on any day, and trucks on only weekends.
- (b) In parking area A, people may park cars on only weekends, mopeds on only weekends, and trucks on only weekends.

Their subjects showed a significant preference for option (b) (over 70%), giving [on weekends] wide scope over all of the vehicles, not just the final noun, [trucks]. The researchers took this to mean that their subjects “strongly invoked” the Series Quantifier Canon and “strongly rejected” the Last Antecedent Rule.

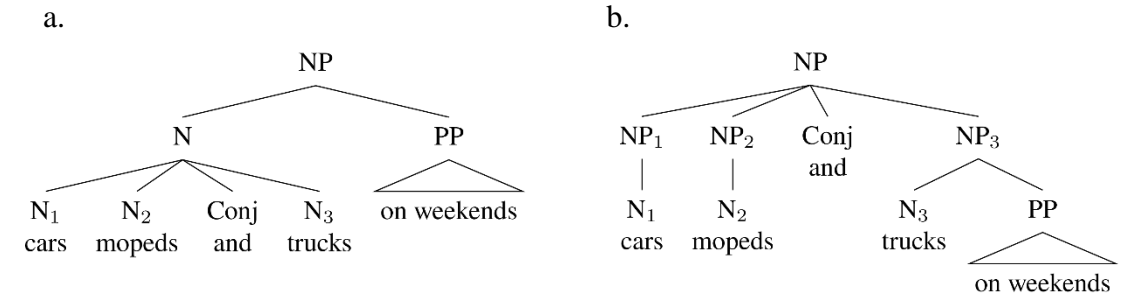
There is a problem with drawing this conclusion from their study, however. Notice that their law in (28), *In parking area A, people may park cars, mopeds, and trucks on weekends.*” is different from the readings in (1), above, which were captured with the trees in (2) and (3).

(1) Only cars and trucks [with permits] are allowed.



In (1), the ambiguity lies in whether the PP [with permits] modifies the entire series of nouns or only the last noun. But in (28) there is actually no ambiguity because, in fact, the two corresponding trees, (29a) and (29b), don't make sense.

(29)



The PP in (28), [on weekends], is not describing the noun(s) at all. It is describing the parking, the verb. Unlike the PPs we have been looking at – [with permits], [without trailers], [with their cameras], [in New York] – which can modify nouns that describe people like [athletes] or things like [trucks] or [apartments], the PP [on weekends] indicates time and belongs to a class of “temporal” modifiers ([at dawn], [for an hour], etc.), which are incompatible with these kinds of nouns. This is clear from seeing them in isolation, away from a verb. Compare (30a) with (30b). The phrases in (30a) sound strange, while the phrases in (30b) make sense, and this is because the PPs in (30b) are modifying the verbs, [park], [drive], [enjoy] and [operate]. (The asterisks in the (a) versions mean that the phrases are ungrammatical.)

- (30) a. *cars [on weekends]
 *trucks [before dawn]
 *mopeds [for two hours]
 *tractors [in February]
- b. park cars [on weekends]
 drive trucks [before dawn]
 enjoy mopeds [for two hours]
 operate tractors [in February]

This is not to say that temporal PPs are blocked from **every** noun. As (31) shows, they are felicitous with “event” nouns, because events happen, and we can say *when* they happen.

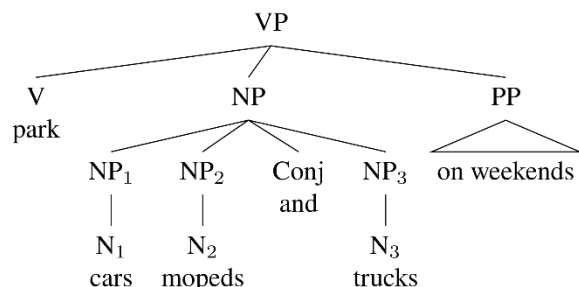
- (31) regattas [on weekends]
 hikes [before dawn]
 naps [for two hours]
 movies [in the autumn]

As such, these temporal elements can also appear pre-nominally with event nouns as in (32a) but not with objects like cars, mopeds, and trucks, as shown in (32b).

