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Syntactic Priming without Lexical Overlap in Reading Comprehension

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Abstract

Syntactic priming without lexical overlap is well-documented in language production. In contrast, reading-time comprehension studies, which typically use locally ambiguous sentences, generally find syntactic priming only with lexical overlap. This asymmetry has led some researchers to propose that distinct mechanisms underlie the comprehension and production of syntactic structure. Instead, we propose that methodological differences in how priming is assessed are largely responsible for the asymmetry: in comprehension, lexical biases in a locally ambiguous target sentence may overwhelm the influence of syntactic priming effects on a reader's interpretation. We addressed these issues in a self-paced reading study by (1) using target sentences containing global attachment ambiguities, (2) examining a syntactic structure which does not involve an argument of the verb, and (3) factoring out the unavoidable lexical biases associated with the target sentences in a mixed-effects regression model. Under these conditions, syntactic priming affected how ambiguous sentences were parsed, and facilitated reading times when target sentences were parsed using the primed structure. This resolves discrepancies among previous findings, and suggests that the same mechanism underlies syntactic priming in comprehension and production.

Keywords

Syntactic priming, sentence comprehension, reading, attachment ambiguity

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1 Introduction

After processing a sentence, a speaker becomes more likely to produce another sentence with the same structure. For example, using the double-object construction as in 'The boy showed the teacher the drawing' makes a speaker more to subsequently use the double-object construction again (as in 'The babysitter threw the kids the ball') instead of the prepositional-object alternative ('The babysitter threw the ball to the kids'). This phenomenon is known as *syntactic priming*. Since the classic demonstrations of syntactic priming in language production (e.g. Bock, 1986), numerous production studies have shown robust priming effects on syntactic choice using a variety of structures (see Pickering & Ferreira, 2008 for review). Priming occurs without lexical overlap between prime and target sentences, indicating that *syntactic*, rather than lexical, representations are being primed (Bock & Griffin, 2000; Bock & Loebell, 1990).

In contrast to language production, evidence for syntactic priming without lexical overlap in language *comprehension* has been more elusive, especially in reading comprehension studies (e.g. Arai, van Gompel, & Scheepers, 2007; Branigan, Pickering, & McLean, 2005; Pickering & Traxler, 2008; Tooley, Traxler, & Swaab, 2009; see Tooley & Traxler, 2010 for review). Such studies typically measure the effects of reading an unambiguous prime on the subsequent comprehension of sentences with local syntactic ambiguities. Typically, unambiguous primes facilitate reading times only when the target contains the same verb (Traxler & Tooley, 2008). This absence of priming effects without lexical overlap is surprising, because reading times show sensitivity to frequencies of distributional patterns (Fine & Jaeger, 2011; Wells, Christiansen, Race, & MacDonald, 2009), which should reflect experience with recent structures.

Discrepancies between production and comprehension studies have prompted suggestions that producing syntactic structures involves different representations or mechanisms than parsing sentences (e.g. Ledoux, Traxler, & Swaab, 2007). However, several types of results are inconsistent with such a hypothesis. First, the effect of syntactic priming on language production does not appear to be dependent on whether the prime is heard or spoken. If a person comprehends a primed structure, this affects subsequent language production just as much as if the person produced the primed structure. Many experiments have tested strength of syntactic priming on language production using a methodology where the primes are heard or read followed by a spoken or written response from the participant. Priming effects appear just as consistently in studies where primes are heard by the participant (e.g. Levelt & Kelter, 1982) as they do in studies where primes are read aloud by participants (e.g. Bock, 1986; Hartsuiker & Kolk, 1998).

Second, although studies of syntactic priming in dialogue measure the effect of priming on language production, the prime is almost always comprehended by a listener who on the next turn becomes the speaker (e.g. Branigan, Pickering, & Cleland, 2000; Branigan, Pickering, McLean, & Cleland, 2007; Hartsuiker, Bernolet, Schoonbaert, Speybroeck, & Vanderelst, 2008). Research showing robust syntactic priming effects in dialogue shows robust effects of comprehended syntactic structures on subsequently spoken structures, that is, priming from comprehension to production. The fact that such effects are often cited as stronger or bigger than syntactic priming outside of dialogue is inconsistent with the idea of different syntactic representations or structure building mechanisms for production and comprehension.

Finally, a number of recent studies have found that syntactic priming *does* influence comprehension, at least under certain conditions (e.g. Thothathiri & Snedeker, 2008; Traxler 2008). Tooley and Bock (2011) have suggested that the magnitudes of priming effects in comprehension and production tasks are comparable. Taken together, these three types of findings suggest that different mechanisms between comprehension and production—if different mechanisms exist at all—cannot account for the lack of priming observed in most reading time studies. This raises the question: what is the difference between studies that provide evidence for syntactic priming in sentence comprehension in some cases, and those that show a sharp asymmetry between comprehension and production in others?

