THE INTERACTION OF PROSODIC PHRASING, VERB BIAS, AND PLAUSIBILITY DURING SPOKEN SENTENCE COMPREHENSION

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
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* * * * *

The Ohio State University
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ABSTRACT

Three cross-modal naming experiments revealed the interaction of prosodic phrasing, verb bias, and plausibility during spoken language comprehension in English. Each experiment investigated the online resolution of a temporary syntactic closure ambiguity (e.g., *Whenever the lady checks the room*) across three verb bias sets: transitive-bias, equi-bias, intransitive-bias. Experiments 1 and 2 used auditory stimuli that ended with the structurally ambiguous NP. Whereas Experiment 1 used intonation phrase (IP) boundaries, Experiment 2 used intermediate phrase (ip) boundaries. Phrase boundaries occurred either before or after the structurally ambiguous NP. Experiment 3 used auditory stimuli that ended with the verb in one of three phrase boundary conditions: no boundary, ip, or IP.

The results provide new evidence that IP boundary location can determine the initial syntactic structure for these closure ambiguities—regardless of verb bias. The results support previous claims that IP boundaries trigger semantic wrap-up, and they provide new evidence that these boundaries trigger syntactic wrap-up as well. Although these wrap-up processes helped disambiguate the closure ambiguity, other prosodic and lexical factors were also involved. When wrap-up occurred at a transitive-bias verb, it resulted in syntactic and semantic representations that conflicted in terms of transitivity.
Resolution of this conflict depended on the location of the structurally ambiguous NP within the global prosodic representation and the predictability of that NP as a direct object.

The results further suggest that ip boundaries and verb bias both influenced the initial parse. However, only the combination of an intransitive-bias verb and an early ip boundary might have led to an initial early closure structure. Because the current materials suffer from a late closure bias, the results might suggest that ip boundaries function like plausibility. That is, ip boundaries can determine the initial syntactic structure, but only when auditory fragments equally support syntactic alternatives.

The results are most consistent with the phon-concurrent model—a new constraint-based lexicalist account in which prosody and verb bias influence the initial parse and in which wrap-up mechanisms can trigger commitment to conflicting syntactic and semantic representations.
This work is dedicated to my family.
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TABLE OF CONTENTS

Abstract ........................................................................................................................................ii  
Dedication ......................................................................................................................................iv  
Acknowledgments ..........................................................................................................................v  
Vita ................................................................................................................................................vii  
List of Figures ...............................................................................................................................xv  

Chapters:

1. Introduction ..................................................................................................................................1  
1.1 The problem ..............................................................................................................................1  
1.2 The prosodic structure of mainstream American English .....................................................7  
1.3 Prior work on prosodic phrasing and syntactic processing ......................................................11  
1.3.1 Lehiste (1973) ..................................................................................................................11  
1.3.2 Price, Ostendorf, Shattuck-Hufnagel, and Fong (1991) ......................................................12  
1.3.3 Marslen-Wilson, Tyler, Warren, Grenier, and Lee (1992) .................................................12  
1.3.4 Warren, Schafer, Speer, and White (2000) .......................................................................14  
1.3.5 Carlson, Clifton, and Frazier (2001) ..............................................................................17  
1.3.6 Schafer, Speer, Warren, and White (2000) ....................................................................19  
1.3.7 Kjelgaard and Speer (1997) .........................................................................................21  
1.3.8 Schafer (1997) ..............................................................................................................25
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4 Prior work on the influence of lexico-syntactic frequency information and plausibility on syntactic processing</td>
<td>29</td>
</tr>
<tr>
<td>1.4.1 Trueswell, Tanenhaus, and Kello (1993)</td>
<td>29</td>
</tr>
<tr>
<td>1.4.2 Trueswell (1996)</td>
<td>31</td>
</tr>
<tr>
<td>1.4.3 Garnsey, Pearlmutter, Myers, and Lotocky (1997)</td>
<td>33</td>
</tr>
<tr>
<td>2. Processing accounts</td>
<td>37</td>
</tr>
<tr>
<td>2.1 Introduction</td>
<td>37</td>
</tr>
<tr>
<td>2.2 The traditional garden path model</td>
<td>37</td>
</tr>
<tr>
<td>2.3 Schafer’s (1997) prosody-first account</td>
<td>38</td>
</tr>
<tr>
<td>2.4 The phon-concurrent model</td>
<td>41</td>
</tr>
<tr>
<td>2.4.1 Constraint-based lexicalist models</td>
<td>41</td>
</tr>
<tr>
<td>2.4.2 The original concurrent model</td>
<td>42</td>
</tr>
<tr>
<td>2.4.3 Adding the phonological processor</td>
<td>43</td>
</tr>
<tr>
<td>2.4.4 Goodness-of-fit between prosody and syntax</td>
<td>44</td>
</tr>
<tr>
<td>2.5 Summary</td>
<td>54</td>
</tr>
<tr>
<td>3. Auditory stimuli for Experiments 1 and 2</td>
<td>55</td>
</tr>
<tr>
<td>3.1 Introduction</td>
<td>55</td>
</tr>
<tr>
<td>3.2 Verb bias</td>
<td>57</td>
</tr>
<tr>
<td>3.3 Prosody of the auditory stimuli</td>
<td>59</td>
</tr>
<tr>
<td>3.3.1 The prosodic contours</td>
<td>59</td>
</tr>
<tr>
<td>3.3.2 Recording</td>
<td>62</td>
</tr>
<tr>
<td>3.3.3 Duration analysis</td>
<td>63</td>
</tr>
<tr>
<td>3.3.4 Fundamental frequency analysis</td>
<td>69</td>
</tr>
<tr>
<td>3.4 Summary</td>
<td>75</td>
</tr>
</tbody>
</table>
4. Pretest of Experiment 1 Stimuli .................................................................76

4.1 Introduction ...............................................................................................76
4.2 Method ........................................................................................................78
  4.2.1 Participants .......................................................................................78
  4.2.2 Materials ..........................................................................................79
  4.2.3 Procedure .........................................................................................79
4.3 Results ........................................................................................................80
  4.3.1 Written fragment ratings .................................................................80
  4.3.2 Spoken fragment ratings ..................................................................84
  4.3.3 Final word intelligibility ratings ......................................................86
4.4 Discussion .................................................................................................87

5. Experiment 1: Verb bias and intonation boundaries .................................88

5.1 Introduction ...............................................................................................88
5.2 Processing predictions ..............................................................................91
  5.2.1 Traditional garden path model .........................................................91
  5.2.2 Schafer’s (1997) prosody-first account .............................................91
  5.2.3 The phon-concurrent model .............................................................96
  5.2.4 Summary of predictions ..................................................................101
5.3 Method ......................................................................................................103
  5.3.1 Participants .....................................................................................103
  5.3.2 Materials ........................................................................................103
  5.3.3 Procedure .......................................................................................106
5.4 Results ........................................................................................................109
  5.4.1 Sentence completion data...............................................................109
  5.4.2 Missing reaction time data ...............................................................111
  5.4.3 Cross-modal naming time data .........................................................113
    5.4.3.1 Overall naming times .............................................................113
5.4.3.2 Correlations ................................................................. 116
5.5 Discussion ..................................................................................... 118
5.6 General discussion ............................................................................. 122

6. Pretest of Experiment 2 stimuli ................................................................. 125

6.1 Introduction ..................................................................................... 125
6.2 Method ............................................................................................. 126
   6.2.1 Participants ............................................................................. 126
   6.2.2 Materials ............................................................................... 126
   6.2.3 Procedure ............................................................................. 126
6.3 Results ............................................................................................. 126
   6.3.1 Written fragment ratings ...................................................... 126
   6.3.2 Spoken fragment ratings ...................................................... 131
   6.3.3 Final word intelligibility ratings ........................................... 133
6.4 Discussion .......................................................................................... 135

7. Experiment 2: Verb bias and intermediate boundaries .......................... 137

7.1 Introduction ..................................................................................... 137
7.2 Processing predictions ........................................................................ 139
   7.2.1 Traditional garden path model .............................................. 139
   7.2.2 Schafer’s (1997) prosody-first account .................................. 139
   7.2.3 The phon-concurrent model ............................................... 141
   7.2.4 Summary of predictions ..................................................... 144
   7.2.5 Influence of late closure bias .............................................. 145
7.3 Method ............................................................................................. 145
   7.3.1 Participants ............................................................................. 145
   7.3.2 Materials ............................................................................... 146
   7.3.3 Procedure ............................................................................. 147
7.4 Results ...........................................................................................................147
  7.4.1 Sentence completion data ..............................................................147
  7.4.2 Missing reaction time data .............................................................148
  7.4.3 Cross-modal naming time data ......................................................150
    7.4.3.1 Overall naming times ......................................................150
    7.4.3.2 Correlations .................................................................153
  7.5 Discussion ..............................................................................................155
  7.6 General discussion ..............................................................................156

8. Pretest of Experiment 3 stimuli .................................................................158
  8.1 Introduction ...........................................................................................158
  8.2 Method ..................................................................................................159
    8.2.1 Participants ..................................................................................159
    8.2.2 Materials ....................................................................................159
    8.2.3 Procedure .................................................................................161
  8.3 Results ....................................................................................................161
    8.3.1 Plausibility manipulation ............................................................161
    8.3.2 Spoken fragment ratings ............................................................164
    8.3.3 Final word intelligibility ratings .................................................167
  8.4 Discussion ..............................................................................................168

9. Experiment 3: Verb bias, prosodic boundaries, and plausibility ..............170
  9.1 Introduction ...........................................................................................170
  9.2 Processing predictions ..........................................................................174
    9.2.1 Schafer’s (1997) prosody-first account .......................................174
      9.2.1.1 Prosody-first without syntactic wrap-up ................................174
      9.2.1.2 Prosody-first with syntactic wrap-up ...................................176
LIST OF FIGURES

2.1 Direct object (late closure) syntax with late and early intermediate phrase (ip) boundaries .................................................................45

2.2 Subject (early closure) syntax with early and late intermediate phrase (ip) boundaries ........................................................................45

2.3 VP-attachment syntax and two intermediate phrase (ip) possibilities ........49

2.4 NP-attachment syntax and two intermediate phrase (ip) possibilities ........49

2.5 Incremental stages of syntactic and prosodic (ip = intermediate phrase) representations in goodness-of-fit approach ...............................................................52

2.6 Summary of verb bias and prosodic boundary effects on parsing ..............54

3.1 Summary of conditions and example stimuli for Experiments 1 and 2 ........56

3.2 Example of late intonation boundary prosodic contour ............................60

3.3 Example of early intonation boundary prosodic contour ............................60

3.4 Example of late intermediate boundary prosodic contour ........................61
3.5 Example of early intermediate boundary prosodic contour ........................................61
3.6 Summary of duration measurements for intonation boundary stimuli ...................64
3.7 Summary of duration measurements for intermediate boundary stimuli ..............65
3.8 Summary of pre-boundary lengthening effects .......................................................67
3.9 Mean F₀ by condition and location (b = beginning of periodic region, m = middle of periodic region, e = end of periodic region) ......................................................71
3.10 Summary of F₀ measurements in intonation boundary stimuli .........................73
3.11 Summary of F₀ measurements in intermediate boundary stimuli .......................74
4.1 Mean acceptability ratings (and standard deviations) of visually-presented early and late closure fragments from Experiment 1 (1 = completely unacceptable, 7 = completely acceptable) ...................................................................................80
4.2 Correlations between verb bias and acceptability of visually-presented early and late closure fragments from Experiment 1 ...............................................................82
4.3 Mean acceptability ratings (and standard deviations) of spoken intonation boundary fragments (1 = not said as intended, 7 = said as intended) .........................84
4.4 Mean intelligibility ratings (and standard deviations) of the final word in spoken intonation boundary fragments (1 = completely unclear, 7 = completely clear) ..................................................................................................................86
5.1 Direct object (late closure) syntax with late and early intonation phrase boundaries (ip = intermediate phrase, IP = intonation phrase) .................................89

5.2 Subject (early closure) syntax with early and late intonation phrase boundaries (ip = intermediate phrase, IP = intonation phrase) ................................................89

5.3 Representations at the verb in early boundary conditions in Schafer’s (1997) account (ip = intermediate phrase, IP = intonation phrase) .............................................92

5.4 Example of topicalized NP tree structure with an early intonation phrase boundary (ip = intermediate phrase, IP = intonation phrase) .................................................95

5.5 Summary of predicted naming times in Experiment 1 for each processing account ..............................................................................................................................102

5.6 Summary of conditions and example stimuli for Experiment 1 .........................104

5.7 Rotation of conditions across lists (horizontal lines separate groups of matched items) ...................................................................................................................105

5.8 Proportion of data replacement by condition in Experiment 1 ..........................112

5.9 Corrected naming times and standard errors (in ms) by condition for Experiment 1 .........................................................................................................................114

5.10 Proportion of data replacement by list in the two conditions with a boundary-target conflict .............................................................................................................115

5.11 Relationship between acceptability of visually-presented unambiguous early closure sentence fragments and naming time .................................................117

xvii
6.1 Mean acceptability ratings (and standard deviations) of visually-presented early and late closure fragments from Experiment 2 (1 = completely unacceptable, 7 = completely acceptable) .................................................................................127

6.2 Correlations between verb bias and acceptability of visually-presented early and late closure fragments from Experiment 2 .............................................................................................129

6.3 Mean acceptability ratings (and standard deviations) of spoken intermediate boundary fragments (1 = not said as intended, 7 = said as intended) .............................131

6.4 Mean intelligibility ratings (and standard deviations) of the final word in spoken intermediate boundary fragments (1 = completely unclear, 7 = completely clear) ...................................................................................................................134

7.1 Direct object (late closure) syntax with late and early intermediate phrase (ip) boundaries .................................................................................................................................138

7.2 Subject (early closure) syntax with early and late intermediate phrase (ip) boundaries .................................................................................................................................138

7.3 Summary of predicted naming times in Experiment 2 for each processing account ..................................................................................................................................144

7.4 Summary of conditions and example stimuli for Experiment 2 .................................146

7.5 Proportion of data replacement by condition in Experiment 2 .................................149

7.6 Corrected naming times and standard errors (in ms) by condition for Experiment 2 ........................................................................................................................................151
7.7 Proportion of subjects removed because of consistent late closure completions in the late boundary *is* condition .................................................................152

7.8 Summary of correlations between verb bias and corrected naming time for the visual target *is* in Experiment 2 .................................................................153

8.1 Mean written frequency (and standard deviation) of plausible and implausible NP targets across verb bias conditions .................................................160

8.2 Mean plausibility ratings (and standard deviations) for visually-presented target NPs (1 = completely implausible, 7 = completely plausible) ....................162

8.3 Mean acceptability ratings (and standard deviations) for spoken sentence fragments (1 = not said as intended, 7 = said as intended) .........................165

8.4 Mean intelligibility ratings (and standard deviations) of the final word in spoken sentence fragments (1 = completely unintelligible, 7 = completely intelligible) ..........................................................167

9.1 Summary of conditions and example stimuli for Experiment 3 ...............172

9.2 Direct object syntax and three prosodic phrasings from Experiment 3 (ip = intermediate phrase, IP = intonation phrase) .................................................178

9.3 Subject of main clause syntax and three prosodic phrasings from Experiment 3 (ip = intermediate phrase, IP = intonation phrase) .............................178

9.4 Proportion of late closure completions in Experiment 3 by condition .........190
9.5 Summary of transitive-bias verb and plausible NP targets including number of late closure completions, transitivity-bias score, and mean pretest scores (7-point scale, 1 = unacceptable) .................................................................192

9.6 Proportion of cells requiring data replacement in the implausible target conditions for reasons other than a late closure completion ........................................194

9.7 Mean corrected naming times to implausible targets in Experiment 3 by condition ........................................................................................................195

10.1 Prosodic, syntactic, and semantic representations at offset of early intermediate phrase boundary fragment .................................................................213

10.2 Prosodic, syntactic, and semantic representations following wrap-up at early intonation phrase boundary .................................................................214
CHAPTER 1

INTRODUCTION

1.1 The problem

In November 2002, *USA Today* ran the following headline:

(1) CRUISE SHIP DUMPING POISONS SEAS

At first glance, this headline appears ungrammatical. If a cruise ship had been dumping poisons, then it had to be dumping them *into* seas. Of course, there is no error. The sentence is grammatical as it is written. Yet something about this sentence leads many people to misunderstand it, at least the first time they read it through. Why should this headline cause readers such trouble?

One way to address this question is to consider how changing the headline might make it easier to read and understand. For example, consider how written text differs from spoken utterances. Written text lacks the rhythmic grouping of words into phrases that is an inherent part of spoken utterances. While readers probably do mentally group or chunk written words into phrases as they read, there is no guarantee that the phrases they
choose correspond to the ones that the writer intended. But, if the headline could appear with a visual cue to the intended phrasing, as in (2), chances are that readers would have little, if any, difficulty in comprehension.

(2) (CRUISE SHIP DUMPING) (POISONS SEAS)

A different change might also make the headline easier to understand. Try reading the version of the headline in (3). It contains a different verb.

(3) CRUISE SHIP PARTYING POISONS SEAS

Why should changing dumping to partying make the sentence easier to understand? One reason is that readers are no longer misled by the semantic plausibility of the words poisons as a direct object of the verb. Because readers know that it is impossible to talk about someone partying poisons, they can use this information to reach the right interpretation (e.g., Garnsey, Pearlmutter, Myers, & Lotocky, 1997; Trueswell, 1996; Trueswell, Tanenhaus, & Garnsey, 1994).

The revised headline is also easier to understand because readers implicitly know that partying is more likely to occur in a syntactic structure that does not provide an explicit direct object than in one that does. In contrast, dumping is more likely to occur in a syntactic structure that does provide an explicit direct object than in one that does not. Such lexically-based syntactic frequency information can help readers build the right structure and interpretation, or it can lead them astray (e.g., Garnsey et al., 1997; Trueswell, 1996; Trueswell, Tanenhaus, & Kello, 1993).
The research in this dissertation focuses on these three pieces of information—the prosodic phrasing of the spoken utterance, the likelihood of two possible structures given a particular verb, and the plausibility of a noun phrase (NP) as a direct object—and the way they influence spoken language comprehension. At issue is how listeners integrate these three factors during syntactic and semantic processing.

Recent experiments by Kjelgaard and Speer (1999) have documented that prosodic phrasing interacts with syntactic processing at the earliest possible moment. More specifically, they presented evidence that phrasing could eliminate garden path effects at the point of syntactic disambiguation in the following temporary syntactic ambiguity.

(4) Whenever the lady checks the room...

This fragment is ambiguous because the NP the room could function either as the direct object of the verb checks, as in (5a), or as the subject of the main clause, as in (5b).¹

(5a) Whenever the lady checks the room it’s empty.

(5b) Whenever the lady checks the room is empty.

This ambiguity is traditionally referred to as an early/late closure ambiguity (e.g., Frazier & Rayner, 1982; Kjelgaard & Speer, 1999). The term early closure applies when the beginning clause ends at the verb or closes early, as in (5b). The term late closure applies when the beginning clause ends at the direct object or closes late, as in (5a).

In Kjelgaard and Speer’s (1999) cross-modal naming task, participants listened to spoken versions of these ambiguous sentence fragments. At the end of each fragment,

¹ Although comma placement disambiguates written versions of this ambiguity, the commas are omitted here to the give the reader a sense of how useful prosodic phrasing could be in resolving this ambiguity during spoken language processing.
participants named a visually-presented target word that was congruent with either the
direct object structure (i.e., it’s) or the subject structure (i.e., is). Participants then used
the visual target to complete the sentence. This was done to ensure that participants
integrated the auditory fragment and the visual target.

When the sentence fragment contained a prosodic boundary at the end of the
fragment, participants were faster at naming it’s than is. When the sentence fragment
contained a prosodic boundary at the end of the verb checks, participants were faster at
naming is than it’s. The pattern held for both types of prosodic boundaries in English:
tonation phrase boundaries and intermediate phrase boundaries.² Thus, the results
suggested that the location of the prosodic boundary resolved the structural ambiguity
and determined the initial parse.

While this finding is quite important, Kjelgaard and Speer’s (1999) study is the
only study of this particular ambiguity to control the prosodic phrasing of the utterances
and to use an on-line measure of processing. Furthermore, their effects might well have
hinged on their choice of verbs. All their verbs could be used with or without a direct
object, but few were strongly biased toward a transitive or intransitive use. This is an
important point because the finding that phrasing immediately influenced which of two
syntactic structures was built—when the verbs as a group occurred equally frequently
with the structural alternatives—was quite similar to the results of Garnsey, Pearlmutter,
Myers, and Lotocky (1997). They found that plausibility immediately influenced the

² These two levels of prosodic phrasing (Beckman & Pierrehumbert, 1986; Beckman, 1996)—the
intonation phrase (IP) and the intermediate phrase (ip)—are referred to as the intonation phrase (IP) and
phonological phrase (PPh) in Kjelgaard and Speer (1999) and other works (e.g., Selkirk, 1986, 1995;
Schafer, 1997).
resolution of a syntactic ambiguity during reading, but only when the verbs were equi-biased. Thus, it remains to be seen whether phrase boundary location determines the initial syntactic structure for this ambiguity under all verb-bias conditions. If prosodic phrasing and plausibility have similar effects on syntactic processing, it might well be the case that boundary location has little effect in determining the initial structure for verbs that are strongly biased toward a direct object or subject structure.

Through a series of experiments, the current research investigates several main questions: Does phrase boundary location determine the initial structure and meaning of this closure ambiguity regardless of verb bias? How do intonation phrase boundaries and intermediate phrase boundaries influence the ambiguity resolution process? What are the underlying syntactic, semantic, and prosodic representations?

Experiments 1 and 2 investigate the interaction of prosodic boundary location and verb bias for the two types of prosodic boundaries in English. Experiment 1 uses intonation phrase (IP) boundaries; Experiment 2 uses intermediate phrase (ip) boundaries. Auditory stimuli in both these experiments end with the structurally ambiguous NP (e.g., *the room* in *Whenever the lady checks the room*...), and the relevant prosodic boundaries occur before or after the structurally ambiguous NP. At the offset of each spoken fragment, participants name the visual target *it’s* or *is*. Experiment 3 investigates the interaction of prosodic boundary type, verb bias, and plausibility. In contrast to Experiments 1 and 2, auditory stimuli in Experiment 3 end with the verb in one of three prosodic boundary conditions (no boundary, ip, or IP). Participants name structurally ambiguous NPs that are either plausible or implausible direct objects of the verb. Because Experiment 3 taps processing one word position earlier than Experiments 1 and 2, the
results provide new information about the ambiguity resolution process and new
information about the interaction of prosodic, syntactic, and semantic representations at
two different points in time.

The results suggest that the location of an IP boundary can disambiguate the
temporary syntactic ambiguity regardless of verb bias. In contrast, the location of an ip
boundary (at least in the current materials) cannot. The results further suggest that the
disambiguation process involves more than simple reference to an IP boundary location.
For starters, IP boundaries seem to trigger a process of syntactic wrap-up, in addition to
triggering wrap-up of any outstanding semantic/pragmatic processing (Schafer, 1997).
Furthermore, these wrap-up mechanisms can lead to conflicting syntactic and semantic
representations. More specifically, Experiments 1 and 3 both suggest that when wrap-up
occurs at a transitive-bias verb (e.g., Whenever the lady loads ]IP), the syntactic processor
commits to an intransitive structure, while the semantic processor commits to assigning a
theme (to an upcoming direct object NP). Resolution of the conflict involves the global
prosodic representation (e.g., whether the structurally ambiguous NP is mid-prosodic
phrase or not) and other lexical factors (e.g., perhaps how likely a plausible NP is as a
direct object).

The results discriminate among the competing predictions of three sentence
processing accounts. These accounts are the traditional garden path model (e.g., Frazier,
1990; Frazier & Clifton, 1996), Schafer’s (1997) prosody-first model, and a newly
modified version of Boland’s (1997) concurrent model. The concurrent model is
modified in order to provide an explicit account regarding how prosody might influence
an initial structure and interpretation within a constraint-based lexicalist framework. This
new model is referred to as the *phon-concurrent* model. In addition, the results have implications for Watson and Gibson’s (2003) anti-attachment hypothesis, a parsing strategy against attaching incoming material to syntactic nodes that precede IP boundaries.

In the end, the results are most consistent with the phon-concurrent model. This model provides the best account of:

- Early and robust effects of IP boundary location on syntactic and semantic processing
- Effects of verb bias on the initial construction of direct object structures
- The independence of syntactic and semantic representations at wrap-up

None of the other accounts adequately handles all three main findings.

The rest of this introductory chapter covers the following areas: Section 2 reviews the prosodic framework being assumed. Section 3 reviews the relevant literature regarding effects of prosodic phrasing on spoken language comprehension. Section 4 reviews the relevant literature on the effects of lexico-syntactic frequency information and plausibility during syntactic processing.

1.2 The prosodic structure of mainstream American English

The prosodic framework discussed in Beckman and Pierrehumbert (1986; Beckman, 1996) is assumed throughout this dissertation. Consistent with that assumption, auditory stimuli are described using the Tones and Break Indices (ToBI) system. ToBI is a system for annotating the prosody of utterances in several varieties of English, including mainstream American English (Silverman, Beckman, Pitrelli, Ostendorf, Wightman, Price, Pierrehumbert, & Hirschberg, 1992).
ToBI captures the two main components of a spoken utterance that have been of particular interest to psycholinguists: phrasing and accent. Phrasing refers to the way that speakers rhythmically group the words in an utterance. Accent refers to the relative prominence of particular syllables at the phrasal level. Consider how the same string of words can be represented in (6a) and (6b).

(6a) [The CAT went to the vet on TUESDAY.]
(6b) [The cat WENT to the vet][on TUESDAY.]

The brackets represent the way that the speaker grouped the words into one or more phrases. Whereas the speaker produced all the words as a single phrase in (6a), she produced them as two phrases in (6b). Capitalization represents the words that the speaker accented or stressed within each utterance. Whereas cat and Tuesday are the prominent words in the first utterance, went and Tuesday are the prominent words in the second utterance. Of course many other phrasings and accent patterns are possible for this string of words. The examples serve only to demonstrate that phrasing and accentuation are independent of syntactic structure.

ToBI includes two non-recursive levels of phrasing: the intonation phrase, and within that level of phrasing, one or more intermediate phrases. Look again at the sentences from (6), repeated here as the sequence in (7).

(7a) [ [The cat went to the vet on Tuesday]ip ]IP
(7b) [ [The cat went to the vet]ip [on Tuesday]ip ]IP
(7c) [ [The cat went to the vet]ip ]IP [ [on Tuesday]ip ]IP

Utterances are now double-bracketed to represent the two levels of phrasing: the intonation phrase (IP) and the intermediate phrase (ip). In (7a), the speaker produced the
words as a single group. Thus, the entire utterance is one intonation phrase, and it contains a single intermediate phrase. In (7b) and (7c), the speaker produced the words as two groups. In (7b), the two groups are intermediate phrases, and they are contained within a single intonation phrase. In (7c), the groups are intonation phrases, and each contains a single intermediate phrase.

Intonation phrases are marked at their right edge by a low (L%) or high (H%) boundary tone. Intermediate phrases are marked at the right edge by a low (L-) or high (H-) phrase accent. Phrase accents represent a lower level of disjuncture than boundary tones, and phrase accents spread backward to the last accented syllable in the intermediate phase (the nuclear accent). Low and high phrase accents can each combine with low or high boundary tones.

In terms of accent, ToBI contains a set of pitch accents that indicate the relative highs and lows in pitch across an utterance (e.g., H*, L*, L+H*). In English, pitch accent placement is largely unpredictable in the sense that speakers can accent any word. However, it is predictable in the sense that pitch accents usually align with a stressed syllable. The asterisk indicates the tone that aligns to the stressed syllable.

Sentence (7a) is repeated here as (8) with a possible sequence of ToBI labels. As before, cat and Tuesday are the accented words in the utterance. This time, however, pitch accents replace the capitalization and indicate the accompanying tones. A phrase accent and boundary tone sequence (L-L%) replaces the brackets. In this example, the words were spoken as a single intonation phrase containing a single intermediate phrase.
The cat went to the vet on Tuesday.

The next section and the current research focus on the role that prosodic phrasing plays during syntactic processing. However, this statement is not intended to imply that this is the only role for phrasing. In fact, Schafer (1997) demonstrated that phrasing has an influence on focus projection. The statement is also not intended to imply that the relationship between phrasing and syntactic structure is necessarily unidirectional. Beckman (1996) points out that when talking about the abstract prosodic representation and its alignment to text, one can either say that a tune is anchored to the text or that a text is anchored to the tune. In this sense, multiple abstract representations are linked to one another without one necessarily being primary. Whether or not the relationship between phrasing and syntactic structure is unidirectional is a question for later study.
1.3 Prior work on prosodic phrasing and syntactic processing

1.3.1 Lehiste (1973)

Several of the early works on prosody and sentence processing established that speakers and listeners could use prosody to disambiguate at least some syntactically ambiguous utterances. In a set of classic experiments, Lehiste (1973) had speakers produce globally ambiguous utterances three times. The first time, they simply read the sentences and then indicated the meaning they had intended. The second and third times, they picked a meaning and then purposely tried to convey that meaning. Listeners typically scored above chance when identifying the intended meanings of sentences that had two different syntactic groupings, as in (9). They scored at or below chance in sentences that did not, as in (10).

(9a) [Steve or Sam] and Bob will come.
(9b) Steve or [Sam and Bob] will come.
(10) Visiting relatives can be a nuisance.

In addition to demonstrating that prosody could disambiguate structures that have syntactic boundaries in different locations, Lehiste (1973) documented the acoustic information that speakers and listeners might be using. She noted that word durations were longer in regions that contained syntactic boundaries. Thus, this study is one of the first to demonstrate pre-boundary lengthening or increased word durations before prosodic phrase boundaries.
1.3.2 Price, Ostendorf, Shattuck-Hufnagel, and Fong (1991)

Price, Ostendorf, Shattuck-Hufnagel, and Fong (1991) similarly used a wide-range of syntactic ambiguities and found that listeners could successfully disambiguate spoken versions of those ambiguities. In a production task, four trained speakers read sentences in disambiguating contexts. In a listening task, participants identified which context an ambiguous utterance was likely to have come from. The results were consistent with Lehiste (1973). Listeners were able to perform above chance, and they performed better on some sentences than on others. Those utterances that were successfully disambiguated tended to involve intonation phrase boundaries at major syntactic boundaries, and word durations increased in pre-boundary position.

One aspect of the Price et al. (1991) work is especially interesting. They noted that some of the utterances that were successfully disambiguated involved differences in relative break size. In addition, they raised the possibility that equal breaks (on either side of an ambiguous constituent) might represent a neutral prosody that allows both structures and interpretations. These points are particularly relevant to more recent work on relative break size that will be reviewed later (Carlson, Clifton, & Frazier, 2001; Schafer, Speer, Warren, & White, 2000).

1.3.3 Marslen-Wilson, Tyler, Warren, Grenier, and Lee (1992)

Whereas early work on prosodic phrasing and syntactic processing established that speakers and listeners could use phrasing to disambiguate a range of syntactically ambiguous utterances, later work investigated to what extent phrasing determines the initial syntactic parse.
Marslen-Wilson, Tyler, Warren, Grenier, and Lee (1992) conducted a cross-modal naming experiment to see if prosody could be used as successfully as lexical information to resolve the temporary syntactic ambiguity associated with (11b) and (11c). The phrase the last offer from the management is ambiguous because it could either be the direct object of considered, as in (11c), or the subject of the main clause, as in (11b). The sentence in (11a) is lexically disambiguated by the complementizer that.

(11a) The workers considered that the last offer from the management * was a real insult.

(11b) The workers considered the last offer from the management * was a real insult.

(11c) The workers considered the last offer from the management * of the factory.

When the auditory stimuli were recorded, the speaker made no overt attempt to disambiguate the three sentence types prosodically. Rather, changes in duration and pitch were expected to occur naturally with the syntactic break in the main clause condition.

In the example sentences, the asterisk indicates the end of the auditory fragments and the point at which a visual target appeared for naming. Visual targets were either consistent with a main clause continuation (was) or inconsistent with any completion because of a number violation (were).

The results suggested that phrasing determines the syntactic parse. Participants named was in the main clause conditions as quickly as in the lexically unambiguous that conditions. Participants also named was more slowly in the direct object conditions.

While it might be possible that prosodic phrasing is responsible for the pattern of naming times, it is not possible to know for certain without an acoustic or prosodic analysis. In fact, Watt and Murray (1996) highlight the importance of providing an acoustic and prosodic analysis of auditory materials: They were unable to replicate
Marslen-Wilson et al.’s (1992) effects. Because neither article describes the auditory fragments in detail, there is no way of knowing if the two sets of materials were comparable.

Even if phrasing caused the effects in Marslen-Wilson et al. (1992), it is still not possible to know exactly how phrasing interacted with parsing. For example, it could be that the auditory fragments from the main clause utterances contained a prosodic boundary that served as a local cue to the main clause structure. Or, more in line with the work that will be discussed later on, a more global prosodic representation might have influenced syntactic processing. In addition, Marslen-Wilson et al. (1992) never established whether their verbs were biased toward one or the other of the possible structures (direct object or sentence complement). Thus, it is possible that prosody does influence syntactic parsing but only under certain conditions (e.g., when verbs are equi-biased or biased toward a less frequent syntactic representation).

1.3.4 Warren, Schafer, Speer, and White (2000)

The studies discussed so far have contributed important insights. Speakers and listeners can use phrasing to disambiguate syntactic structure, and the effects on syntactic processing might very well be immediate. However, these studies have little to say about the prosody of their stimuli. They cannot address whether phrasing interacts with other syntactic aspects of the utterance, such as verb bias. They cannot say whether speakers naturally produce disambiguating prosody for ambiguous utterances, and they cannot say whether listeners are sensitive to that information in conversational contexts. Nor can they say anything convincing about the time course with which prosodic information is used or the way in which a processing model might use it.
Fortunately, recent work has improved in several of these areas. The remaining studies all include ToBI transcriptions of their materials, and to different extents, detailed acoustic analyses. This is a big step forward because it enables researchers to build comparable materials or materials that are different in well-defined ways. Acoustic analyses and ToBI transcriptions are both important because factors such as speech rate and pitch range can influence how prosodic boundaries (and pitch accents) are realized. In addition, different speakers might employ slightly different acoustic strategies (e.g., Lehiste, 1973) that appear as the same categorical differences in the abstract prosodic representation. For example, pre-boundary lengthening and pausing can each contribute to the percept of a phrase boundary (Warren, 1999). In short, a purely acoustic analysis might not capture the categorical nature of phrasing.

Acoustic analyses and transcriptions are also important because the prosodic representation has its own ambiguities (Beckman, 1996). To use an example from Beckman, it can be difficult to determine if the low tone between the two high tones in H* L- H* L-L% and H* L+H* L-L% is really a phrase accent or part of a bitonal pitch accent when the starred tones are close together. While some researchers have actually capitalized on the ambiguous nature of the prosodic representation (Kjelgaard & Speer, 1999), they have also included acoustic measurements that support their claim regarding that prosodic ambiguity.