- (32) a. weekend regattas
 pre-dawn hikes
 two-hour naps
 autumn movies
- b. *weekend cars
 *pre-dawn mopeds
 *two-hour trucks
 *autumn cars, mopeds, and trucks

Given this, instead of either of the trees in (29), the correct tree for the law in (28) is (33).

(33)



This now changes how we should view Tobia et. al.’s claim that their subjects “strongly invoked” the Series Quantifier Canon and “strongly rejected” the Last Antecedent Rule. In fact, Tobia et. al.’s subjects had no choice in how to interpret the temporal PP [on weekends] in (28). The only possible interpretation is as a verb modifier, specifying when the parking can happen. This sentence, then, is not a true test of whether subjects prefer the Series Quantifier Canon over the Last Antecedent Rule. We now need to ask: what would a true test be? And how would subjects behave? We designed Experiment 3 in order to find out.

D. Experiment 3: Two kinds of PP: VP modifiers vs. NP modifiers

Experiment 3 compared how subjects interpreted two kinds of PP modifiers: VP modifiers like [on weekends] in (34a), which can modify the verb but not the nouns, and NP modifiers like [with permit stickers] in (34b), which **can** modify one or more nouns):

- (34) a. VP modifier: In parking area A, people may park cars, mopeds, and trucks
[on weekends].
b. NP modifier: In parking area A, people may park cars, mopeds, and trucks
[with permit stickers].

The (b) cases replicate the unbiased cases in Experiments 1 and 2, so this experiment again tests Hypothesis I, that there will be a preference for high-attachment, wide-scope readings for noun modifiers.

And for the (a) cases, given what we have said about VP modifiers, the preferred interpretation – because it is the *only* grammatical interpretation – is also wide-scope. Subjects should not even consider any structures in which a PP like [on weekends] is modifying an NP, so narrow-scope should not be an option. We formulate this as Hypothesis IV.

Hypothesis IV: For VP modifiers, the preferred PP reading is wide-scope (high attachment) over narrow-scope (low-attachment).

In other words, subjects should prefer a “wide-scope” high attachment reading for both the (a) and the (b) cases.

But now notice: though the ultimate choice for both is wide scope, we are claiming that there is a difference in how subjects arrive at this choice. The VP modifiers have only one attachment

option, the one shown in (33), but the NP modifiers are grammatical in either a high or a low position, as in trees (2) and (3). As such, whereas the interpretation of (34b) will be unambiguous, the NP cases will present subjects with an attachment choice. So it might take them longer to assign an interpretation to (34a) than (34b). We formulate this idea as Hypothesis V.

Hypothesis V: The decision-times should be shorter for the sentences with VP modifiers than for sentences with NP modifiers.

Before moving on, there is one more idea that Experiment 3 explored. Notice that (34) contains a string of three conjoined nouns, [cars, mopeds, and trucks], unlike two-conjunct series like [cars and trucks] in Experiments 1 and 2. We used three conjoined nouns here for two reasons. First, our goal was to replicate the Tobia et. al. study as closely as possible and Tobia et. al.'s example in (28) used three. Second, what if our high-attachment results were the result of having only two conjuncts? Would three conjuncts make a difference? To test this question, six of our 12 test sentences had three conjuncts, (e.g., *cars, mopeds, and trucks*) and six had just two (e.g., *cars and trucks*) as in Experiments 1 and 2. In fact, we don't think this will matter, and we state this as Hypothesis VI.

Hypothesis VI: The number of conjuncts in the NP modifier cases should not affect the wide-scope preference. The preference should be equally strong for NPs with two or three conjuncts.

To sum up, Experiment 3 tested four hypotheses:

Hypothesis I: For NP modifiers, the preferred PP reading is wide-scope (high attachment) over narrow-scope (low-attachment).