We propose that methodological differences between reading-time and production studies could result in structural priming effects being masked in some reading-time studies. Priming in production is measured by a speaker's choice between two syntactic alternatives for expressing the same message content, which is typically determined by a depicted scene. Since the alternatives have identical message content, words, and thematic relationships between the verb and its arguments, the speaker can freely use either structure. For example, many such production studies use the dative alternation (e.g. Bock, 1986). After producing a double object or a prepositional dative structure, participants subsequently produce a description of a picture compatible with either of these structures. Because neither alternative requires the speaker to revise the content of the message expressed, even small increases in structural availability should produce priming effects.

Indeed, syntactic priming in production has been observed across a range of constructions and paradigms: dative alternation with picture description (Bock, 1989; Bock & Loebell, 1990) and sentence completion (Branigan et al., 2000; Branigan, Pickering, McLean, & Stewart, 2006; Pickering & Branigan, 1998; Pickering, Branigan, & McLean, 2002); passive alternation with picture description (Bock, 1986; Bock & Griffin, 2000; Bock & Loebell, 1990); verb-particle alternation with Rapid Serial Visual Presentation (Konopka & Bock, 2009); complementizer omission with sentence recall (Ferreira, 2003); and relative clause attachment in German with sentence completion (Scheepers, 2003). In each of these cases, the alternatives have equivalent message content, lexical items, and grammatical relations among the lexical items.

In contrast, reading-time studies have examined whether syntactic priming reduces the processing difficulty associated with a temporarily ambiguous sentence. Crucially, structural priming is said to have occurred when prior processing of an unambiguous sentence facilitates subsequent processing of a syntactically analogous, temporarily ambiguous sentence. An important consequence of using temporary ambiguities is that the relevant alternatives differ in ways other than syntactic structure.

Many comprehension studies investigating syntactic priming have used the main verb/reduced relative ambiguity, which is highly sensitive to lexically-based constraints, which often override structural biases (MacDonald, Pearlmutter, & Seidenberg, 1994; Tanenhaus & Trueswell, 1995). For example, the sentence 'The defendant examined by the lawyer was unreliable' (from Pickering & Traxler, 2004) is temporarily ambiguous between a structure where 'examined' introduces a reduced relative clause ('The defendant who was examined by the lawyer was unreliable') and one where 'examined' is the main verb ('The defendant examined the document'). The two temporarily viable parses differ in message content, and relatedly, lexical content and the thematic relations among the verb and its arguments (e.g. 'the defendant' is either the agent or the patient of 'examine'). As a result, syntactic priming in comprehension studies is observable only if it overcomes a number of other biases (for discussion see Hare, Tanenhaus, & McRae, 2007; MacDonald et al., 1994; McRae, Spivey-Knowlton, & Tanenhaus, 1998; Tanenhaus & Trueswell, 1995; Trueswell, 1996). In the sentence given above, at the subject argument, lexical biases (reflecting the frequency with which 'the defendant' occurs as an agent versus as a patient) and prior structural biases (frequency with which a subject argument occurs as an agent/active voice versus as a patient/passive voice) already influence how 'examined' is likely to be interpreted. At 'examined,' additional sources of bias come into play, including verb form bias (frequency with which 'examined' occurs as a past tense main verb versus as a passive participle), and the thematic fit of 'the defendant' as agent or patient of 'examined,' given a main verb or reduced relative clause analysis. If lexical and (preexisting) structural biases favor a main verb analysis, a structural prime representing the relative clause analysis would have to overturn the combined effects of the other biasing factors. Because the alternative analyses differ in the thematic mappings between the verb and its arguments, this requires that the comprehender reanalyze her interpretation of the input in a way that does not arise in a typical production study. In such circumstances, the effect of the prime may not be detectable, even though it is having the expected effect.

Since most of the structural differences are conditioned on the verb, it is perhaps not surprising that syntactic priming effects emerge in reading comprehension only when repeating the verb minimizes factors other than structural bias. For example, Tooley et al. (2009) report syntactic priming in comprehension for prime–target pairs with the same verb ('The man watched by the woman…' and 'The child watched by the parent…'), but not with different synonymous verbs (e.g. watched versus observed).