One study to include detailed acoustic measurements and transcriptions is Warren, Speer, Schafer, and White (2000). They analyzed the prosodic structure of globally ambiguous sentences that contained a prepositional phrase (PP) attachment ambiguity. Pairs of participants played a game that required them to act together to move game
pieces to particular locations. Participants could structure the dialog as they wanted, but they were limited to a set of possible utterances. In this way, these utterances represent a more natural example of phrasing in production than any of the aforementioned studies. The critical utterances are shown in (12).

(12a) I want to change the position of the square with the triangle.
(12b) I want to change the position of the square with the cylinder.

The underlined PPs in (12) are ambiguous. They can either attach low to the preceding NP (the square) or attach high to the VP (change the position...). Even though (12b) is structurally ambiguous, the attachment was unambiguous in the game. Because no object consisted of a square with a cylinder, with the cylinder could only attach to the VP. In contrast, (12a) was ambiguous during the game. There was a square game piece that could be moved with a triangle or a cylinder, and there was a house-shaped “square with a triangle” game piece.

Warren et al.’s (2000) prosodic analysis demonstrated that the VP-attachment conditions were more likely to have a phrase boundary before the PP regardless of whether the PP referred to the triangle or the cylinder. Thus, even though VP-attachment was the only possibility for with the cylinder, that fact seemed not to matter. It also did not matter if the attachment were disambiguated mid-game. This happened when only certain pieces could be moved or were more likely to be moved a second time. There was also little difference between the productions of the person giving the directions and the person confirming the moves.

Listeners were able to identify whether the utterances in (12a) indicated changing the position of the square using the triangle or changing the position of the house-shaped
object (the square with the triangle). Furthermore, listeners did not perform better on utterances that had been produced in ambiguous contexts. Rather, performance on the low-attachment utterances that came from an ambiguous context was actually worse. This suggests that, if anything, because they had been more carefully articulated, they might have contained increased durations that signaled pre-PP boundaries.

This study is important because it suggests that average speakers and listeners use phrase boundaries to disambiguate structure in real discourse. It also suggests that this process is independent of any ambiguity in the context.

1.3.5 Carlson, Clifton, and Frazier (2001)

Carlson, Clifton, and Frazier (2001) also investigated a high/low attachment ambiguity using the underlined temporal phrases in (13). In a series of experiments, they found that the overall distribution of breaks, as opposed to purely local break information, influenced attachment decisions.

(13a) Susie learned \(_L-H\) that Bill telephoned \(_L-H\) after John visited.
(13b) Susie learned \(_L-H\) that Bill telephoned \(_L\) after John visited.
(13c) Susie learned \(_L-H\) that Bill telephoned after John visited.
(13d) Susie learned \(_H\) that Bill telephoned \(_L\) after John visited.

In (13b) and (13c) the preceding break is stronger than the following break. In (13a) and (13d) the breaks are of equal size. Listeners were more likely to say that the temporal phrase was attached high (i.e., Susie learned something after John visited), when there was no difference in break size. (There was, however, an overwhelming bias to attach low. High attachments occurred at the most 25\% of the time in [13d].)
Conversely, when they tested the materials with the phrasing patterns in (14), high attachments were assigned to (14a), (14c), and (14d) about 38% of the time. These are the conditions in which a smaller break precedes a larger break. There were significantly more high attachments in these conditions than in the condition with equal breaks (14b).

(14a) Susie learned ]_L_ that Bill telephoned ]_L-H%_ after John visited.

(14b) Susie learned ]_L_ that Bill telephoned ]_L_ after John visited.

(14c) Susie learned ]_L_ that Bill telephoned ]_L-H%_ after John visited.

(14d) Susie learned ]_L_ that Bill telephoned ]_L_ after John visited.

The finding that relative boundary size influences the attachment of ambiguous constituents is consistent with Schafer’s (1997) prosodic visibility hypothesis. Although this hypothesis will be discussed in more detail later in this section, the hypothesis essentially claims that intermediate phrase boundaries influence the accessibility of syntactic attachments. For example, when attaching after John visited in (13a), the preceding intermediate phrase boundary (L-) makes telephoned less visible than if there were no break. But because learned is two intermediate phrase boundaries away, it is even less visible than telephoned. Thus, it is not surprising that low attachment prevails in these materials.

Carlson et al. (2001) characterized the effect a bit differently than the prosodic visibility hypothesis. According to their informative break hypothesis, equivalent breaks are merely uninformative during parsing. In contrast, a [smaller break/larger break] pair suggests high attachment and a [larger break/smaller break] pair suggests low attachment.

With the exception that this hypothesis appeals to pairs of breaks as opposed to individual breaks, this hypothesis still does nothing more than treat prosodic information
as one more local cue to a syntactic decision. In contrast, Schafer’s (1997) prosodic visibility hypothesis allows effects to stem from the integration of prosodic and syntactic representations. That is, the parser does not use prosody to inform its parsing decisions per se. Rather, as the phonological processor closes off its constituents, the integrated syntactic/prosodic representation becomes less accessible to the syntactic parser than any current material that it has yet to integrate.

There is another contrast between the prosodic visibility hypothesis and the informative break hypothesis; namely, what to do when the first break is encountered. If we look at the utterances in (15), the informative break hypothesis makes no predictions regarding syntactic processing immediately following the early intermediate phrase (L-) at learned in (15a).

(15a) Susie learned L that Bill telephoned L-H%

(15b) Susie learned L that Bill telephoned L-H%

In contrast, because prosodic visibility always applies, it must predict that attachment of the complement clause in (15a) will be delayed relative to attachment of the complement clause in (15b). Of course, this would be difficult to test given that the attachment is unambiguous. That said, the fact remains that the informative break hypothesis has nothing to say about phrasing and the resolution of the early/late closure ambiguity under investigation in this dissertation because the boundary manipulation involves the first and only boundary in the utterance.

1.3.6 Schafer, Speer, Warren, and White (2000)

Examples are shown in (16). (16a) is the late closure utterance because *the square* closes the first constituent late and serves as the direct object of *moves*. (16b) is the early closure utterance because the first constituent closes early at the verb. *The square* serves as the subject of the second clause.

(16a) When that moves the square it should land in a good spot.

(16b) When that moves the square will encounter a cookie.

When Schafer et al. (2000) looked at the phrasing for (16a) and (16b), they found that speakers consistently put a stronger boundary after *moves*, relative to the boundary after *square*, in the early closure condition. In contrast, the early boundary was likely to be weaker than the later boundary (in the same locations) in the late closure utterances. This pattern is consistent with both the informative break hypothesis and prosodic visibility. Schafer et al. also found that listeners could use those patterns of relative boundary strength to interpret the early and late closure meanings.

Interestingly, Schafer et al. (2000) found that listeners also successfully identified early closure utterances that were produced either with equal breaks in the two positions or with the stronger break in the second position. A similar effect was not found for the late closure conditions. As Schafer et al. note, this might be because listeners were rating fragments that were truncated at the end of *the square*, and some of the break information was probably truncated as well. Nonetheless, these results suggest that there must be something other than just relative break size that listeners rely on when making their judgments.
1.3.7 Kjelgaard and Speer (1999)

The experiments in this dissertation build on Kjelgaard and Speer (1999). Like Schafer et al. (2000), Kjelgaard and Speer also investigated prosodic phrasing and ambiguous early/late closure utterances. However, Kjelgaard and Speer adopted an online task to investigate whether prosody boundary location determined the initial syntactic parse. Perhaps critically, Kjelgaard and Speer used ambiguous utterances that were not strongly biased toward either the early or late closure structure. They presented these utterances in three prosodic conditions: cooperating, baseline, and conflicting. These conditions are recreated with their ToBI labels in (17) and (18).

(17a) **Early Closure Cooperating**

\[
\begin{align*}
H^* & \quad L-L\% \\
\end{align*}
\]

When Roger leaves the house is dark

(17b) **Early Closure Baseline**

\[
\begin{align*}
L+H^* & \quad L- \\
H^* & \quad L-L\% \\
\end{align*}
\]

When Roger leaves the house is dark

(17c) **Early Closure Conflicting**

\[
\begin{align*}
H^* & \quad L-L\% \\
H^* & \quad L-L\% \\
\end{align*}
\]

When Roger leaves the house is dark
The prosodic conditions in these materials are specific to the two syntactic structures. For example, cooperating prosody is different for the early and late closure conditions. With early closure syntax, a cooperating boundary occurs before the ambiguous NP. With late closure syntax, a cooperating boundary occurs after the ambiguous NP. In the baseline conditions, the prosodic representation includes a phrase accent in the right location for each syntactic condition. However, the exact position of this phrase accent is ambiguous because there is a large stretch of unaccented material between the pitch accents. As Kjelgaard and Speer (1999) demonstrated in their acoustic analyses, the words in these baseline conditions have similar pitch contours and durations. As a result, the acoustic information could lead to either phonological representation.

Over multiple experiments using different offline and online tasks (e.g., end-of-sentence comprehension, cross-modal naming), Kjelgaard and Speer (1999) found several effects. First, there was no evidence of any garden path effect in the early closure cooperating condition. Naming times for these utterances were as fast as naming times in
the late closure cooperating conditions. There was, however, a garden path in the early closure baseline condition. This was the condition in which the prosodic representation was compatible with either early or late closure. This suggested that cooperating early closure prosody eliminated a garden path that is traditionally reported in reading studies. It also suggested that cooperating early closure prosody eliminated a garden path that is found in early closure utterances when the prosody is ambiguous.

Second, there were interference and facilitation effects. Interference effects were seen in both the late closure conflicting condition and the early closure conflicting condition relative to their respective baseline conditions. The effect occurred most consistently for the early closure conflicting conditions. Facilitation effects were observed for the cooperating conditions, although again the effects occurred most consistently for the cooperating early closure condition. These interference and facilitation effects suggested that prosody could support and interfere with syntactic analyses that would be preferred during reading. The facilitation effects are particularly important because they demonstrate that the influence of prosodic information was not restricted to syntactic reanalysis.

The results as summarized demonstrated that intonation phrase boundaries had an immediate influence on syntactic processing. However, it is important to note that Kjelgaard and Speer (1999) demonstrated similar effects for intermediate phrase boundaries.³

³ Kjelgaard and Speer’s (1999) intermediate phrase materials, which were extensively normed, and their accompanying processing effects provide counterevidence to Marcus and Hindle’s (1990) claim that intonation phrase boundaries are obligatory in these early closure utterances.
At this point, it is useful to summarize the critical results and hypotheses and to add in the results from Schafer (1997). Schafer is particularly relevant because she provides an account of the Kjelgaard and Speer (1999) results within a garden path model.

Kjelgaard and Speer (1999) demonstrated that prosodic phrasing influences the syntactic representation that is initially constructed in early and late closure ambiguities, at least when lexical content is not strongly biased toward a single structure. This pattern of results seems to be different from the high/low attachment results that the informative break hypothesis (Carlson et al., 2001) was intended to describe. At least as it is currently proposed (i.e., in terms of pairs of boundaries), it is not obvious how the hypothesis would explain any of Kjelgaard and Speer’s effects given that only one boundary was present in the auditory stimuli. The question then becomes, is there a hypothesis that can (1) explain the offline high/low attachment effects, (2) explain the online early/late closure results, and (3) make testable predictions for the current experiments.
1.3.8 Schafer (1997)

As mentioned earlier, Schafer’s (1997) prosodic visibility hypothesis accounts for the Carlson et al. (2001) results. The hypothesis is presented here in (19). Note that Schafer’s phonological phrases are the same as intermediate phrases.

(19) The Prosodic Visibility Hypothesis

- The phonological phrasing of an utterance determines the visibility of syntactic nodes.
- Nodes within the phonological phrase currently being processed are more visible than nodes outside of that phonological phrase; visibility is gradient across multiple phonological phrases.
- In first analysis and reanalysis, attachment to a node with high visibility is less costly in terms of processing/attentional resources than attachment to a node with low visibility.

Schafer’s (1997) supporting data came from an investigation of the high/low attachment ambiguity in (20). The underlined PP can attach to either the VP (angered the rider) or the NP (the rider). The number at the end of each sentence is the percentage of VP-attachment interpretations reported from an offline task.

(20a) The bus driver angered the rider with a mean look [L-L% 61.5%]
(20b) The bus driver angered the rider with a mean look [L-L% 44.3%]
(20c) The bus driver angered the rider with a mean look [L-L% 59.9%]
(20d) The bus driver angered the rider with a mean look [L-L% 52.6%]

According to prosodic visibility, the VP and NP nodes in (20a) are equally visible to the PP. The VP and NP nodes in (20c) are also equally visible to the PP. As such, the
A parsing strategy of minimal attachment should apply, and the VP-attached structure should predominate in these conditions. In (20b), the NP node is the only visible attachment. As a result, there should be more NP-attachments in (20b) than in the other conditions. Because the PP in (20d) has less access to the VP node than the PP in (20a) or the PP in (20c), there should be fewer VP-attachments in (20d) than in (20a) or (20c).

Furthermore, the PP in (20d) has less access to the VP than in (20a) but more access than in (20b). As a result, the proportion of VP-attachments for (20d) should fall between (20a) and (20b). Schafer found the predicted pattern of VP-attachments.

Schafer (1997) explained the Kjelgaard and Speer (1999) results with prosodic visibility. She argued that in their early closure cooperating conditions, processing was facilitated because the early boundary reduced visibility between the ambiguous NP (e.g., the room in Whenever the lady checks the room) and the preceding material. As a result, the direct object attachment was difficult to build. By the time the target is appeared, the correct attachment could be built because the room and is were in the same intermediate phrase. They were visible to one another. In the baseline conditions, the ambiguous boundary did not reduce visibility between the verb and the NP, and the late closure structure was always constructed. In the late closure conflicting conditions, the early boundary again reduced visibility between the room and the preceding material. As a

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4 Minimal attachment dictates that the parser builds the structure requiring the fewest nodes (Frazier, 1978). VP-attachments for PPs in this position are claimed to be more minimal than NP-attachments (Frazier & Clifton, 1996).

5 Of course, prosodic visibility should also predict a greater number of NP-attachments than VP-attachments in (20d). That prediction was neither cast nor supported.

6 This raises an interesting question regarding ambiguity resolution. If the syntactic and prosodic representations are both ambiguous, does the plausible NP lead the listener to resolve the syntactic ambiguity in favor of late closure which in turn resolves the prosodic ambiguity in favor of late closure?
result, the direct object attachment was difficult to build. By the time the target "it’s appeared, the syntactic conflict triggered reanalysis. In essence, whether or not an intonation boundary was present, the intermediate phrase boundary caused the effects.

Although Schafer’s (1997) hypothesis regarding intonation boundaries is not necessary to explain the results in Kjelgaard and Speer (1999), it is relevant to the current experiments and to other claims regarding phrasing and parsing. This hypothesis is called the interpretive domain hypothesis, and it is shown in (21).

(21) The Interpretive Domain Hypothesis

- An intonational phrase boundary defines a point at which the processor performs any as yet outstanding semantic/pragmatic evaluation and integration of material within the intonational phrase.

Schafer (1997) supported this hypothesis with the results of an experiment in which an independent clause disambiguated an ambiguous word from a preceding dependent clause. For example, *Although the glasses were ugly* was disambiguated by either *Stacey wore them anyway* or *they held a lot of juice*. When the word was disambiguated toward its less frequent meaning (here, drinking glasses), participants took significantly more time to indicate that the sentence made sense when an intonation phrase boundary separated the two clauses, as opposed to when an intermediate phrase boundary separated the two clauses. Boundary type did not significantly affect response times when the word was disambiguated to its more frequent meaning. This suggested that listeners committed to the more frequent meaning in the intonation boundary condition, and that reanalysis to the subordinate meaning took longer following an intonation boundary than following an intermediate boundary.
In her two hypotheses, Schafer (1997) argued that intermediate phrases and intonation phrases affect different processing levels. Whereas intermediate phrases influence syntactic processing, intonation phrases influence semantic processing. This account is different from claims that intonation boundaries affect syntactic processing by signaling to the parser that a constituent should be closed (Marcus & Hindle, 1990; Watson & Gibson, 2003). According to Marcus and Hindle, intonation boundaries operate as unknown lexical items that trigger the parser to close a constituent and to prevent otherwise mandatory processes (e.g., late closure) from applying. In the case of Watson and Gibson’s *anti-attachment hypothesis*, intonation phrases mark the end of a constituent in language production. As a result, there is a parsing strategy against attaching to words that precede intonation phrases.

Of course, intonation boundaries never occur without intermediate boundaries. Only intermediate boundaries can occur alone. As a result, it is hard to know if intonation boundaries or intermediate boundaries actually drive the claims of Marcus and Hindle (1990) and Watson and Gibson (2003). In contrast, Schafer (1997) provided empirical evidence that the two boundary types differ in their effects on semantic processing, and Kjelgaard and Speer (1999) demonstrated similar effects for the two boundary types on syntactic processing.

What is most important for the current research is that Schafer (1997) provides an architecture through which prosodic representations might drive syntactic and semantic processing. The account is particularly attractive because it allows for the integration of syntactic, semantic, and prosodic representations, and it makes clear predictions for the current materials. These predictions will be outlined in Chapter 2.
1.4 Prior work on the influence of lexico-syntactic frequency information and plausibility on syntactic processing

1.4.1 Trueswell, Tanenhaus, and Kello (1993)

Words differ in terms of how often they occur in different syntactic structures. For example, the verb forgot occurs more often in direct object structures (e.g., *The vet forgot the cat at home*) than in sentence complement structures (e.g., *The vet forgot the cat was under the table*). Words also differ in terms of how semantically acceptable they are in different syntactic structures. In the previous examples, the NP *the cat* represents a plausible direct object (DO) and a plausible sentence complement subject. An NP such as *the floor*, however, seems more plausible as a subject (*The vet forgot the floor was...*) than as a direct object (*The vet forgot the floor*).

Lexically-based syntactic frequency information and plausibility have both been shown to influence syntactic processing. In fact the two factors are often manipulated within the same experiment. These studies (as opposed to those that manipulate only frequency or only plausibility) are most relevant to the current work for two reasons. First, they show the clearest evidence that lexically-based syntactic frequency information influences the initial parse. Second, the third experiment in this dissertation also crosses lexico-syntactic frequency and plausibility in its design.

Trueswell, Tanenhaus, and Kello (1993) manipulated lexico-syntactic frequency information and argued that it influenced the initial parse. In two experiments, they compared verbs that occurred most often in direct object structures (e.g., *accepted, forgot*; DO-bias verbs) to verbs that occurred most often in sentence complement structures (e.g., *insisted, hoped*; SC-bias verbs).
The first experiment used a cross-modal naming task in which participants listened to fragments such as \textit{The old man accepted} or \textit{The old man insisted}. At the offset of the verb, they named a visual target. The target was congruent with either the SC structure (\textit{he}) or the DO structure (\textit{him}). Naming times to \textit{him} were faster for DO-bias verbs than SC-bias verbs. While this pattern of naming times might indeed suggest that lexico-syntactic frequencies influenced naming times via the availability of syntactic structures, it might also be the case that naming times to \textit{him} were slower for SC-bias verbs than for DO-bias verbs simply because \textit{him} is not a grammatical continuation for these SC-bias verbs.

The second experiment used a self-paced word-by-word reading task in which participants read sentence complement structures like the one in (22). The braces indicate that either a DO-bias or SC-bias verb was presented in each sentence.

(22) The student \{forgot/hoped\} the solution was in the back of the book.

The underlined NP is structurally ambiguous. It can serve either as a direct object of the preceding verb or as the subject of the following verb. \textit{Was} resolves the ambiguity to the sentence complement structure. The results showed an increase in reading times for the DO-bias verbs at the preposition \textit{in}. Trueswell et al. (1993) argued that the DO-bias verbs led readers to mistakenly structure the ambiguous NP as a direct object. In contrast, the SC-bias verbs led the reader to interpret the ambiguous NP correctly as the subject of an embedded sentence. However, it is also the case that \textit{the solution} is implausible as a direct object of the DO-bias verb \textit{hoped}. Because plausibility was not manipulated as a variable in this experiment, it is impossible to know to what extent the implausible NP aided the syntactic process.
1.4.2 Trueswell (1996)

While Trueswell et al.’s (1993) experiments suggested that lexico-syntactic frequency information influences syntactic parsing, they did not provide convincing evidence that lexico-syntactic frequency influences the initial parse. In the case of their naming data, increased reaction times might have stemmed from ungrammaticality effects. In the case of their self-paced reading data, the critical effect appeared one word position after the disambiguating information (i.e., the effect was not immediate), and it might have resulted from a combination of lexically-based syntactic frequency information and plausibility. Trueswell (1996) improved on Trueswell et al. (1993) in several respects. First, lexico-syntactic frequency was manipulated within one verb type (i.e., all verbs could be used in the possible structures). Second, plausibility was manipulated as an independent variable.

Trueswell (1996) conducted two self-paced word-by-word reading studies of relative clauses. The examples in (23) are representative of the sentences in the first experiment. Without that was, the structural position of the verb is temporarily ambiguous. It can either be a past participle (as in a reduced relative clause) or a main verb. The by-PP disambiguates the sentence to the relative clause structure.

(23a) The room {that was} searched by the police...

(23b) The hostage {that was} released by the terrorist...

In the first experiment, Trueswell (1996) compared verbs that occurred frequently as past participles (e.g., searched) to verbs that occurred infrequently as past participles (e.g., released). In each critical sentence the grammatical subject (e.g., the room, the hostage) supported the reduced relative structure. The results showed that at the
disambiguating region, participants read reduced relative clauses as quickly as unreduced relative clauses, when the relative clauses contained high frequency past participles. In contrast, participants took significantly longer to read reduced relatives than unreduced relatives, when the relative clauses contained low frequency past participles.

In the second experiment, Trueswell (1996) used the same verb manipulation and grammatical subjects that supported the main verb interpretation. This time, participants took significantly longer to read reduced relatives than unreduced relatives at the disambiguating region. It wasn’t until one region later that participants read relative clauses with high frequency past participles as quickly as unreduced relatives.

The results of the two experiments suggested that high frequency past participles did not by themselves lead readers to build a reduced relative. Only the combination of frequency and plausibility information had such an effect. Trueswell (1996) reasoned that because main verb structures are more frequent overall than reduced relative structures, a verb that occurs frequently as a past participle merely allows a reduced relative structure to compete with a main verb structure. Plausibility information tilts the syntactic analysis in favor of one structure. Such an explanation is quite consistent with the account provided in the next study.
1.4.3 Garnsey, Pearlmutter, Myers, and Lotocky (1997)

Garnsey, Pearlmutter, Myers, and Lotocky (1997) is an especially important study of lexically-based syntactic frequency and plausibility effects for several reasons. First, unlike the prior two studies, it presents eye tracking data as well as self-paced reading results. By using both methodologies, Garnsey et al. are able to substantiate claims regarding the immediate influence of verb bias and plausibility. Second, the results motivate one of the central hypotheses being tested in this dissertation; namely, that like plausibility, prosodic phrasing determines syntactic structure but only when structural alternatives are equally frequent.

Garnsey et al. (1997) designed three groups of sentence complement stimuli. Examples are shown in (24)-(26). Each pair of sentences represents a different verb bias condition (DO-bias, Equi-bias, SC-bias). The first sentence in each pair contains an NP that is plausible as a direct object. The second sentence contains an NP that is implausible as a direct object. Sentences with that are unambiguously relative clauses.

(24) **DO-bias**

(24a) The talented photographer accepted {that} the money could not be spent yet.

(24b) The talented photographer accepted {that} the fire could not have been prevented.

(25) **Equi-bias**

(25a) The salesclerk acknowledged {that} the error should have been detected earlier.

(25b) The salesclerk acknowledged {that} the shirt should have been marked down.

(26) **SC-bias**

(26a) The ticket agent admitted {that} the mistake had been careless and stupid.

(26b) The ticket agent admitted {that} the airplane had been late taking off.
Garnsey et al. (1997) used sentence completions (e.g., Proper name verb _____ ) to determine the bias of each verb. They used acceptability ratings to establish the plausibility manipulation. The plausible and implausible NPs for any pair of sentences were always separated by at least 2.5 units on a 7-point scale.

In the eye tracking experiment, first pass reading times and first fixations—the earliest measures of processing difficulty—increased in the disambiguating region of the reduced sentences relative to the unreduced sentences but only in the DO-bias condition. In addition, the first pass reading times for the equi-bias verbs demonstrated a reliable interaction with plausibility. Whereas plausible NPs in reduced sentences tended to have longer first pass reading times than NPs in unreduced sentences, implausible NPs in reduced sentences tended to have faster times those in unreduced. A similar plausibility effect was observed for the DO-bias verbs at the ambiguous NP.

In the self-paced reading study, reading times in the disambiguating region of the reduced sentences again increased relative to the unreduced sentences in the DO-bias condition. This time there was a similar, but smaller, effect in the Equi-bias condition. And as with the eye tracking data, there was no effect in the SC-bias condition. At the ambiguous NP, reduced sentences took longer to read than unreduced regardless of verb bias, but plausibility influenced reading time in the Equi-bias condition. Plausible NPs took longer to read than implausible NPs.
The results of these two experiments suggested that when the verbs were strongly biased toward one of two possible structures, plausibility had little influence on the initial syntactic structure. DO-bias verbs led to initial DO structures, and SC-bias verbs led to initial SC structures. Yet when the verb supported two structures equally, plausibility determined the initial structure. Plausible NPs led to a DO structure; implausible NPs led to an SC structure.

In addition to assessing the overall pattern of reading times, Garnsey et al. (1997) looked at the relationship between verb bias and reading time from both experiments. In general, they found that verb bias did indeed influence reading time, but only when plausibility supported the less frequent structural alternative. When SC-bias verbs were used with plausible NPs, reading time increased as the DO-bias of the verbs increased. In contrast, DO-bias had little effect on reading time when SC-bias verbs were used with implausible NPs. Likewise, when DO-bias verbs were used with implausible NPs, reading time decreased as the SC-bias of the verbs increased. Because these correlations could not be associated with any reanalysis process (i.e., there was no evidence of processing difficulty in the overall pattern of reading time data), Garnsey et al. interpreted the correlation data as evidence of competing structural alternatives.

The three studies reviewed in this section suggest that lexically-based syntactic frequency information has immediate effects on syntactic processing (cf. Ferreira & Clifton, 1986; Ferreira & Henderson, 1990). They also suggest that when frequency information is consistent with multiple parses, plausibility can determine which one prevails. This pattern of results is most consistent with constraint-based lexicalist accounts of processing (e.g., Boland, 1997; MacDonald, Pearlmuter, & Seidenberg,
1994; Trueswell, Tanenhaus, & Garnsey, 1994; Spivey-Knowlton & Sedivy, 1995), one of which will be described in the next chapter. Suffice it to say for now, that the verb bias, prosodic phrasing, and plausibility manipulations in the current experiments provide additional tests of constraint-based, prosody-first (Schafer, 1997), and syntax-first (e.g., Frazier, 1990; Frazier & Clifton, 1996) approaches.

The remaining chapters are organized as follows: Chapter 2 presents three different accounts of sentence processing. Chapter 3 describes the auditory stimuli for Experiments 1 and 2. Chapters 4 through 9 cover the three main experiments and the relevant predictions for each processing account. A chapter on normative data precedes each main experiment. Chapter 10 provides conclusions and a summary of the phon-concurrent model.
CHAPTER 2

PROCESSING ACCOUNTS

2.1 Introduction

The main experiments in this dissertation test the predictions of three different accounts of processing: the traditional garden path model (e.g., Frazier, 1990; Frazier & Clifton, 1996), Schafer’s (1997) prosody-first account, and the phon-concurrent model, a newly modified version of Boland’s (1997) concurrent model.¹

2.2 The traditional garden path model

According to the traditional garden path model (e.g., Frazier, 1990; Frazier & Clifton, 1996), there are two autonomous processors, one for syntactic processing and one for semantic processing. The syntactic processor constructs syntactic representations using only syntactic category information (i.e., part of speech), grammatical rules, and two parsing strategies. The strategy of minimal attachment drives the parser to build the structure that requires the fewest number of additional nodes. The strategy of late closure, which operates when more than one minimal structure is possible, drives the parser to

¹ While the current experiments do not directly test the anti-attachment hypothesis (Watson & Gibson, 2003), the overall results do have implications for this parsing strategy against attaching incoming material to words that precede intonation phrase boundaries.
attach incoming material to the most recent node. At each word position, the syntactic processor outputs a syntactic structure to the semantic processor, which has access to more detailed lexical information. At the semantic processor, a thematic processor accesses all the possible thematic relations and assesses the plausibility of those relations. The thematic processor selects the thematic relations that “confirm the structurally favored constituent structure” (Frazier, 1990), and it triggers reanalysis if a more plausible set of thematic relations exists (Frazier & Clifton, 1996). It is only during the reanalysis stage that all available information can guide the parser to the appropriate syntactic structure. In short, the syntactic processor builds its initial structure without regard to lexically-based syntactic frequencies, plausibility, or prosody.2

2.3 Schafer’s (1997) prosody-first account

Schafer (1997) added an additional autonomous processor—the phonological processor—to the garden path model in order to allow prosodic information to have an early role in syntactic and semantic processing. The phonological processor builds an abstract representation that includes prosodic and lexical information, and it incrementally sends its representation to both the syntactic and semantic processor.

As in the traditional garden path model, the syntactic processor constructs syntactic representations using syntactic category information, grammatical rules, and parsing strategies, and it incrementally outputs a syntactic structure to the semantic processor. However, in contrast to the traditional garden path model, the syntactic processor is also sensitive to intermediate phrasing. According to Schafer’s (1997) account...

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2 The traditional garden path model, not construal (Frazier & Clifton, 1996), is relevant for the current study because the closure ambiguity involves an argument position or a “primary relation.”
prosodic visibility hypothesis, attaching a syntactic node into an existing structure is easier when the attachment site is within the same intermediate phrase as compared to when it is not. In addition, successive intermediate phrases gradiently reduce the visibility between an incoming node and its potential attachment sites. One result of decreased visibility is that before the syntactic processor can incorporate new material into an existing syntactic structure, a new phonological representation—one that contains disambiguating syntactic information—can become available to the parser. In turn, this reduces the number of garden path experiences. For example, Schafer explains that an intermediate phrase boundary at the right edge of checks in (1) would reduce visibility between the verb and the ambiguous NP the room. As a result, the attachment of the ambiguous NP as a direct object would be delayed. If is were the next word, the room and is would be visible, and the NP and verb would be attached into an early closure structure.

(1) Whenever the lady checks the room...

Because the syntactic processor is sensitive to phrase accents, but not boundary tones, intermediate phrases reduce visibility independently of whether they occur at the right edge of an intonation phrase.

The syntactic processor incrementally sends its syntactic structure to the semantic processor. The thematic processor takes the phonological representation and computes all the possible thematic relations. It assesses the plausibility of those relations and selects the ones that match the syntactic structure (if they’re available). As in the classic garden path model, a more plausible set of thematic relations (e.g., a set that supports an alternative structure) triggers reanalysis.
In contrast to the classic account, intonation phrases represent domains in which semantic/pragmatic integration is completed. That is, according to Schafer’s (1997) interpretive domain hypothesis, the right edge of an intonation phrase marks a point at which the semantic (and pragmatic) processor wraps up any outstanding semantic (and pragmatic) processing. For example, a boundary tone at the right edge of *checks* in (1) would cause the semantic processor to finalize its interpretation for *Whenever the lady checks* before the ambiguous NP *the room* even appears. While Schafer does not outline how this wrap-up process might interact with verb bias, she does provide evidence that the semantic/pragmatic processor commits to the more frequent meaning of lexically ambiguous nouns. When clauses containing ambiguous nouns (e.g., *glasses* in *Although the glasses were ugly...*) were disambiguated toward either their more frequent meaning (*Stacey wore them anyway*) or their less frequent meaning (*they held a lot of juice*), participants took longer to indicate that the sentence made sense when an intonation phrase boundary separated the two clauses, as opposed to when an intermediate phrase boundary separated the two clauses. Thus, one possibility for the current ambiguity is that the semantic/pragmatic processor commits to the more frequent meaning of verbs as well. However, this is not the only possibility. In contrast to Schafer’s semantically ambiguous nouns, the current ambiguity includes a syntactic ambiguity as well. Because of this, the semantic/pragmatic processor might commit to an intransitive meaning when wrap-up occurs at the verb, perhaps because there is no overt direct object at that point. Both possibilities for the resolution of the current verb bias ambiguity are outlined with the processing predictions for each experiment (See Chapters 5, 7, and 9).
2.4 The phon-concurrent model

2.4.1 Constraint-based lexicalist models

Boland’s (1997) concurrent model contrasts with the previous two processing accounts in that it is a constraint-based lexicalist model. The term constraint-based refers to models that allow syntactic and nonsyntactic information to influence the initial parse. Each piece of information represents a constraint, and in the most general form of a constraint-based model, all constraints operate simultaneously and in parallel (e.g., Trueswell, Tanenhaus, & Garnsey, 1994; Trueswell, Tanenhaus, & Kello, 1993; Spivey-Knowlton & Sedivy, 1995). Constraint information has been argued to include (nonexhaustively) verb subcategorization (e.g., Trueswell, Tanenhaus, & Kello, 1993; Trueswell, 1996), thematic role information (e.g., Ferreira & McClure, 1997; McRae, Spivey-Knowlton, & Tanenhaus, 1998), referential information (e.g., Spivey-Knowlton & Sedivy, 1995), and discourse context (e.g., Altmann & Steedman, 1988). This is not to say, however, that all constraints are created equal. Rather, one constraint might create structural alternatives at a point of ambiguity, while others might have varying degrees of influence over the weights of those generated alternatives. Within constraint-based models, constraints support different structural alternatives, which compete for selection at any point of syntactic ambiguity.

The purpose of the current experiments is not to choose among the various constraint-based models, but to investigate whether verb bias and prosodic phrasing both influence the initial parse, as would only be allowed in a constraint-based model. In order to be explicit about the underlying mechanisms and representations that drive the predictions, one particular constraint-based account has been selected: Boland’s (1997)
concurrent model. Because the concurrent model, like other constraint-based models, does not include a phonological processor for creating and handling prosodic representations, the model has been modified here to include one.

2.4.2 The original concurrent model (Boland, 1997)

In the original concurrent model (Boland, 1997), the syntactic processor generates multiple, weighted syntactic alternatives using lexical information and syntactic rules. These syntactic alternatives are sent to the semantic processor, which has been building only the most likely interpretation. (This is in contrast to most constraint-based models, which also allow activation of competing thematic roles [e.g., MacDonald, Pearlmutter, & Seidenberg, 1994].) Although the semantic processor does not have to wait for the output of the syntactic processor in order to develop an interpretation, interpretations that are not syntactically supported are not maintained.

In this model, the strongest syntactic competitor is selected at each word position. The remaining syntactic alternatives, as well as any new ones, are reactivated at the next word if they are consistent with the incoming lexical information. Syntactic competitors also serve as alternative parses for reanalysis.
2.4.3 Adding the phonological processor

In modifying the concurrent model, it makes sense to follow Schafer (1997) and to add a phonological processor. This phonological processor creates an abstract prosodic representation that helps keep lexical information in memory and that serves as input to the syntactic and semantic processors (e.g., Speer, Kjelgaard, & Dobroth, 1996). Kjelgaard and Speer (1999) note several factors that motivate having prosodic representations available from an early point. Prosodic structures are nonrecursive and for that reason are probably easier to build. In addition, prosodic structures in English, unlike syntactic and semantic structures, do not depend on lexical information.