Hypothesis IV: For VP modifiers, the preferred PP reading is wide-scope (high attachment) over narrow-scope (low-attachment).

Hypothesis V: The decision-times should be shorter for the sentences with VP modifiers than for sentences with NP modifiers.

Hypothesis VI: The number of conjuncts in the NP-modifier cases should not affect the wide scope preference. The preference should be equally strong for NPs with two and three conjuncts.

Subjects

Subjects came from the same Lucid subject pool as our subjects in Experiments 1 and 2 (but none participated in more than one experiment). Out of a total of 132 subjects recruited, 75 were disqualified using the same criteria as in our first two experiments (incomplete responses or not following instructions), leaving a total pool of 57 who completed the survey.

Materials, Design and Procedure

As in Experiments 1 and 2, subjects saw a total of 24 sentences (12 test sentences and 12 distractor items), intermingled and presented in different randomized orders. Each subject saw the 12 test sentences in only one version, with either a VP modifier or an NP modifier. The test sentences were of four types, shown in (35) and (36). Half of each type (six sentences) had 3

conjuncts, as in (35), half (six sentences) had 2 conjuncts, as in (36). Following each test sentence was a multiple-choice question like (37), with the answers randomly ordered.

- (35) 3 conjuncts:
- a. VP modifier: In parking area A, people may park [**cars**], [**mopeds**], and [**trucks**] [**on weekends**].
 - b. NP modifier: In parking area A, people may park [**cars**], [**mopeds**], and [**trucks**] [**with permit stickers**].
- (36) 2 conjuncts:
- a. VP modifier: At the Golden Dragon, the waitresses set out [**fortune cookies**] and [**chopsticks**] [**before the restaurant opens**]
 - b. NP modifier: At the Golden Dragon, the waitresses set out [**fortune cookies**] and [**chopsticks**] [**in wrappers**].

Following each sentence was a multiple-choice question, with the answers randomly ordered. The 3-conjunct cases had 4 choices, as in (37). The 2-conjunct cases had 3 choices, as in (38).

- (37) Three conjuncts:
- a. VP: In parking area A, which vehicles may people park only on weekends?
A. cars B. mopeds C. trucks D. cars, mopeds, and trucks
E. none of the above
 - b. NP: In parking area A, which vehicles must have permit stickers?
A. cars B. mopeds C. trucks D. cars, mopeds, and trucks
E. none of the above

- (38) Two conjuncts
- a. VP: What do the waitresses set out before the restaurant opens?
A. the fortune cookies B. the chopsticks
C. the fortune cookies and the chopsticks E. none of the above
 - b. NP: What has wrappers?
A. the fortune cookies B. the chopsticks
C. the fortune cookies and the chopsticks E. none of the above

The PP modifiers for the VP and NP cases differed. The VP modifiers, such as [on weekends] in (35) and [before the restaurant opens] in (36), cannot be understood as modifying an NP. The NP modifiers, such as [with permit stickers] in (35) and [in wrappers] in (36) could not be understood as modifying a VP. As in Experiment 1 and 2, these PPs could be interpreted only on noun(s), with either wide or narrow scope.

The procedure was the same as in Experiments 1 and 2, and in addition, to test Hypothesis V, this experiment compared the times for subjects to process VP-modifier and NP-modifier sentences. The time was recorded for each participant from their first click – to display the question – to their last click, to move to the next question.

The complete list of test sentences and distractor items for Experiment 3 appear in Appendix 3.