Traxler (2008) does show reading-time facilitation without lexical overlap, for sentences where a prepositional phrase (PP) was temporarily ambiguous between a goal argument ('The vendor tossed the peanuts in(to) the box') and a modifier ('The vendor tossed the peanuts (that were) in the box into the crowd'), when preceded by a prime with the same structural analysis for the PP ('The dentist poured the fluid in the beaker into the flask'). With respect to the lexical and structural biases discussed above, these sentences are more comparable to the alternations typical of production studies. Like with the dative alternation, both alternatives have the same syntactic analysis for the subject and main verb, and the only difference is in the order and thematic fit of post-verbal dependencies. Thus, unlike materials from other reading comprehension studies, Traxler's sentences do not require reanalysis of the structure up to and including the main verb.

The current reading comprehension study examines whether priming without lexical overlap emerges under conditions that approximate those used to evaluate priming in production. We used the self-paced reading task because it is arguably as sensitive to reading times as other methods, and the additional information about regressions that eye-tracking would provide was not needed to test our hypothesis. An additional benefit is that self-paced reading has been by far the most frequently used methodology for studies of syntactic priming in language comprehension that show small or no effects. This allows us to more directly compare our results with the most relevant past studies, and draw stronger conclusions about the differences between our results and the results of past work.

Three design features allow us to examine syntactic priming in a way that is more comparable to production studies as well as previous comprehension studies finding little or no effect. First, we use globally ambiguous target sentences to examine how priming affects the structure 'chosen' by the reader. Second, our target sentences use adjunct PPs which are not arguments of the verb (see Figure 1), and thus are somewhat less dependent on verb-based constraints. Third, we factor out remaining item-specific biases using a mixed-effects regression model, allowing us to examine syntactic priming effects when they are not masked by the stronger influence of lexical information. As noted above, using the same verb from prime to target minimizes the influence of lexical biases that are conditioned on the verb. Our methodology can be seen as doing the same thing, but without requiring verb repetition. Our results are consistent with the idea that syntactic priming in reading, while difficult to observe when pitted against lexical constraints, clearly emerges once these constraints are factored out of the analysis.

We used sentences where a sentence-final PP was ambiguously attached (see Figure 1). The PP 'with the crack' can either attach high, modifying 'mirror,' or low, modifying 'wall.' As shown in Table 1, participants answered a comprehension question after reading each sentence. The answers revealed whether the sentence was parsed with low or high attachment.

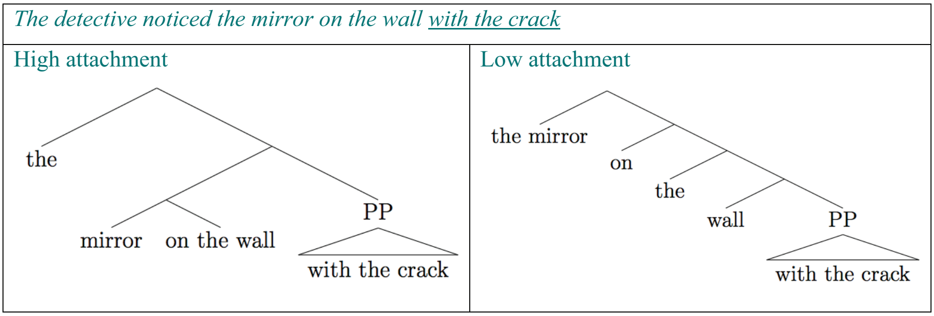

Figure 1. Example sentence with global attachment ambiguity with syntactic structures (ambiguously-attached PP underlined).

Table 1. Example items. Participants read either a high- or low-attachment prime, followed by an ambiguous target sentence.

	High-attachment prime	Low-attachment prime
Prime sentence	The gardener watered the tree with the bird's nest with tangled roots.	The party took place at the house in the alley with the potholes.
Target sentence	The FBI agent noticed the mirror on the wall with the crack.	
Question	What had a crack? (a) the wall (b) the mirror	

As in production studies, an unambiguous prime preceded each ambiguous target (see Table 1). We expected that participants would be more likely to select a parse for the target that was compatible with the prime structure, indicating a syntactic priming effect. This measure is analogous to how typical production studies involving picture description or sentence recall assess syntactic priming. Further, we predict that processing will be faster when participants choose the interpretation of a target that is congruent with the prime, compared with the prime-incongruent interpretation. Finally, perceptual learning-based accounts of priming (Chang, Dell, & Bock, 2006; Chang, Dell, Bock, & Griffin, 2000) predict that the magnitude of priming due to a structural analysis will be inversely related to the frequency of that structure. The current studies present the same number of unambiguous high- and low-attachment structures, which differs from the distribution of these structures in English, where low attachment is more frequent than high attachment. Learning accounts therefore predict that as participants get increasing exposure to the new distribution of structures within the experiment, there should be a corresponding change in the relative effectiveness of high- and low-attachment primes.