With the addition of the phonological processor, there are three autonomous processors—phonological, syntactic, and semantic. Although each is responsible for an independent representation, the processors do share information (e.g., the syntactic processor sends structural alternatives to the semantic processor; the syntactic and semantic processors access prosodic phrasing information from the phonological representation). This sharing allows the processors to develop representations that cohere to the greatest extent possible.

Because the phonological processor continuously updates its abstract prosodic representation and sends that representation to the syntactic and semantic processors, prosodic phrasing can influence the earliest syntactic and semantic processing. More specifically, the phon-concurrent model adopts Schafer’s (1997) interpretive domain hypothesis: boundary tones at the right edge of intonation phrases trigger the semantic processor to wrap up any outstanding semantic/pragmatic processing.
2.4.4 Goodness-of-fit between prosody and syntax

In contrast to Schafer (1997), however, the phon-concurrent model does not adopt prosodic visibility. Rather, goodness-of-fit between the prosodic representation and the generated syntactic alternatives acts as a separate constraint on the weights (and thus, selection) of those alternatives. The more closely intermediate phrases align with the constituent structure of syntactic alternatives, the more weight the prosodic representation adds to those syntactic alternatives.³ For example, *Whenever the lady checks the room* has at least the two syntactic competitors in Figures 2.1 and 2.2. In Figure 2.1, *the room* is the direct object of *checks*. In Figure 2.2, *the room* is the subject of the main clause.

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³ Because there is no one-to-one relationship between syntactic structure and prosodic phrasing, it cannot be the case that prosodic phrases *must* correspond to syntactic constituents in order for the prosody to add weight to the syntactic alternatives. However, given a single prosodic phrasing that is felicitous for two structural alternatives, the phrasing will add more weight to the structure in which the prosodic phrasing actually aligns with the constituent structure.
Whenever the lady checks the room

Late boundary: [.................................]_{ip}

Early boundary: [.................................]_{ip} [.........]

Figure 2.1: Direct object (late closure) syntax with late and early intermediate phrase (ip) boundaries

Whenever the lady checks the room

Early boundary: [.................................]_{ip} [.........]

Late boundary: [.................................]_{ip}

Figure 2.2: Subject (early closure) syntax with early and late intermediate phrase (ip) boundaries
In the case of a late intermediate phrase boundary (i.e., a single ip ending at the right edge of the room), the prosodic phrase aligns with or matches the direct object structure in Figure 2.1. The lexical string Whenever the lady checks the room is contained within the intermediate phrase and within a completed syntactic constituent (i.e., S-bar). This late intermediate phrase boundary does not align, however, with the constituents in the subject structure in Figure 2.2. This is because the lexical string never corresponds to a completed syntactic constituent. Furthermore, additional boundaries from the upcoming prosodic representation fail to correct the misalignment. Thus, the late intermediate phrase boundary should add weight to the direct object structure, but none to the subject structure.

In the case of an early intermediate phrase boundary (i.e., the ip follows checks), the prosodic representation aligns with or matches the subject structure in Figure 2.2. The lexical string Whenever the lady checks is contained within the intermediate phrase and within a completed syntactic constituent (i.e., an S-bar). The lexical string the room is contained within an incomplete intermediate phrase and within an incomplete syntactic constituent (i.e., an S). Although the room also corresponds to a completed syntactic constituent (i.e., an NP), nothing in the grammar requires a prosodic boundary at every syntactic boundary. Thus, so long as there is at least one incomplete syntactic constituent corresponding to the incomplete prosodic phrase indicated here, the goodness-of-fit between the prosodic and syntactic representations should be high. The early intermediate phrase boundary should add weight to the subject structure.
The early intermediate phrase boundary should also add some weight to the direct object structure, but not as much as weight as it added to the subject structure. The early boundary should add weight to the direct object structure because a later boundary, one following a heavy NP, is possible. This later boundary would allow the lexical string—through the heavy NP (e.g., *Whenever the lady checks the room with the broken window*)—to be contained within two intermediate phrases and one complete syntactic constituent. However, because *Whenever the lady checks* never forms a syntactic constituent, even with the addition of a heavy NP, the early boundary should not add as much weight to the direct object structure as it should add to the subject structure.

At this point, it is useful to return to Schafer’s (1997) original evidence regarding prosodic visibility and to consider whether a prosody/syntax goodness-of-fit account predicts the results. Recall that Schafer investigated a high/low attachment ambiguity in materials like those in (2). The underlined PP can attach to the VP (*angered the rider*) or to the NP (*the rider*). The number at the end of each sentence is the percentage of VP-attachment interpretations reported from an offline task.

(2a) The bus driver angered the rider \[ \text{with a mean look} \] \[ \text{L-L} \% \] 61.5%
(2b) The bus driver angered \[ \text{the rider} \] \[ \text{with a mean look} \] \[ \text{L-L} \% \] 44.3%
(2c) The bus driver angered the rider \[ \text{with a mean look} \] \[ \text{L-L} \% \] 59.9%
(2d) The bus driver \[ \text{angered} \] \[ \text{the rider} \] \[ \text{with a mean look} \] \[ \text{L-L} \% \] 52.6%

4 Because *the room* is uttered mid-prosodic phrase, not phrase finally, there would have to be a heavy NP of some sort (e.g., NP + PP, NP + relative clause) in order for the phrasing to be felicitous.
According to prosodic visibility, VP-attachments predominated in (2a) and (2c) because the VP and NP nodes within each sentence were equally visible, and VP-attachments are more minimal than NP-attachments. (2b) had the fewest VP-attachments because the NP was the only visible attachment. (2d) had fewer VP-attachments than (2a) because the verb was less visible in (2d) than in (2a). (2d) had more VP-attachments than (2b) because the verb in (2d) was more visible relative to when the noun was the only visible attachment.

According to the goodness-of-fit account, VP-attachments predominate in (2a) because the location of the prosodic boundary matches the VP-attachment syntax better than it matches the NP-attachment syntax. In the VP-attachment syntax shown in Figure 2.3, the VP branches into two phrasal constituents: VP1 *angered the rider* and the PP *with a mean look*. Given (2a) prosody, one constituent (the PP) is contained within its own intermediate phrase. The daughters of the other constituent (VP2) are also contained within an intermediate phrase.5

5 The absence of a boundary at the left edge of the entire VP occurs in VP- and NP-attachment.
angered the rider with a mean look

2a prosody: ..................................\[...............................]_{ip}

2b prosody: .................. \[...............................................\]_{ip}

Figure 2.3 VP-attachment syntax and two intermediate phrase (ip) possibilities

angered the rider with a mean look

2a prosody: ..................................\[...............................]_{ip}

2b prosody: .................. \[...............................................\]_{ip}

Figure 2.4 NP-attachment syntax and two intermediate phrase (ip) possibilities
In the NP-attachment syntax shown in Figure 2.4, the VP branches into the verb *angered* and NP₁ *the rider with a mean look*. However, given (2a) prosody, neither of these daughters is contained within its own intermediate phrase. NP₁ is spread across two intermediate phrases, and there is no additional phrase boundary at its left edge. The verb is accompanied by lexical material that is not its sister syntactically.

Conversely, NP-attachments predominate in (2b) because the location of the prosodic boundary matches the NP-attachment syntax better than it matches the NP-attachment syntax. With (2b) prosody and the NP-attachment syntax in Figure 2.4, NP₁ is contained within its own intermediate phrase. But in the VP-attachment syntax in Figure 2.3, *the rider with a mean look* never forms a syntactic constituent, and VP₂ is spread across two intermediate phrases without an additional boundary at the right syntactic edge.

In (2c), there is only one large prosodic phrase. According to the goodness-of-fit approach, this prosodic phrasing supports both structural alternatives, and VP-attachments predominate for nonprosodic reasons (e.g., definite NPs tend to occur more often with VP-attached PPs than NP-attached PPs, Spivey-Knowlton & Sedivy, 1995).

This leaves an account of (2d). Schafer (1997) did not explicitly discuss how prosodic visibility must predict a greater number of NP-attachments than VP-attachments for (2d). Because the verb is two intermediate phrases away, it should be less visible than the noun, which is only one intermediate phrase away. Of course, the percentage of VP-attachments that Schafer reports (52.6%) does not support this prediction.
Now consider the goodness-of-fit account that is outlined in Figure 2.5 for V NP PP structures with (2d) prosody (e.g., *The bus driver* ]_ip angered ]_ip the rider ]_ip with a mean look ]_ip). Brackets represent intermediate phrase boundaries. At (a), the first intermediate phrase aligns with the subject NP, and the next intermediate phrase aligns with the VP. Because the VP only contains the head verb, the intermediate phrase simultaneously aligns with that verb. At (b), the VP is expanded to include a direct object, and the latest intermediate phrase aligns with the direct object. At the PP, the final intermediate phrase aligns with the end of the PP regardless of whether that PP is VP-attached as in (c) or NP-attached as in (d). As a result, it is no longer surprising that this prosodic representation elicits practically an equal number of VP- and NP-attachments. The prosodic representation is an equally good fit for either syntactic representation.
Figure 2.5: Incremental stages of syntactic and prosodic (ip = intermediate phrase) representations in goodness-of-fit approach
Perhaps more importantly, the prosody/syntax goodness-of-fit account also predicts the finding in Kjelgaard and Speer (1999) that the location of an intermediate phrase boundary determines the structure for ambiguous early/late closure sentence fragments that by themselves were not biased toward either a direct object or subject structure (e.g., *Whenever the lady checks the room*). Because both structures were equally competitive, the early intermediate phrase boundary added more weight to the main subject structure than the direct object structure, and the subject structure was selected. The late intermediate phrase boundary added support to the direct object structure, and that structure was selected.

Because the parser only builds a single syntactic structure in the traditional garden path model and in Schafer’s (1997) prosody-first account, prosodic visibility remains essential to those accounts. However, all accounts predict increased processing time in the case of any prosody/syntax mismatches.
2.5 Summary

Figure 2.6 summarizes for each account the point at which verb bias and prosodic boundary information are said to influence syntactic processing.

<table>
<thead>
<tr>
<th>Processing Account</th>
<th>Role during Parsing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Garden Path Model</td>
<td>Reanalysis</td>
</tr>
<tr>
<td>Schafer’s (1997) Prosody-First Account</td>
<td>Reanalysis</td>
</tr>
<tr>
<td>Modified Concurrent Model</td>
<td>Initial Parse</td>
</tr>
</tbody>
</table>

Figure 2.6: Summary of verb bias and prosodic boundary effects on parsing

Each of these processing accounts assumes different underlying mechanisms for the integration of prosodic, syntactic, and semantic representations. As a result, each account makes different predictions regarding how the current stimuli will be processed. The processing steps and subsequent predictions for each account will be addressed separately in the chapters pertaining to each main experiment.
CHAPTER 3

AUDITORY STIMULI FOR EXPERIMENTS 1 AND 2

3.1 Introduction

Experiments 1 and 2 use the same cross-modal naming task as Kjelgaard and Speer (1999). Participants listen to auditory fragments that end with a structurally ambiguous NP (e.g., the room). At the offset of each sound file, a disambiguating visual target appears (is or it’s). Participants say each target as quickly as they can and then use the target to create a sentence ending for the auditory fragment. The auditory fragments in these experiments incorporate two independent variables: the transitivity bias of the verb (transitive, equi, or intransitive) and the location of a phrase boundary (either before or after the ambiguous NP the room). The ambiguous NP in each auditory fragment always represents a plausible direct object for the verb.

While both experiments involve a boundary location manipulation, they differ in terms of boundary type. Whereas the auditory stimuli for Experiment 1 contain intonation phrase boundaries, the stimuli for Experiment 2 contain intermediate phrases. Figure 3.1 summarizes the stimuli for Experiments 1 and 2.
<table>
<thead>
<tr>
<th>Verb Bias</th>
<th>Prosodic Boundary</th>
<th>Auditory Fragment with Prosodic Contour</th>
<th>Visual Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXP 1</td>
<td>H*</td>
<td>H* L-H%</td>
<td></td>
</tr>
<tr>
<td>EXP 2</td>
<td>H*</td>
<td>H* H-</td>
<td></td>
</tr>
<tr>
<td>Tran Late</td>
<td>Whenever the lady loads the car</td>
<td>it's is</td>
<td></td>
</tr>
<tr>
<td>Equi Late</td>
<td>Whenever the lady checks the room</td>
<td>it's is</td>
<td></td>
</tr>
<tr>
<td>Intran Late</td>
<td>Whenever the lady moves the door</td>
<td>it's is</td>
<td></td>
</tr>
<tr>
<td>EXP 1</td>
<td>H* L-H%</td>
<td>H*</td>
<td></td>
</tr>
<tr>
<td>EXP 2</td>
<td>H* H-</td>
<td>H*</td>
<td></td>
</tr>
<tr>
<td>Tran Early</td>
<td>Whenever the lady loads the car</td>
<td>it's is</td>
<td></td>
</tr>
<tr>
<td>Equi Early</td>
<td>Whenever the lady checks the room</td>
<td>it's is</td>
<td></td>
</tr>
<tr>
<td>Intran Early</td>
<td>Whenever the lady moves the door</td>
<td>it's is</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 3.1: Summary of conditions and example stimuli for Experiments 1 and 2**

There are 36 critical items arranged into groups of three (one sentence for each verb bias condition). The verbs within a group are matched on number of syllables, and with one exception, on stress pattern. The ambiguous NPs in each group are matched on number of syllables, frequency (high/low), stress pattern, and final segment (+/- stop). Appendix A contains a complete list of critical sentence fragments, individual transitivity-bias scores, and Francis and Kucera (1982) mean written frequency counts for the ambiguous NPs.

The auditory stimuli are further described in the following sections: Section 3.2 describes the verb bias manipulation. Section 3.3 describes the prosody.
3.2 Verb bias

Verb bias refers to an estimate of how frequently each critical verb is used transitively (i.e., with a direct object) or intransitively. Each experiment used three bias sets—transitive-bias, equi-bias, and intransitive-bias—and each set contained 12 verbs.

A transitivity bias score for each verb was calculated from the Connine, Ferreira, Jones, Clifton, and Frazier (1984) sentence completion data using the subtraction metric that Kjelgaard and Speer (1999) applied to their own sentence completion data (i.e., percent transitive completions – percent intransitive completions = transitivity-bias score).

Connine et al. (1984) reported the percentage of time that participants produced various intransitive or transitive structures (e.g., with a direct object, with a direct and indirect object) when asked to write sentences for a list of words that included verbs. For each verb in the current study, two values were calculated from the Connine et al. data: the mean of all percentages across six intransitive categories and the mean of all percentages across six transitive categories. The intransitive mean was then subtracted from the transitive mean to determine a transitivity-bias score. Negative numbers indicate an intransitive-biased verb.
The equi-bias set of verbs came directly from Kjelgaard and Speer’s (1999) materials in an attempt to replicate their effects. In terms of transitivity-bias scores, this set is equi-bias in two senses. One, it includes a mix of transitive- and intransitive-biased verbs. Two, none of the verbs is strongly biased toward a transitive or intransitive use. The mean transitivity-bias score for the equi-bias set is 2.03, and scores range from -5.8 to 9.2. In addition, Kjelgaard and Speer’s sentence completion data demonstrates that these verbs are not strongly biased toward a transitive or intransitive use when presented in a subordinate structure (e.g., *When Frank performs...*)

Whereas the equi-bias set of verbs includes transitive- and intransitive-biased verbs, the transitive-biased set and the intransitive-biased set include only same-bias verbs. The mean transitivity-bias score for the intransitive-biased set is -9.68, and scores range from -15.8 to -4.1. The mean score for the transitive-biased set is 11.26, and scores range from 17 to 5.3. Appendix A contains the complete list of transitivity-bias scores.
3.3 Prosody of the auditory stimuli

3.3.1 The prosodic contours

The ToBI labels that correspond to the boundary manipulation are shown in Figure 3.1 at the beginning of this chapter. Figures 3.2 and 3.3 illustrate representative prosodic contours for the late and early intonation phrase boundary conditions from Experiment 1. Figures 3.4 and 3.5 illustrate representative prosodic contours for the late and early intermediate boundary conditions from Experiment 2.

The intonation boundaries in Experiment 1 always consist of a low phrase accent followed by a high boundary tone (L-H%). The intermediate boundaries in Experiment 2 always consist of a high phrase accent (H-). Late boundaries align to the right edge of the ambiguous NP. Early boundaries align to the right edge of the verb. In each auditory fragment, the subject NP is always the first word to be accented, and it is generally produced with a H* pitch accent. The verb is never accented, but there is generally a H* on the ambiguous NP.¹

¹ A few H* accents might actually be L+H* accents.
Figure 3.2: Example of late intonation boundary prosodic contour

Figure 3.3: Example of early intonation boundary prosodic contour
Whenever the lady checks the room

<table>
<thead>
<tr>
<th>Whenever</th>
<th>the</th>
<th>lady</th>
<th>checks</th>
<th>the</th>
<th>room</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3.4: Example of late intermediate boundary prosodic contour

Whenever the lady checks the room

<table>
<thead>
<tr>
<th>Whenever</th>
<th>the</th>
<th>lady</th>
<th>checks</th>
<th>the</th>
<th>room</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3.5: Example of early intermediate boundary prosodic contour
3.3.2 Recording

A native speaker of mainstream American English with extensive ToBI experience produced all the utterances. Although participants only heard the beginnings of those utterances, the speaker did produce complete sentences during recording. She produced four versions of the 36 critical sentences in groups of the same prosodic contour. For example, she produced late closure *Whenever the lady checks the room* it's *cold* twice, once with a late L-H% boundary and once with a late H- boundary. She produced early closure *Whenever the lady checks* the room *is cold* twice, once with an early L-H% boundary and once with an early H- boundary. The speaker produced no additional prosodic boundaries.

The speaker produced the materials over several sessions in a sound dampened room. The files were digitally recorded with an iMac (44.1 kHz sampling rate, 16 bit) and saved in .wav format to a PowerMac G4 using SoundEdit 16 version 2 and a Macintosh microphone. Praat 4.0.35 was used to view and edit the audio files and to downsample them to 22.1 kHz.

The speaker re-recorded utterances as needed. Ultimately, the speaker, the experimenter, and a third trained ToBI transcriber verified that the utterances were produced with the intended prosodic contours (i.e., there was agreement as to the ToBI transcriptions). In addition, the results of the following phonetic analysis support these phonological interpretations and demonstrate that prosodic contours did not differ systematically for the different verb bias conditions.

The critical stimuli consist of utterances that were truncated at the end of any silence following the ambiguous NP (i.e., late intonation boundaries include the silent
duration that frequently accompanies intonation phrases). In the absence of any silence, fragments were truncated at the offset of the ambiguous NP. Truncation points were determined by visual and audio inspection.

Detailed acoustic analyses of duration and fundamental frequency were conducted in order to support the ToBI transcriptions phonetically and to ensure that verb bias did not interact with the prosodic contours in some unexpected way.

3.3.3 Duration analysis

Duration measurements were calculated automatically using Praat 4.0.35 after labeling five landmarks in the sound files. The five landmarks were the onset of the verb, the offset of the verb, the onset of the determiner in the ambiguous NP, the offset of the noun in the ambiguous NP, and the onset of the target word it’s or is.

Because Praat does not allow two landmarks to occupy the same time point, the offset of the verb was never coincident with the onset of the determiner, and the offset of the ambiguous NP was never coincident with the onset of the target word. When there was no visible or audible silence between these pairs of points, the onsets were marked as closely to the offsets as possible. Praat scripts then automatically generated the durations of the entire sound file, the verb, the silence (if any) between the verb and determiner, the ambiguous NP, and the silence (if any) between the ambiguous NP and the target word.

Figure 3.6 contains the mean durations of the intonation boundary stimuli as well as mean durations for the verb, the silence between the verb and determiner, the ambiguous NP, and the silence between the ambiguous NP and the target word. Figure 3.7 contains these measurements for the intermediate boundary stimuli.
## Mean Duration in Milliseconds (SD) by Region

<table>
<thead>
<tr>
<th>Verb Bias</th>
<th>Fragment</th>
<th>Verb</th>
<th>Early Silence</th>
<th>Ambiguous NP</th>
<th>Late Silence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Early Intonation Boundary</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H*</td>
<td>H*</td>
<td>NP</td>
<td>V</td>
<td>L-H%</td>
<td>NP</td>
</tr>
<tr>
<td>Transitive</td>
<td>2141.4</td>
<td>640.0</td>
<td>321.1</td>
<td>442.7</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td>(182.9)</td>
<td>(88.0)</td>
<td>(85.9)</td>
<td>(78.8)</td>
<td>(1.5)</td>
</tr>
<tr>
<td>Equi</td>
<td>2183.0</td>
<td>678.9</td>
<td>360.2</td>
<td>414.6</td>
<td>5.2</td>
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<tr>
<td></td>
<td>(202.5)</td>
<td>(94.2)</td>
<td>(88.2)</td>
<td>(49.7)</td>
<td>(1.8)</td>
</tr>
<tr>
<td>Intransitive</td>
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<td>628.1</td>
<td>356.6</td>
<td>452.4</td>
<td>6.1</td>
</tr>
<tr>
<td></td>
<td>(184.0)</td>
<td>(81.3)</td>
<td>(101.8)</td>
<td>(47.3)</td>
<td>(2.5)</td>
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<tr>
<td><strong>Late Intonation Boundary</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H*</td>
<td>H*</td>
<td>NP</td>
<td>V</td>
<td>L-H%</td>
<td>NP</td>
</tr>
<tr>
<td>Transitive</td>
<td>1997.0</td>
<td>338.1</td>
<td>4.2</td>
<td>634.2</td>
<td>328.3</td>
</tr>
<tr>
<td></td>
<td>(227.1)</td>
<td>(86.5)</td>
<td>(1.5)</td>
<td>(97.3)</td>
<td>(144.2)</td>
</tr>
<tr>
<td>Equi</td>
<td>2081.3</td>
<td>363.7</td>
<td>3.8</td>
<td>640.4</td>
<td>378.4</td>
</tr>
<tr>
<td></td>
<td>(243.7)</td>
<td>(63.6)</td>
<td>(0.4)</td>
<td>(80.2)</td>
<td>(170.6)</td>
</tr>
<tr>
<td>Intransitive</td>
<td>1955.5</td>
<td>339.2</td>
<td>3.5</td>
<td>643.7</td>
<td>296.2</td>
</tr>
<tr>
<td></td>
<td>(255.1)</td>
<td>(86.6)</td>
<td>(0.5)</td>
<td>(62.5)</td>
<td>(156.2)</td>
</tr>
</tbody>
</table>

Figure 3.6: Summary of duration measurements for intonation boundary stimuli
### Mean Duration in Milliseconds (SD) by Region

<table>
<thead>
<tr>
<th>Verb Bias</th>
<th>Fragment</th>
<th>Verb</th>
<th>Early Silence</th>
<th>Ambiguous NP</th>
<th>Late Silence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Early Intermediate Boundary</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H*</td>
<td>H*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NP</td>
<td>V</td>
<td>NP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transitive</td>
<td>1449.7</td>
<td>412.0</td>
<td>7.7</td>
<td>386.0</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>(209.9)</td>
<td>(63.7)</td>
<td>(12.3)</td>
<td>(77.7)</td>
<td>(1.6)</td>
</tr>
<tr>
<td>Equi</td>
<td>1475.6</td>
<td>445.5</td>
<td>7.0</td>
<td>376.5</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td>(164.4)</td>
<td>(82.7)</td>
<td>(11.2)</td>
<td>(70.5)</td>
<td>(1.9)</td>
</tr>
<tr>
<td>Intransitive</td>
<td>1486.7</td>
<td>438.0</td>
<td>4.7</td>
<td>401.2</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>(165.2)</td>
<td>(61.4)</td>
<td>(3.7)</td>
<td>(56.6)</td>
<td>(1.1)</td>
</tr>
</tbody>
</table>

| **Late Intermediate Boundary** |          |      |               |              |              |
| H*         | H*       |      |               |              |              |
| NP         | V        | NP   |               |              |              |
| Transitive | 1468.8   | 323.1| 2.4           | 490.2        | 4.7          |
|            | (259.0)  | (83.6)| (0.4)         | (91.3)       | (1.5)        |
| Equi       | 1476.2   | 347.4| 2.9           | 490.3        | 5.4          |
|            | (181.9)  | (89.1)| (1.0)         | (37.9)       | (3.4)        |
| Intransitive | 1469.4   | 313.2| 2.8           | 503.2        | 4.4          |
|            | (266.9)  | (97.5)| (0.9)         | (79.2)       | (1.9)        |

**Figure 3.7: Summary of duration measurements for intermediate boundary stimuli**

Mean silent durations of less than eight milliseconds generally do not reflect silence. Rather, they reflect noise when marking adjacent offsets and onsets. Only two critical items, both in the early intermediate boundary condition, have true silences. The equi-bias item *When the animal strikes the dirt* contains a 42.2 ms gap between *strikes*...
and the. The transitive-bias item *Every time the person visits the nation* contains a 44.4 ms gap between visits and the. Even with these short silences, the three ToBI transcribers agreed that these critical items contained intermediate boundaries, not intonation boundaries. The fact that the shortest early intonation boundary (212.3 ms) is nearly five times longer than these short gaps supports that interpretation.

Two patterns emerge in Figure 3.6 and 3.7. First, ambiguous NP durations are always longest in the intransitive-bias conditions. Second, verb durations are always longest in the equi-bias conditions. These effects are not surprising given that the auditory stimuli contain different NPs and different verbs (i.e., the duration differences are most likely lexical).

The durations of the verbs and the ambiguous NPs demonstrate pre-boundary lengthening that is consistent with the locations of the early and late prosodic boundaries. Verbs are longer when they precede an early boundary (mean 540.4 ms, SD 135.3 ms) than when they precede no boundary (mean 337.4 ms, SD 83.7 ms). Ambiguous NPs are longer when they precede a late boundary (mean 567 ms, SD 104.4 ms) than when they precede no boundary (mean 412.2 ms, SD 68.6 ms).

The early and late silent durations are also consistent with the locations of the early and late prosodic boundaries. In the intonation phrase conditions, the mean duration of the early silence is 346.0 ms (SD 92.6 ms) in the early boundary condition, but only 3.8 ms (SD 1.0 ms) in the late boundary condition. The mean duration of the late silence is 334.3 ms (SD 156.6 ms) in the late boundary condition, but only 5.5 ms (SD 2.0 ms) in the early boundary condition. In the intermediate boundary conditions, there are essentially no silent durations. Mean durations are all 7.7 ms or less, and these values
generally reflect noise when marking adjacent offsets and onsets. The absence of lengthy silent durations is consistent with the presence of intermediate boundaries, which were primarily marked by pre-boundary lengthening.

Differences in the degree of pre-boundary lengthening are consistent with the intonation and intermediate boundary classification. As shown in Figure 3.8, there is a greater degree of pre-boundary lengthening with intonation phrase boundaries than with intermediate phrase boundaries. There is also evidence of pre-boundary lengthening for intermediate phrases relative to when the verbs and NPs in these stimuli are produced without a following boundary. In other words, when the boundary is late, the mean duration of the NP (but not the verb) steadily increases from no boundary to intermediate boundary to intonation boundary. When the boundary is early, the mean duration of the verb (but not the NP) steadily increases. Thus, it is not the case that duration differences can be simply attributed to the longer overall duration of intonation boundary fragments.

<table>
<thead>
<tr>
<th>Boundary</th>
<th>Mean Duration in ms (SD)</th>
<th>Boundary</th>
<th>Mean Duration in ms (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Verb</td>
<td>NP</td>
<td>Early</td>
</tr>
<tr>
<td>Late Intonation</td>
<td>347.0</td>
<td>639.4</td>
<td>649.0</td>
</tr>
<tr>
<td>(78.2)</td>
<td>(79.0)</td>
<td></td>
<td>(89.7)</td>
</tr>
<tr>
<td>Late Intermediate</td>
<td>327.9</td>
<td>494.6</td>
<td>431.9</td>
</tr>
<tr>
<td>(88.8)</td>
<td>(71.3)</td>
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<td>(69.5)</td>
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<tr>
<td>No Boundary</td>
<td>337.4</td>
<td>412.2</td>
<td>No</td>
</tr>
<tr>
<td>(83.7)</td>
<td>(68.6)</td>
<td></td>
<td>Boundary</td>
</tr>
</tbody>
</table>

Figure 3.8: Summary of pre-boundary lengthening effects
Also note that differences in the degree of pre-boundary lengthening provide evidence that the high phrase accents (H-) in the intermediate phrase conditions are high phrase accents and not high phrase accents followed by low boundary tones (L%). The two contours, H- and H-L%, are potentially ambiguous because the pitch contour is essentially high and flat in both cases (Beckman, 1996); that is, a low boundary tone doesn’t lower the fundamental frequency when it follows a high phrase accent. Had a L% followed the H- in the intermediate phrase conditions, the mean durations of the NP and verb would probably have more closely resembled the mean durations of the intonation phrase conditions. Instead, for each item, the duration of the NP and the duration of the verb were always longer at the intonation phrase boundary.

To ensure that verb bias did not influence the durations of the sound files in some unexpected way, a 2 (boundary type: intonation vs. intermediate) X 2 (boundary location: early vs. late) X 3 (verb bias: intransitive, equi, transitive) repeated measures ANOVA was conducted on the durations of the auditory fragments. There were main effects of boundary type (F[1,33] = 915.00, p < .01) and boundary location (F[1,33] = 18.07, p < .01), but these effects were qualified by an interaction of boundary type and location (F[1,33] = 18.53, p < .01). All remaining Fs < 1.5.

Two factors account for the reliable effects of boundary type and location. First, the lengthy silent durations following the intonation phrase boundaries made the intonation phrase stimuli significantly longer than the stimuli that contained only intermediate phrase boundaries. Second, there happened to be a greater degree of pre-boundary lengthening on the verb in the early boundary conditions (mean difference 302 ms; SD 11.4 ms) than pre-boundary lengthening on the ambiguous NP in the late
boundary conditions (mean difference 202.9, SD 17.6 ms), but only when the boundary was an intonation phrase. There were comparable degrees of pre-boundary verb lengthening (104.0 ms, SD -19.4 ms) and NP lengthening (106.7 ms, SD 3.5 ms) in the intermediate phrase conditions.

All stimulus files included any silence following an early or late boundary. Although the intermediate phrases were not marked by any measurable silent duration, the intonation boundary conditions had a mean silent duration of just over 300 ms. This is notable because the silent duration in the late intonation boundary conditions occurs at the end of the sound files. By preserving the silent duration at the end of these files, the same tonal and durational cues marked both early and late intonation boundaries.

### 3.3.4 Fundamental frequency analysis

Seven locations were estimated by eye and marked (using Praat) in the visible pitch contour of each auditory fragment (e.g., *Whenever the lady checks the room…*): the peak of the H* on the subject NP (e.g., *lady*); the beginning, middle, and end of the periodic regions of the verb; and the beginning, middle, and end of the periodic regions of the ambiguous NP.
When the verb consisted of more than one syllable (e.g., *questions, imitates, babysits, debates*), the beginning of the verb was marked in the middle of the periodic region of the first syllable. In the early boundary conditions, this syllable reflects the phrase accents (L-, H-), which spread leftward to the last pitch accent (H*). In the late boundary conditions, this syllable is simply unaccented. The middle of the verb was marked in the middle of the periodic region of the final syllable. The end of the verb was marked at the end of the periodic region in the final syllable. In the early boundary conditions, this syllable reflects the L-H% and H-. In the late boundary conditions, this syllable is again unaccented.

When the ambiguous NP consisted of two syllables (e.g., *answer, system*), the beginning location was marked in middle of the periodic region in the stressed syllable. The stressed syllable was always the first syllable, and it is the stressed syllable that is aligned to the H* pitch accent. The middle of the NP was marked in the middle of the periodic region in the final syllable. The end of the NP was marked in the end of the periodic region in the final syllable. In the early boundary conditions, the final syllable continues the H*. In the late boundary conditions, this syllable holds the L-H% and H-.

A Praat script automatically calculated the fundamental frequency (F₀) at each location. Figure 3.9 shows the mean fundamental frequency of each location by condition. The line corresponding to the early intonation phrase boundary condition (H* L-H% H*) is discontinuous because the speaker paused after the boundary tone (H%).
As expected, the mean values suggest contours for the intonation phrase (L-H%) conditions that have high-low-high patterns at different locations. When the intonation boundary occurs early, a “scoop” pattern tends to be realized over the subject NP and the verb. When the intonation boundary occurs late, this pattern tends to be realized over the ambiguous NP. The contours suggested for the intermediate phrase (H-) conditions are remarkably similar, but still consistent with the assigned prosody; the speaker never falls to a low.
Figure 3.10 contains the mean fundamental frequencies for the seven landmarks of the intonation boundary stimuli: the subject NP (e.g., *the lady*); the beginning, middle, and end of the verb (e.g., *checks*); and the beginning, middle, and end of the ambiguous NP (e.g., *the room*). Figure 3.11 contains measurements for the intermediate boundary stimuli.
<table>
<thead>
<tr>
<th>Region</th>
<th>Mean $F_0$ in Hertz (SD) by Region</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>beginning</td>
</tr>
<tr>
<td>NP Verb Ambiguous NP</td>
<td></td>
</tr>
<tr>
<td><strong>Early Intonation Boundary</strong></td>
<td></td>
</tr>
<tr>
<td>H* H*</td>
<td>NP V L-H%</td>
</tr>
<tr>
<td>Tran</td>
<td>271</td>
</tr>
<tr>
<td></td>
<td>(8)</td>
</tr>
<tr>
<td></td>
<td>220</td>
</tr>
<tr>
<td></td>
<td>(10)</td>
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<td>(11)</td>
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<td>217</td>
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<td></td>
<td>219</td>
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<td>Intran</td>
<td>249</td>
</tr>
<tr>
<td></td>
<td>(16)</td>
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<tr>
<td></td>
<td>175</td>
</tr>
<tr>
<td></td>
<td>(22)</td>
</tr>
</tbody>
</table>

Figure 3.10: Summary of $F_0$ measurements in intonation boundary stimuli
<table>
<thead>
<tr>
<th></th>
<th>beginning</th>
<th>middle</th>
<th>end</th>
<th>beginning</th>
<th>middle</th>
<th>end</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean F₀ in Hertz (SD) by Region</strong></td>
<td></td>
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<tr>
<td></td>
<td>NP</td>
<td>Verb</td>
<td></td>
<td>Ambiguous NP</td>
<td></td>
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<tr>
<td><strong>Early Intermediate Boundary</strong></td>
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<td></td>
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<tr>
<td>H*</td>
<td>H*</td>
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<tr>
<td>NP V ] H- NP</td>
<td>247</td>
<td>245</td>
<td>242</td>
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<td>235</td>
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<td></td>
<td>(7)</td>
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<td>Tran</td>
<td>250</td>
<td>246</td>
<td>243</td>
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<td>238</td>
<td>234</td>
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<td></td>
<td>(17)</td>
<td>(13)</td>
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<tr>
<td>Equi</td>
<td>247</td>
<td>243</td>
<td>241</td>
<td>244</td>
<td>240</td>
<td>233</td>
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<td>Intran</td>
<td>246</td>
<td>243</td>
<td>239</td>
<td>237</td>
<td>231</td>
<td>236</td>
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<td>(12)</td>
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<td>(16)</td>
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<tr>
<td>Late Intermediate Boundary</td>
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<td>H*</td>
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<tr>
<td>NP V ] H- NP</td>
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<td>243</td>
<td>239</td>
<td>237</td>
<td>231</td>
<td>236</td>
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<tr>
<td>Tran</td>
<td>245</td>
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<td>(14)</td>
<td>(12)</td>
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<td>(12)</td>
<td>(16)</td>
<td>(12)</td>
</tr>
<tr>
<td>Equi</td>
<td>245</td>
<td>244</td>
<td>238</td>
<td>237</td>
<td>226</td>
<td>229</td>
</tr>
<tr>
<td></td>
<td>(13)</td>
<td>(13)</td>
<td>(11)</td>
<td>(11)</td>
<td>(35)</td>
<td>(36)</td>
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<tr>
<td>Intran</td>
<td>245</td>
<td>244</td>
<td>239</td>
<td>236</td>
<td>233</td>
<td>236</td>
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<tr>
<td></td>
<td>(13)</td>
<td>(13)</td>
<td>(11)</td>
<td>(11)</td>
<td>(35)</td>
<td>(36)</td>
</tr>
</tbody>
</table>

**Figure 3.11:** Summary of F₀ measurements in intermediate boundary stimuli
As shown in Figure 3.10, the “scoop” pattern associated with the H* L-H% of the intonation boundary is realized across the subject NP and verb in the early boundary condition, regardless of verb bias. In the late boundary condition, the pattern is realized across the ambiguous NP, also regardless of verb bias. As expected, a comparable pattern does not appear in the intermediate boundary conditions in Figure 3.11. Values for the intermediate boundary conditions remained high regardless of verb bias.