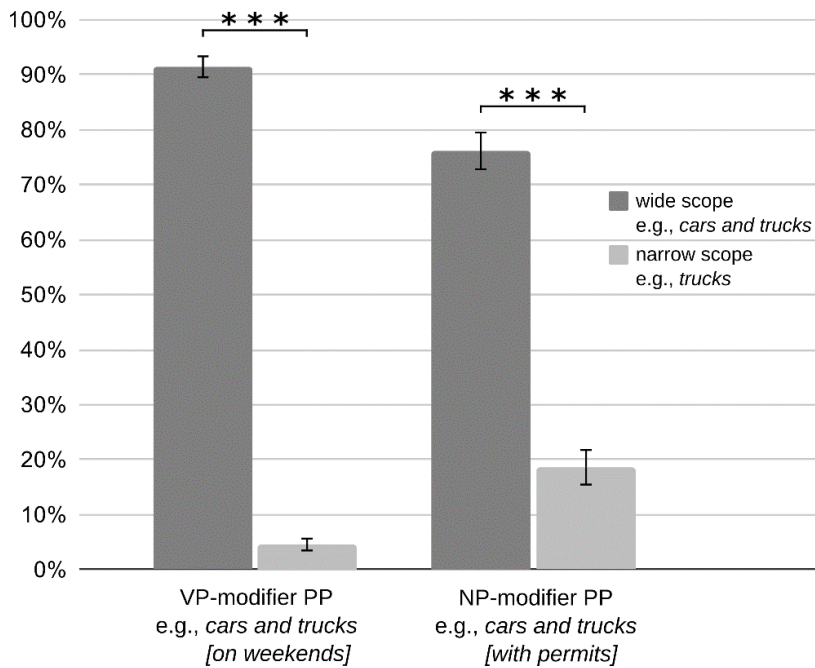
Results

The results confirmed all four hypotheses that this experiment tested. As Table 3 and Figure 4 show, just as in Experiments 1 and 2, sentences with NP modifiers strongly favored wide-scope over narrow-scope readings, 76.3% vs. 18.7%. A paired-samples t-test showed the difference to be highly significant ($t(56) = 9.10, p < .001$). This confirmed Hypothesis I once again: wide-scope readings are preferred for PP modifiers of nouns in a series. Hypothesis IV was also confirmed: sentences with VP modifiers were overwhelmingly interpreted with wide-scope rather than narrow-scope readings 91.5% vs 4.68%. A paired-samples t-test showed that the difference was highly significant difference ($t(56) = 31.48, p < .001$). (Note that the illegal “N1-only” readings are shown in Table 3, for completeness, but not in Figure 4.)

Table 3. Experiment 3: PP Attachment Rates

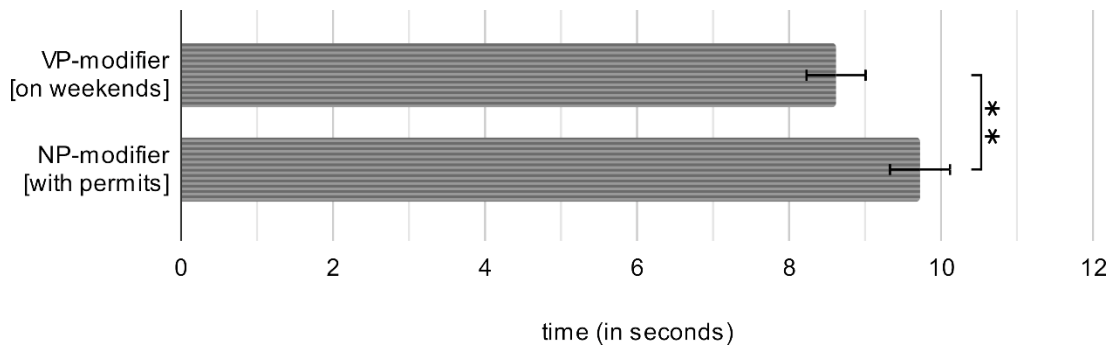
	Wide scope (N1 & N2)	Narrow scope (N2 only)	N1 only (Illegal)
NP	76.3%	18.7%	3.51%
VP	91.5%	4.68%	3.22%

Figure 4. Rates of wide- & narrow-scope interpretations for VP- & NP-modifier PPs



Hypothesis V was also confirmed, as Figure 5 shows. The mean decision time for sentences with VP modifiers, 8.62 seconds, was significantly less than for sentences with NP modifiers, 9.72 seconds, according to a paired-samples t-test ($t(56) = -3.44, p < .01$).