We evaluated these predictions using mixed-effects regression models, with item bias (determined by norming), trial number, and prime type as fixed factors.

2 Method

2.1 Participants

Twenty-seven University of Rochester undergraduates, who were native English speakers, were paid to participate.

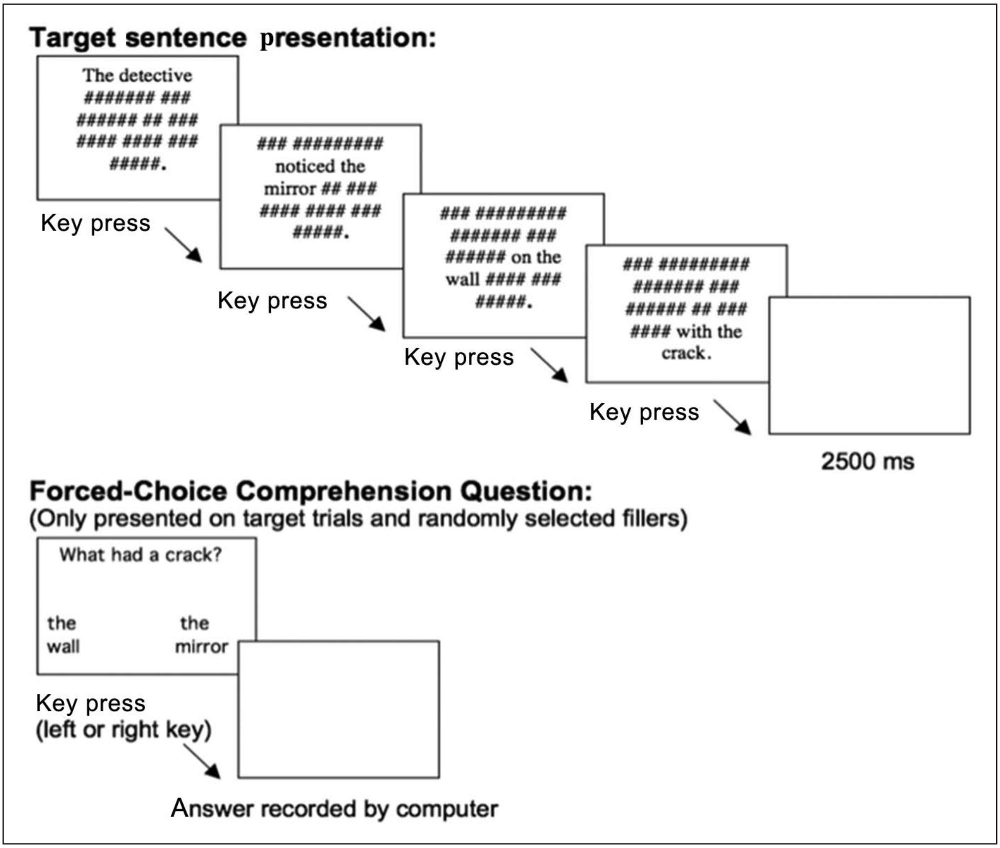

Figure 2. Experimental procedure. Presentation of the target sentence preceded the comprehension question—the answer to which reflected how the target sentence had been parsed.

2.2 Materials and procedure

We constructed 32 sentences containing ambiguously-attached PPs (see Appendix 1). Sixteen were semantically disambiguated primes (half high-attachment, half low-attachment primes). Another 16 sentences were targets, which contained the same ambiguity, but were plausible on either attachment. Eight pseudo-randomized lists with different prime–target pairings were created. The 16 prime–target sequences were interspersed among 80 unrelated length-matched fillers, half of which were followed by comprehension questions. This contingency matching ruled out the possibility that participants might learn during the experiment that only target sentences were followed by questions, or that questions focused on potential attachment ambiguities. Note that when a question appeared, it was presented *after* the sentence was no longer displayed on the screen (Figure 2). This procedure, along with the distribution of fillers and question types, prevented the questions from affecting reading strategies.