3.4 Summary

Both the duration and fundamental frequency analyses suggest the critical materials were spoken with the intended prosodic contours. Early and late intonation boundaries were marked by pre-boundary lengthening, silent durations, and high-low-high pitch excursions. Early and late intermediate boundaries were marked predominantly by pre-boundary lengthening.
CHAPTER 4

PRETEST OF EXPERIMENT 1 STIMULI

4.1 Introduction

Visual and auditory pretests of the sentence fragments from Experiment 1 were conducted to obtain additional measures of verb bias. These measures complement the transitivity scores that were used initially to classify the verbs as transitive-bias, equi-bias, or intransitive-bias. These pretests also ensure that each fragment represents an acceptable sentence beginning and an acceptable spoken utterance.

Sentence fragments were judged on three factors: (1) the overall acceptability of the fragment presented visually through the disambiguating visual target (e.g., Whenever the lady checks the room it’s...), (2) the extent to which the auditory fragment (e.g., Whenever the lady checks the room) seemed to have been said as the speaker intended, and (3) the intelligibility of the last word in the auditory fragment (e.g., room).¹ The closure of the written fragment (visual target it’s or is) always matched the boundary of the auditory fragment (late or early). Participants completed all three ratings for each item.

¹ Commas were not included in the visual presentation.
in the order just described before moving on to the next item. Participants indicated their ratings as numbers on a scale from 1 to 7, and 7 was always at the high end of the scale (i.e., completely acceptable, said as intended, completely clear or intelligible).

Ratings of the overall acceptability of the visual fragments, in which the syntactic structure of the fragment was explicitly resolved, were predicted to be sensitive to verb bias. Such an effect would be consistent with reports in the literature demonstrating verb bias effects during reading (e.g., Garnsey, Pearlmutter, Myers, & Lotocky, 1997; MacDonald, 1994; Trueswell, 1996; Trueswell, Tanenhaus, & Kello, 1993). Fragments that were disambiguated with it’s were expected to require a transitive or late closure structure. Thus, these fragments were predicted to be rated as more acceptable as the transitivity bias of the verbs increased. In categorical terms, transitive-bias and equi-bias verbs in these late closure conditions were predicted to receive higher acceptability ratings than intransitive-bias verbs. Fragments that were disambiguated with is as the final word were expected to require an intransitive or early closure structure. These fragments were predicted to be rated as less acceptable as the transitivity bias of the verbs increased (i.e., transitive-bias verbs were predicted to receive lower acceptability ratings than equi-bias and intransitive-bias verbs). In addition, 14 filler items with number or gender mismatches were included to serve as unacceptable beginnings of sentences. Ratings for these items were predicted to be lower than ratings for critical items.

Ratings of whether the auditory fragments seemed to be said as the speaker intended were predicted to be high for all critical materials. This is because the location

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2 The sentence completions obtained during the main experiments suggest that is does not necessarily disambiguate to an early closure structure.
of the prosodic boundary always matched the syntactic structure of the written fragment (i.e., utterances with late boundaries followed late closure fragments and utterances with early boundaries followed early closure fragments). Thus, this auditory rating reflects the appropriateness of each utterance given a particular syntactic structure.

In comparison to the critical items, 14 filler items with unlikely boundary locations (e.g., The young girls) were predicted to receive low acceptability ratings. Auditory acceptability ratings were not necessarily predicted to be sensitive to verb bias. Because participants rated the productions immediately after seeing and rating the written fragment with its disambiguating word it’s or is, participants were expected to pay more attention to the prosodic phrasing or to the way the words sounded and less attention to whether the transitivity bias of the verb was met.

Finally, ratings of the intelligibility of the final word of the auditory fragment were predicted to be high for all critical materials. By comparison, 10 filler items that were poorly truncated were predicted to receive low ratings.

4.2 Method

4.2.1 Participants

Thirty students from undergraduate linguistics classes at Ohio State University received course credit in exchange for their participation.
4.2.2 Materials

Each of two lists contained the entire set of 36 critical fragments randomized with 98 fillers. The order of presentation was the same across lists. Critical fragments on a list always had the same syntactic structure (i.e., all ended in it’s or all ended in is) and a matching boundary location (i.e., a late intonation boundary for it’s and an early intonation boundary for is).

Of the 98 fillers, 14 contained mismatches in number (e.g., Whenever the partner are) or gender (e.g., Of the daddies she’s). An additional 14 contained unlikely boundary locations (e.g., The young L-L% girls). Ten more were truncated prematurely so that the final word or a portion of that word was deleted.

4.2.3 Procedure

Pretesting was conducted in a quiet room in groups of up to four, and participants were assigned to separate PCs. E-Prime was used to present visual stimuli on the computer screens and auditory stimuli binaurally over headphones.

During the task, the numbers in the 1 to 7 scale always appeared in the middle of the computer screen with their respective end labels. Accompanying text (i.e., the end labels, the written sentence fragment, and the final word) appeared above the scale.

Each trial in the pretest had the same sequence of events. First, a written fragment (e.g., Whenever the lady checks the room it’s) appeared at the top of the computer screen. Participants rated how acceptable it was as the beginning of a sentence. As soon as participants rated the written version, it disappeared and the auditory fragment with the matching boundary location played (e.g., Whenever the lady checks the roomL-H%). Participants rated to what extent they thought the speaker had said the fragment as she
intended. As soon as they rated the auditory fragment, the last word of the fragment appeared at the top of the screen in capital letters (e.g., ROOM), and the auditory fragment played a second time. Participants rated the intelligibility of that last word.

Participants were instructed to use the full range of the scale when making their judgments, and they were instructed to use the linear row of number keys at the top left of the keyboard to enter their responses. Participants completed a five-trial practice session before proceeding to the main experiment. The entire session took less than an hour.

4.3 Results

4.3.1 Written fragment ratings

Figure 4.1 summarizes the mean acceptability ratings of the visually-presented late closure (e.g., *Whenever the lady checks the room it’s...*) and early closure (e.g., *Whenever the lady checks the room is...*) fragments.

<table>
<thead>
<tr>
<th>Syntactic Closure</th>
<th>Transitive</th>
<th>Equi</th>
<th>Intransitive</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late</td>
<td>5.41</td>
<td>5.36</td>
<td>5.32</td>
<td>5.36</td>
</tr>
<tr>
<td></td>
<td>(1.13)</td>
<td>(1.01)</td>
<td>(1.04)</td>
<td>(1.04)</td>
</tr>
<tr>
<td>Early</td>
<td>4.16</td>
<td>4.71</td>
<td>4.99</td>
<td>4.62</td>
</tr>
<tr>
<td></td>
<td>(1.37)</td>
<td>(1.38)</td>
<td>(1.42)</td>
<td>(1.40)</td>
</tr>
</tbody>
</table>

*Figure 4.1: Mean acceptability ratings (and standard deviations) of visually-presented early and late closure fragments from Experiment 1 (1 = completely unacceptable, 7 = completely acceptable)*
The results in Figure 4.1 demonstrate that, consistent with the prediction for the late closure fragments, intransitive-bias verbs received numerically lower ratings than equi-bias and transitive-bias verbs. However, these numerical differences are clearly quite small, and the results of planned comparisons between the transitive-bias condition and (1) the mean of the intransitive- and equi-bias conditions and (2) the equi-bias condition failed to find any significant differences (all Fs < 1.2).

In contrast, the prediction for the early closure fragments was supported. The intransitive-bias and equi-bias conditions were rated as significantly more acceptable than the transitive-bias condition. In planned comparisons, transitive-bias fragments were rated as significantly less acceptable than the average of intransitive-bias and equi-bias fragments (F[1,14]=13.52, p < .01), and they were rated as significantly less acceptable than equi-bias fragments alone (F[1,14]=5.81, p < .05). All planned comparisons were conducted using contrast analysis freeware called PSY: A Program for Contrast Analysis (Bird, Hadzi-Pavlovic, & Isaac; www.psy.unsw.edu.au/research/PSY.htm). The current comparisons used data from the late closure or early closure conditions only. In this way, error terms were calculated over just one type of closure ratings, and separate error terms were calculated for each contrast.

The pattern of correlations between verb bias and acceptability ratings further demonstrates that verb bias influenced the acceptability of the written fragments, but only in the early closure conditions. As shown in Figure 4.2, the early closure conditions showed a moderate, predicted negative correlation ($R^2 = -.18$, $F[1,32]=7.183$, $p = .01$). Fragments were rated as better sentence beginnings as transitivity bias decreased. The late closure conditions showed practically no correlation ($R^2 = .02$, $F < 1.0$).
Figure 4.2: Correlations between verb bias and acceptability of visually-presented early and late closure fragments from Experiment 1
While verb bias clearly influenced acceptability ratings in the early closure conditions, the same could not be said of the late closure conditions. The absence of the predicted verb bias effect in the late closure conditions might be due to a late closure bias. The results of subject- and item-based 2 (Closure: late and early) X 3 (Verb Bias: intransitive, equi, and transitive) repeated measures ANOVAs showed that late closure fragments were rated as more acceptable as sentence beginnings than early closure fragments. The main effect of closure was marginal by subjects (F1[1,28]=2.93, p = .10) and reliable by items (F2[1,33]=85.39, p < .01). Because the late closure scores represent a narrower range of scores, it is possible that there is simply less range for the verb bias effect to manifest itself.

During a debriefing session after the experiment, some participants volunteered that they based their visual ratings on how easily they could think of a completion. Thus, the late closure bias might indicate that it is easier for participants to think of a completion for the contraction *it’s* in the context of an unambiguous late closure structure than it is for them to think of a modifier interpretation for an NP (e.g., *the door*) in the context of an unambiguous early closure structure. To guard against such an effect influencing reaction times to naming *it’s* and *is* in the main experiment, participants in the main experiment are instructed (just as in Kjelgaard and Speer, 1999) to name the target as quickly as possible and not to wait until they have thought of a completion.

Finally, critical fragments (mean 4.99, SD 1.28) were rated as more acceptable than fragments that contained number or gender mismatches (e.g., *All the parents is;*

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3 Huynh-Feldt (Huynh & Feldt, 1976) adjusted probability values are reported in all repeated measures analyses with unadjusted degrees of freedom.
mean 3.06, SD 1.40). The difference in means is statistically significant by subjects (t1[148]=8.70, p < .01) and by items (t2[98]=13.65, p < .01). All critical items received an average rating of 3.5 or higher on the 1-7 scale, with the exception of *If the couple reads the verse is*. It received a slightly lower mean of 3.2.

### 4.3.2 Spoken fragment ratings

Participants were asked to judge to what extent they thought that the speaker said the fragment as she intended. Figure 4.3 summarizes the mean acceptability ratings for the spoken versions of the late intonation boundary and early intonation boundary fragments.

<table>
<thead>
<tr>
<th>Prosodic Boundary</th>
<th>Verb Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transitive</td>
</tr>
<tr>
<td>Late</td>
<td>5.13</td>
</tr>
<tr>
<td></td>
<td>(1.51)</td>
</tr>
<tr>
<td>Early</td>
<td>4.84</td>
</tr>
<tr>
<td></td>
<td>(1.41)</td>
</tr>
</tbody>
</table>

*Figure 4.3: Mean acceptability ratings (and standard deviations) of spoken intonation boundary fragments (1 = not said as intended, 7 = said as intended)*

In contrast to the results from the visual ratings, the results in Figure 4.3 do not suggest a late closure (or rather late boundary) bias. Not surprisingly, there was no effect of boundary in the results of subject- and item-based 2 (Boundary: late and early) X 3 (Verb Bias: intransitive, equi, and transitive) repeated measures ANOVAs (Fs < 1.2).
Even though these ratings were not predicted to be sensitive to verb bias, post hoc Tukey comparisons were conducted between the two boundary conditions at each level of verb to follow up reliable verb by boundary interactions ($F1[2,56]=8.81, p < .01$; $F2[2,33]=4.05, p < .05$). Even though none of the comparisons was significant (all $t’s < 2$), it is worth noting that the conditions in which boundary location and verb bias conflicted (late boundary intransitive bias and early boundary transitive bias) elicited the lowest acceptability ratings.

As one final check of verb bias, correlations between transitivity bias and acceptability ratings were conducted even though effects were not predicted to be robust. In the late boundary conditions, a weak positive correlation between transitivity bias and acceptability was nonsignificant ($R^2 = 0.07, F[1,32]=2.40, p = .13$). In the early boundary conditions, a weak negative correlation suggested that acceptability scores might have decreased as transitivity bias increased ($R^2 = -0.10, F[1,32]=3.54, p = .07$). These patterns resemble the ones from the acceptability ratings for written fragments.

Lastly, critical fragments were rated as significantly more acceptable than the fragments that contained a boundary in an unlikely location (e.g., *The young girls*) both by subjects ($t1[58]=8.40, p < .01$) and by items ($t2[98]=32.29, p < .01$). Whereas the mean for critical items was 5.06 with scores ranging from 3.80 to 6.00, the mean for items with an unpredictable boundary was 2.19 with scores ranging from 1.67 to 3.73. Thus, the stimuli represent acceptable renditions of the intended utterances.
4.3.3 Final word intelligibility ratings

In this stage of pretesting, participants were asked to rate the intelligibility of the last word in the auditory fragment. The means were subjected to subject- and item-based 2 (Boundary: late and early) X 3 (Verb Bias: intransitive, equi, and transitive) repeated measures ANOVAs. Figure 4.4 summarizes the scores by condition.

<table>
<thead>
<tr>
<th>Prosodic Boundary</th>
<th>Transitive</th>
<th>Equi</th>
<th>Intransitive</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late</td>
<td>6.26 (0.61)</td>
<td>6.19 (0.50)</td>
<td>6.18 (0.54)</td>
<td>6.21 (0.54)</td>
</tr>
<tr>
<td>Early</td>
<td>5.09 (0.99)</td>
<td>5.32 (1.15)</td>
<td>5.33 (1.01)</td>
<td>5.25 (1.04)</td>
</tr>
</tbody>
</table>

Figure 4.4: Mean intelligibility ratings (and standard deviations) of the final word in spoken intonation boundary fragments (1 = completely unclear, 7 = completely clear)
Not surprisingly, the late boundary conditions were rated as more intelligible than the early boundary conditions both by subjects (F1[1,28]=10.66, p < .01) and by items (F2[1,33]=167.83, p < .01). Whereas the final word in the late boundary conditions was followed by silence and influenced by phrase final lengthening, the final word in the early boundary conditions was truncated midphrase. Fortunately, the final words in the early boundary critical items (mean 5.25, SD 1.04) were rated on the high end of the scale and as significantly more intelligible than items on the same list that had been truncated prematurely (mean 2.83, SD 1.31) both by subjects (t1[28]=5.64, p < .01) and by items (t2[44]=14.52, p < .01). All critical items received an average rating of 4.67 or higher on the 1-7 scale.

The only other effect to report from the ANOVAs was a marginal verb by boundary interaction in the subjects analysis (F1[2,56]=2.87, p = .07; F2[2,33]=1.92, p = .16). Because the main effect of boundary already demonstrated that late boundary conditions were rated as more intelligible than early boundary conditions, two post hoc Tukey comparisons were conducted, each within one level of boundary. Neither comparison of the transitive-bias fragments to the equi- and intransitive-bias fragments was significant (all t’s < 2.06).

4.4 Discussion

Overall, the auditory fragments for Experiment 1 earned ratings on the acceptable end of the scale in pretests of written acceptability, spoken intention, and final word intelligibility. While fragments demonstrated a possible late closure bias in the visual ratings, no such bias was evident in the auditory ratings.
CHAPTER 5

EXPERIMENT 1: VERB BIAS AND INTONATION BOUNDARIES

5.1 Introduction

Experiment 1 investigates whether the location of an intonation phrase boundary interacts with the transitivity bias of a verb during auditory processing of early/late closure ambiguities. An example ambiguity is shown in (1) – (2). The fragment in (1) is ambiguous because the noun phrase (NP) the room could either be the direct object of the verb checks, as in the late closure structure in (2a), or the subject of the main clause, as in the early closure structure in (2b). These syntactic structures, as well as representations of the early and late prosodic boundaries, are also shown in Figures 5.1 and 5.2.

(1) Whenever the lady checks the room...

(2a) Whenever the lady checks the room it's cold.

(2b) Whenever the lady checks the room is cold.
Whenever the lady checks the room

Late boundary:  [ ........................................................... ]_{ip} \ IP

Early boundary: [ .............................................. ]_{ip} \ IP [ ................. ]

**Figure 5.1: Direct object (late closure) syntax with late and early intonation phrase boundaries (ip = intermediate phrase, IP = intonation phrase)**

Whenever the lady checks the room

Early boundary:  [ .............................................. ]_{ip} \ IP [ ................. ]

Late boundary:  [ ........................................................... ]_{ip} \ IP

**Figure 5.2: Subject (early closure) syntax with early and late intonation phrase boundaries (ip = intermediate phrase, IP = intonation phrase)**
In this cross-modal naming experiment, three independent variables are manipulated. The first variable is the transitivity bias of the verb. As discussed in Chapter 3, verbs are classified into three bias groups: transitive, equi, or intransitive. The second variable is the location of a high intonation phrase boundary (H%). Early intonation boundaries occur just after the verb (e.g., *Whenever the lady checks* ]L-H% the room). Late intonation boundaries occur just after the ambiguous NP (e.g., *Whenever the lady checks the room* ]L-H%). A low intermediate phrase accent (L-) accompanies both boundaries. The third variable is the visual target (*it’s* or *is*). *It’s* is intended to resolve the ambiguity in favor of a transitive or late closure structure. *Is* is intended to resolve the ambiguity in favor of an intransitive or early closure structure.

The extent to which the visual targets resolved critical items in these predicted directions will be addressed in the results and discussion. For now, suffice it to say that *it’s* is also compatible with an early closure topicalized NP structure (e.g., *Whenever the lady checks, the door—it’s locked*). *Is* is also compatible with a late closure time reference or event reading (e.g., *Whenever the lady checks the room is when she expects to find someone there; When the kid cleans the track is Tuesday*) or a late closure question structure (e.g., *Whenever the lady checks the room is someone there?*).

Experiment 1 tests the three processing accounts described in Chapter 2: the traditional garden path model, Schafer’s (1997) prosody-first account, and the phon-concurrent model, a version of Boland’s (1997) concurrent model newly modified to incorporate prosodic phrasing. Each of these accounts assumes different underlying mechanisms for the integration of prosodic, syntactic, and semantic representations, and each makes different predictions about how the stimuli will be processed.
5.2 Processing predictions

5.2.1 Traditional garden path model

According to the traditional garden path model (e.g., Frazier, 1990; Frazier & Clifton, 1996), the parser should build a direct object structure for the ambiguous structures being tested here because adding a direct object is more economical than opening a new clause. Because the ambiguous NPs are always plausible direct objects, the thematic processor should have no trouble assigning thematic relations that match the direct object structure. Thus, the traditional garden path model predicts a main effect of target, and naming times to it’s should be shorter than naming times to is.

It is worth noting that the predictions of the garden path model are also consistent with the claim that argument structure influences the initial parse (Ferreira & McClure, 1997). Assigning the structurally ambiguous NP to direct object position allows the verb to assign agent and theme roles, which maximizes the argument structure of the verb.

5.2.2 Schafer’s (1997) prosody-first account

According to Schafer’s (1997) interpretive domain hypothesis, intonation boundaries trigger wrap-up of any outstanding semantic or pragmatic processing. According to her prosodic visibility hypothesis, intermediate boundaries decrease visibility between a node that needs to be attached and any potential attachment sites. These hypotheses as Schafer applied them to the garden path model predict the following interaction between boundary location and visual target.

In the late boundary conditions, the verb and the ambiguous NP are both prosodically visible, and late closure applies. The parser builds the direct object structure and sends it to the thematic processor. Because each verb can be used transitively and
because each ambiguous NP is a plausible direct object, the thematic processor assigns the theme role to the ambiguous NPs regardless of verb bias. The intonation boundary at the right edge of the ambiguous NP commits the semantic processor to the direct object interpretation for each verb. The visual target is triggers reanalysis because it cannot be integrated into the existing structure. Under this account, naming times to it's should be shorter than naming times to is.

In the early boundary conditions, the parser incorporates the verb into its existing syntactic structure and sends the structure in Figure 5.3 to the semantic processor.

![Figure 5.3: Representations at the verb in early boundary conditions in Schafer’s (1997) account (ip = intermediate phrase, IP = intonation phrase)](image)

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1 It turns out that for many participants in the current experiments, it is possible to integrate is into the late boundary late closure structure at least some of the time. (See Sections 5.4.1 and 5.4.2.)
At the semantic processor, the intonation boundary forces interpretation. One possibility is that the absence of any overt NP forces an intransitive interpretation for each verb. A second possibility is that the interpretation reflects the transitivity bias of the verb (i.e., the thematic processor anticipates the most likely set of thematic relations). For the set of intransitive-bias verbs, this would entail assigning the agent role to the subject and committing to the argument structure that does not include a theme role. For the set transitive-bias verbs this would entail assigning the agent role to the subject and committing to the argument structure that involves assigning a theme.\(^2\) Within the set of equi-bias verbs, few verbs are strongly biased toward a transitive or intransitive use. As a result, the absence of a direct object would probably lead to an intransitive interpretation for most.

At the ambiguous NP, the early intermediate phrase reduces visibility between the NP and the existing syntactic structure. Because of this, the NP is not incorporated into the structure before the target appears. If the visual target is appears, the NP and target should be visible, and the early closure (subject) structure should be constructed via grammatical rules. This structure should be sent to the thematic processor, which assigns the appropriate thematic roles for the structure. If the thematic processor committed to an intransitive interpretation for each verb, no reanalysis should be required. If the thematic processor committed to a theme assignment for the transitive-biased verbs, then a conflict should arise. The thematic processor should have to reevaluate its transitive interpretation.

\(^2\) The interpretation might also depend in part on the phrase accent/boundary tone sequence. For example, the L-H% used in the current materials is sometimes referred to as a continuation rise, an indication that there is more to come. One hypothesis is that a L-H% leads to a transitive interpretation for transitive verbs (perhaps in anticipation of a heavy NP), while a L-L% leads to an intransitive interpretation for all verbs.
to match the intransitive structure. This predicts increased naming times for *is* in the early boundary transitive-bias conditions relative to the early boundary equi-bias and intransitive-bias conditions. Although the thematic processor could theoretically trigger reanalysis to the direct object structure, this seems unlikely given the combination of an early boundary and an *is* target. Such factors are accessible during reanalysis, and they would most likely contribute to an early closure structure and interpretation.

If the visual target *it’s* appears, it should be difficult for the parser to integrate the ambiguous NP and target. However, it should also be difficult for the parser to build the direct object structure given decreased visibility. When the parser does build the direct object structure, the prosodic boundary should conflict with the syntax. Naming times to *it’s* should be longer than naming times to *is*.

If the thematic processor committed to an intransitive interpretation for all verbs, a conflict should arise when it finally receives the direct object structure. On the one hand, the thematic processor might be forced to reanalyze its thematic assignments to match the direct object structure (i.e., “the structurally favored constituent structure,” Frazier, 1990). On the other hand, all information becomes available during reanalysis. Thus, semantic commitment to an intransitive interpretation and the location of the early boundary might cause the parser to reanalyze its direct object structure into the topicalized NP structure in Figure 5.4. Although this structure is syntactically complex, it is the best match for the prosodic, syntactic, and semantic representations. Of course, if the thematic processor committed to assigning a theme for the transitive-bias verbs, then a direct object structure would not trigger semantic reanalysis. There would simply be increased reaction times due to the prosody/syntax mismatch.
Whenever the lady checks the room, it’s

Figure 5.4: Example of topicalized NP tree structure with an early intonation phrase boundary (ip = intermediate phrase, IP = intonation phrase)

In terms of overall reaction times, Schafer’s (1997) account makes the following predictions: In the late boundary conditions, naming times to it’s should be shorter than naming times to is, and is should trigger syntactic (and semantic) reanalysis. In the early boundary conditions, naming times should be longer for it’s than is.

Schafer’s (1997) prosody-first account makes two additional sets of predictions. First, naming times should reflect the influence of verb bias on reanalysis. As a result,

- Naming times to is in the late boundary condition should increase as transitivity increases for all verbs because of syntactic and semantic reanalysis to the subject structure.
• Naming times to *is* in the early boundary condition should increase as transitivity increases for transitive-bias verbs if there is semantic reanalysis to an intransitive interpretation.

• Naming times to *it’s* in the early boundary condition should decrease as transitivity increases for intransitive-bias verbs or all verbs if the semantic processor reanalyzes intransitive interpretations to match direct object structures.

• Naming times to *it’s* in the early boundary condition should increase as transitivity increases for intransitive-bias verbs if the parser reanalyzes direct object structures into topicalized NPs.

Second, prosodic visibility predicts that naming times should be shorter overall in the early boundary conditions because the ambiguous NP and target are more visible than in the late boundary conditions. Of course, such an effect might be most robust in the conditions that do not require reanalysis. If so, naming times to *it’s* should be longer in the late boundary conditions than naming times to *is* in the early boundary equi-bias and intransitive-bias conditions (and also in the transitive-bias condition if semantic or syntactic reanalysis is not required).

5.2.3 The phon-concurrent model

This constraint-based model predicts a three-way interaction among verb bias, prosodic boundary location, and visual target. At the verb in all conditions, a direct object structure and a subject structure are automatically generated and weighted by frequency. This means that both structures are equally accessible for equi-bias verbs. The semantic processor assigns the agent role to the grammatical subject in all verb conditions and anticipates a theme in the transitive-bias conditions.
At the ambiguous NP in the late boundary conditions, the late boundary aligns with the direct object structure, but not the subject structure. As shown in the direct object structure in Figure 5.1, the lexical string *Whenever the lady checks the room* is contained within the ip (and the IP) and within a completed syntactic constituent (i.e., S-bar). However, in the subject structure in Figure 5.2, the lexical string never corresponds to a completed syntactic constituent. In addition, additional boundaries from the upcoming prosodic representation cannot fix the misalignment. As a result, the late boundary adds weight to the direct object structure only.

Because the structurally ambiguous NP is plausible as a direct object and the intonation boundary forces commitment to an interpretation, the semantic processor assigns the theme role in all verb conditions. This information is sent to the syntactic processor, which selects the direct object structure. Thus, naming times to *it’s* should be shorter than naming times to *is* in the late boundary conditions, and *is* should require syntactic reanalysis.

At the verb in the early boundary conditions, direct object and subject structures are again automatically generated and weighted by frequency. This time the early boundary is a better match for the subject structure than the direct object structure.

As shown in the subject structure in Figure 5.2, the lexical string *Whenever the lady checks* is contained within the ip (and IP) and within a completed syntactic constituent (i.e., an S-bar). The lexical string *the room* is contained within an incomplete ip (and IP) and within an incomplete syntactic constituent (i.e., an S). Although *the room* also corresponds to a completed syntactic constituent (i.e., an NP), nothing in the grammar requires a prosodic boundary at every syntactic boundary. So long as there is at
least one incomplete syntactic constituent corresponding to the incomplete prosodic phrase, goodness-of-fit between the prosodic representation and the subject structure should be high.

Note, however, that the early ip boundary should also add some weight to the direct object structure in Figure 5.1, just not as much weight as it added to the subject structure in Figure 5.2. The early ip boundary should add weight to the direct object structure because a later boundary, one following a heavy NP, is possible. Indeed, because the room is uttered mid-prosodic phrase, there would have to be a heavy NP (e.g., NP + PP, NP + relative clause) to make the phrasing felicitous. This later boundary would allow the lexical string—through the heavy NP—to be contained within two intermediate phrases and one completed syntactic constituent.3

As a result of the goodness-of-fit between the prosodic representation and the syntactic alternatives, the early boundary should add more weight to the subject structure than the direct object structure. In the case of intransitive-bias and equi-bias verbs, the subject structure is the stronger competitor. In the case of the transitive-bias verbs, the subject structure is probably only as strong as the direct object structure. As just explained, the early boundary does not rule out the direct object structure given that an early boundary is appropriate in a late closure structure if it occurs before a heavy NP (e.g., Whenever the lady loads the van that she bought last year] she packs it full).

3 Although goodness-of-fit is described as a constraint involving intermediate phrases, work by Carlson, Clifton, and Frazier (2001) and Schafer, Speer, Warren, and White (2000) suggests that the post-NP boundary under discussion should be of equal or greater strength (i.e., an IP in the current example). It remains to be seen whether an ip in this position is indeed infelicitous and whether the wrap-up effects of IPs can account for processing phenomena that rely on relative break size.
In terms of semantic processing, the intonation boundary forces commitment to an interpretation. With respect to the verbs in the current materials, this involves commitment to an argument structure. For the intransitive- and transitive-bias verbs, the interpretation is consistent with their verb biases. The thematic processor anticipates assigning a theme for the transitive-bias verbs, but abandons the theme role for the intransitive-bias verbs. For the equi-bias verbs, the semantic processor is influenced by the strongest syntactic representation (i.e., the subject structure), and it again commits to the argument structure that does not include a theme role.

At the NP, verb bias still matters. For the intransitive- and equi-bias verbs, the subject structure is the strongest syntactic competitor, and the semantic processor has committed to an interpretation that does not include a theme. When the NP appears, it is attached into the subject structure as the main clause subject. The NP is also attached as a direct object into a weak direct object structure. However, this structure is too weak to be selected, and it is inconsistent with the semantic representation. If the visual target *is* appears, it will be attached into the subject structure. If *it’s* appears, the topicalized NP structure will become most active. This is the structure that best matches the boundary location information, the lexical content, and the commitment to not assigning a theme.

In the case of the transitive-bias verbs, the semantic processor has committed to assigning a theme, and the direct object structure is probably slightly more active than the subject structure. When the NP appears, it is attached as the direct object, and it receives the theme role. The NP is also attached as the subject of the main clause in a weak subject structure. However, this structure is not as strong as the direct object structure, and the thematic processor, which supports only one semantic representation, has already
assigned the theme role. If the visual target it’s appears, the target matches this structure and interpretation. However, the absence of a heavy NP results in a prosody/syntax mismatch. This should increase reaction times and/or trigger reanalysis to a topicalized NP structure and interpretation. If the visual target is appears, the target should trigger reanalysis to the intransitive structure and interpretation.

In sum, in the late boundary conditions, naming times to it’s are predicted to be shorter than naming times to is, and is should require syntactic reanalysis. In the early boundary equi-bias and intransitive-bias conditions, naming times to is are predicted to be shorter than naming times to it’s, and it’s should trigger reanalysis. In the early boundary transitive-bias conditions, naming times to it’s and is should both be long albeit for different reasons.

The phon-concurrent model makes one additional prediction. Because verb bias always influences the availability of syntactic alternatives, naming times in all conditions should be correlated with transitivity bias. For example, whenever the target requires the subject structure (is), overall naming times should increase as verbs occur more frequently with a direct object structure, even in the early boundary conditions.

The pattern of correlations in this constraint-based account might actually turn out to be more complicated than that just described. More specifically, Garnsey, Pearlmutter, Myers, and Lotocky (1997) found that verb bias had an influence on reading time, but only when plausibility supported the less frequent structural alternative. When intransitive-bias verbs were used with plausible direct objects in structures that required an intransitive use, reading time increased as the verbs occurred more frequently with direct objects. In contrast, transitivity bias had little effect on reading time when
intransitive-bias verbs were used with implausible direct objects in structures that required an intransitive use. Likewise, when transitive-bias verbs were used with implausible direct objects in structures that required an intransitive use, reading time decreased as the verbs occurred more frequently without direct objects. Intransitivity bias, however, had little effect on reading time when transitive-bias verbs were used with plausible direct objects in structures that required an intransitive use. Garnsey et al. interpreted this pattern of correlations as evidence of competing structural alternatives because these correlations were observed when the overall reading times did not indicate any processing difficulty or reanalysis.

In Experiment 1, the ambiguous NP is always a plausible direct object. Thus, naming times to *is* with intransitive-bias verbs in early boundary conditions most closely resemble the Garnsey, Pearlmutter, Myers, and Lotocky (1997) situation. Naming times should increase as the verbs occur more frequently with direct objects. Although naming times to *is* with intransitive-bias verbs in late boundary conditions also represent a situation in which the plausible NP supports the less frequent structural alternatives, any correlation in this condition is likely to reflect reanalysis.

5.2.4 Summary of predictions

Figure 5.5 summarizes the predicted pattern of overall naming times for each processing account. For the garden path model, naming times to *it’s* should always be shorter than naming times to *is*. For Schafer’s (1997) prosody-first account, naming times to *it’s* should be shorter than naming times to *is* in late boundary conditions, but longer than naming times to *is* in the early boundary conditions. For the phon-concurrent model, naming times to *it’s* should be shorter than naming times to *is* in the late boundary
conditions. In the early boundary transitive-bias conditions, naming times for *it’s* and *is* should be comparable. In the early boundary intransitive-bias and equi-bias conditions, naming times to *is* should be shorter than naming times to *it’s*.

A critical distinction between Schafer’s (1997) account and the phon-concurrent model concerns the patterns of correlations. In Schafer’s account, correlations are only predicted for reanalysis conditions. For example, naming times should decrease as transitivity bias decreases given reanalysis from a late closure structure to an early closure structure. In the phon-concurrent model, correlations are also predicted for non-reanalysis conditions. For example, naming times should decrease as transitivity bias increases given an initial late closure structure, and naming times should decrease as transitivity bias decreases given an initial early closure structure.

<table>
<thead>
<tr>
<th>Processing Accounts</th>
<th>Predicted Overall Naming Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Garden Path Model</td>
<td>IT’S &lt; IS</td>
</tr>
<tr>
<td>Schafer’s (1997) Prosody-First Account</td>
<td>Late Boundary: IT’S &lt; IS</td>
</tr>
<tr>
<td></td>
<td>Early Boundary: IS &lt; IT’S</td>
</tr>
<tr>
<td>Phon-Concurrent Model</td>
<td>Late Boundary: IT’S &lt; IS</td>
</tr>
<tr>
<td></td>
<td>Early Boundary (Tran): IT’S = IS</td>
</tr>
<tr>
<td></td>
<td>Early Boundary (Intran/Equi): IS &lt; IT’S</td>
</tr>
</tbody>
</table>

**Figure 5.5: Summary of predicted naming times in Experiment 1 for each processing account**
5.3 Method

5.3.1 Participants

One hundred students from undergraduate linguistics classes at Ohio State University participated in exchange for course credit.