Figure 5. Mean Decision Times in Experiment 3.

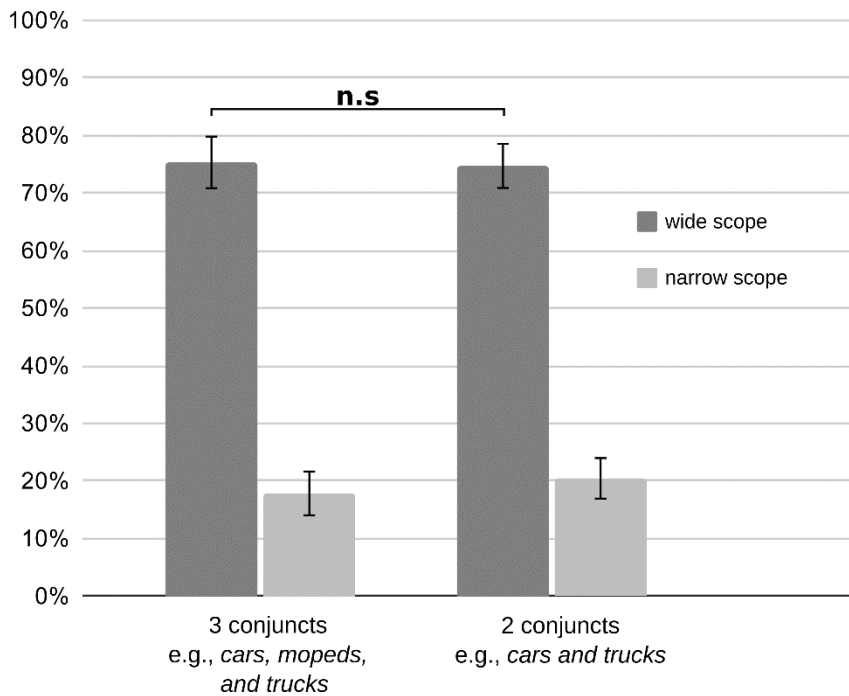


Finally, Hypothesis VI was also confirmed, as shown in Table 4 and Figure 6. Wide-scope readings were preferred for all sentences. A paired-samples t-test showed no significant difference between 3- and 2-conjunct versions: 75.4% vs. 75.0% ($t(56) = 0.10, p > .05$).

Table 4. Rates of wide- and narrow-scope interpretations for 3- and 2-conjunct sentences

	Wide scope	Narrow scope
3 conjuncts	75.4%	18.0%
2 conjuncts	75.0%	20.6%

Figure 6. Rates of wide- and narrow-scope interpretations for 3 and 2 conjuncts



IV. Overall Discussion & Conclusions

We started out with an ambiguous sign in a parking lot:

- (1) Only cars and trucks [with permits] are allowed

which led us to explore a number of legal cases where the courts have weighed in on just this sort of ambiguity. The question is: should the prepositional phrase be given a wide-scope reading, modifying all the nouns it follows – here, [[cars] and [trucks]] – or a narrow-scope reading, modifying only the last conjunct – here, [trucks]. The wide-scope and narrow-scope readings are at odds; each is supported by a different legal principle – the “Series Qualifier Canon” and the “Last Antecedent Rule” – and each has been used to justify majority or minority Supreme Court opinions. With judges at odds but claiming that they want to find “the way that people speak and listen, write and read,” we set out to help them do so.