Participants read sentences phrase-by-phrase on a computer. Each ambiguous target was preceded by a semantically-disambiguated prime. Targets were followed by a two-alternative forced-choice question, constructed to determine how participants parsed the target. Table 1 shows example stimuli.[1]

Table 2. Summary of fixed effects for the mixed-effects logit regression model predicting response type.[a]

Model: LowAttachResponse ~ 1 + ItemBias + LowAttachPrime + Trial + ItemBias:LowAttachPrime + ItemBias:Trial + LowAttachPrime:Trial + ItemBias:LowAttachPrime:Trial + (1|Subject) + (1|Item)

Predictor	Coefficient	SE	Z	p
Intercept	–0.11	0.26	–0.41	NS
Item Bias	–0.31	0.048	–6.4	< 0.001
Low Attach Prime	0.13	0.065	1.9	0.05
Trial	0.022	0.012	1.9	< 0.1
Item Bias:Low Attach Prime	–0.038	0.022	–1.7	< 0.1
Item Bias:Trial	–0.0048	0.0039	–1.2	NS
Low Attach Prime:Trial	0.0064	0.012	0.55	NS
Item Bias:Low Attach Prime:Trial	–0.015	0.0040	–3.8	< 0.001

[a]Item Bias was based on the norming study. Both Item Bias and Trial were centered.

3 Results and discussion

We report data from responses and from response-contingent reading times. We compared reading times from targets parsed using a prime-congruent structure to those parsed with a prime-incongruent structure, as indicated by question responses.

3.1 Responses

A norming study with 15 separate participants determined the baseline rate of high-attachment parses for each target, when presented without a prime (see Appendix 2). *Item Bias* was defined as the number of norming study participants who parsed the item with a high-attachment structure. Item bias was included as a factor in the mixed-effects model predicting responses in the main experiment.

The model predicted responses (low or high parse) from several independent variables: item bias (from norming); prime type (low or high attachment); and trial number. We centered both continuous predictors (item bias and trial number), and contrast-coded the categorical predictor (prime type), to minimize the sensitivity of the model to scale mismatches and make the model coefficients more easily interpretable with respect to each other (Baayen, 2008). We included Participant and Item as random effects.[2] Table 2 shows the model coefficient estimates.

As expected, Item Bias primarily determined how items were parsed ($p < 0.001$). There was, however, a smaller effect of Prime Type: Low-Attachment responses were more likely to follow low-attachment primes ($p = 0.05$). Thus, when variance due to item bias is factored out, we do indeed find evidence for syntactic priming. As shown in Table 3, when Item Bias is not included as a predictor of response, the effect of Prime Type is no longer reliable.

One influential explanation for syntactic priming treats priming as a form of perceptual learning/adaptation (Chang et al., 2000, 2006; Fine & Jaeger, 2011, in press; Haskell, Thornton, & MacDonald, 2010; Wells et al., 2009). On this view, structural biases reflect the higher frequency of the preferred alternative, in this case low attachment, which occurs more frequently in English. A learning-based account predicts that priming should be stronger for less-frequent structures than for more-frequent structures—a prediction that has been confirmed in production studies

Table 3. Summary of fixed effects for the mixed-effects logit regression model predicting response type (Item Bias excluded).

Model: LowAttachResponse ~ 1 + LowAttachPrime + Trial + LowAttachPrime:Trial + (1|Subject) + (1|Item)

Predictor	Coefficient	SE	Z	p
Intercept	–0.15	0.36	–0.41	NS
Low Attach Prime	0.11	0.065	1.7	0.10
Trial	0.013	0.011	1.2	NS
Low Attach Prime:Trial	0.00050	0.011	0.45	NS

(e.g. Ferreira, 2003; Hartsuiker & Kolk, 1998; Scheepers, 2003). Since the current studies present the same number of unambiguous high- and low-attachment structures, the magnitude of priming for the more frequent structure should increase relative to the less frequent structure as participants are exposed to an oversampling of high-attachment sentences. Once we take into account the fact that the lexical biases in our materials were stronger for the high-attachment biased items, then the perceptual learning hypothesis predicts that as the experiment progresses, low-attachment primes will have an increasing effect on low-attachment biased items, as the structural bias in favor of low attachment weakens. By contrast, the fact that the high-attachment biased items were more strongly biased in our materials predicts that they will be more resistant to priming at any point during the experiment.

These predictions were borne out in a three-way interaction of Item Bias, Prime Type, and Trial ($p < 0.001$). As the experiment progressed, the effect of the immediately preceding prime became stronger for low-attachment biased items compared with high-attachment biased items, which had stronger item-specific constraints. In addition, as the experiment unfolded, low-attachment primes had a stronger effect on low-attachment biased items. Finally, the high-attachment targets were unaffected by priming, and this did not change over the course of the experiment, accounting for the three-way interaction. Figure 3 shows the interaction of Item Bias and Prime Type by Trial halves.

3.2 Reading times

Having demonstrated that priming affects choice of structure in comprehension, we can evaluate our predictions about reading times. For target sentences parsed with the primed structure, reading times should be faster than reading times for sentences parsed with the structure that was incongruent with the prime. The parse of each sentence was determined by the question that occurred after the target sentence, and all reading time analysis was contingent on the interpretation indicated by the participant.