5.3.2 Materials

The conditions and example stimuli for Experiment 1 are summarized in Figure 5.6. As discussed in Chapter 3, the 36 critical items are arranged into groups of three (one item for each verb bias condition). The verbs within a group are matched on number of syllables, and with one exception, on stress pattern. The ambiguous NPs in each group are also matched on number of syllables, frequency (high/low), stress pattern, and final segment (+/- stop). Appendix A contains a complete list of critical items organized by group. See Chapter 3 for a discussion of the verb bias variable and for acoustic analyses of the auditory stimuli. See Chapter 4 for a discussion of pretests of the stimuli.
<table>
<thead>
<tr>
<th>Verb Bias</th>
<th>Prosodic Boundary</th>
<th>Auditory Fragment with Prosodic Contour</th>
<th>Visual Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tran</td>
<td>Late</td>
<td>Whenever the lady loads the car</td>
<td>it's is</td>
</tr>
<tr>
<td>Equi</td>
<td>Late</td>
<td>Whenever the lady checks the room</td>
<td>it's is</td>
</tr>
<tr>
<td>Intran</td>
<td>Late</td>
<td>Whenever the lady moves the door</td>
<td>it's is</td>
</tr>
<tr>
<td>Tran</td>
<td>Early</td>
<td>Whenever the lady loads the car</td>
<td>it's is</td>
</tr>
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<td>it's is</td>
</tr>
<tr>
<td>Intran</td>
<td>Early</td>
<td>Whenever the lady moves the door</td>
<td>it's is</td>
</tr>
</tbody>
</table>

**Figure 5.6: Summary of conditions and example stimuli for Experiment 1**

There are twelve conditions in this 3 (Verb Bias: Intransitive, Equi, Transitive) X 2 (Prosodic Boundary: Late, Early) X 2 (Syntactic Target: Late *it’s*, Early *is*) design. The conditions rotate across four lists in the Latin square design shown in Figure 5.7. Prosodic boundary and syntactic target rotate as between-subjects variables, and they are counterbalanced across lists. Verb bias is a between-items variable. There are three observations per cell per list.
Verb Bias-Prosodic Boundary-Syntactic Closure Combinations

<table>
<thead>
<tr>
<th>List 1</th>
<th>List 2</th>
<th>List 3</th>
<th>List 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tran-Early-Late</td>
<td>Tran-Early-Early</td>
<td>Tran-Late-Late</td>
<td>Tran-Late-Early</td>
</tr>
<tr>
<td>Equi-Early-Early</td>
<td>Equi-Late-Late</td>
<td>Equi-Late-Early</td>
<td>Equi-Early-Late</td>
</tr>
<tr>
<td>Intran-Late-Late</td>
<td>Intran-Late-Early</td>
<td>Intran-Early-Late</td>
<td>Intran-Early-Early</td>
</tr>
<tr>
<td>Tran-Late-Early</td>
<td>Tran-Early-Late</td>
<td>Tran-Early-Early</td>
<td>Tran-Late-Late</td>
</tr>
<tr>
<td>Equi-Early-Late</td>
<td>Equi-Early-Early</td>
<td>Equi-Late-Late</td>
<td>Equi-Late-Early</td>
</tr>
<tr>
<td>Intran-Early-Early</td>
<td>Intran-Late-Late</td>
<td>Intran-Late-Early</td>
<td>Intran-Early-Late</td>
</tr>
</tbody>
</table>

Figure 5.7: Rotation of conditions across lists (horizontal lines separate groups of matched items)

Although participants encounter all three items from a group, several factors should minimize the chance that a participant will notice similarities across sentences. First, participants encounter these items in different conditions. Second, each group contains a generic subject NP (e.g., the lady, the man, the child), as opposed to occupations or proper names that might make sentences from the same group more memorable. Third, the ambiguous NP changes within a group as the verb changes in order to ensure that the NP is a plausible direct object for the verb.
The 36 critical items on each list are randomized with 70 fillers with various syntactic structures, including single clauses (e.g., *Because the woman’s shoes are small*), adjunct phrases (e.g., *At the lake*), and noun phrases (e.g., *A younger sibling*). For 30 of the fillers, 15 end with an intonation boundary and 15 end with an intermediate boundary. Forty contain no boundary. The visual targets for the fillers are *will, we’ll, are, they’re, is, he’s,* and *she’s*. Following Kjelgaard and Speer (1999), participants name each critical target word (*it’s, is*) three times in random order in the carrier phrase *The next word will be ___* at the end of the experiment. These naming times are used to correct for any baseline difference between the two targets for individual participants.

5.3.3 Procedure

Participants were instructed that they would be listening to spoken sentence fragments presented one at a time over headphones, and that as soon as each spoken fragment was completely presented, they would see a word flash onto a computer screen in front of them. They were told that their job was to say the word they saw on the screen as quickly, as accurately, and as loudly as they could into a tabletop microphone placed at about chin height in front of them. They were further instructed to finish the sentence that they had just heard, in some way that made sense to them, using the word that they had just seen. After they were given a verbal example, they were instructed to concentrate on three things: (1) listening to the spoken sentence so that they could understand it properly, (2) saying the visual word as quickly, as accurately, and as loudly as they could, and (3) completing the sentences sensibly. With respect to the second point, they were told that their response time would be immediately displayed on the computer screen and that they should try to keep those times as fast or as low as possible. With respect to the
third point, they were told that their completions did not have to be long, creative, or original, but that they did need to make sense. They were also reminded that they were not being timed on how quickly they gave a completion, only on how quickly they said the word on the screen.

After the spoken instructions from the experimenter, participants completed five practice trials. During the practice, participants had the opportunity to ask questions at any time, and the experimenter corrected any mistakes in performance (e.g., naming the wrong word, failing to complete the sentence, failing to use the target word in the completion). Before starting the 106 trials in the main experiment, participants were reminded to say the word on the screen immediately and not to wait until they had thought of a completion.

At the conclusion of the main trials, participants responded to 12 control sentences. Participants were instructed that the sentence fragment would always be The next word will be..., and they were told that they only needed to say the visual target; they did not need to provide a completion. They were told that the words would be some of the ones that they had seen in the main part of the experiment, and that they would see these words several times in random order. Lastly, participants were told that the purpose of the control session was to determine how long it took them to respond to these words when they didn’t need to think of a completion so that those average response times could be subtracted from their average response times in the main experiment, as a way of producing clearer results in the main experiment. The control words included three tokens of each critical visual target (it’s and is) and three tokens each of two filler targets (will and we’ll).
Participants were seated in a small sound-dampened room, and trials were conducted on a Micron PC using E-Prime experiment running software, AKG K141 Monitor (600 ohms) headphones, and a tabletop Audio-Technica ATR-20 microphone. Sound files played in the right ear only, and the microphone was adjusted for each participant to be at about chin level. The experimenter sat beside participants with her back turned toward them during all trials. The experimenter wrote down sentence completions and documented whether or not participants named each word correctly.

Participants controlled the presentation rate of all trials by pressing a button labeled #1 on an SRS response box. As soon as a participant pressed the button, a sound file played. Visual targets appeared immediately at the offset of each sound file, and as soon as participants responded, their response time in seconds replaced the visual target. After two seconds, a message to press button #1 for the next sentence replaced the response time on the screen. During the instructions, participants were told that if they needed to take a break at any time, they should do so when the press button #1 message appeared because the machine would wait indefinitely for them to start the next trial. Participants were tested individually, and each session took less than one hour.
5.4 Results

5.4.1 Sentence completion data

Sentence completions were sorted into the following categories: early closure, late closure, neither, no completion, and nonsensical. Completions were assessed with respect to the intended closure of the visual target. That is, sentences with *is* as the target were initially assessed as early closure sentences, and sentences with *it’s* as the target were initially assessed as late closure sentences. If the sentence did not make sense, the alternative closure was considered.

Completions that fell into the neither category were typically sentence complement structures for the verbs *guesses* and *knows*.

(3) Every time the person guesses the answer is right she’ll get a point.

(4) If the couple knows the scheme is going to work they will participate.

Responses that failed to make sense as either closure type were coded as nonsensical. These included completions to the target *is* that were incomprehensible, as in (5) and (6), or that resembled late closure structures, as in (7) and (8).

(5) Whenever the parent cheats the system is going to a meeting.

(6) If the girl buys the poster is a place that will go in her room.

(7) Every time the friend pulls the sheet is because she’s cold.

(8) If the man flies the plane is a bumpy ride.
Completions that did not continue the target, as in (9) – (11), were also coded as nonsensical. These occurred with both visual targets.

(9) Every time the person studies the picture is moves.
(10) Every time the boy walks the trail it’s gets longer.
(11) If the girl jumps the puddle it’s won’t be wet.

When sentence completions did make sense, they did not always match the intended closure of the target. On some early boundary trials, participants created relative clauses as a way to provide an early closure completion to a late closure target. Sample completions are shown in (12) through (14).

(12) Whenever the teen imitates, the squad it’s working with goes on break.
(13) When the animal strikes, the dirt it’s wearing flies everywhere.
(14) When the kid kicks, the mud it’s kicking is going everywhere.

On late boundary trials, participants tended to create two different completion types when they provided a late closure completion to an early closure target. Sometimes participants ended the sentence with a time reference or event reading, as shown in (15) and (16). Other times participants ended the sentence as a question, as in (17) and (18).

(15) Whenever the lady moves the door is when we can enter.
(16) Every time the friend pulls the sheet is annoying.
(17) If the girl plays the fiddle, is she a musician?
(18) When the animal swims the creek, is it going to make it?
5.4.2 Missing reaction time data

Thirty-nine participants were excluded from the reaction time analysis because they consistently produced late closure sentence completions in the late boundary *is* condition. That is, they produced late closure sentences for at least five of the nine late boundary *is* trials. After excluding these participants, lists 1 and 2 contained 14 participants apiece. One additional participant was removed from list 3 and an additional four participants were removed from list 4 to balance the number of subjects across lists at 14 participants per list. During this process, participants with the highest number of cells requiring data replacement (e.g., for voice key errors, wrong completion type, etc.) were removed. In the end, no participant required data replacement for all three trials of a given condition in more than one condition (i.e., participants who completely missed more than one condition for any reason were excluded).

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4 The fact that these participants persisted in completing late boundary *is* trials with late closure completions suggests two related points. First, at least some listeners are consistently able to find grammatical structures and interpretations for these trials (although even for these participants, late boundary naming times to *is* were still slower than late boundary naming times to *it’s*). Second, when faced with the choice of finding either a completion that matches the prosodic boundary and the target or a completion that matches only the target (i.e., that results in a prosody/syntax mismatch), participants work hard to preserve the match between the prosodic and syntactic representations.
Following the procedure in Kjelgaard and Speer (1999), raw naming times were replaced with the average of the experiment-wise individual subject and item means (Winer, 1971). This was done in the following cases: on any trial in which a participant named the wrong word, on any trial with a voice key error, on any trial greater than two seconds or less than 150 ms, on any trial with no completion or a nonsensical completion, and on any trial in which a completion did not match the syntactic closure that the visual target was intended to create (i.e., late closure completions for *is* targets and early closure completions for *it’s* targets were replaced). This procedure replaced 11% of the data.

Figure 5.8 shows the proportion of replaced data in each condition.

<table>
<thead>
<tr>
<th>Verb Bias and Visual Target</th>
<th>Transitive</th>
<th>Equi</th>
<th>Intransitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boundary</td>
<td>IT'S</td>
<td>IS</td>
<td>IT’S</td>
</tr>
<tr>
<td>Late</td>
<td>.02</td>
<td>.36</td>
<td>.01</td>
</tr>
<tr>
<td>Early</td>
<td>.10</td>
<td>.04</td>
<td>.07</td>
</tr>
</tbody>
</table>

**Figure 5.8: Proportion of data replacement by condition in Experiment 1**

Not surprisingly, data replacement in each verb condition was always greater when the boundary location and visual target conflicted than when they matched. In the late boundary conditions, reaction times were replaced more often for *is* than *it’s*. In the early boundary conditions, reaction times were replaced more often for *it’s* than *is*.

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5 It is possible that the early boundary *it’s* responses contain topicalized NP structures and direct object structures. They have the same linear word order.
The transitive-bias verbs in the late boundary *is* condition required the greatest proportion of data replacement, and the other bias conditions were not far behind. In these conditions, the large number of nonsensical and late closure completions (described in the previous section) contributed to the high proportions of data replacement.

### 5.4.3 Cross-modal naming time data

#### 5.4.3.1 Overall naming times

Each participant’s average response times to naming *it’s* and *is* as a target in the control sentences were calculated. In the six control sentences (three of each critical target), the auditory input was a neutral carrier sentence, and the participant did not need to think of a completion. Following Kjelgaard and Speer (1999), these times were subtracted from (1) each participant’s average naming time to the three tokens in each *is* or *it’s* condition prior to the subject analysis and (2) each participant’s naming time to each critical *is* or *it’s* item prior to the item analysis. This procedure was done to correct for any baseline differences in naming times to the two targets, which might be due in part to differences in frequency or orthography.
As Figure 5.9 shows, naming times to *it’s* were shorter than naming times to *is* in the late boundary conditions. In contrast, naming times to *it’s* were longer than naming times to *is* in the early boundary conditions. Both effects occurred consistently and robustly across the three bias conditions. The interaction between boundary and target was reliable by subjects and items in subject- and item-based 2 (boundary: early, late) X 3 (verb bias: transitive, equi, intransitive) X 2 (target: *it’s*, *is*) repeated measures ANOVAs (F1[1,52]=51.333, p < .01; F2[1,24]=51.811, p < .01). Item group and list were included as between-items and between-subjects variables, respectively.
The results included additional effects involving list and item group. In the subjects analysis, list interacted with target (F1[3,52]=2.333, p = .09), target and verb bias (F1[6,104]=2.358, p < .05), and boundary, target, and verb bias (F1[6,104]=1.900, p = .09). In the items analysis, item group interacted with target (F2[3,24]=3.523, p < .05), boundary (F2[3,24]=6.386, p < .01), and target and boundary (F2[3,24]=5.399, p < .01).

These effects are not all that surprising given that some lists seemed to be harder for participants than others. For example, the first critical trial on the second list was a difficult trial, one with a boundary-target conflict: a late boundary rendition of If the couple reads the verse with the early closure target is. In addition, this trial happens to contain the one item that received a relatively low written acceptability during pretesting (mean score 3.2 on a scale of 1 [low] to 7). As shown in Figure 5.10, the participants randomly assigned to this list produced more responses requiring data replacement in the late boundary is conditions than the participants randomly assigned to the other lists.

A similar pattern was seen for list 3. Again, the first critical trial on this list was If the couple reads the verse with a boundary-target conflict: an early boundary rendition with the late closure target it’s. The participants on this list produced the most responses requiring data replacement in this conflict condition.

<table>
<thead>
<tr>
<th>Condition</th>
<th>List 1</th>
<th>List 2</th>
<th>List 3</th>
<th>List 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late boundary is</td>
<td>.26</td>
<td>.39</td>
<td>.30</td>
<td>.26</td>
</tr>
<tr>
<td>Early boundary it’s</td>
<td>.08</td>
<td>.06</td>
<td>.14</td>
<td>.09</td>
</tr>
</tbody>
</table>

Figure 5.10: Proportion of data replacement by list in the two conditions with a boundary-target conflict
5.4.3.2 Correlations

Correlations were conducted to test for the predicted effects of verb bias on naming times. All verbs were exhaustively classified as transitive (N = 17) or intransitive (N = 17) on the basis of their original transitivity-bias scores (See Chapter 2). The bias scores from each group were then regressed against the naming times for each target (e.g., late boundary transitive it’s, late boundary transitive is, late boundary intransitive it’s, etc.). Naming times greater than 2.5 standard deviations away from the mean were identified as outliers and removed from analyses.

Surprisingly, only one effect emerged as reliable: Naming times to *is* in the transitive-bias late boundary condition decreased as transitivity-bias decreased (R² = .37, F[1,15]=8.079, p = .01).

Because fragment bias, not just verb bias, might also predict naming times, naming times were regressed against the measures of visual and auditory acceptability that were obtained during pretesting.

In the visual pretest, participants rated how acceptable unambiguous versions of the early and late closure sentence fragments were as the beginnings of sentences (e.g., *Whenever the lady checks the room it’s*). As shown in Figure 5.11, naming times decreased as early closure written acceptability increased. The effect was reliable in various conditions, and across all conditions, the direction of the effect was the same. This suggests that written acceptability reflects the overall acceptability of the fragment. As overall acceptability improved, naming times decreased.

---

6 Two verbs from Kjelgaard and Speer’s (1999) original equi-bias set (i.e., babysits and deals) were excluded from regression analyses because they had no corresponding transitivity-bias score in Connine, Ferreira, Jones, Clifton, and Frazier (1984).
Acceptability of Written Versions of Unambiguous Early Closure Fragments
(e.g., *Whenever the lady checks the room is*)

<table>
<thead>
<tr>
<th>Boundary</th>
<th>Verb Bias and Target</th>
<th>Strength of Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(always faster as more acceptable)</td>
</tr>
<tr>
<td>Late</td>
<td>Transitive IS</td>
<td>$R^2 .16 p = .12$</td>
</tr>
<tr>
<td></td>
<td>Intransitive IS</td>
<td>$R^2 .35 p = .01$</td>
</tr>
<tr>
<td></td>
<td>Transitive IT’S</td>
<td>$R^2 .13 p = .16$</td>
</tr>
<tr>
<td></td>
<td>Intransitive IT’S</td>
<td>$R^2 .39 p = .01$</td>
</tr>
<tr>
<td>Early</td>
<td>Transitive IS</td>
<td>$R^2 .37 p = .01$</td>
</tr>
<tr>
<td></td>
<td>Intransitive IS</td>
<td>$R^2 .17 p = .11$</td>
</tr>
<tr>
<td></td>
<td>Transitive IT’S</td>
<td>$R^2 .22 p = .06$</td>
</tr>
<tr>
<td></td>
<td>Intransitive IT’S</td>
<td>$R^2 .29 p = .03$</td>
</tr>
</tbody>
</table>

Figure 5.11: Relationship between acceptability of visually-presented unambiguous early closure sentence fragments and naming time

In contrast to early closure acceptability, late closure acceptability never predicted naming time. The two strongest correlations were in the late boundary transitive *it’s* condition ($R^2 = .17, p = .10$) and early boundary transitive *is* ($R^2 = .14, p = .14$) condition. But, just as with the early closure measure, the trend was for naming times to decrease as overall acceptability improved. It is not surprising that the early closure bias measure was more sensitive than the late closure measure. The range of scores was wider for the early closure measure (3.2-5.6) than the late closure measure (4.4-5.9).
In the auditory pretest, participants rated to what extent they thought the speaker said the utterance as she intended. In terms of late boundary acceptability, naming times in the early boundary transitive-bias conditions increased as the late boundary utterances were rated as more acceptable. This occurred both when the target was it’s ($R^2 = .28, p = .03$) and when the target was is ($R^2 = .21, p = .06$).

In terms of early boundary acceptability, there was only one marginal effect. In the late boundary transitive it’s condition, naming times decreased as early boundary utterances were rated as more acceptable ($R^2 = .19, p = .08$). By all accounts, this is a non-reanalysis condition both semantically and syntactically. It is possible that this correlation also reflects some measure of overall fragment acceptability.

### 5.5 Discussion

The overall pattern of naming times demonstrated that naming times to it’s were reliably shorter than naming times to is in the late boundary condition, while naming times to is were reliably shorter than naming times to it’s in the early boundary conditions. This pattern replicates Kjelgaard and Speer’s (1999) finding that intonation phrase boundaries determine the structure for equi-bias verbs, and it provides new evidence that the effect occurs regardless of verb bias.
The results of Experiment 1 are most consistent with Schafer’s (1997) prosody-first account. It predicted the reliable boundary by target interaction, as well as the correlation between verb bias and naming times to *is* in the late boundary transitive-bias verb condition. Of course, all accounts predicted that naming times in this condition would decrease as transitivity-bias decreased because of reanalysis from a direct object to a subject structure. However, the lack of a correlation in the corresponding intransitive-bias condition is also consistent with Schafer’s interpretive domain hypothesis.

As shown in Figure 5.9, naming times to *is* in the late boundary condition are longer than naming times to *it’s* in all three bias conditions. Furthermore, the sentence completions demonstrate that participants did ultimately produce early closure structures and interpretations. According to the interpretive domain hypothesis, the late intonation phrase boundary triggers the semantic processor to wrap up any outstanding processing. This means that for transitive-bias verbs, the semantic processor commits to the dominant meaning of the verb, but for intransitive-bias verbs, the semantic processor commits to the *subordinate* meaning of the verb. Recall Schafer’s (1997) finding that reanalysis to the subordinate meaning of lexically ambiguous nouns resulted in longer makes-sense judgment times following an intonation phrase boundary than following an intermediate phrase boundary. Thus, the correlations in the late boundary *is* conditions suggest that reanalysis happens post-naming when the subordinate meaning has been selected, but at naming when the dominant meaning has been selected.

Schafer’s (1997) account also correctly predicted that correlations for the target *is* in the early boundary condition would hold for transitive-bias verbs only—if the semantic processor committed to the dominant meaning of the verb at the early intonation phrase
boundary. Because the thematic processor would commit to assigning a theme for the transitive-biased verbs, but not the intransitive-biased verbs, semantic reanalysis would be required for the visual target *is*. Such semantic reanalysis was observed when naming times to *is* in the early boundary transitive-bias condition increased as late boundary versions of the utterances were rated as better reflections of the speaker’s intent.

Notice, however, that Schafer’s (1997) account did not predict the similar pattern of semantic reanalysis that was observed for the target *it’s*. Either there should have been no reanalysis at all (because the structurally ambiguous NP was finally attached as a direct object and assigned a theme role), or there should have been semantic reanalysis to a transitive interpretation (because all verbs were interpreted as intransitive at the early intonation boundary).

In short, the correlation data suggest that transitive-bias verbs are interpreted as transitive when the early intonation boundary triggers semantic wrap-up. In other words, the semantic processor commits to the argument structure that involves assigning a theme role. Then, at the visual target, there is semantic reanalysis to an intransitive interpretation regardless of whether the target is *is* or *it’s*. This is easily explained if, contrary to Schafer’s (1997) account, intonation boundaries trigger syntactic wrap-up.

If intonation phrase boundaries trigger commitment to syntactic structure, as well as commitment to semantic interpretation, then the following should happen. With early intonation phrase boundaries, the parser should commit to an intransitive structure. Prosodic visibility should still delay attachment of the structurally ambiguous NP as a direct object.

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7 Syntactic reanalysis would not be required. In the early boundary condition, the structurally ambiguous NP and the visual target *is* would be prosodically visible.
direct object. If it’s appears, the parser can maintain the intransitive structure and attach the structurally ambiguous NP with it’s by building a topicalized NP. Thus, there should be no syntactic reanalysis in the early boundary condition. However, because the semantic processor committed to assigning a theme for transitive-bias verbs, semantic reanalysis to an intransitive interpretation (i.e., no theme assignment) should be required. If is appears, the structurally ambiguous NP and the visual target should be attached as the main clause, and semantic reanalysis from a transitive to an intransitive interpretation should only be required for the transitive-bias verbs.

Finally, Schafer’s (1997) prosodic visibility account predicted that in the absence of reanalysis, naming times should be shorter when the target is visible to the existing attachment site and longer when visibility is reduced. Because the regression data suggest that there is semantic reanalysis in the early boundary transitive-bias conditions, the most direct comparisons fall to the equi-bias and intransitive-bias conditions. More specifically, naming times to it’s should be longer in the late boundary conditions than naming times to is in the early boundary conditions. As shown in Figure 5.9, naming times to it’s do tend to be longer than naming times to is in these conditions, but it is also clear that these reaction times are unlikely to be significantly different from one another.
5.6 General discussion

The results of Experiment 1 demonstrate that the location of an intonation boundary determines the initial syntactic structure for the early/late closure ambiguity at the beginning of a subordinate clause. The results replicate the findings of Kjelgaard and Speer (1999) and further demonstrate that the effect occurs regardless of verb bias. In contrast to the effect of plausibility reported in Garnsey, Pearlmutter, Myers, and Lotocky (1997), the location of an intonation phrase determines the initial structure for biased and equi-bias verbs.

Provided that Schafer’s (1997) prosody-first account is modified to include syntactic wrap-up at intonation phrase boundaries, prosody-first provides the best account of the current naming data. Consistent with Schafer’s interpretive domain hypothesis, there is evidence that the intonation boundaries caused the semantic/pragmatic processor to commit to an interpretation. The data further suggest that verb bias interacted with this process of semantic wrap-up. In the late boundary conditions, reanalysis seemed to occur post-naming when the semantic processor was forced to commit to a subordinate interpretation, but at naming when it committed to a dominant interpretation. This effect resembles the original evidence (from the processing of lexically ambiguous nouns) for the interpretive domain hypothesis.

In the early boundary conditions, the semantic processor seemed to commit to the dominant meaning of each verb. The subsequent pattern of semantic reanalysis suggested that for the transitive-bias verbs, the semantic processor committed to an argument structure that included assigning a theme role despite an early intonation boundary and the absence of any overt direct object.
The pattern of semantic reanalysis that was observed for transitive-bias verbs in the early boundary condition is inconsistent with Schafer’s (1997) original account. Yet, the effects can be easily explained if intonation boundaries trigger commitment to syntactic structure as well as commitment to semantic interpretation. Furthermore, the commitments can conflict in terms of transitivity, as in the following account.

With the early intonation boundaries, the parser commits to an intransitive structure. If it’s appears, the parser can maintain that intransitive structure and attach the ambiguous NP with it’s by building a topicalized NP. Thus, there is no syntactic reanalysis in the early boundary it’s condition, and there is no mismatch between the prosodic and syntactic representations. But because transitive-bias verbs are interpreted as assigning a theme, semantic reanalysis to an intransitive interpretation, one that does not involve assigning a theme, is required.

The processing account just outlined is also consistent with regression data from the late boundary conditions. Recall that reanalysis occurred post-naming when the late boundary triggered semantic commitment to the subordinate meaning (i.e., assign a theme) for the intransitive-bias verbs. In the processing account outlined for the early boundary conditions, commitment to an intransitive structure is commitment to the subordinate structure for the transitive-bias verbs. Yet, the semantic processor committed to their dominant meaning. Thus, when it came time for reanalysis—either syntactic reanalysis (i.e., intransitive to transitive) or semantic reanalysis (i.e., theme to no theme)—semantic reanalysis occurred.

This account is particularly attractive because it begins to make testable predictions regarding when a more plausible set of thematic relations might trigger
reanalysis. That is, when intonation boundaries trigger commitment to a subordinate interpretation and a dominant syntactic structure, the thematic relations should trigger syntactic reanalysis. When there is commitment to the dominant interpretation and a subordinate syntactic structure, the syntactic structure should trigger semantic reanalysis. When there are two dominant structures and interpretations, one might expect to see support for the original claim that the semantic relations take precedence. In addition, one might expect to see increased processing load in a double subordinate case relative to the double dominant case.

Finally, the pattern of semantic reanalysis in the transitive-bias verbs suggests that a plausible set of thematic relations failed to trigger reanalysis to a direct object structure even in the presence of the visual target its. This contradicts one account of reanalysis in a serial model (e.g., Frazier & Clifton, 1996).

Under the original Schafer (1997) prosody-first account, prosodic visibility drives the initial structure for these materials, not the interpretive domain hypothesis. Although it can only be seen as suggestive at best, naming times in Figure 5.9 did appear to be slightly shorter in non-reanalysis early boundary is conditions than in non-reanalysis late boundary it’s conditions. But, if prosodic visibility truly explains the pattern of results in Experiment 1, then the same pattern should be seen in Experiment 2 when the auditory stimuli contain only intermediate phrases in the same two boundary locations.
CHAPTER 6

PRETEST OF EXPERIMENT 2 STIMULI

6.1 Introduction

The intermediate phrase materials from Experiment 2 were subjected to the same visual and auditory pretests as the intonation phrase materials from Experiment 1 (reported in Chapter 4). These pretests provide additional measures of verb bias, and they ensure that each fragment represents an acceptable sentence beginning and an acceptable spoken utterance.

Recall that each sentence fragment is rated for three factors in the following order: (1) overall acceptability when presented visually through the disambiguating visual target (e.g., *Whenever the lady checks the room it’s*), (2) the extent to which the auditory fragment with the matching boundary seemed to have been as the speaker intended, and (3) the intelligibility of the last word in the spoken fragment (e.g., *room*).\(^1\)

\(^1\) Commas were not included in the visual presentation.
6.2 Method

6.2.1 Participants

Forty students from undergraduate linguistics classes at Ohio State University participated in exchange for course credit.

6.2.2 Materials

Just as before, each of two lists contained the entire set of 36 critical fragments randomized with 98 fillers. The order of presentation was the same across lists. Critical fragments on a list always had the same syntactic structure (i.e., all ended in it’s or is) and a matching boundary location (i.e., a late boundary for it’s and an early boundary for is).

Of the 98 fillers, 14 contained mismatches in number (e.g., Whenever the partner are) or gender (e.g., Of the daddies she’s) that were intended to serve as unacceptable sentence beginnings. Fourteen contained unlikely boundary locations (e.g., The young L. L% girls) that were intended to serve as utterances not said as the speaker intended. Ten more were truncated prematurely so that the final word or a portion of that word was deleted. These were intended to serve as utterances with unintelligible final words.

6.2.3 Procedure

The procedure was the same as reported in the Experiment 1 pretest in Chapter 4.

6.3 Results

6.3.1 Written fragment ratings

Figure 6.1 summarizes the mean acceptability ratings of the visually-presented late closure (e.g., Whenever the lady checks the room it’s...) and early closure (e.g., Whenever the lady checks the room is...) fragments.
<table>
<thead>
<tr>
<th>Syntactic Closure</th>
<th>Transitive</th>
<th>Equi</th>
<th>Intransitive</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late</td>
<td>4.80</td>
<td>4.94</td>
<td>5.00</td>
<td>4.92</td>
</tr>
<tr>
<td></td>
<td>(1.45)</td>
<td>(1.50)</td>
<td>(1.52)</td>
<td>(1.47)</td>
</tr>
<tr>
<td>Early</td>
<td>3.83</td>
<td>4.60</td>
<td>4.74</td>
<td>4.39</td>
</tr>
<tr>
<td></td>
<td>(0.96)</td>
<td>(1.12)</td>
<td>(1.01)</td>
<td>(1.09)</td>
</tr>
</tbody>
</table>

Figure 6.1: Mean acceptability ratings (and standard deviations) of visually-presented early and late closure fragments from Experiment 2 (1 = completely unacceptable, 7 = completely acceptable)

The pattern of verb bias effects in Figure 6.1 is similar to the pattern observed in the Experiment 1 pretest (see Chapter 4, Figure 4.1). Such similarity is expected, given that the written fragments (i.e., the lexical content) in the two pretests are identical.
Fragments that were disambiguated with *it’s* were expected to require a transitive or late closure structure. As a result, these fragments were predicted to be rated as more acceptable as transitivity bias increased. This prediction, as in Experiment 1, was not supported. In the late closure condition in Figure 6.1, the transitive-bias mean is numerically lower than the means for intransitive-bias and equi-bias verbs. Because fragments that were disambiguated with *is* were expected to require an intransitive or early closure structure, these fragments were predicted to be rated as less acceptable as transitivity bias increased. Consistent with that prediction, intransitive-bias and equi-bias verbs in the early closure condition were rated as significantly more acceptable than transitive-bias verbs in a series of planned comparisons. On average, transitive-bias fragments were rated as significantly less acceptable than the average of intransitive-bias and equi-bias fragments (F[1,19]=24.49, p < .01), and they were rated as significantly less acceptable than equi-bias fragments alone (F[1,19]=18.75, p < .01).

Correlations also demonstrated that, just as in Experiment 1, verb bias only influenced the acceptability of the early closure conditions. As shown in Figure 6.2, early closure conditions showed a moderate, predicted negative correlation (R^2 = -.11, F[1,32]=4.13, p = .05).^2 Late closure conditions showed no correlation (R^2 = -.02, F < 1.0).

^2 No outliers were identified in either regression. The leftmost early closure symbols (open triangles) correspond to *reads* at the far left and then *kills*. 
Figure 6.2: Correlations between verb bias and acceptability of visually-presented early and late closure fragments from Experiment 2

Just as in the Experiment 1 pretest, the absence of the predicted verb bias effect in the late closure conditions might be due to a late closure bias. Late closure fragments were rated as more acceptable than early closure fragments, and the range of late closure means might have been too narrow for a verb bias effect to appear. The main effect of closure was again only reliable by items in subject- and item-based 2 (Closure) × 3 (Verb Bias) repeated measures ANOVAs ($F_{1}[1,38]=1.83$, $p > .10$; $F_{2}[1,33]=28.04$, $p < .01$).

Although the visual fragments were identical in the Experiment 1 and Experiment 2 pretests, the current acceptability ratings are slightly lower than those for Experiment 1. This is probably due in part to the fact that different participants provided scores. Also
recall that on each trial, participants rated auditory fragments immediately after rating written fragments. It might be the case that the different auditory fragments in the two pretests (intonation boundaries for Experiment 1 and intermediate boundaries for Experiment 2) influenced the ratings of the visually-presented fragments. In the acoustic analyses discussed in Chapter 3, the intonation boundary stimuli were shown to have longer durations than the intermediate boundary stimuli. This stemmed from the silent durations that typically followed intonation boundaries and from the greater degree of pre-boundary lengthening in the intonation boundary conditions. It is likely that these prosodic differences, in conjunction with the speaker’s strategy of using a faster overall speech rate to produce intermediate boundaries on demand, helped to make the intonation boundary stimuli easier to understand than the intermediate boundary conditions.

Consistent with this claim, acceptability of the spoken fragments and final word intelligibility ratings for the Experiment 2 stimuli are also lower across the board than those for the Experiment 1 stimuli. As auditory acceptability scores fell, visual acceptability scores probably fell with them.

Lastly, critical fragments (mean 4.65, SD 1.32) were rated as more acceptable than fragments that contained number or gender mismatches (e.g., All the parents is; mean 2.92, SD 1.48). The difference in means is statistically significant by subjects (t1[118]=6.33, p < .01) and by items (t2[48]=9.43, p < .01).

The means of four critical items fell below the midpoint of the 1-7 scale. When the man saves the bill is and When the man starts the class is dipped just below the midpoint with means of 3.45. Of greater concern are the means of two transitive-bias early closure items: If the couple reads the verse is (mean 2.15) and When the animal
kills the cat is (mean 2.85). Although these latter scores are quite low, these items were
used in Experiment 2 as is for several reasons. First, no obvious alternatives existed that
improved acceptability while meeting the criteria that the ambiguous NPs in each item set
be matched on frequency, number of syllables, stress pattern, and final segment. Second,
these same two items received higher mean ratings in the written acceptability pretest for
Experiment 1 (mean score 3.2 and 3.53, respectively). This suggests that their overall
acceptability might actually be higher than the current ratings reflect. Third, these items
received acceptable ratings in the spoken acceptability and final word intelligibility tasks.