Our first two experiments investigated how people interpret ambiguous prepositional phrase modifiers after a series of parallel nouns (the situation in *Lockhart*) and found that in the default case, these phrases are overwhelmingly given wide scope. However, when there is a semantic bias between the modifier and the last noun, while the preference is still overwhelmingly wide-scope, it is significantly weaker than the preference in the unbiased cases. The wide-scope preference become even more robust where the semantic bias is toward a noun in a syntactically unavailable position. Here, though a semantic connection exists from the modifier to the first noun, it is ignored. Semantics must operate within the formal constraints dictated by syntax. Our third experiment followed up on a study by Tobia, et. al., and examined how people interpret PP modifiers that follow a series of nouns but modify the verb. There, a wide-scope reading was also overwhelmingly favored, but not for the same reason as for the noun modifiers, which is what Tobia et. al. incorrectly assumed these were. Our subjects recognized the difference: they took a significantly shorter time to choose their answers for the verb-modifier cases than for noun-modifier cases, showing that they detected only one interpretation for PPs that unambiguously modified the verb.

Are we saying that ALL modification is interpreted with a wide-scope default? No. Recall *Judge*, where the boldface participle in the phrase [*Conviction of a felony or of any crime involving moral turpitude*] might have been claimed to have two potential readings, a wide-scope reading on [conviction] and a narrow scope reading on [crime]. We argued for the narrow-scope reading, because giving the phrase a wide-scope reading means that it modifies [conviction], which makes no sense given the logic of the situation and the syntax. Unfortunately, the judges did not consider those factors, which are as critical as any when trying to figure out “the way that people speak and listen, write and read.”

There are other kinds of ambiguities to consider, many of which have been discussed in the legal literature. Goldfarb (2012) and Solan (1993) both discuss pre-modification, as in phrases like [**forcibly** assault, resist, or impede]. Does [forcibly] apply with wide-scope, to all of the verbs, or only narrowly, to [assault]? Such ambiguous pre-modifying adverbs have been at issue in a number of cases. One is *Liparota v. United States* (1985): “*whoever knowingly uses, transfers, acquires, alters, or possesses coupons or authorization cards in any manner not authorized by [the statute] or the regulations.*” Another is *Ratzlaf v. United States* (1994): “*[a] person willfully violating the anti-structuring provision, which forbids structuring transactions with a purpose of evading the reporting requirements of section 5313(a).*” This kind of ambiguity, and others, deserve empirical psycholinguistic attention in future studies.

For now, what can we conclude about legal language? Trivially, in sentence (1), both trucks **and** cars need permits. But more importantly, given the potential for confusion that ambiguous language poses, not only parking lot signs like (1), but statutes, jury instructions, contracts – all legal documents – should be worded to avoid misunderstandings. Judges aim to interpret ambiguous legal language in the “most natural way.” With our studies, we hope to add psycholinguistic tools to establish what that is and improve how justice is done.

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Appendices

Appendix 1: Experiment 1 Test Sentences

1.
 - a. Athletes and photographers with their gear waited by the van.
Q: Who had their gear?
 - b. Athletes and photographers with their cameras waited by the van.
Q: Who had their cameras?
2.
 - a. Dancers and musicians with nervous faces bustled around the backstage area.
Q: Who had nervous faces?
 - b. Dancers and musicians with instruments bustled around the backstage area.
Q: Who had instruments?
3.
 - a. Books and magazines with bright covers lay on the coffee table.
Q: What had bright covers?
 - b. Books and magazines with pictures of movie stars lay on the coffee table.
Q: What had pictures of movie stars?
4.
 - a. Pies and cakes with gluten-free flour are on display in the bakery window.
Q: What had gluten-free flour?
 - b. Pies and cakes with birthday candles are on display in the bakery window.
Q: What had birthday candles?
5.
 - a. Horror movies and comedies with cheesy dialogue are fun to watch with friends.
Q: What had cheesy dialogue?
 - b. Horror movies and comedies with good jokes are fun to watch with friends.
Q: What had good jokes?
6.
 - a. Plates and cups with brown residue sat in the sink.
Q: What had brown residue?
 - b. Plates and cups with coffee residue sat in the sink.
Q: What had coffee residue?
7.
 - a. Deserts and forests with well-marked trails are the best for hiking.
Q: What has well-marked trails?
 - b. Deserts and forests with rivers running through them are the best for hiking.
Q: What has rivers running through them?
8.
 - a. Coffee and tea with sugar are Harrison's favorite drinks in the morning.
Q: What does Harrison like to drink with sugar?
 - b. Coffee and tea with lemon are Harrison's favorite drinks in the morning.