Analyses were performed on residual reading times, calculated by subtracting a subject's predicted reading time (from a regression of reading time on phrase length) from the observed reading time (Ferreira & Clifton, 1986; Trueswell, Tanenhaus, & Garnsey, 1994). Residual reading times were trimmed at two standard deviations from the mean.

Table 4 summarizes the estimated fixed effects. Because participants in self-paced reading studies generally read faster across an experimental session due to practice with the task (Fine, Qian, Jaeger, & Jacobs, 2010; Hofmeister, 2011), we anticipated that a fixed effect of trial number would primarily reflect practice-related changes in reading times. Therefore, we chose to include trial number as a random effect in the model, along with Participant.

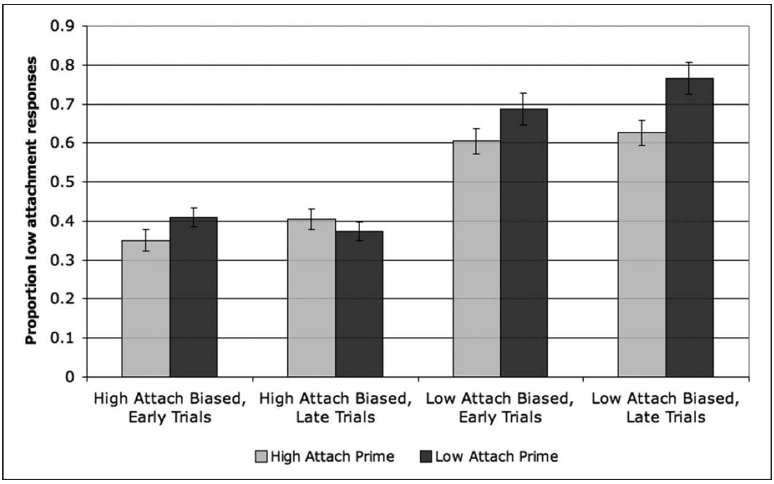

Figure 3. Proportion of Low-Attachment responses, by *Item Bias, Prime Type*, and *Trial half* (error bars represent standard error). *Item Bias*: attachment bias of item (number of times the item received a high-attachment response in the norming study); *Low/High Attach Prime*: prepositional phrase attachment site in prime sentence; *Early Trials*: first half of trials; *Late Trials*: second half of trials.

Table 4. Summary of fixed effects on residual reading times, linear mixed-effects model.

Model: RESIDUAL READING TIME ~ 1 + PrimeCongruence + LowAttachPrime + ItemBias + PrimeCongruence:LowAttachPrime + PrimeCongruence:ItemBias + LowAttachPrime:ItemBias + PrimeCongruence:LowAttachPrime:ItemBias + (1|Subject) + (1|Trial)

Predictor	Coefficient	SE	*t*	*p*
Intercept	–115.55	81.32	–1.42	NS
Prime Congruence	–75.05	36.97	2.03	< 0.05
Low Attach Prime	–104.90	37.38	–2.81	< 0.01
Item Bias	18.64	11.42	1.63	NS
Prime Congruence:Low Attach Prime	83.98	39.14	2.15	< 0.05
Prime Congruence:Item Bias	–12.37	11.41	–1.08	NS
Low Attach Prime:Item Bias	–7.45	11.95	–0.62	NS
Prime Congruence:Low Attach Prime:Item Bias	1.42	11.67	0.13	NS.

As expected, there was a main effect of Prime–Target congruence ($p < 0.05$): prime-congruent parsing facilitated reading times for the ambiguously-attached phrase. A main effect of Prime Type revealed that the ambiguously-attached phrase was read more quickly after low-attachment than after high-attachment primes ($p < 0.01$). The Prime Type by Prime-Target congruence interaction was significant ($p < 0.05$): prime-congruence resulted in a larger decrease in reading times with high-attachment than for low-attachment primes, indicating that the less-preferred structure was more effective as a prime (Figure 4).