6.3.2 Spoken fragment ratings

Participants were asked to judge to what extent they thought that the speaker said
each fragment as she intended. Figure 6.3 summarizes the mean acceptability ratings of
the spoken late and early intermediate boundary fragments.

<table>
<thead>
<tr>
<th>Prosodic Boundary</th>
<th>Transitive</th>
<th>Equi</th>
<th>Intransitive</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late</td>
<td>4.66</td>
<td>4.71</td>
<td>4.71</td>
<td>4.69</td>
</tr>
<tr>
<td></td>
<td>(1.23)</td>
<td>(1.24)</td>
<td>(1.20)</td>
<td>(1.20)</td>
</tr>
<tr>
<td>Early</td>
<td>4.28</td>
<td>4.39</td>
<td>4.38</td>
<td>4.35</td>
</tr>
<tr>
<td></td>
<td>(1.16)</td>
<td>(1.25)</td>
<td>(1.20)</td>
<td>(1.18)</td>
</tr>
</tbody>
</table>

Figure 6.3: Mean acceptability ratings (and standard deviations) of spoken
intermediate boundary fragments (1 = not said as intended, 7 = said as intended)
The main purpose of this task was to ensure that the stimuli represented acceptable renditions of intended utterances, and indeed they do. Critical fragments were rated as significantly more acceptable than fragments containing a boundary in an unlikely location (e.g., *The young girls*) both by subjects ($t_{1[78]}=8.72$, $p < .01$) and by items ($t_{2[48]}=22.92$, $p < .01$). Whereas the mean for critical items was 4.52 with scores ranging from 3.60 to 5.40, the mean for items with an unlikely boundary was 2.18 with scores ranging from 1.55 to 2.95.

In contrast to the results from the intonation boundary pretest (See Chapter 4 Figure 4.3), the current results suggest a late boundary bias for these materials. That is, participants judged late boundary fragments to be better reflections of the speaker’s intention than early boundary fragments overall. Indeed the results of subject- and item-based 2 (Boundary) X 3 (Verb Bias) repeated measures ANOVAs demonstrated only one reliable effect: a main effect of boundary by items ($F_{2[2,33]}=21.77$, $p < .01$).

What might explain this late boundary bias? One possible explanation is that participants considered the early intermediate boundaries to be too weak (relative to an early intonation boundary) to indicate the unambiguous early closure structures that had been presented visually. Said another way, in the context of the late closure bias that was evident in the written acceptability judgments, participants judged the speaker’s pronunciation to be felicitous, but not ideal. This explanation is consistent with the pretest results from Experiment 1. Recall that while the intonation boundary stimuli also elicited a late closure bias in the written acceptability judgments, there was no evidence of a late boundary bias. Alternatively, the fact that participants in Experiments 1 and 2 were able to create late closure completions on late boundary *is* trials suggests that *is*
does not necessarily resolve the ambiguity in favor of early closure. Thus, without a comma in the visual presentation, participants might have assessed the fragments in terms of a late closure structure and completion.

Regardless of its explanation, the late boundary bias suggests that the current equi-bias materials are not comparable to those from Kjelgaard and Speer (1999). Although the equi-bias verbs in their study and the current study are identical, Kjelgaard and Speer were also able to demonstrate that their sentence fragments were equi-biased. In contrast, because a late closure bias persists in the current materials despite the presence of an early intermediate boundary, the bias is likely to speed reaction times to it’s and slow reaction times to is.

Lastly, no verb bias effects were predicted for this task, and no correlations were found between transitivity bias and acceptability ratings in the late and early boundary conditions (R²’s < .01).

6.3.3 Final word intelligibility ratings

Participants were asked to rate the intelligibility of the last word in the auditory fragment. The means were subjected to subject- and item-based 2 (Boundary) X 3 (Verb Bias) repeated measures ANOVAs. Figure 6.4 summarizes the means by condition.
<table>
<thead>
<tr>
<th>Prosodic Boundary</th>
<th>Transitive</th>
<th>Equi</th>
<th>Intransitive</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late</td>
<td>5.46</td>
<td>5.51</td>
<td>5.56</td>
<td>5.51</td>
</tr>
<tr>
<td></td>
<td>(0.79)</td>
<td>(0.85)</td>
<td>(0.93)</td>
<td>(0.85)</td>
</tr>
<tr>
<td>Early</td>
<td>4.72</td>
<td>5.05</td>
<td>5.05</td>
<td>4.94</td>
</tr>
<tr>
<td></td>
<td>(0.97)</td>
<td>(1.07)</td>
<td>(1.01)</td>
<td>(1.07)</td>
</tr>
</tbody>
</table>

Figure 6.4: Mean intelligibility ratings (and standard deviations) of the final word in spoken intermediate boundary fragments (1 = completely unclear, 7 = completely clear)

As expected, late boundary conditions were rated as more intelligible than early boundary conditions both by subjects (F1[1,38]=4.10, p = .05) and items (F2[1,33]=34.21, p < .01). Whereas the final word in the late boundary conditions underwent phrase final lengthening, the final word in the early boundary conditions was truncated midphrase. Fortunately, the final words in the early boundary critical items (mean 4.94, SD 1.07) were rated on the high end of the scale and as significantly more intelligible than items on the same list that had been truncated prematurely (mean score 2.75, SD 1.24) both by subjects (t1[14]=5.48, p < .01) and by items (t2[44]=9.29, p < .01). Only 2 of the 36 critical items scored below the midpoint of the 1-7 scale: *When the man saves the bill is* (mean 3.35) and *When the friend pulls the sheet is* (mean 3.40).

The only other effect to report from the ANOVAs was a main effect of verb that was reliable in the subjects analysis (F1[2,76]=3.76, p < .05; F2 < 1.0). The effect seems to stem from a lower mean for the final words in transitive-bias conditions (mean 5.09) relative to the mean ratings for final words in other verb bias conditions (equi-bias mean
5.28, intransitive-bias mean 5.30). Of course, this “lower” mean rating still suggests that the words are intelligible, and there is no reason to believe that a slight decrease in intelligibility in the transitive-bias condition would interfere with the hypotheses being tested. At worst, naming times to both target words (it’s and is) in the transitive-bias condition might be slowed relative to naming times in the other two verb bias conditions.

6.4 Discussion

Overall, the auditory fragments for Experiment 2 earned ratings on the acceptable end of the scale in pretests of written acceptability, spoken intention, and final word intelligibility. However, the pretest of spoken intention revealed a late boundary bias in the auditory fragments. The effect suggests that, in contrast to Kjelgaard and Speer (1999), there is late closure bias in the current materials that is not deterred by early intermediate boundaries.

The source of the late closure bias is unknown, but several possible culprits come to mind. It could be the case that the words in each fragment—as a group—support the direct object structure and interpretation in these particular complementizer + NP + verb + plausible direct object NP fragments. Because Kjelgaard and Speer (1999) surrounded the same set of equi-bias verbs with different lexical content (including different plausible direct object NPs), their fragments did not show a late closure bias.

A second possibility is that the Connine, Ferreira, Jones, Clifton, and Frazier (1984) sentence completion data or the metric for calculating verb bias from these data were simply inadequate for finding truly intransitive-bias verbs.
A third possibility is that some unidentified prosodic factor (e.g., speech rate, pitch range) supports the late closure structure and interpretation. While the current materials use the same prosodic contours as Kjelgaard and Speer (1999), the two studies used different speakers.

Because the current intermediate phrase materials contain a late closure bias, they provide a challenging test of the prosody-first (Schafer, 1997) and phon-concurrent models.
CHAPTER 7

EXPERIMENT 2: VERB BIAS AND INTERMEDIATE BOUNDARIES

7.1 Introduction

Experiment 2 investigates whether the location of an intermediate phrase boundary interacts with the transitivity bias of a verb during auditory processing of early/late closure ambiguities. In contrast to the auditory stimuli from Experiment 1, the intermediate phrase accents in the current stimuli are not accompanied by boundary tones. This experiment uses the same design as Experiment 1, and lexical content of the stimuli is identical in the two experiments.

The ambiguity in question is repeated here in (1) – (2). The fragment in (1) is ambiguous because the noun phrase (NP) the room could either be the direct object of the verb checks, as in the late closure structure in (2a), or the subject of the main clause, as in the early closure structure in (2b). These syntactic structures, as well as representations of the early and late prosodic boundaries, are shown in Figures 7.1 and 7.2.

(1) Whenever the lady checks the room...

(2a) Whenever the lady checks the room it's cold.

(2b) Whenever the lady checks the room is cold.
Figure 7.1: Direct object (late closure) syntax with late and early intermediate phrase (ip) boundaries

Figure 7.2: Subject (early closure) syntax with early and late intermediate phrase (ip) boundaries
In this cross-modal naming experiment, the same three independent variables as in Experiment 1 are manipulated: the transitivity bias of the verb, prosodic boundary location, and the syntactic structure of a visual target.

Experiment 2 tests the predictions of the same three processing accounts as in Experiment 1: the traditional garden path model (e.g., Frazier, 1990; Frazier & Clifton, 1996), Schafer’s (1997) prosody-first account, and the phon-concurrent model.

7.2 Processing predictions

7.2.1 Traditional garden path model

The traditional garden path model (e.g., Frazier, 1990; Frazier & Clifton, 1996) makes the same predictions as it did before: the parser should always build the direct object structure first. Because the ambiguous NPs are plausible direct objects, the thematic processor should have no trouble assigning thematic relations that match the direct object structure. This predicts a main effect of the syntactic closure of the target such that it’s should be named more quickly than is.

This prediction is again consistent with the claim that argument structure influences the initial parse (Ferreira & McClure, 1997). Assigning the structurally ambiguous NP to the direct object position maximizes the argument structure of the verb.

7.2.2 Schafer’s (1997) prosody-first account

As in Experiment 1, Schafer’s (1997) prosody-first account predicts an interaction between boundary location and visual target. In the late boundary conditions, the verb and the ambiguous NP are prosodically visible during syntactic processing. The parser follows late closure and builds the direct object structure. Because each verb can be used transitively and because each structurally ambiguous NP is a plausible direct object, the
thematic processor assigns a theme role from each verb to each NP. If the visual target
it’s appears, it should be integrated into the existing structure. If the visual target is
appears, it should trigger reanalysis. In these late boundary conditions, it’s should be
named more quickly than is. Because there is no intonation boundary to force the
semantic processor to wrap up any outstanding semantic/pragmatic processing, reanalysis
might proceed more quickly than in Experiment 1.

At the verb in the early boundary conditions, the parser attaches the verb into its
existing syntactic structure. It then sends the structure to the semantic processor, which
assigns an agent role to the grammatical subject. At the structurally ambiguous NP,
decreased prosodic visibility delays syntactic attachment, and no new structure is sent to
the semantic processor. At the visual target, the NP and target are prosodically visible.

If the visual target is appears, the main clause structure is built. This structure is
sent to the thematic processor, which assigns the appropriate thematic relations. If the
visual target it’s appears, it is difficult for the parser to attach the structurally ambiguous
NP and the target. However, it is also difficult for the parser to build the direct object
structure because of decreased visibility. When the parser does build the direct object
structure, the prosodic boundary will conflict with the syntax. It’s should be named more
slowly than is.

Schafer’s (1997) account again makes the following two predictions. First,
naming times should correlate with verb bias during reanalysis. More specifically,
naming times to is in the late boundary conditions should increase as transitivity bias
increases. Second, naming times should be slower overall in the late boundary conditions as compared to the early boundary conditions because of decreased prosodic visibility. Given that the effect should be most robust in the conditions that do not require reanalysis, it’s should be named more slowly in the late boundary conditions than is in the early boundary conditions.

7.2.3 The phon-concurrent model

This constraint-based model again predicts a three-way interaction among verb bias, boundary location, and target. At the verb in all conditions, a direct object structure and a main clause structure are automatically generated and weighted by frequency. This means that for equi-bias verbs, both structures are equally accessible. The semantic processor assigns the agent role to the grammatical subject in all verb conditions and anticipates assigning a theme in the transitive-bias conditions.

At the structurally ambiguous NP in the late boundary conditions, the prosodic representation aligns with the direct object structure but not the main clause structure. Thus, the prosodic representation adds weight to the direct object structure only.

In the case of the transitive-bias and equi-bias verbs, the direct object structure is weighted most heavily. For these verbs, the semantic processor assigns the theme role to the structurally ambiguous NP. In the case of the intransitive-bias verbs, the direct object and main clause structures are competitive. Because the NP is plausible as a direct object, the semantic processor assigns the theme role to the structurally ambiguous NP for these

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1 There is no reanalysis in the early boundary it’s condition. Prosodic visibility simply hinders or delays syntactic integration.

2 See Chapter 2 for a more thorough discussion of the goodness-of-fit between the prosodic representation and the syntactic alternatives.
verbs as well. In each case the semantic interpretation adds weight to the late closure structure. At the target, it’s should be named more quickly than is, and is should trigger reanalysis to the subject structure.

In the early boundary conditions, the prosodic representation aligns more closely with the main clause structure than the direct object structure. Because of this difference in goodness-of-fit, the early boundary representation adds more weight to the main clause structure than the direct object structure.

In the case of the intransitive-bias and equi-bias verbs, the subject structure will be weighted most heavily. Because this structure is most active, the semantic processor assigns the agent role to the structurally ambiguous NP. The semantic interpretation adds additional weight to the main clause structure. At the target, is should be faster than it’s, and it’s should trigger reanalysis to the direct object or topicalized NP structure.

In the case of the transitive-bias verbs, the direct object and main clause structures are competitive. Because the structurally ambiguous NP is plausible as a direct object, the semantic processor assigns the theme role, which adds weight to the direct object structure. At the target, it becomes apparent that there is no heavy NP in direct object position. Thus, the target it’s should trigger a prosody/syntax mismatch, while the target is should trigger reanalysis to the main clause structure. Naming times are likely to be comparable.

3 Recall that in Garnsey, Pearlmutter, Myers, and Lotocky (1997) plausibility determines the structure when the syntactic alternatives are competitive.

4 Topicalized NPs will probably be more likely for strongly intransitive verbs.
Without an intonation boundary to force semantic wrap-up, reanalysis might proceed more quickly than in Experiment 1 (the predicted reanalysis conditions are *is* in the late boundary condition, *it’s* in the early boundary intransitive-bias and equi-bias verb conditions, and *is* in the early boundary transitive-bias condition).

Finally, the phon-concurrent model predicts that naming times in all conditions should be correlated with transitivity bias. Whenever the main clause structure is initially weighted most heavily, naming times to *is* should increase as transitivity bias increases. And whenever the direct object structure is weighted most heavily, naming times to *it’s* should decrease as transitivity bias increases. However, it might be the case that verb bias only influences naming times when the less frequent structural alternative is supported, as in Garnsey, Pearlmutter, Myers, and Lotocky (1997). One condition most closely resembles the Garnsey et al. situation. In the intransitive-bias early boundary condition, the plausible NP supports the less frequent direct object structure. Thus, naming times to *is* should increase as transitivity increases.
7.2.4 Summary of predictions

The differences in processing across accounts translate into different patterns of predicted naming times. For the garden path model, it’s should always be named more quickly than is. For Schafer’s (1997) prosody-first account, it’s should be named more quickly than is in the late boundary conditions and more slowly than is in the early boundary conditions. For the phon-concurrent model, it’s should be named more quickly than is in the late boundary conditions. In the early boundary intransitive-bias and equi-bias conditions, is should be named more quickly than it’s. But in the transitive-bias condition, there should be little difference in naming time to it’s and is. Furthermore, the latter two accounts predict that reanalysis should proceed more quickly than in Experiment 1 because there are no intonation boundaries to trigger semantic (or syntactic) wrap-up. The predicted overall naming times are summarized in Figure 7.3.

<table>
<thead>
<tr>
<th>Processing Accounts</th>
<th>Predicted Overall Naming Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Garden Path Model</td>
<td>IT’S &lt; IS</td>
</tr>
<tr>
<td>Schafer’s (1997) Prosody-First Account</td>
<td>Late Boundary: IT’S &lt; IS</td>
</tr>
<tr>
<td></td>
<td>Early Boundary: IS &lt; IT’S</td>
</tr>
<tr>
<td>Phon-Concurrent Model</td>
<td>Late Boundary: IT’S &lt; IS</td>
</tr>
<tr>
<td></td>
<td>Early Boundary (Tran): IT’S = IS</td>
</tr>
<tr>
<td></td>
<td>Early Boundary (Intran/Equi): IS &lt; IT’S</td>
</tr>
</tbody>
</table>

Figure 7.3: Summary of predicted naming times in Experiment 2 for each processing account
7.2.5 Influence of late closure bias

Recall that the visual and auditory pretests of the Experiment 2 stimuli (reported in Chapter 6) demonstrated a late closure bias. That is, participants judged written versions of unambiguous late closure fragments to be better sentence beginnings than written versions of unambiguous early closure fragments. They also judged spoken versions of the late boundary fragments to be better reflections of the speaker’s intention than spoken versions of the early boundary fragments.

These biases are likely to speed naming times to it’s and slow naming times to is. As a result, the auditory stimuli favor the garden path model, which predicts that it’s should always be named more quickly than is. In terms of the competing accounts, the biases should amplify the effect in the late boundary condition (where it’s should be named faster than is) but make it harder to see the predicted effect in the early boundary condition (where is should be named faster than it’s).

The biases also suggest that the current materials are different from those in Kjelgaard and Speer (1999), which were unbiased as a set of sentence fragments.

7.3 Method

7.3.1 Participants

One hundred thirteen students from undergraduate linguistics classes at Ohio State University participated in exchange for course credit.
7.3.2 Materials

The materials are the same as in Experiment 1, with the exception that the critical auditory fragments now contain only intermediate boundaries. Figure 7.4 summarizes the conditions and example stimuli for Experiment 2. See Chapter 3 for a discussion of the verb bias variable and for acoustic analyses of the auditory stimuli. See Chapter 6 for a discussion of stimuli pretesting.

<table>
<thead>
<tr>
<th>Verb Bias</th>
<th>Prosodic Boundary</th>
<th>Auditory Fragment with Prosodic Contour</th>
<th>Visual Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tran</td>
<td>Late</td>
<td>Whenever the lady loads the car</td>
<td>it's is</td>
</tr>
<tr>
<td>Equi</td>
<td>Late</td>
<td>Whenever the lady checks the room</td>
<td>it's is</td>
</tr>
<tr>
<td>Intran</td>
<td>Late</td>
<td>Whenever the lady moves the door</td>
<td>it's is</td>
</tr>
<tr>
<td>Tran</td>
<td>Early</td>
<td>Whenever the lady loads the car</td>
<td>it's is</td>
</tr>
<tr>
<td>Equi</td>
<td>Early</td>
<td>Whenever the lady checks the room</td>
<td>it's is</td>
</tr>
<tr>
<td>Intran</td>
<td>Early</td>
<td>Whenever the lady moves the door</td>
<td>it's is</td>
</tr>
</tbody>
</table>

Figure 7.4: Summary of conditions and example stimuli for Experiment 2
For this experiment, one change was made to the order in which critical items were presented. During Experiment 1, the first critical item on each list was one that had received relatively low written-acceptability ratings during the pretests: If the couple reads the verse is. The average acceptability of the written fragment on a scale of 1-7 (7 = completely acceptable) was 3.20 in the Experiment 1 pretest and 2.15 in the Experiment 2 pretest. This item was moved to the end of each list in Experiment 2.

7.3.3 Procedure

Experiment 2 used the same procedure as Experiment 1, with the exception that sound files were presented binaurally, not monaurally.

7.4 Results

7.4.1 Sentence completion data

Sentence completions were sorted into the following categories: early closure, late closure, neither, no completion, and nonsensical. As in Experiment 1, completions were first assessed with respect to the intended closure of the visual target. If the sentence did not make sense with that closure, the alternative closure was considered.

Completions that fell into the neither category were typically sentence complement structures for the verb knows.

(3) If the couple knows the scheme is flawed, then it won’t work.

(4) If the couple knows the scheme is difficult, they won’t go.

Responses that failed to make sense as either closure type were coded as nonsensical. These included completions to the target is that were incomprehensible, as in (5) and (6), or that resembled late closure structures, as in (7) and (8).

(5) If the girl plays the fiddle is good at it.
(6) Whenever the teen babysits the pet is paid for her work.

(7) Every time the friend deals the deck is cheating.

(8) When the kid tries the lock is not able to do it.

Completions that did not continue the target, as in (9)-(10), were also coded as nonsensical. These occurred with both visual targets.

(9) When the kid cleans the track is looks brand new.

(10) Everytime the boy leaves the chair it’s squeaks.

Completions that did not match the intended closure of the target were exclusive to the visual target is. In contrast to Experiment 1, early boundaries never elicited relative clause completions to it’s. However, on late boundary trials, participants again responded to is with a time reference or event reading, as in (11) and (12), or a question structure, as in (13) and (14).

(11) When the animal swims the creek is quite an interesting thing to see.

(12) Whenever the lady loads the car is when she’s going to get groceries.

(13) Everytime the person studies the picture is he seeing new things?

(14) If the man starts the class is it going to be a good class?

7.4.2 Missing reaction time data

Missing reaction time data were handled in the same way as in Experiment 1. In the current experiment, 27 participants were excluded from the reaction time analysis because they produced at least five late closure sentence completions to the nine late boundary is trials. An additional seven participants were excluded because they would have required complete data replacement in more than one condition. After excluding these participants, list 2 contained 18 participants. To balance the number of subjects
across lists, two participants were removed from list 1, three were removed from list 3, and two were removed from list 4. During this process, participants with the highest number of cells requiring data replacement for any reason were removed.

Following the procedure in Kjelgaard and Speer (1999), raw naming times were replaced with the average of the experiment-wise individual subject and item means (Winer, 1971). As in Experiment 1, this was done in the following cases: on any trial in which a participant named the wrong word, on any trial with a voice key error, on any trial greater than two seconds or less than 150 ms, on any trial with no completion or a nonsensical completion, and on any trial in which a completion did not match the syntactic closure that the visual target was intended to create. This procedure replaced 9% of the data. Figure 7.5 displays the proportion of replaced data in each condition.

<table>
<thead>
<tr>
<th>Verb Bias and Syntactic Closure of Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transitive</td>
</tr>
<tr>
<td>Boundary</td>
</tr>
<tr>
<td>Late</td>
</tr>
<tr>
<td>Early</td>
</tr>
</tbody>
</table>

Figure 7.5: Proportion of data replacement by condition in Experiment 2
Consistent with the late closure and late boundary biases that were observed during pretesting, data replacement was always higher for *is* than for *it’s*. While the effect was numerically stronger in the late boundary conditions than in the early boundary conditions, any question of significance is irrelevant. The fact remains that participants clearly had difficulty with the early boundary *is* conditions.

### 7.4.3 Cross-modal naming time data

#### 7.4.3.1 Overall naming times

As shown in Figure 7.6, naming times to *it’s* were faster than naming times to *is* in all late boundary conditions, and in the transitive-bias and equi-bias early boundary conditions.\(^5\) In the intransitive-bias early boundary condition, naming times to *it’s* appeared to be comparable naming times to *is*. However, the results of subject- and item-based 2 (boundary: early, late) X 3 (verb bias: transitive, equi, intransitive) X 2 (target: *it’s, is*) repeated measures ANOVAs failed to show a reliable boundary by verb bias by target interaction in either the subjects or items analyses (Fs < 1.0).\(^6\)

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\(^5\) See Chapter 5 for a discussion of the correction procedure (i.e., removing baseline naming times to the visual targets).

\(^6\) Item group and list were included as between-items and between-subjects variables, respectively.
The results did show a reliable boundary by target interaction (F1[1,68]=9.486, p < .01; F2[1,24]=5.102, p < .05). The interaction suggests that while naming times to *it’s* were faster than naming times to *is* in both boundary conditions, naming times to *it’s* were faster in the late boundary condition than in the early boundary condition.

There was also a marginal interaction between verb bias and target (F1[2,136]=2.507, p = .09; F2[2,24]=3.344, p = .05). This interaction suggests that while naming times to *it’s* were faster than naming times to *is* across verb conditions, naming times to *is* were faster in the intransitive-bias condition than in the transitive and equi-bias conditions.
The results of the ANOVAs again included additional effects involving list and item group. In the subjects analysis, a main effect of list (F1[3,68]=3.847, p = .01) was qualified by interactions with verb bias (F1[6,136]=3.443, p < .01), boundary and target (F1[3,68]=8.262, p < .01), boundary and verb bias (F1[6,136]=3.225, p < .01), and boundary, target, and verb bias (F1[6,136]=2.494, p < .05). In the items analysis, item group interacted with boundary (F2[3,24]=22.432, p < .01), target (F2[3,24]=30.195, p < .01), boundary and target (F2[3,24]=29.233, p < .01), and boundary, target, and verb bias (F2[6,24]=2.137, p < .10).

As in Experiment 1, list and item group effects are not all that surprising given that some lists still seemed to be harder for participants than others. For example, list 3 participants were more likely to be excluded from analysis than participants on other lists because list 3 participants produced more late closure completions on late boundary *is* trials than participants assigned to other lists. In contrast, list 1 participants were the least likely to be excluded for this reason. Figure 7.7 summarizes the proportion of participants excluded for this reason on each list.

<table>
<thead>
<tr>
<th>Proportion of Subjects Removed</th>
<th>List 1</th>
<th>List 2</th>
<th>List 3</th>
<th>List 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Given the first 20 participants per list</td>
<td>.10</td>
<td>.20</td>
<td>.45</td>
<td>.20</td>
</tr>
<tr>
<td>Among all participants on a list</td>
<td>.09</td>
<td>.21</td>
<td>.37</td>
<td>.22</td>
</tr>
</tbody>
</table>

*Figure 7.7: Proportion of subjects removed because of consistent late closure completions in the late boundary *is* condition*
7.4.3.2 Correlations

As in Experiment 1, correlations were conducted to test for effects of verb bias on naming times. All verbs were again classified as transitive or intransitive on the basis of their original transitivity-bias scores (See Chapter 2). The transitivity-bias scores were then regressed against the naming times for each target. Naming times greater than 2.5 standard deviations away from the mean were identified as outliers and removed from analyses. The results to the visual target *is* are summarized in Figure 7.8. There were no significant correlations for *it’s*.

<table>
<thead>
<tr>
<th>Boundary</th>
<th>Verb Bias</th>
<th>Regression for visual target <em>IS</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>late</td>
<td>transitive</td>
<td>$R^2 = .00$, $F[1,15]&lt;1.0$</td>
</tr>
<tr>
<td>late</td>
<td>intransitive</td>
<td>$R^2 = .32$, $F[1,16]=7.176$, $p = .02$</td>
</tr>
<tr>
<td>early</td>
<td>transitive</td>
<td>$R^2 = .18$, $F[1,16]=3.306$, $p = .09$</td>
</tr>
<tr>
<td>early</td>
<td>intransitive</td>
<td>$R^2 = .16$, $F[1,15]=2.665$, $p = .13$</td>
</tr>
<tr>
<td>early</td>
<td>intransitive</td>
<td>$R^2 = .42$, $F[1,13]=8.721$, $p = .01$</td>
</tr>
</tbody>
</table>

(minus *tries & continues*)

**Figure 7.8: Summary of correlations between verb bias and corrected naming time for the visual target *is* in Experiment 2**

As shown in Figure 7.8, naming times to *is* in the late boundary intransitive-bias condition decreased as verbs became more strongly intransitive. No correlation was observed for the transitive-bias verbs. Returning to Figure 7.6, however, notice that

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7 Recall that *babysits* and *deals* are excluded because they are not represented in the Connine, Ferreira, Jones, Clifton, and Frazier (1984) sentence completion data.
naming times for *is* are longer than naming times for *it’s* in both verb bias conditions. In addition, the sentence completions demonstrate that participants ultimately produced early closure structures and interpretations. Thus, the pattern for these two bias conditions suggests that reanalysis seems to happen post-naming for the transitive-bias verbs but at naming for the intransitive-bias verbs. In other words, reanalysis is especially difficult when neither the prosodic boundary nor the verb is consistent with an alternative parse.

In the early boundary conditions, there was a marginal effect for the transitive-bias verbs: Naming times to *is* increased as verbs became more transitive. Within the intransitive-bias verbs, naming times also increased as transitivity bias increased. While the effect is not significant, it achieves significance when the two most intransitive verbs (*tries* and *continues*) are removed from the analysis. Although these verbs were not identified as outliers in the original regression analysis, their bias scores (-15.8 and -15.3) do place them apart from even the next most biased verbs (-10.8 for *guesses* and *walks*).
7.5 Discussion

The results of Experiment 2 seem to be most consistent with the traditional garden path model (e.g., Frazier, 1990; Frazier & Clifton, 1996). Although there was a significant interaction between boundary and target, the direction was inconsistent with Schafer (1997). The interaction suggested that while naming times to it’s were faster than naming times to is in both boundary conditions, naming times to it’s were faster in the late boundary condition than in the early boundary condition. The garden path model would account for this effect as follows: Naming times to it’s should be slower in the early boundary condition because of a mismatch between the direct object syntax and the prosodic representation.8 Naming times to is should be slower than naming times to it’s because is triggers reanalysis.

In addition, it is difficult to argue for the phon-concurrent model, even though naming times to it’s and is appear to be comparable in the early boundary intransitive-bias condition. First, the predicted three-way interaction of boundary, verb bias, and target was not observed. Second, there were no correlations between verb bias and the visual target it’s. However, these are both null effects, which should be interpreted cautiously. Indeed, both the garden path model and the phon-concurrent model can account for the marginal interaction between verb bias and target, as well as the correlations between verb bias and is in the early boundary conditions.

In terms of the interaction between verb bias and target, naming times to it’s seemed to be faster than naming times to is across verb bias conditions. Whereas the garden path model would attribute this effect to late closure, the phon-concurrent model

8 All accounts predict this.
would appeal to the late closure bias that was observed for these materials in pretesting. The interaction further suggested that naming times to *is* were faster in the intransitive-bias condition than in the transitive- and equi-bias conditions. While the traditional garden path model would explain this effect as verb bias aiding reanalysis, the phon-concurrent model would explain this effect as verb bias influencing the initial generation and selection of an intransitive structure and interpretation (prosodic phrasing would further aid selection).

In terms of the correlation data, naming times to *is* in the early boundary condition tended to increase as verbs became more transitive. Such a pattern would be expected whether the effect stemmed from reanalysis from a direct object to a main clause structure or from the initial generation and selection of an intransitive structure and meaning. Indeed, the early boundary intransitive-bias *is* condition is the one condition that most closely resembles Garnsey, Pearlmutter, Myers, and Lotocky (1997). In this condition, the plausible NP supports the less frequent direct object structure, and naming times to *is* are predicted to increase as transitivity increases.

### 7.6 General discussion

The results of Experiment 2 suggest that—at least for the current materials—intermediate phrase boundary location does not determine the initial parse. The results fail to replicate Kjelgaard and Speer’s (1999) intermediate phrase boundary effects for equi-bias verbs, and as such, they suggest that those effects might have hinged on the use of equi-bias sentence fragments.

Both the traditional garden path model and the phon-concurrent model provide some explanation for the results. However, there are several ways to argue that the phon-
concurrent model provides a better account. First, naming times to *is* in the early boundary intransitive-bias condition show little evidence of processing difficulty in Figure 7.6. This condition requires reanalysis in the garden path model, but not in the phon-concurrent model. Second, even if the intransitive-bias early boundary *is* condition is a reanalysis condition, reanalysis is only apparent when the two most intransitive verbs (*tries* and *continues*) are removed from analysis. Thus, it would seem that given a verb with a strong enough intransitive bias, verb bias *does* influence the initial parse, as only the phon-concurrent model allows. Third, the garden path model must be excluded on independent grounds. Regardless of the findings here, the garden path model cannot explain the robust effects of intonation phrasing observed in Experiment 1.

The contrast between the current results and Kjelgaard and Speer’s (1999) finding that intermediate phrase boundaries did determine the initial parse suggests that the late closure bias in the current materials might have overwhelmed any influence of intermediate phrasing. It could very well be the case that less biased auditory stimuli would replicate the effect from Kjelgaard and Speer (1999). It is worth noting that while Experiments 1 and 2 are designed to investigate verb bias and phrasing effects on initial structure, they actually tap processing at a fairly late position structurally (i.e., one word position after the ambiguous—and plausible—NP). Experiment 3 will attempt to tap an earlier stage of processing by having participants name structurally ambiguous NPs that are plausible and implausible as direct objects.
8.1 Introduction

In Experiment 3, participants listen to fragments that end with the verb, and they name a visually-presented NP that is either plausible or implausible as a direct object. The auditory fragments differ in terms of their prosodic phrasing and end in one of three ways: without a boundary, with an intermediate boundary, or with an intonation boundary.

The main goal of the current pretest is to assess the strength of the plausibility manipulation. Garnsey, Pearlmutter, Myers, and Lotocky (1997) effectively demonstrated online effects of plausibility using plausible and implausible NPs that were separated by at least 2.5 units on a 7-point scale. The current plausibility test also uses a 7-point scale in order to find NP pairs that are comparably far apart. To test plausibility, participants are asked to rate how acceptable written versions of the fragments are as the beginning of a sentence. NPs are rated for plausibility in direct object position (e.g., *Whenever the lady loads the van, it’s*) and in subject position (e.g., *Whenever the lady loads, the van is*).  

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1 In contrast to the pretests for Experiments 1 and 2, the visual presentation for the Experiment 3 pretest did include commas.
While plausible NPs in direct object position are predicted to be rated as better sentence beginnings than implausible NPs in direct object position, all NPs are predicted to be rated as acceptable sentence beginnings in subject position.

In addition to testing the strength of the plausibility manipulation, this pretest also obtains a measure of to what extent the auditory fragment seems to reflect the speaker’s intention and a measure of how intelligible the verb, the final word in the fragment, is. These are the same measures that were obtained for the auditory stimuli in Experiments 1 and 2.

8.2 Method

8.2.1 Participants

Forty-eight students from undergraduate linguistics classes at Ohio State University received course credit in exchange for their participation.

8.2.2 Materials

Recall that in a cross-modal naming task, participants provide a baseline naming time to all targets. In Experiments 1 and 2, participants repeatedly named the visual targets *is* and *it’s* in response to a carrier phrase (i.e., *The next word will be*). To limit the number of visual targets in Experiment 3 that would require baseline responses, the 36 plausible NPs were assigned to different verbs to create the 36 implausible NPs. For example, *the infant* is the plausible direct object for *babysits*, but the implausible direct object for *debates*.

To the greatest extent possible, the plausible and implausible NPs for each verb were matched on number of syllables and stress pattern. As shown in Figure 8.1, plausible NPs in the transitive-bias condition appear to have a higher frequency than the
other conditions. However, there were no significant differences between pairs of verb-bias conditions in either the plausible or implausible conditions ($t's < 1.2$). Appendix B contains a complete list of critical sentence fragments, each verb’s plausible and implausible visual targets, and the Francis and Kucera (1982) mean written frequency counts for visual targets.