- Q: What does Harrison like to drink with lemon?
9. a. Tee-shirts and sweatshirts without logos are acceptable at work.
Q: What is acceptable at work, only if it has no logo?
 - b. Tee-shirts and sweatshirts without hoods are acceptable at work.
Q: What is acceptable at work, only if it has no hood?
 10. a. Cats and dogs with matted fur filled the groomer's waiting room.
Q: Which pets had matted fur?
 - b. Cats and dogs on leashes filled the groomer's waiting room.
Q: Which pets were on leashes?
 11. a. Customers and waiters with loud voices filled the crowded diner.
Q: Who had loud voices?
 - b. Customers and waiters in uniforms filled the crowded diner.
Q: Who was wearing a uniform?
 12. a. Schools and apartments near public transportation attract families to this city.
Q: What is near public transportation?
 - b. Schools and apartments with affordable rates attract families to this city.
Q: What has affordable rates?

Appendix 2: Experiment 2 Test Sentences

1. a. Photographers and athletes with their gear waited by the van.
Q: Who had their gear?
- b. Photographers and athletes with their cameras waited by the van.
Q: Who had their cameras?
2. a. Musicians and dancers with nervous faces bustled around the backstage area.
Q: Who had nervous faces?
- b. Musicians and dancers with instruments bustled around the backstage area.
Q: Who had instruments?
3. a. Magazines and books with bright covers lay on the coffee table.
Q: What had bright covers?
- b. Magazines and books with pictures of movie stars lay on the coffee table.
Q: What had pictures of movie stars?
4. a. Cakes and pies with gluten-free flour are on display in the bakery window.
Q: What had gluten-free flour?
- b. Cakes and pies with birthday candles are on display in the bakery window.
Q: What had birthday candles?
5. a. Comedies and horror movies with cheesy dialogue are fun to watch with friends.
Q: What had cheesy dialogue?
- b. Comedies and horror movies with good jokes are fun to watch with friends.
Q: What had good jokes?
6. a. Cups and plates with brown residue sat in the sink.
Q: What had brown residue?
- b. Cups and plates with coffee residue sat in the sink.
Q: What had coffee residue?
7. a. Forests and deserts with well-marked trails are the best for hiking.
Q: What has well-marked trails?

- b. Forests and deserts with rivers running through them are the best for hiking.
Q: What has rivers running through them?
- 8. a. Tea and coffee with sugar are Harrison's favorite drinks in the morning.
Q: What does Harrison like to drink with sugar?
- b. Tea and coffee with lemon are Harrison's favorite drinks in the morning.
Q: What does Harrison like to drink with lemon?
- 9. a. Sweatshirts and tee-shirts without logos are acceptable at work.
Q: What is acceptable at work, only if it has no logo?
- b. Sweatshirts and tee-shirts without hoods are acceptable at work.
Q: What is acceptable at work, only if it has no hood?
- 10. a. Dogs and cats with matted fur filled the groomer's waiting room.
Q: Which pets had matted fur?
- b. Dogs and cats on leashes filled the groomer's waiting room.
Q: Which pets were on leashes?
- 11. a. Waiters and customers with loud voices filled the crowded diner.
Q: Who had loud voices?
- b. Waiters and customers in uniforms filled the crowded diner.
Q: Who was wearing a uniform?
- 12. a. Apartments and schools near public transportation attract families to this city.
Q: What is near public transportation?
- b. Apartments and schools with affordable rates attract families to this city.
Q: What has affordable rates?