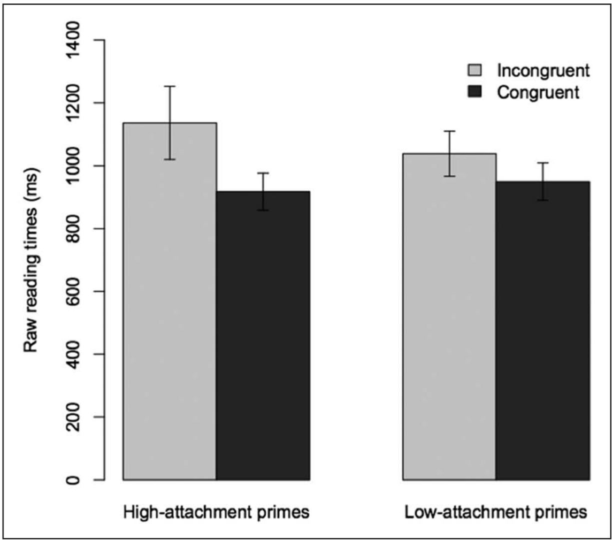

Figure 4. Mean reading times for the ambiguously-attached prepositional phrase of the target sentence: Prime Type by Prime–Target congruence interaction.

4 Conclusions

We hypothesized that previous reading-time studies using temporary ambiguities failed to find syntactic priming without lexical overlap because they pitted the relatively weak structural bias of the prime against stronger lexical constraints. In the current study, we found syntactic priming for sentences with PP-attachment ambiguities—readers were more likely to re-use the primed structure than the alternative when parsing an ambiguous target sentence—but only when item-related biases (i.e. biases related to the combination of lexical items occurring in an experimental item) were taken into account. Additionally, we observed reading time facilitation when participants parsed target sentences using the prime structure. This demonstrates that priming can be observed in reading-time studies with carefully constructed stimuli and an experimental paradigm that more closely mirrors production studies. Our results differ substantially from most previous reading-time studies, because we directly compare reading times for sentences parsed using the primed structure with those of sentences parsed using the alternative structure. Finally, the pattern of data for both choice of structure and reading times is consistent with predictions made by perceptual learning accounts of priming (Bock & Griffin, 2000; Bock, Dell, Chang, & Onishi, 2007).

The difference in outcome between the current study and previous studies highlights the fact that lexical bias strongly influences how a sentence is parsed. McRae et al. (1998) simulated reading times for sentences with main verb/reduced relative clause ambiguities in a competition model using independently-estimated syntactic and lexical constraints. This showed that small changes in the availability of the main clause versus reduced relative structure—as would occur in priming without lexical overlap—are unlikely to have large effects on ambiguity resolution. Instead, reading times were largely determined by lexical constraints, like the thematic fit of the pre-verbal argument, and the relative frequency with which the verb appears as a passive participle versus past tense (MacDonald et al., 1994; Trueswell, 1996).

The relatively small effect size associated with syntactic priming in our experiment may reflect the fact that syntactic priming effects are due to very recent exposure to the prime structures. Given a lifetime of experience with sentence comprehension, we can only expect readers to show very small learning effects in response to a single prime. On the other hand, sentence-specific content biases the listener toward one structural analysis over another, often in a deterministic way. During reading, the parses under consideration as a sentence unfolds are constrained by lexical content: every new word narrows down the set of still viable parses, because only parses compatible with lexical content are considered (MacDonald et al., 1994; Trueswell et al., 1994). However, the reverse situation—where the structural analyses under consideration constrain the upcoming lexical content during reading—is difficult to imagine. A more direct way of comparing the relative effects of lexical content and structural primes would be to compare their time courses over a series of trials. While the experiment presented here does not shed light directly on this, it may be that lexical effects are observed earlier than, and are shorter-lived than, structural ones, as demonstrated by Bock and Griffin (2000) for sentence production. We leave the question of dissociating lexical and structural effects by time course for future work.

How should we explain the observation of syntactic priming without lexical overlap, in the few studies where this has been reported? If syntactic priming changes the likelihood of initially assigning the post-verbal noun in the target sentence to the same thematic role as in the prime, then priming should be detectable with a response measure sensitive to initial thematic assignment, rather than processing difficulty. Indeed, the recent studies showing clear evidence for syntactic priming in comprehension without lexical overlap have used the visual world paradigm (Cooper, 1974; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995) to measure expectations generated by unfolding sentences. When priming is measured this way, there are strong effects of the prime on the interpretation of the target sentence (Scheepers & Crocker, 2004; Thothathiri & Snedeker, 2008): listeners shift their attention to the alternative that they predict will come next in the sentence, reflecting initial thematic assignment.

Our methodological demonstration points to a broader explanation for the difference between production and comprehension studies, related to the fact that producing and comprehending a sentence are fundamentally different tasks for a speaker/comprehender. For one, producing a sentence begins with the speaker formulating a message, and as such there is less ambiguity for the speaker (for structures with incompatible messages) than for the comprehender, who encounters massive ambiguity due to the incremental nature of parsing a sentence. Note that this difference is unrelated to the question of whether production and comprehension share mechanisms for structure-building. Consequently, we cannot conclude simply on the basis of an asymmetry in how easy it is to observe syntactic priming that production and comprehension processes use separate mechanisms. The current study demonstrates that a phenomenon like syntactic priming may appear quite differently in production and comprehension studies, not because the phenomena involved are different, but because production and comprehension have different properties.