<table>
<thead>
<tr>
<th>NP</th>
<th>Transitive</th>
<th>Equi</th>
<th>Intransitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plausible</td>
<td>117.5 (102.7)</td>
<td>70.3 (79.2)</td>
<td>78.9 (62.5)</td>
</tr>
<tr>
<td>Implausible</td>
<td>81.4 (90.9)</td>
<td>92.0 (78.7)</td>
<td>94.5 (86.4)</td>
</tr>
</tbody>
</table>

**Figure 8.1:** Mean written frequency (and standard deviation) of plausible and implausible NP targets across verb bias conditions

Each of four lists contained the entire set of 36 critical fragments randomized with 98 fillers. The order of presentation was the same across lists. Lists 1 and 2 contained the direct object plausibility manipulation. Written versions of these critical fragments ended in it’s and were unambiguously transitive (e.g., *Whenever the lady loads the van, it’s*; *Whenever the lady loads the sun, it’s*). The auditory fragments for these lists ended without a boundary (e.g., *Whenever the lady loads*). Lists 3 and 4 contained the plausible and implausible NPs in embedded subject position. Versions of these critical fragments were unambiguously intransitive (e.g., *Whenever the lady loads, the van is*; *Whenever the lady loads, the sun is*). The auditory fragments on list 3 ended in intermediate boundaries. The auditory fragments on list 4 ended in intonation boundaries.
Plausibility was balanced across the two lists. Due to an oversight, it was not balanced across verb bias. Participants rated equal numbers of plausible and implausible fragments in the equi-bias verb conditions, but they rated unequal numbers (10 and 2) in the other two verb-bias conditions.

Of the 98 fillers, 14 contained semantic violations (e.g., *All the parents elapsed*). These were intended to serve as implausible beginnings of sentences. An additional 14 contained unlikely boundary locations (e.g., *The young L-L% girls*) that were intended to serve as utterances that were not said as the speaker intended. Ten more were truncated prematurely so that the final word or a portion of that word was deleted. These were intended to serve as utterances with unintelligible final words.

### 8.2.3 Procedure

The procedure was the same as reported in the Experiment 1 pretest in Chapter 4.

### 8.3 Results

#### 8.3.1 Plausibility manipulation

Only 15 of the 36 plausible and implausible NP pairs received ratings that were at least 2.5 units apart on the 7-point scale. For this reason, the NPs were redesigned and retested. An additional 40 participants from the same population performed the first two rating tasks on the new NPs (i.e., they rated the acceptability of written fragments as sentence beginnings and to what extent the auditory fragments seemed to match the speaker’s intention). Plausibility was balanced across lists, and this time, also across verb bias.

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2 Because participants did not rate intelligibility of the final word, the ten unintelligible foils were removed from each list.
In the second round of pretesting, only 13 of the 36 plausible and implausible NP pairs received ratings that were at least 2.5 units apart on the 7-point scale. In short, it was difficult to find 36 NPs that could function as an implausible direct object for one verb and a plausible direct object for another. In some cases (e.g., checks, describes), it was especially difficult to find implausible direct objects. Because it was so difficult to find pairs of NPs that met the Garnsey et al. (1997) criteria, this second set of NPs was used in Experiment 3 despite its shortcomings. Figure 8.2 summarizes the mean acceptability scores across conditions for these visually-presented fragments.

<table>
<thead>
<tr>
<th>Verb Bias</th>
<th>Direct Object NP</th>
<th>Transitive</th>
<th>Equi</th>
<th>Intransitive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plausible</td>
<td>4.63 (1.19)</td>
<td>5.12 (1.24)</td>
<td>4.98 (1.42)</td>
</tr>
<tr>
<td></td>
<td>Implausible</td>
<td>2.77 (0.98)</td>
<td>3.12 (1.12)</td>
<td>2.55 (0.83)</td>
</tr>
<tr>
<td>Subject NP</td>
<td>Transitive</td>
<td>4.94 (0.98)</td>
<td>5.47 (1.20)</td>
<td>5.46 (1.36)</td>
</tr>
<tr>
<td></td>
<td>Implausible</td>
<td>4.48 (1.09)</td>
<td>4.78 (1.16)</td>
<td>4.88 (0.97)</td>
</tr>
</tbody>
</table>

Figure 8.2: Mean plausibility ratings (and standard deviations) for visually-presented target NPs (1 = completely implausible, 7 = completely plausible)

The mean acceptability ratings were subjected to subject- and item-based 2 (structure: direct object, subject) X 2 (plausibility: plausible, implausible) X 3 (verb bias: intransitive, equi, transitive) repeated measures ANOVAs. There was a reliable interaction between structure and plausibility both by subjects and items (F1[1,38]=18.346, p < .01; F2[1,30]=63.525, p < .01). The direct object sentence
fragments with implausible NPs were significantly less acceptable than the direct object sentence fragments with plausible NPs (t1[118]=10.029, p < .01; t2[70]=12.220, p < .01). They were also significantly less acceptable than subject structure sentence fragments with implausible NPs (t1[118]=10.083, p < .01; t2[70]=10.513, p < .01).

It was also the case that in the subject structure conditions, plausible NPs were rated as more acceptable sentence beginnings than implausible NPs (t1[118]=2.777, p = .01; t2[70]=2.892, p < .01). This is not surprising given that the plausible NPs are probably more likely to support the overall context of the sentence. That is, implausible NPs are probably implausible in part because they are less likely to fit into the context set up by the grammatical subject and verb.

In addition to the interaction between structure and plausibility just detailed, the ANOVAs also revealed several other effects. By subjects, there was a reliable interaction between verb bias and structure (F1[2,76]=3.439, p < .05). This effect might be attributable to the intransitive-bias condition in which direct object structures (3.77) seemed to be rated as less acceptable than subject structures (5.17). There was a significant main effect of plausibility (F1[1,38]=56.460, p < .01; F2[1.30]=176.554, p < .01) such that plausible NPs resulted in more acceptable fragments than implausible NPs. There was a significant main effect of structure (F1[1,38]=16.709, p < .01; F2[1,30]=119.481, p < .01) such that subject structures were rated as more acceptable than direct object structures. There was a significant main effect of verb bias (F1[2,76]=11.924, p < .01; F2[2.30]=6.196, p < .01) such that fragments with equi-bias verbs (4.62) were rated as more acceptable than intransitive-bias verbs (4.47), which were rated as more acceptable than transitive-bias verbs (4.21).
Given how difficult it was to find one set of 36 NPs that could double as plausible and implausible direct objects, it is not surprising that the ANOVAs also revealed item group effects in the items analysis. Item group interacted with structure and plausibility together (F2[1,30]=10.481, p < .01), with plausibility (F2[1,30]=48.937, p < .01), and with structure (F2[1,30]=12.261, p < .01). Item group also contributed its own main effect (F2[1,30]=21.564, p < .01).

Even though the plausibility manipulation failed to be as effective as in Garnsey et al. (1997), the implausible NPs in direct object structures (mean 2.81, SD 0.99) seemed to be at least as unacceptable as the fillers on the same lists that contained semantic violations (mean 3.25, SD 0.91; t[78]=1.725, p < .10).

8.3.2 Spoken fragment ratings

In this stage of pretesting, participants were asked to judge to what extent they thought that the speaker had said the fragment as she intended. Figure 8.3 summarizes the scores by condition. Note that these data come from the second round of pretesting. Furthermore, data in the no boundary condition come from 20 participants (lists 1 and 2), while data from the other two boundary conditions come from 10 participants each (list 3, list 4).
Figure 8.3: Mean acceptability ratings (and standard deviations) for spoken sentence fragments (1 = not said as intended, 7 = said as intended)

As expected, mean scores for critical items in all conditions fell on the acceptable end of the scale. In contrast to the means displayed in Figure 8.3, the mean acceptability score for the 14 filler items produced with boundaries in unlikely locations (e.g., The young girls) fell well below the midpoint of the scale (mean 2.14, SD 1.36).

Because plausibility and boundary were never fully crossed in the design, two separate analyses were done. In the first analysis, the mean scores for the no boundary (direct object) cases were subjected to subject- and item-based 2 (plausibility: plausible, implausible) X 3 (verb bias: intransitive, equi, transitive) repeated measures ANOVAs. There was a clear main effect of plausibility (F1[1,18]=5.976, p < .05; F2[1,30]=17.628, p < .01) such that auditory fragments following plausible NPs were judged to sound more
like the speaker’s intention than auditory fragments following implausible NPs. Thus, in some sense, the no boundary fragments are more acceptable in the context of a plausible NP than in the context of an implausible NP. There was a marginal interaction between plausibility and verb bias (F1[2,36]=2.779, p < .10, F2[2,30]=2.488, p = .10), which might be due to the relatively low scores in the intransitive-bias implausible condition. Similarly to the main effect of plausibility, there is some sense in which the no boundary fragments seem to be relatively unacceptable when the verb bias and NP fail to support a direct object structure. There was a main effect of verb bias, reliable by subjects (F1[2,36]=3.747, p < .05), such that fragments with transitive-bias verbs (4.84) were rated as more acceptable than equi-bas verbs (4.76), which were rated as more acceptable than intransitive-bias verbs (4.56). Finally, plausibility interacted with item group (F2[1,30]=52.445, p < .01), which is to be expected given the varying degrees of success in finding plausible and implausible NP pairs for each verb.

In the second analysis, the mean scores for the intermediate and intonation phrase (subject) cases were subjected to a 2 (plausibility: plausible, implausible) X 3 (verb bias: intransitive, equi, transitive) repeated measures ANOVA with boundary (intermediate, intonation) as a between-subjects factor. There were no reliable effects (all Fs < 1.8).
8.3.3 Final word intelligibility ratings

In this stage of pretesting, participants were asked to rate the intelligibility of the last word in the auditory fragment (i.e., the verb). Note that because these data come from the original round of pretesting, the data in the no boundary condition come from 24 participants (lists 1 and 2), and data from the other two boundary conditions came from 12 participants (list 3, list 4) each. Because plausibility was not balanced across verb bias conditions, it is not included here as a factor. Figure 8.4 summarizes the scores by condition.

<table>
<thead>
<tr>
<th>Boundary</th>
<th>Transitive</th>
<th>Equi</th>
<th>Intransitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>4.60 (1.59)</td>
<td>5.03 (1.37)</td>
<td>4.88 (1.41)</td>
</tr>
<tr>
<td>Intermediate</td>
<td>5.22 (1.73)</td>
<td>5.64 (1.50)</td>
<td>5.72 (1.26)</td>
</tr>
<tr>
<td>Intonation</td>
<td>5.78 (1.39)</td>
<td>5.96 (1.36)</td>
<td>6.07 (1.19)</td>
</tr>
</tbody>
</table>

Figure 8.4: Mean intelligibility ratings (and standard deviations) of the final word in spoken sentence fragments (1 = completely unintelligible, 7 = completely intelligible)
As expected, intelligibility ratings improve from the no boundary condition to the intermediate boundary condition and again to the intonation boundary condition. This is not surprising given that in the acoustic analyses, verb duration progressively lengthened across these conditions as well. As words increase in duration, they are likely to be easier to understand.

The results of subject- and item-based 3 (verb bias: intransitive, equi, transitive) X 3 (boundary: no boundary, intermediate, intonation) repeated measures ANOVAs demonstrated that the main effect of boundary was reliable by subjects and by items (F1[2,66]=58.238, p < .01; F2[2,33]=7.163, p < .01). The only other reliable effect was a main effect of verb bias (F1[2,33]=3.391, p = .05; F2[2,66]=17.779, p < .01). This probably reflects the fact that the transitive-bias conditions received the lowest intelligibility ratings in all boundary conditions. Similar effects were seen in the intelligibility pretest for the Experiment 1 and 2 stimuli. However, in contrast to even these transitive-bias critical items, the mean intelligibility rating for items that were truncated prematurely fell well below the midpoint of the scale (mean 2.64, SD 1.76).

8.4 Discussion

The results of this pretest suggest that the plausibility manipulation in Experiment 3 is unlikely to be as effective as that in Garnsey et al. (1997). Fewer than half of the 36 plausible/implausible noun pairs were separated by at least 2.5 units on a 7-point scale. That said, this is not a reason to dismiss Experiment 3. First, the direct object sentence fragments containing implausible NPs were judged to be significantly less acceptable than those fragments containing plausible NPs. Thus, to a certain extent, the plausibility manipulation was effective. Second, even if the strength of the current plausibility
manipulation matched Garnsey et al., the fact remains that the structures in these studies are different, and thus not completely comparable for that reason. Whereas the current study uses an early/late closure ambiguity in a subordinate clause, Garnsey et al. used a direct object/sentence complement ambiguity.

Lastly, the auditory fragments for Experiment 3 did earn ratings on the acceptable end of the scale in pretests of spoken intention and final word intelligibility.
CHAPTER 9

EXPERIMENT 3:
VERB BIAS, PROSODIC BOUNDARIES, AND PLAUSIBILITY

9.1 Introduction

In Experiments 1 and 2, participants listened to structurally ambiguous fragments (e.g., *Whenever the lady loads the car*). The fragments contained a prosodic boundary that was either located early, before the structurally ambiguous noun phrase (NP; *the car*), or late, after the NP. At the offset of each fragment, participants named a visually-presented target (*it’s* or *is*) that was intended to disambiguate the fragment toward either a late closure or early closure structure and interpretation.

The results of Experiment 1 suggested that the location of the intonation boundary determined the initial structure for this ambiguity regardless of how likely it was for the verb to take a direct object. Consistent with Schafer’s (1997) interpretive domain hypothesis, intonation boundaries triggered the semantic processor to commit to a semantic interpretation and that interpretation seemed to be to the dominant meaning of the verb. In addition, the results suggested that intonation boundaries triggered the syntactic processor to commit to syntactic structure (i.e., intransitive for an early
boundary and transitive for a late boundary). Finally, during reanalysis, commitment to a subordinate structure and meaning (i.e., intransitive-bias verbs in the late boundary condition) resulted in reanalysis that occurred post-naming, while commitment to a dominant structure and meaning (i.e., transitive-bias verbs in the late boundary condition) resulted in reanalysis that occurred at naming. Commitment to a subordinate structure and dominant meaning (i.e., transitive-bias verbs in the early boundary condition) resulted in reanalysis of the dominant meaning.

In contrast to the robust effects of the intonation boundaries in Experiment 1, the location of the intermediate boundaries in Experiment 2 tended to influence reanalysis. Only the combination of an intransitive-bias verb and an early boundary might have led to an initial early closure structure and interpretation. While this experiment failed to replicate Kjelgaard and Speer’s (1999) finding that intermediate boundary location determines the initial structure for equi-bias verbs, the failure to replicate was probably due, at least in part, to a late closure bias in the current materials. This bias was described in Chapter 6.

The plausible NPs that ended the auditory fragments in Experiment 2 (and also in Experiment 1) are likely to be one source of the late closure bias. However, it is worth noting that the visual targets in Experiments 1 and 2 tapped processing one word position after the structurally ambiguous NP and two word positions after the verb. Thus, verb bias or early intermediate phrases might have influenced the initial parse in some unobserved way prior to the onset of the plausible NP or visual target. Experiment 3 is designed to limit the influence of the late closure bias and to tap the earliest possible interaction between verb bias and intermediate phrasing.
For this experiment, the structurally ambiguous NP was removed from each critical fragment. As a result, auditory fragments end at the verb in one of three boundary types: no boundary (i.e., mid-phrase), intermediate phrase, or intonation phrase. Visual targets are NPs that are either plausible or implausible as direct objects. Figure 9.1 summarizes the critical stimuli for Experiment 3.

<table>
<thead>
<tr>
<th>Verb Bias</th>
<th>Prosodic Boundary</th>
<th>Auditory Fragment with Prosodic Contour</th>
<th>Visual Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>H*</td>
<td>Plausible</td>
<td>Implausible</td>
<td></td>
</tr>
<tr>
<td>Tran</td>
<td>None</td>
<td>Whenever the lady loads the van</td>
<td>the sun</td>
</tr>
<tr>
<td>Equi</td>
<td>None</td>
<td>Whenever the lady checks the weather</td>
<td>the IRS</td>
</tr>
<tr>
<td>Intran</td>
<td>None</td>
<td>Whenever the lady moves her elbow</td>
<td>the weather</td>
</tr>
<tr>
<td>H*</td>
<td>Intonation</td>
<td>Whenever the lady loads the van</td>
<td>the sun</td>
</tr>
<tr>
<td>Tran</td>
<td>Intermediate</td>
<td>Whenever the lady checks the weather</td>
<td>the IRS</td>
</tr>
<tr>
<td>Equi</td>
<td>Intermediate</td>
<td>Whenever the lady moves her elbow</td>
<td>the weather</td>
</tr>
<tr>
<td>Intran</td>
<td>Intermediate</td>
<td>Whenever the lady loads the van</td>
<td>the sun</td>
</tr>
<tr>
<td>H*</td>
<td>Intonation</td>
<td>Whenever the lady checks the weather</td>
<td>the IRS</td>
</tr>
<tr>
<td>Tran</td>
<td>Intonation</td>
<td>Whenever the lady moves her elbow</td>
<td>the weather</td>
</tr>
<tr>
<td>Equi</td>
<td>Intonation</td>
<td>Whenever the lady loads the van</td>
<td>the sun</td>
</tr>
<tr>
<td>Intran</td>
<td>Intonation</td>
<td>Whenever the lady checks the weather</td>
<td>the IRS</td>
</tr>
</tbody>
</table>

Figure 9.1: Summary of conditions and example stimuli for Experiment 3
In Experiments 1 and 2, the visual targets were intended to disambiguate the structures syntactically. The reaction time analysis included only late closure completions to *it’s* and early closure completions to *is*. In Experiment 3, the targets are intended to disambiguate the structures semantically. This reaction time analysis includes only late closure completions to plausible NPs and early closure completions to implausible NPs.¹

Experiment 3 tests two of the processing accounts from Experiments 1 and 2: Schafer’s (1997) prosody-first account and the phon-concurrent model. In addition, the experiment tests the processing claims from Experiment 1; namely, that early intonation boundaries trigger commitment to the dominant meaning of the verb, but syntactic commitment to an intransitive structure; and that given a situation requiring reanalysis of either a dominant representation or a subordinate representation, the dominant representation will undergo reanalysis. The results also have implications for Watson and Gibson’s (2003) anti-attachment hypothesis, a parsing strategy against attaching incoming material to words preceding intonation phrase boundaries.

The traditional garden path model is not pursued here because it was unable to explain the robust effects of intonation phrase boundary location observed in the first experiment.

¹ As it turns out, the reaction time analysis only included early closure completions to implausible NPs. This is because a comparable plausible NP late closure analysis would require replacing 25-52% of the data in the intermediate boundary conditions and 47-73% of the data in the intonation boundary conditions.
9.2 Processing predictions

9.2.1 Schafer’s (1997) prosody-first account

9.2.1.1 Prosody-first without syntactic wrap-up

According to Schafer’s (1997) prosody-first account, intermediate phrases reduce visibility between an incoming node and potential attachment sites. Intonation phrases trigger the semantic/pragmatic processor to wrap up any outstanding processing.

There is a critical difference between the boundary conditions in Experiment 3 and the boundary conditions in Experiments 1 and 2, or even in Kjelgaard and Speer (1999): no additional disambiguating information arrives after the structurally ambiguous NP (i.e., the current visual target). As a result, the intermediate phrase should reduce prosodic visibility and delay syntactic attachment in both boundary conditions, but the reduction should not prevent the parser from building the direct object structure.

Because the parser ultimately builds a direct object in all conditions, Schafer’s (1997) original account makes the same predictions as the traditional garden path model (the model on which it is based) for the no boundary and intermediate boundary conditions. Naming times should be shorter for plausible targets than implausible targets because implausible targets trigger reanalysis. For the plausible NPs, naming times should be shorter in the no boundary condition than in the intermediate phrase boundary condition because of prosodic visibility or a prosody/syntax mismatch. For the implausible NPs, naming times should be shorter in the intermediate phrase boundary condition than in the no boundary condition because of a prosody/syntax mismatch.

With respect to the intermediate phrase boundary and intonation phrase boundary conditions, intonation boundaries in Schafer’s (1997) account trigger wrap-up of any
outstanding semantic/pragmatic processing. That wrap-up should change the reanalysis process in the intonation boundary conditions relative to comparable intermediate boundary conditions.

Consider the possibilities. In one scenario, the early intonation phrase boundary triggers wrap-up to the dominant meaning of the verb. Then the visual target appears. In the case of transitive-bias verbs and plausible NPs, the verb meaning and the target are consistent with the direct object structure and interpretation. However, a prosody-syntax mismatch might trigger reanalysis. (That is, unless a participant builds a heavy NP or inserts a second intonation boundary, one following the visual NP target, into the prosodic representation.) In the case of intransitive-bias verbs and plausible NPs, the commitment to an intransitive interpretation (and possibly a prosody-syntax mismatch) should trigger reanalysis of the direct object structure. In the case of implausible targets, there should always be reanalysis.

This particular account of semantic wrap-up predicts the following interaction. Reanalysis to an early closure structure for the transitive-bias verbs should be less likely and/or result in longer naming times following an intonation boundary than following an intermediate boundary. That is, wrap-up to a transitive interpretation in the intonation boundary condition should make the intransitive interpretation less available than in the intermediate boundary condition and thus result in more late closure completions. In contrast, reanalysis for the intransitive-bias cases should be more likely following an intonation boundary than following an intermediate boundary. Wrap-up to an intransitive interpretation should make the intransitive interpretation more available than in the intermediate phrase boundary condition and thus result in fewer late closure completions.
In a second scenario, the intonation boundary triggers semantic wrap-up to an *intransitive* interpretation for all verbs. This predicts reanalysis of the direct object structure to an early closure structure for all verbs. It also predicts that reanalysis should be *more* likely in the intonation boundary condition than in the intermediate boundary condition because of the increased commitment to the intransitive interpretation. Because all verbs have an intransitive interpretation, this scenario predicts few late closure completions in the intonation boundary condition.

**9.2.1.2 Prosody-first with syntactic wrap-up**

In contrast to Schafer’s (1997) original account, the results of Experiment 1 suggested that intonation boundaries trigger semantic/pragmatic and *syntactic* wrap-up. Because the intonation phrase boundary in the current experiment occurs just after the verb, this should cause the parser to commit to an intransitive structure. The results of Experiment 1 further suggested that intonation phrase boundaries cause the semantic processor to commit to the dominant interpretation of the verb.

If the parser really does commit to an intransitive structure, then in a serial processing account, it should incorporate any NP target (plausible or implausible) following an intonation boundary as the subject of the main clause. This predicts few, if any, late closure completions in this condition. However, because the semantic processor commits to the dominant interpretation of the verb, semantic reanalysis is predicted for the transitive-bias verbs. In the case of intransitive-bias and equi-bias verbs, and in contrast to Schafer’s (1997) original account, no semantic or syntactic reanalysis would be expected. In fact, naming times in these conditions should be as short as naming times in the plausible NP no boundary condition. In the case of transitive-bias verbs, however,
there should be semantic reanalysis to an intransitive interpretation. Just as in Experiment 1, semantic commitment to the dominant verb meaning (i.e., assign a theme) and syntactic commitment to the subordinate structure (i.e., no direct object) should result in semantic reanalysis (and few, if any, late closure completions). This account is also consistent with reanalysis in the traditional garden path model, on which the Schafer account is based. Because the subject structure is the structurally-favored analysis, the thematic roles that confirm the structurally favored analysis should be assigned (Frazier, 1990).

9.2.2 The phon-concurrent model

9.2.2.1 The phon-concurrent model without syntactic wrap-up

In contrast to the previous two accounts, this constraint-based account does not predict that the parser always builds a direct object first. Rather, a direct object structure (see Figure 9.2) and a subject structure (see Figure 9.3) are automatically generated at each verb and weighted by frequency. At each word position, the prosodic representation adds weight to any syntactic representation that it matches (i.e., the goodness-of-fit between the prosodic and syntactic representations constrains the weights of the generated syntactic alternatives). Intonation boundaries trigger wrap-up of any outstanding semantic/pragmatic processing, just as in Schafer (1997).
Whenever the lady Vs the N

No boundary: [ ............................... ]

Early ip boundary: [.................................]_{ip}

Early IP boundary: [.................................]_{ip}IP

Figure 9.2: Direct object syntax and three prosodic phrasings from Experiment 3 (ip = intermediate phrase, IP = intonation phrase)

Whenever the lady Vs the N

No boundary: [ ............................... ]

Early ip boundary: [.................................]_{ip}

Early IP boundary: [.................................]_{ip}IP

Figure 9.3: Subject of main clause syntax and three prosodic phrasings from Experiment 3 (ip = intermediate phrase, IP = intonation phrase)
The no boundary condition highlights certain assumptions regarding a goodness-of-fit approach to prosodic and syntactic representations. On the one hand, the absence of a boundary following the verb should add weight to all syntactic structures, even the subject structure. This is because speakers are not obliged to produce an early prosodic boundary for the subject structure. For example, it is fairly easy to imagine the absence of such a boundary in short utterances and fast speech. However, production studies suggest that there is a high probability of speakers producing an early prosodic boundary for early closure structures like the ones being tested here (Anderson & Carlson, 2004; Schafer, Speer, Warren, & White, 2000). It seems reasonable to assume that listeners somehow encode and access this prosodic frequency information, just as they encode and access other types of frequency information, such as lexically-based syntactic frequencies (e.g., Garnsey, Pearlmutter, Meyers, & Lotocky, 1997; Trueswell, Tanenhaus, & Kello, 1993) and overall syntactic frequencies (e.g., MacDonald, Pearlmutter, & Seidenberg, 1994; McRae, Spivey-Knowlton, & Tanenhaus, 1998). In turn then, a goodness-of-fit constraint likely comprises two distinct components: the quality of fit between the prosodic representation and the syntactic alternatives, and the likelihood of the prosodic representation for each syntactic alternative.²

Because production studies show that the absence of a boundary after the verb is much more likely to occur with direct object structures than subject structures (Anderson & Carlson, 2004; Schafer, Speer, Warren, & White, 2000), the absence of a boundary should add more weight to the direct object structure than to the subject structure. As a

² Of course, prosodic representations that fit poorly with a syntactic structure probably have a low likelihood for that structure.
result (and perhaps in conjunction with the late closure bias in the current materials), the
direct object structure should be more accessible than the subject structure in all verb bias
conditions. Plausible direct object NPs should elicit late closure completions, although
there should still be an effect of verb bias on naming times and the proportion of late
closure completions. Implausible direct object NPs should trigger reanalysis. Naming
times to plausible NPs should be shorter than naming times to implausible ones.

When an intermediate phrase boundary follows the verbs, the prosodic
representation should add weight to the subject structure and reduce the proportion of late
closure completions in each condition relative to the comparable no boundary condition.
That said, one can only speculate as to how much weight the early intermediate phrase
boundary should add. The early boundary is probably more likely for the subject
structure, and as shown in Figures 9.2 and 9.3, the goodness-of-fit is higher for the
subject structure than for the direct object structure. Whereas the intermediate phrase
contains a completed syntactic constituent in the subject structure (i.e., the S-bar
Whenever the lady Vs), there is no similar syntactic constituent in the direct object
structure. Of course, the early intermediate phrase boundary is not inconsistent with a
direct object structure at this point in the fragment (i.e., another boundary could follow
the direct object, as would be likely for a heavy direct object NP).

For intransitive- and equi-bias verbs, the subject structure should be more
accessible than the direct object structure given the verb bias and the early intermediate
phrase boundary. As a result, naming times in both these conditions should be equally
short for plausible and implausible targets. For transitive-bias verbs, it is unclear whether the early intermediate phrase boundary adds enough weight to make the subject structure as accessible as the direct object structure. For transitive-bias verbs, naming times might still be shorter for plausible NPs than implausible NPs, and late closure completions might still outnumber early closure completions.

When an intonation phrase boundary follows the verb, the intonation phrase boundary triggers wrap-up of any outstanding semantic/pragmatic processing. The early intermediate phrase boundary adds weight to the subject structure. Because semantic processing also affects the weights of the syntactic alternatives, verb bias is important.

For the intransitive-bias and equi-bias verbs, wrap-up to the dominant meaning of the verb adds weight to the subject structure. As a result, there should be no difference in naming times to plausible and implausible targets. There should be few, if any, late closure completions, and certainly fewer late closure completions than in the intermediate boundary condition. For the transitive-bias verbs, the early boundary adds weight to the subject structure, while the dominant (transitive) interpretation supports the more frequent direct object structure. As a result, the direct object structure is probably still more accessible than the subject structure and even more accessible than in the intermediate phrase condition. This predicts that naming times to plausible NPs should be shorter than naming times to implausible NPs, and there should be a greater number of late closure completions than in the intermediate boundary condition.

3 If late closure completions outnumber early closure completions for these two verb conditions, then technically speaking, naming times should be longer for plausible NPs than implausible NPs. This is because the plausible NP should trigger reanalysis of the intransitive structure and interpretation. That said, the results of Experiment 2 suggest that this is unlikely.
9.2.2.2 The phon-concurrent model with syntactic wrap-up

The processing steps described so far do not incorporate the findings in Experiment 1 that an intonation phrase boundary triggers wrap-up to the dominant meaning of the verb and wrap-up to a syntactic structure (here in Experiment 3 to an intransitive structure). According to results of Experiment 1, there should be wrap-up to intransitive semantic and syntactic representations for the intransitive-bias and equi-bias verbs. As a result, there should be few, if any, late closure completions, and there should be no difference in naming times to plausible and implausible targets. Plausible targets that do result in late closure completions should do so as a result of reanalysis.

For transitive-bias verbs, there should be a semantic commitment to assigning a theme (i.e., the dominant interpretation) and a syntactic commitment to an intransitive (i.e., the subordinate) structure. At the visual target, the NP should be attached as a subject into the stronger subject structure. However, consistent with the design of the original concurrent model (Boland, 1997), which allows syntactic representations to be reactivated at each word position if those alternatives are consistent with the lexical input, an NP target should also be attached as a direct object into a weaker direct object structure. If the target is an implausible NP, it should trigger semantic reanalysis to an intransitive interpretation. If the target is a plausible NP (i.e., plausible as a direct object, but also plausible as a main clause subject), two possibilities for resolving the conflict between the syntactic and semantic representations should emerge.\textsuperscript{4}

\textsuperscript{4} Because the syntactic and semantic processors share information, and because commitment to the intransitive structure is as strong as the commitment to assigning a theme, theme assignment does not automatically prevail, despite the fact that the semantic processor builds only a single representation.
When the semantic representation (i.e., assign a theme) adds enough support to the syntactic processor to trigger syntactic reanalysis from the subject structure to a direct object structure, late closure completions should result. When the syntactic representation (i.e., the early closure structure) adds enough support to the semantic processor to trigger semantic reanalysis from assigning a theme to not assigning a theme, early closure completions should result. In short, this condition should elicit early and late closure completions. That said, there should be fewer late closure completions than the intermediate phrase condition given the syntactic commitment to an intransitive structure, and there should be more late closure completions than in the other two intonation phrase verb conditions given the semantic commitment to a transitive interpretation.

At first glance, this prediction seems contrary to the findings of Experiment 1, which suggested that a subordinate representation is preserved even when a visual target supports a dominant one. It seems that Experiment 1 should predict that, even with a plausible NP, the transitive-bias verb should undergo semantic reanalysis to an intransitive interpretation.
However, there is a critical difference between Experiment 1 and Experiment 3. In the early boundary transitive-bias verb condition in Experiment 1, the visual target it’s appeared immediately after the plausible NP. In Experiment 3, there is only the plausible NP. Thus, in Experiment 1, there was a grammatical alternative—the topicalized NP structure—that ultimately preserved the goodness-of-fit between the given prosodic representation and the syntactic representation. That is, semantic reanalysis was not only more likely because it did not involve changing commitment to a subordinate representation, but semantic reanalysis ultimately resulted in a better output than syntactic reanalysis.5

Here in Experiment 3, it is true that building a subject structure for the plausible NP in the transitive-bias early intonation boundary condition would also preserve the goodness-of-fit between the prosodic and syntactic representations. However, speakers have a second, equally grammatical option. They can assign a second intonation boundary after the plausible NP as a way of preserving goodness-of-fit between the given prosodic representation and a direct object structure.

Unfortunately, the nature of the cross-modal naming task makes it difficult to know whether participants really did assign a second intonation phrase boundary. Participants named each target as quickly as they could and then took as long as they needed to produce a completion. As a result, participants often named targets without any attempt to match the prosodic contour.

5 The late boundary is conditions in Experiment 1 provided additional evidence that reanalysis of a subordinate representation is harder than reanalysis of a dominant one.
The difference between these two versions of the phon-concurrent model is not trivial. Within Schafer’s (1997) original hypotheses, the functional differences between intonation boundaries and intermediate boundaries correspond to differences in shared vocabulary among the different processors (i.e., intonation boundaries are common vocabulary for the phonological and semantic processors, while intermediate boundaries are common vocabulary for the phonological and syntactic processors). Without syntactic wrap-up, that distinction is preserved. Intonation boundaries trigger semantic wrap-up, which in turn influences the weights of the syntactic alternatives. With syntactic wrap-up, however, intonation boundaries trigger syntactic wrap-up directly. As a result, intonation boundaries must represent vocabulary that is common to the phonological, semantic, and syntactic processors.

Are there competing predictions that can make a distinction between these two accounts? Yes, the accounts make different predictions for plausible NP targets. If intonation boundaries trigger semantic commitment to the dominant verb meaning without triggering syntactic commitment to an intransitive structure, then transitive-bias verbs should elicit more late closure completions in the intonation boundary condition than in the intermediate boundary condition. But, if intonation boundaries trigger semantic commitment to the dominant verb meaning and syntactic commitment to an intransitive structure, then transitive-bias verbs should elicit both late closure and early closure completions in the intonation boundary condition, but fewer late closure completions in the intonation boundary condition than in the intermediate boundary condition.
9.2.3 Summary of predictions

The processing accounts just discussed are flexible in the sense that each provides a range of predictions. However, one condition is critical: the transitive-bias early intonation phrase boundary condition (e.g., *Whenever the lady loads $\text{IP}$*).

Assuming that early intonation phrase boundaries trigger semantic wrap-up to the dominant meaning of the verb and syntactic wrap-up to an intransitive structure, as the results of Experiment 1 suggest, Schafer’s (1997) prosody-first account and the phon-concurrent model make different predictions.

- **Prosody-first**: There should be few late closure completions, and there should be semantic reanalysis to an intransitive meaning.

- **Phon-concurrent**: There should be late closure and early closure completions with syntactic reanalysis in the case of late closure completions and semantic reanalysis in the case of early closure completions.

In addition, the phon-concurrent model predicts effects of verb bias on the initial parse. In Schafer’s (1997) account, non-categorical effects of verb bias (i.e., effects observed in regression analyses) are strictly limited to reanalysis processes.

9.3 Methods

9.3.1 Participants

Sixty students from undergraduate linguistics classes at The Ohio State University received course credit in exchange for their participation.
9.3.2 Materials

The conditions and example stimuli for Experiment 3 are summarized previously in Figure 9.1. The auditory fragments were created by truncating the stimuli from Experiments 1 and 2 immediately after the verb. The intonation boundary stimuli were created from the early boundary conditions in Experiment 1. The intermediate boundary stimuli were created from the early boundary conditions in Experiment 2. The no boundary stimuli were created from the late boundary conditions in Experiment 2.

In terms of critical visual targets, one set of NPs was used for both the plausible and implausible conditions. NPs in the plausible direct object condition were reassigned to other verbs to create implausible direct object targets. This was done to limit the number of NPs that participants would need to name in isolation at the end of the main experiment.