Appendix 3: Experiment 3 Test Sentences

- 1. a. In parking area A, people may park cars, mopeds, and trucks on weekends.
Q: In parking area A, which vehicles may people park only on weekends?
- b. In parking area A, people may park cars, mopeds, and trucks with permit stickers.
Q: In parking area A, which vehicles must have permit stickers?
- 2. a. When she goes to the archive, my history professor likes to look at prints, maps, and manuscripts for hours.
Q: What does the history professor like to look at for hours?
- b. When she goes to the archive, my history professor likes to look at prints, maps, and manuscripts with ornate lettering.
Q: What has ornate lettering?
- 3. a. On work days, Joe likes to eat sandwiches, wraps, and salads at lunchtime.
Q: What does Joe like to eat at lunchtime?
- b. On work days, Joe likes to eat sandwiches, wraps, and salads with bacon.
Q: What does Joe like to eat with bacon?
- 4. a. In this town, residents may recycle glass, plastic, and cardboard in their blue bins.
Q: What can residents recycle in their blue bins?
- b. In this town, residents may recycle glass, plastic, and cardboard without food residue.
Q: What cannot have food residue?
- 5. a. At the Golden Dragon, the waitresses set out fortune cookies and chopsticks before the restaurant opens.
Q: What do the waitresses set out before the restaurant opens?

- b. At the Golden Dragon, the waitresses set out fortune cookies and chopsticks in wrappers.
Q: What is in wrappers?
6. a. Before the cabaret show, the TV reporter interviewed singers and dancers about the music.
Q: Who did the TV reporter interview about the music?
b. Before the cabaret show, the TV reporter interviewed singers and dancers in colorful costumes.
Q: Who was in colorful costumes?
7. a. In its patio department, the furniture store will be discounting chairs and couches at its Labor Day sale.
Q: What will the furniture store be discounting at its Labor Day sale?
b. In its patio department, the furniture store will be discounting chairs and couches with extra cushions.
Q: What has extra cushions?
8. a. Kyle likes to watch sitcoms and funny movies at night.
Q: What does Kyle like to watch late at night?
b. Kyle likes to watch sitcoms and funny movies from the 1950s.
Q: What is from the 1950s?
9. a. The TV channel often shoots interviews and documentaries in remote locations.
Q: What does the TV channel often shoot in remote locations?
b. The TV channel often shoots interviews and documentaries about natural disasters.
Q: What is about natural disasters?
10. a. The cancer research lab uses monkeys and mice on Tuesdays.
Q: What does the lab use on Tuesdays?
b. The cancer research lab uses monkeys and mice with genetic defects.
Q: What has genetic defects?
11. a. The museum will show ceramics, sculptures, and photographs in April.
Q: What will the museum show in April?
b. The museum will show ceramics, sculptures, and photographs by a new artist.
Q: Which pieces are by a new artist?
12. a. In some cities, it is illegal to ride skateboards, scooters, and bikes through tunnels.
Q: In some cities, which of these is it illegal to ride through tunnels?
b. In some cities, it is illegal to ride skateboards, scooters, and bikes with motors.
Q: In some cities, which of these must not use motors?

Appendix 4: Distractor Sentences (same across all experiments)

1. While Grandma was knitting the sweater the yarn fell off her lap.
Q: What was Grandma knitting?
2. Before the king rides his horse his boots are always polished.
Q: What does the king ride?
3. When Susie was dancing the tango her partner tripped.
Q: What was Susie dancing?
4. When Tom was driving his brand-new car the tire went flat.
Q: What was Tom driving?

5. When Alex bakes bread the kitchen smells delicious.
Q: What does Alex bake?
6. When Jamie walks his dog the leash gets tangled.
Q: What does Jamie walk?
7. While Mary was dusting the clock started to chime.
Q: What was Mary dusting?
8. Whenever the chef cooks dinner is delicious.
Q: What does the chef cook?
9. After we drank the water was found to be contaminated.
Q: What did we drink?
10. Since Jay always runs a mile seems like a very short distance to him.
Q: How far does Jay run?
11. When Kim cleans the car looks spotless.
Q: What does Kim clean?
12. Because Helen reads novels make great gifts for her.
Q: What does Helen read?