In sum, our results show that in the absence of strong lexical biases, prior syntactic processing can affect parsing and syntactic form choice, even without lexical overlap between prime and target sentences. The current study contributes to converging evidence for syntactic priming in language comprehension (e.g. Thothathiri & Snedeker, 2008; Tooley & Bock, 2011; Traxler, 2008), using a new methodology to show that syntactic priming affects the interpretation of globally ambiguous sentences (see Traxler, Boudewyn, Zirnstein, & Swaab, 2012 for an eye-tracking and ERP study using similar materials with global attachment ambiguities). We conclude that syntactic priming in comprehension may not differ fundamentally from syntactic priming in production, and that representational or mechanistic differences in the comprehension and production systems need not be posited based on discrepancies in syntactic priming.

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Notes

1. A reviewer points out that some of the prime sentences additionally allow for a reading where the ambiguously-attached PP modifies the main verb. Since this is true of roughly the same number of primes of each type, it is unlikely that any increased complexity associated with resolving such ambiguities in the prime contributed to any of the Prime Type effects we report.
2. Analyses were performed using the statistics software package R (R Development Core Team, 2005) with the lme4 library (Bates & Sarkar, 2007).

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Appendix 1: Experimental items

High-attachment primes

1. The dog chased the squirrel from the hole in the garden next to the rose bush.
2. Amy prefers the energy drink in the skinny can with the extra caffeine.
3. The instructor examined the books on the Cold War from the university bookstore.
4. Sam edited a draft of the proposal with numerous typos.
5. The company auctioned the letters by the famous author with the authenticated postmarks.
6. The tourists admired the painting of the valley on the wall.
7. The gardener watered the tree with the bird’s nest with tangled roots.
8. The kids were all scared of the spider in the web with the fangs.

Low-attachment primes

1. The cat chased the mouse into the hole in the wall with the window.
2. The barista made the smoothies with the powder from the cupboard with the broken hinge.
3. The students read the book on the revolution in the 18th century.
4. Sam approved the funding for the proposal on the new methodology.
5. The historian donated the letters to the museum with the influential trustees.
6. The party took place at the house in the alley with the potholes.
7. The border collies were watching the bird on the tree branch with yellow leaves.
8. Matt’s girlfriend ate a ton of jellybeans before the Superbowl party at their friends’ house.

Target sentences

1. The interior designer disapproved of the pillow on the couch with the striped pattern.
2. The FBI agent noticed the mirror on the wall with a crack.
3. The movers forgot about the chair under the table with only three legs.
4. The guests all admired the sketch of the women in the restaurant.
5. The waitress brought the hungry customers green tea in mugs from Mexico.
6. The research assistant struggled to find the cords for the keyboard in the closet.
7. The parents were embarrassed by the video of their daughters in the courtroom.
8. Katie warned her family to read the article about identity theft on the internet.
9. The fire marshal ordered the employees to move the chairs in the conference room near the fire escape.
10. Danny purchased a novel about a secret tryst in a bookstore.
11. The sisters demanded a refund for the extra charge at the customer service desk.
12. The bass player co-wrote the song for the girl with lots of friends at the local high school.
13. The kids guarded their water balloons from the other team in the backyard.
14. The secretary misplaced the file on the employee with the important information.
15. Felicia was hired to repair the windows by the sliding doors with several cracks.
16. Sameer found out about the secret meeting about the upcoming negotiations in the department.

Appendix 2: Norming study

Participants read the 16 target sentences used in the main experiment, and answered two-alternative questions indicating their parse of the sentence (Table 5).

Table 5. Norming study results.

Item	Mean reaction time, ms (standard deviation)	Number of high-attachment responses out of 16 (*Item Bias*)
1	3558.0 (1781.4)	10
2	4395.7 (2756.6)	10
3	4252.8 (2140.6)	11
4	7991.5 (6068.7)	8
5	4137.3 (2497.1)	1
6	4223.2 (3180.8)	14
7	5128.7 (5335.2)	4
8	6717.9 (3442.6)	11
9	4131.6 (1603.1)	14
10	3905.1 (2132.4)	13
11	7894.5 (5621.4)	13
12	5056.1 (2737.2)	12
13	5443.6 (2433.9)	10
14	6087.1 (4390.7)	11
15	4937.9 (4415.8)	9
16	7442.4 (3136.7)	5