The set of 70 fillers that was used in Experiments 1 and 2 was also used here. To accommodate the new visual target type, 27 of the original fillers were further truncated. An additional eight were lengthened by re-extracting a longer version from the original sentence recording. In all, seven fillers ended in an intonation boundary, seven ended in an intermediate boundary, and the remaining fillers contained no boundaries. The visual targets for all fillers were plausible continuations of the auditory fragments (e.g., Washing THE CLOTHES, At the lake THE FISH). Eight visual targets contained adjectives instead of nouns (e.g., Of all the fathers here THE TALLEST).

There are 18 conditions in this 3 (Boundary: None, Intermediate, Intonation) X 3 (Verb Bias: Intransitive, Equi, Transitive) X 2 (Visual Target: Plausible, Implausible) design. The conditions rotate across six lists in a Latin Square design. Prosodic boundary
and visual target are between-subjects variables, and they are counterbalanced across lists. Verb bias is manipulated within subjects. Because the same set of NPs is used to create both the plausible and implausible visual targets, participants name seven NP targets in both conditions. On lists 1-3, participants name the implausible target first, 5 out of 7 times. On lists 4-6, participants name the implausible target first, 3 out of 7 times.

See Chapter 3 for the discussion of the verb bias variable, a discussion of the recording procedure, and detailed acoustic analyses of the stimuli. See Chapter 8 for a discussion of the plausibility variable and pretesting. See Appendix B for a complete list of materials.

9.3.3 Procedure

Experiment 3 used the same procedure as Experiments 1 and 2. The sound files were presented binaurally. As in Experiments 1 and 2, and Kjelgaard and Speer (1999), participants named each critical visual target three times in random order. These naming times were collected in response to the carrier phrase The next word will be ___, and the 87 trials were collected at the end of the main experiment. As before, naming times to the two-word targets were used to correct for any baseline difference between the two targets for individual participants.
9.4 Results

9.4.1 Sentence completion data

Sentence completions were sorted into the following categories: early closure, late closure, neither, no completion, and nonsensical. Whereas late closure completions to the fragments included an additional grammatical subject almost immediately after the visual NP target, early closure completions began with a verb. The sentences in (1) and (2) are representative of the late closure and early closure completions that participants produced.

(1) When the kid cleans the hallway he breaks the vacuum.
(2) When the kid kicks the chair hurts his foot.

Completions that fell into the neither category were typically sentence complement structures for the verb knows or ditransitive uses of the verb buys.

(3) If the couple knows the wall is slanted they won’t post pictures.
(4) If the girl buys the clerk a sandwich he serves her better.

Nonsensical completions included ones that simply failed to make sense to the experimenter, as in (5) and (6), or that failed to use the target word as presented, as in (7).

(5) If the man saves his fear will be declined.
(6) When the teen imitates the buzzer loud
(7) If the man starts his dog his dog’s obedience class
As shown in Figure 9.4, which summarizes the proportion of late closure completions by condition, an intonation phrase boundary following a transitive-bias verb did not elicit more late closure completions than following an intermediate phrase boundary.

<table>
<thead>
<tr>
<th>Boundary</th>
<th>Transitive-Bias</th>
<th>Equi-Bias</th>
<th>Intransitive-Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plaus</td>
<td>Implaus</td>
<td>Plaus</td>
</tr>
<tr>
<td>None</td>
<td>.87</td>
<td>.32</td>
<td>.81</td>
</tr>
<tr>
<td>Intermediate</td>
<td>.75</td>
<td>.22</td>
<td>.66</td>
</tr>
<tr>
<td>Intonation</td>
<td>.53</td>
<td>.12</td>
<td>.42</td>
</tr>
</tbody>
</table>

**Figure 9.4: Proportion of late closure completions in Experiment 3 by condition**

Furthermore, all three factors (plausibility, verb bias, and phrasing) contributed to the likelihood of a late closure completion. Late closure completions decreased for implausible NPs relative to plausible NPs; they decreased as verbs became more intransitive; and they decreased as boundary strength increased. A three-way interaction of visual target, verb bias, and boundary was reliable by subjects (F1[4,216]=4.113, p < .01) and by items (F2[4,36]=4.658, p < .01) in subject- and item-based 3 (Boundary: None, Intermediate, Intonation) X 3 (Verb Bias: Intransitive, Equi, Transitive) X 2 (Visual Target: Plausible, Implausible) repeated measures ANOVAs.

The ANOVAs were conducted over arcsine transformed proportion data, and list and item group were included as between-subjects and between-items variables, respectively. Other effects included an interaction between boundary and plausibility.
(F1[2,108]=27.411, p < .01; F2[2,36]=22.374, p < .01) and an interaction between verb bias and plausibility that was reliable by subjects only (F1[2,108]=6.000, p < .01; F2<1.0). There were main effects of verb bias (F1[2,108]=72.399, p < .01; F2[1,18]=3.728, p < .05), plausibility (F1[1,54]=619.103, p < .01; F2[1,18]=184.637, p < .01), and boundary (F1[2,108]=126.132, p < .01; F2[2,36]=77.896, p < .01).

There was a reliable four-way interaction with list in the subjects analysis (F1[20,216]=7.161, p < .01) and a marginal four-way interaction with item group in the items analysis (F2[20,36]=1.662, p = .09). These interactions qualified other list and item group effects. These list effects included a main effect (F1[5,54]=4.146, p < .01), as well as interactions with boundary and verb bias (F1[20,216]=14.770, p < .01), boundary and plausibility (F1[10,108]=8.079, p < .01), verb bias and plausibility (F1[10,108]=3.291, p < .01), boundary (F1[10,108]=1.971, p < .05), plausibility (F1[5,54]=6.153, p < .01), and verb bias (F1[10,108]=2.357, p < .05). Item group interacted with boundary and plausibility (F2[10,36]=3.129, p = .01) and boundary (F2[10,36]=3.118, p = .01).

These list and item group effects are probably due in part to variability in the strength of the plausibility manipulation across items. As discussed in the chapter on pretesting (Chapter 8), few pairs of plausible and implausible targets were at least 2.5 units apart on a 7-point scale, and for a few items (e.g., describes, checks), it was impossible to find truly implausible targets.

That said, other factors probably contributed to the list and item group interaction. For example, roughly half the completions to the plausible targets in the transitive-bias intonation boundary conditions were late closure completions.
Upon closer inspection, the 12 verbs in this condition seem to fall neatly into the two groups in Figure 9.5. This figure lists each verb, its plausible NP target, the number of late closure completions (maximum 10), the transitivity bias of the verb (lower numbers are less transitive), and the scores of various pretests. Stimuli that elicited fewer late closure completions are listed toward the top of the figure.

<table>
<thead>
<tr>
<th>Verb and Plausible NP (# of late closure)</th>
<th>Transitivity Bias (lower = less transitive)</th>
<th>Written Acceptability</th>
<th>Auditory Acceptability No Boundary</th>
<th>With Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>imitates the buzzer (0)</td>
<td>15.3</td>
<td>5.30</td>
<td>4.80</td>
<td>5.30</td>
</tr>
<tr>
<td>visits the teacher (0)</td>
<td>13.4</td>
<td>4.80</td>
<td>6.10</td>
<td>4.80</td>
</tr>
<tr>
<td>kills the ducks (1)</td>
<td>5.3</td>
<td>5.00</td>
<td>5.10</td>
<td>5.00</td>
</tr>
<tr>
<td>asks the price (2)</td>
<td>9.1</td>
<td>4.50</td>
<td>5.10</td>
<td>4.50</td>
</tr>
<tr>
<td>reads the words (2)</td>
<td>7.5</td>
<td>4.60</td>
<td>4.50</td>
<td>4.60</td>
</tr>
<tr>
<td>paints the wall (4)</td>
<td>10.9</td>
<td>3.90</td>
<td>5.10</td>
<td>3.90</td>
</tr>
<tr>
<td>kicks the chair (7)</td>
<td>10.8</td>
<td>5.10</td>
<td>5.90</td>
<td>5.10</td>
</tr>
<tr>
<td>loads the van (8)</td>
<td>7.0</td>
<td>4.20</td>
<td>4.60</td>
<td>4.20</td>
</tr>
<tr>
<td>describes the noise (9)</td>
<td>15.0</td>
<td>5.70</td>
<td>4.00</td>
<td>5.70</td>
</tr>
<tr>
<td>buys the car (10)</td>
<td>14.8</td>
<td>4.30</td>
<td>4.20</td>
<td>4.30</td>
</tr>
<tr>
<td>pulls the rope (10)</td>
<td>9.0</td>
<td>4.20</td>
<td>5.80</td>
<td>4.20</td>
</tr>
<tr>
<td>saves his job (10)</td>
<td>17.0</td>
<td>4.00</td>
<td>4.10</td>
<td>4.00</td>
</tr>
</tbody>
</table>

Figure 9.5: Summary of transitive-bias verb and plausible NP targets including number of late closure completions, transitivity-bias score, and mean pretest scores (7-point scale, 1 = unacceptable)
It is clear that verb bias is unlikely to be the sole source of any increased tendency for late closure completions. Both groups contain a range of high and low transitivity-bias scores. It also appears that none of the pretests explains the number of late closure completions. Both groups contain a similar range of mean acceptability scores within each measure (i.e., acceptability of written direct object fragments, acceptability of written subject fragments, acceptability of auditory fragments with no boundary, acceptability of auditory fragments spoken with a boundary). Lastly, listening to the sound files revealed no likely explanation for the two groups. A possible explanation for the two groups (i.e., the predictability of the plausible NP) is explored in the discussion.

9.4.2 Cross-modal naming time data

9.4.2.1 Overall naming times

As shown in Figure 9.6, the proportion of late closure completions varied considerably across conditions. Unfortunately, this meant that any reaction time analysis involving plausible targets would have required replacing 25-78% of the data in the two boundary conditions. That is, because these responses did not result in late closure completions, they would have to be replaced. For this reason, naming times to plausible targets were not analyzed. As a result, it was impossible to test whether or not the late closure completions to plausible targets in the equi-bias and intransitive-bias intermediate phrase conditions were the result of reanalysis, as the phon-concurrent model predicts.

It was possible to conduct a reaction time analysis for the implausible targets. As previously shown in Figure 9.4, the proportion of cells that required data replacement because they corresponded to a late closure completion never exceeded more than a third

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6 Replacing in favor of early closure completions would not eliminate the data replacement problem.
of the responses. However, a considerable number of additional cells in each condition required data replacement for other reasons (e.g., a participant named a word other than the visual target, the completion type was nonsensical, there was a voice key error, etc.). These data are summarized in Figure 9.6. The no boundary condition consistently required the greatest proportion of data replacement. This effect probably stems from decreased intelligibility of the final word in these fragments relative to fragments in the two boundary conditions.

<table>
<thead>
<tr>
<th>Boundary</th>
<th>Transitive</th>
<th>Equi</th>
<th>Intransitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>.12</td>
<td>.16</td>
<td>.15</td>
</tr>
<tr>
<td>Intermediate</td>
<td>.08</td>
<td>.11</td>
<td>.07</td>
</tr>
<tr>
<td>Intonation</td>
<td>.11</td>
<td>.04</td>
<td>.07</td>
</tr>
</tbody>
</table>

**Figure 9.6: Proportion of cells requiring data replacement in the implausible target conditions for reasons other than a late closure completion**

The reaction time analysis used the same data replacement and correction procedures as in Experiments 1 and 2. These procedures are described in Chapter 5. Figure 9.7 shows the mean corrected naming times for the implausible target conditions in Experiment 3.
The results of subject- and item-based 3 (boundary: none, intermediate, intonation) X 3 (verb bias: transitive, equi, intransitive) repeated measures ANOVAs revealed no reliable effects either by subjects (F1s < 1.7) or by items (F2s < 1.0). However, the fact that intransitive-bias verbs in the no boundary condition seemed to elicit the longest responses overall is consistent with all processing accounts. This condition is predicted to be especially difficult because the implausible target conflicts with a direct object interpretation, while the verb bias and prosodic representation conflict with a subject structure.
9.4.2.2 Correlations

As in Experiments 1 and 2, all verbs were exhaustively classified as transitive (N=17) or intransitive (N=17) on the basis of their original transitivity-bias scores. The scores from each group were then regressed against the naming times for each target. Naming times greater than 2.5 standard deviations away from the mean were identified as outliers and removed from analyses.

Two effects suggested a correlation between verb bias and naming times (all remaining Fs < 1.0). First, in the intermediate phrase condition, naming times to implausible NPs in the *transitive-bias* condition decreased as verbs became *more transitive* \( R^2 = .14, F[1,16]=2.604, p = .13 \). Second, in the intonation phrase condition, naming times to implausible NPs in the *intransitive-bias* condition decreased as verbs became *more intransitive* \( R^2 = .17, F[1,16]=3.704, p = .10 \).

While these effects are not statistically significant, their analyses included naming times to items that had ineffectual implausibility manipulations (e.g., *describes her words, knows the wall*, etc.). These implausible direct object NPs tended to elicit the late closure sentence completions shown in Figure 9.4. A second analysis was conducted in which, for each boundary condition, the items that failed to elicit at least six early closure completions (out of a possible 10) were removed. In this analysis, the same correlations were reliable or marginally significant (all remaining Fs < 1.0). In the intermediate phrase condition, naming times to implausible NPs in the *transitive-bias* condition decreased as verbs became *more transitive* \( R^2 = .28, F[1,13]=4.709, p = .05 \). In the

\[7\] There were probably too few data points (N = 8) in the transitive-bias no boundary condition to detect any effect.
intonation phrase condition, naming times to implausible NPs in the *intransitive-bias* condition decreased as verbs became *more intransitive* ($R^2 = .21$, $F[1,15]=3.371$, $p = .07$).

To understand why the correlations take the shape they do, it is helpful to consider one additional analysis of the transitive-bias and intransitive-bias verbs. Just as in Experiments 1 and 2, naming times from each boundary condition were regressed against the mean acceptability scores for written versions of the late closure (i.e., direct object) and early closure (i.e., subject) fragments. Two reliable effects emerged from these measures of late closure bias (all remaining $Fs < 1.9$, $p’s > .18$).

For the transitive-bias verbs in the no boundary condition, naming times to implausible targets *decreased* as direct object acceptability improved ($R^2 = .21$, $F[1,16]=4.021$, $p = .06$), and not surprisingly, *increased* as subject acceptability improved ($R^2 = .19$, $F[1,16]=3.465$, $p = .08$). When the items with ineffectual plausibility manipulations were removed from the analysis, the effect of subject acceptability became much stronger ($R^2 = .67$, $F[1,7]=12.071$, $p = .01$).\(^8\)

### 9.5 Discussion

The results of Experiment 3 support the claim that intonation phrase boundaries trigger semantic and syntactic wrap-up, and that early intonation phrase boundaries trigger wrap-up to semantic and syntactic representations that conflict in terms of their transitivity. In addition, the results are most consistent with the phon-concurrent model.

The proportion of late closure completions in the transitive-bias conditions suggests that early intonation phrase boundaries trigger syntactic wrap-up to an intransitive structure and semantic wrap-up to the dominant meaning of the verb.

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\(^8\) The effect disappeared for the measure of direct object acceptability ($F[1,7]<1.0$).
First, consider the relative proportion of late closure completions for the transitive-bias verbs in the intermediate phrase boundary and intonation phrase boundary conditions. Without syntactic wrap-up to an intransitive structure, semantic wrap-up to a transitive interpretation (the dominant meaning of the verb) should have made the intransitive interpretation less available than in the intermediate phrase boundary condition. As a result, there should have been more late closure completions in the intonation phrase boundary condition than in the intermediate phrase boundary condition. Contrary to this prediction, there were fewer late closure completions following an intonation phrase boundary than following an intermediate phrase boundary.

Second, consider the relatively high proportion of late closure completions (.53) in the transitive-bias plausible direct object NP intonation phrase boundary condition. Given that roughly half of the completions resulted in direct object structures, it is unlikely that an early intonation phrase boundary triggers syntactic and semantic wrap-up to an intransitive structure and interpretation. Because plausible direct object NPs were also plausible main clause subjects, a process of purely intransitive wrap-up should have resulted in few late closure completions.

This relatively high proportion of late closure completions (.53) is also inconsistent with Watson and Gibson’s (2003) anti-attachment hypothesis. Any parsing strategy against attaching incoming material to words that precede intonation phrases would surely predict few, if any, late closure completions across intonation boundary conditions. Yet even equi-bias verbs (.42) and intransitive-bias verbs (.22) elicited late closure completions in response to plausible direct object NPs.
Recall that the 12 verbs in the transitive-bias intonation phrase boundary condition seemed to fall into the two groups in Figure 9.5. Half tended to elicit late closure completions and half tended to elicit early closure completions. Surprisingly, none of the measures that might be expected to predict membership in one group or the other (i.e., transitivity bias of the verb, plausibility of the NP as a direct object or main clause subject, etc.) accounted for the distribution. Intuitively, however, it seems as though another factor might be at work, namely, the predictability of the plausible NP target. The NP targets that tended to elicit late closure completions also seem to be more predictable objects of the verb. If both a late closure structure and an early closure structure were equally competitive—as predicted by the phon-concurrent model in conjunction with semantic and syntactic wrap-up—an additional constraint (such as NP predictability as a direct object) or combination of constraints would be expected to determine which structure is ultimately selected.

The relatively high proportion of late closure completions (.22) in the intransitive-bias plausible target intonation boundary condition might appear problematic for any processing account other than the traditional garden path model. How could a direct object structure arise for an intransitive-bias verb with an early intonation boundary? Indeed, even Schafer’s (1997) prosody-first account predicts that semantic wrap-up to the dominant (i.e., intransitive) meaning of the verb and a possible prosody/syntax mismatch should trigger reanalysis of any late closure structure to an early closure structure.

In contrast to the transitive-bias cases, the effect did not seem limited to a subset of items. But similarly to those items, verb bias and pretest results offered no explanation as to the source of the late closure completions. In order to accommodate these
completions in Schafer’s (1997) account or the phon-concurrent model, the plausible NP must be able to trigger semantic reanalysis to a transitive interpretation. Fortunately, Experiment 1 demonstrated that reanalysis is not difficult when there is commitment to the dominant meaning of the verb. And as for the prosody/syntax mismatch, speakers need only produce a second intonation boundary after the NP target in their prosodic representations to create a match.

In terms of reaction time data, the results are again consistent with the phon-concurrent model. Consider the correlations between NP acceptability (as a direct object or main clause subject) and naming times in the transitive-bias no boundary implausible NP condition. Naming times decreased as NPs became more acceptable as direct objects, but increased as NPs became more acceptable as main clause subjects. This is just as one would expect if the parser were attempting to build a direct object structure and/or the semantic processor were attempting to build a transitive interpretation. Indeed this result is consistent with Garnsey, Pearlmutter, Myers, and Lotocky (1997), who found in eye tracking that a direct object structure and interpretation was pursued for transitive-bias verbs in spite of an implausible NP. Because the corresponding sentence completions always reflected an early closure structure and interpretation, these correlations must reflect the initial syntactic parse and/or initial semantic interpretation. In order for the correlation to reflect reanalysis to an early closure completion, it would have had to go in the other direction (e.g., naming times would have to have increased as direct object acceptability increased).
The fact that intransitive-bias verbs showed no similar correlations suggests that verb bias influences the initial parse and/or interpretation of the visual target. If the parser were attempting to build a direct object structure regardless of verb bias, or if the semantic processor were attempting a transitive interpretation, then the same correlations should have been observed for the transitive- and intransitive-bias groups. However, support for the phon-concurrent model does not rest on this null effect. Two additional correlations suggest that verb bias influences the initial parse.

At this point, consider the overall pattern of regression effects involving early closure completions and implausible NP targets.

- **No boundary** condition: Naming times to implausible NPs following *transitive*-bias verbs decreased as direct object fragments became more acceptable and increased as subject fragments became less acceptable.
- **Intermediate phrase** condition: Naming times to implausible NPs following *transitive*-bias verbs decreased as verbs became more transitive.
- **Intonation phrase** condition: Naming times to implausible NPs following *intransitive*-bias verbs increased as verbs became more intransitive.

Given the correlations in the no boundary condition, transitive-bias verbs seemed to elicit initial transitive structures and interpretations even for implausible NP targets. In contrast, intransitive-bias verbs did not.⁹

When an intermediate phrase accent preceded the implausible NP target, naming times to *transitive-bias* verbs decreased as verbs became more *transitive*. This effect also suggests that transitive-bias verbs elicited initial transitive structures and interpretations,

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⁹ The intransitive-bias no boundary condition was ultimately slow because of a prosody/syntax mismatch.
in spite of the early intermediate phrase boundary. However, because verb bias modulates the effect, the result is only consistent with constraint-based models, such as the phon-concurrent model, which predict effects of verb bias on the initial parse. The correlation cannot reflect reanalysis given that early closure structures and interpretations should elicit longer naming times, not shorter ones, as verbs become more transitive.

Finally, when an intonation phrase boundary preceded the implausible NP target, naming times to *intransitive-bias* verbs decreased as verbs became more *intransitive*. This effect suggests that intransitive-bias verbs elicited initially intransitive structures and interpretations following an intonation phrase boundary. Again, because verb bias modulates the effect, the correlation supports the phon-concurrent model.10

The verb bias effects reported here are only consistent with a constraint-based model, such as the phon-concurrent model. Critically, the correlation between transitive-bias verbs and naming times following an intermediate phrase boundary involves the construction of a direct object (late closure) structure. Verb bias effects in this condition are particularly challenging for the traditional garden path model.

One might hypothesize that this effect provides the first online evidence of prosodic visibility (i.e., Schafer’s [1997] claim that intermediate phrases reduce visibility and delay syntactic attachment). Prosodic visibility could even account for the correlation between intransitive-bias verbs and naming times following an intonation phrase boundary. The intermediate phrase would delay attachment of the NP as the main clause

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10 The absence of a similar correlation in the corresponding intermediate phrase boundary condition suggests that syntactic and semantic commitment to an intransitive structure and interpretation is necessary to observe the effect or perhaps to generate the initial subject structure. Without a correlation in either direction in the corresponding intermediate phrase condition, it is hard to infer what happened.
subject. However, in contrast to prosodic visibility and the prosody-first account, the goodness-of-fit approach in the phon-concurrent model already combines verb bias and prosodic phrasing. Consider the following examples.

When an intermediate phrase boundary follows a transitive-bias verb (e.g., *Whenever the lady loads*), two syntactic alternatives have been generated and weighted by frequency: the stronger direct object structure and the weaker subject structure. As shown in Figures 9.2 and 9.3, the prosodic representation is a better match for the subject structure than the direct object structure. As a result, the prosodic representation adds most of its weight to the subject structure. However, some weight is added to the stronger direct object structure because the early intermediate phrase boundary is consistent with a later boundary following the direct object NP. At the implausible NP target, attachment of the NP into the direct object structure should result in shorter naming times as verbs become more transitive.

When an intonation phrase boundary follows a transitive-bias verb (e.g., *Whenever the lady loads*), the boundary triggers commitment to an intransitive structure and meaning. At the implausible NP, the target is attached as the main clause subject, and it is attached as a direct object into a much weaker direct object structure. Given the reactivation of the direct object structure and/or the relative availability of the subject structure, attachment of the NP as a main clause subject should result in shorter naming times as verbs become more intransitive.
9.6 General discussion

The results of Experiment 3 provide evidence against any account in which intonation boundaries fail to trigger syntactic wrap-up (e.g., Schafer’s [1997] original account). Without syntactic wrap-up, there should have been more late closure completions following an intonation boundary than following an intermediate boundary for transitive-bias verbs. While the results do suggest that intonation boundaries trigger syntactic wrap-up, the results do not suggest that intonation boundaries prevent syntactic attachment to lexical material immediately preceding the boundary (Watson & Gibson, 2003). If that were the case, there should have been few, if any, late closure completions across the intonation boundary conditions.

The results are most consistent with the phon-concurrent model. Only this model predicted that verb bias would influence the initial parse, and such effects were seen in the regression analyses for transitive-bias and intransitive-bias verbs.

The phon-concurrent model also provides the best account of the sentence completion data—provided that intonation boundaries trigger semantic wrap-up (as Schafer [1997] originally argued) and syntactic wrap-up (as the results of Experiment 1 suggested). Only the phon-concurrent model predicted the observed proportion of late closure completions for plausible targets in the intonation boundary and intermediate boundary transitive-bias conditions. While fewer late closure completions were expected for the intonation boundary condition than the intermediate boundary condition, because of syntactic wrap-up to an intransitive structure, it was not surprising that late closure completions accounted for roughly half the completions, given semantic wrap-up to a transitive interpretation.
It seems only fair to ask whether Schafer’s (1997) prosody-first account could be modified to predict the critical sentence completion data (i.e., the proportion of late closure completions in the transitive-bias intonation boundary and intermediate boundary conditions). In fact, it might be able to if intonation boundaries trigger a greater degree of mismatch between prosodic and syntactic representations than intermediate boundaries, but do not trigger syntactic wrap-up.

Take the case of transitive-bias verbs. An intonation boundary triggers wrap-up to a transitive interpretation. If the boundary does not trigger wrap-up to an intransitive structure, then an implausible NP target should be attached as a direct object. At the semantic processor, reanalysis should be unnecessary. However, an early boundary could trigger a prosody/syntax mismatch and reanalysis. In turn, the strong mismatch of an early intonation boundary and a late closure structure should be more likely to trigger semantic reanalysis than the weak mismatch of an intermediate boundary, despite any semantic wrap-up to a transitive interpretation. Under this account, the late closure completions in the transitive-bias intonation boundary condition are simply those that failed to succumb to a prosody/syntax mismatch. Indeed, when the predictability of the visual target as a direct object is low, the combined effect of the semantic representation and the prosody/syntax mismatch might more likely to trigger reanalysis.

While native speaker intuitions support the idea that intonation boundaries are stronger than intermediate boundaries, and thus capable of signaling a greater mismatch, the syntactic representation must still be differentially sensitive to intermediate and intonation phrase boundaries in order for this to happen. Thus, this account and the
account in which intonation boundaries trigger syntactic wrap-up both require Schafer’s (1997) prosody-first account to be revised to allow intonation boundaries to influence syntactic processing.

In addition, a mismatch account without syntactic wrap-up is incompatible with the results of Experiment 1. There was simply no evidence that structurally ambiguous NPs were ever incorporated as direct objects in early intonation boundary conditions. The mismatch account predicts that there should be some evidence of syntactic reanalysis as the early boundary triggers reanalysis of a direct object structure to a subject structure.

Ultimately then, only a phon-concurrent model that includes syntactic and semantic wrap-up at intonation phrase boundaries seems capable of explaining the distribution of late closure completions and the effects of verb bias that were observed in the regression data.
CHAPTER 10

CONCLUSIONS

10.1 Experimental findings

The experiments presented here are the first to investigate the interaction of prosodic phrasing and lexically-based syntactic frequency information (i.e., verb bias) with an online sentence comprehension task. The results provide new evidence that intonation phrase boundaries have immediate and robust effects on semantic and syntactic processing regardless of verb bias, and they provide additional evidence that verb bias and intermediate phrase boundaries influence the initial syntactic parse.

The results suggest that intonation phrase boundaries demonstrate robust effects because they trigger wrap-up or commitment to semantic and syntactic representations. When wrap-up occurred at a verb (e.g., *Whenever the lady Vs* $\text{ip}$ $\text{VP}$), it involved semantic commitment to the dominant meaning of the verb and syntactic commitment to an intransitive structure. When wrap-up occurred at a transitive-bias verb (e.g., *Whenever the lady loads* $\text{ip}$ $\text{VP}$), it resulted in semantic and syntactic representations that conflicted in terms of their transitivity. Resolution of this conflict involved other prosodic and
lexical factors, such as the position of the following structurally ambiguous NP within the global prosodic representation and perhaps the predictability of that NP as a direct object.

In short, disambiguation of the current closure ambiguity (e.g., Whenever the lady *checks the room*...) involves more than just intonation phrase boundary location. Disambiguation results from the semantic and syntactic wrap-up processes that intonation phrase boundaries trigger and from other constraints, such as the global prosodic representation. Furthermore, that global prosodic representation matters not just in terms of where the prosodic boundaries are, but also in terms of where they are not.

The results of Experiments 1 and 3 could not be explained by semantic wrap-up alone. In contrast to Schafer (1997), it appears that intonation phrase boundaries have similar effects on the syntactic and semantic processors. As a result, intonation phrase boundaries must represent vocabulary that is common to three processors—phonological, semantic, and syntactic.

The semantic wrap-up effects of Experiments 1 and 3 do support Schafer’s (1997) interpretive domain hypothesis, but they do so with new evidence that intonation phrase boundaries trigger semantic wrap-up for verbs. More specifically, when semantic wrap-up occurred at the verb (e.g., Whenever the lady *Vs* [\(V_s\)]IP), the process involved commitment to the dominant meaning of the verb (i.e., transitive for transitive-bias verbs and intransitive for intransitive-bias verbs). This finding is consistent with Schafer’s original evidence that intonation phrase boundaries trigger wrap-up to the dominant meaning of lexically ambiguous nouns.

In addition, semantic wrap-up (and probably syntactic wrap-up, as well) at the structurally ambiguous NP (e.g., Whenever the lady *Vs the N* [\(N_{ip}\)]IP) influenced whether or
not reanalysis was observed in naming times to the visual target is. When the late intonation phrase boundary triggered wrap-up to the subordinate meaning (and structure) for intransitive-bias verbs, reanalysis occurred post-naming. Yet when wrap-up favored the dominant meaning (and structure), as with transitive-bias verbs, reanalysis was observed in naming times to the visual target.

These wrap-up effects and the commitments to subordinate and dominant representations that they entail make testable predictions regarding reanalysis. As mentioned in Chapter 5, commitment to a subordinate interpretation (i.e., the less frequent thematic role assignment) should trigger reanalysis of a dominant syntactic structure. Commitment to a subordinate structure should trigger reanalysis of a dominant interpretation. Given a dominant structure and a dominant interpretation, one might expect to see support for the claim that the semantics takes precedence (e.g., Frazier, 1990; Frazier & Clifton, 1996). In addition, one might expect to see increased processing load during reanalysis of a double subordinate case relative to a double dominant case.

The results of Experiments 1 and 3 suggested that intonation boundaries do not affect processing in the same way that plausibility affects processing. Whereas plausibility seems to act as a constraint on syntactic alternatives (Garnsey, Pearlmutter, Myers, & Lotocky, 1997), intonation boundaries seem to trigger semantic and syntactic wrap-up. Plausibility determined initial structure when verb bias made syntactic alternatives equally available (Garnsey et al.). In contrast, the location of an intonation boundary in Experiment 1 determined initial syntactic structure—regardless of verb bias.

The results of Experiments 2 and 3 suggest that intermediate phrase boundaries do function more along the lines of plausibility. Indeed the cases in which intermediate
phrases appear to influence an initial syntactic parse seem to be those with equally accessible syntactic alternatives. For example, intermediate phrase location determined the initial structure for Kjelgaard and Speer (1999), who used auditory fragments that had no clear bias toward either late closure or early closure. When similar auditory fragments contained a late closure bias, as in Experiment 2, intermediate phrase location tended to aid reanalysis. Only the combination of an intransitive-bias verb and an early intermediate phrase boundary might have led to an initial early closure structure. In Experiment 3, intermediate phrases influenced the construction of an initial late closure structure, but the effect was observed when the visual target supported an early closure structure and interpretation.

To summarize, intonation phrase boundaries seem to trigger wrap-up of any outstanding semantic and syntactic processing. As a result, they elicit robust effects involving initial syntactic parses. In contrast, effects of intermediate phrases on syntactic processing more closely resemble effects of plausibility. Both appear in reanalysis and in cases with fairly competitive syntactic alternatives.

Intermediate phrasing effects are remarkably subtle. Finding them requires carefully designed materials and sensitive measures of online processing. Regrettably, a late closure bias in the current materials made it nearly impossible to detect effects of intermediate phrases on the initial parse at all. However, the results did demonstrate that cross-modal naming is highly sensitive to syntactic, semantic, and prosodic processing. Naming times reflected initial structure building, as well as prosody/syntax mismatches, and semantic and syntactic reanalysis.
10.2 Processing accounts

One of the strengths of this dissertation is that the experiments investigated resolution of the same ambiguity at different points in time. Experiment 3 tapped processing at the ambiguity, and Experiments 1 and 2 tapped processing one word position later. This manipulation, in conjunction with the verb bias variable, provided a picture of the incremental processing involved with intonation phrase boundaries as they influenced syntactic and semantic processing. More specifically, this incremental processing included four main effects.

- Verb bias influenced the initial parse.
- Intermediate phrase boundaries and intonation phrase boundaries influenced the initial parse.
- Intonation phrase boundaries triggered semantic and syntactic wrap-up.
- Wrap-up at a transitive-bias verb resulted in semantic and syntactic representations that conflicted in terms of their transitivity.

Only the phon-concurrent model adequately accounts for all four findings. To begin with, neither the traditional garden path model (e.g., Frazier, 1990; Frazier & Clifton, 1996) nor Schafer’s (1997) prosody-first account allows verb bias to influence the initial parse. However, Experiment 3 demonstrated that transitivity bias influenced the construction of an initial late closure structure. Because the garden path model does not allow prosodic phrasing to influence the initial parse, it has no explanation for the robust effects of intonation phrase boundary location in Experiment 1. And while prosody-first does allow prosodic phrasing to influence the initial parse, prosodic visibility did not explain the intermediate phrase boundary results of Experiment 2.
In contrast to these accounts, the phon-concurrent model allows prosodic phrasing to influence the initial structure and interpretation because the output of the phonological processor—the abstract prosodic representation and its lexical content—is sent simultaneously to the semantic and syntactic processors. Wrap-up can result in equal commitment to conflicting semantic and syntactic representations because the semantic and syntactic processors are autonomous. The processors build their representations independently and simultaneously from the output of the phonological processor. Verb bias influences the initial parse because syntactic alternatives are generated at the verb and weighted by frequency. Similarly, the semantic processor is sensitive to the frequency of thematic alternatives.

Figure 10.1 illustrates the partial prosodic representation for the transitive-bias fragment *Whenever the lady loads* [ip. Because prosodic structure does not depend on lexical content, the onset of the next intermediate phrase can be generated at the close of the first intermediate phrase according to the rules that govern well-formed prosodic structure. In this way, prosodic structure can get ahead of syntactic and semantic representations, just as the original concurrent model allows semantic representations to get ahead of syntactic representations.\(^1\)

\(^1\) The semantic processor can anticipate the thematic role of a *wh*-phrase prior to encountering the verb that assigns the role. For example, consider the beginning of the utterance *Which desk did...* Because *desk* is inanimate, the semantic processor would anticipate assigning a theme role instead of an agent role.
Figure 10.1: Prosodic, syntactic, and semantic representations at offset of early intermediate phrase boundary fragment

Whenever the lady loads
Whenever the lady loads

Figure 10.2: Prosodic, syntactic, and semantic representations following wrap-up at early intonation phrase boundary
The prosodic representation is sent to the syntactic processor, which activates competing syntactic alternatives at the verb. For a transitive-bias verb, the transitive structure is weighted more heavily than the intransitive structure. The prosodic representation is simultaneously sent to the semantic processor, which pursues the most frequent meaning of the verb. (Across Figures 10.1 and 10.2, increases in font size and bolding represent increases in weight.)

The goodness-of-fit between the prosodic representation and the syntactic alternatives adds more support to the intransitive structure than to the transitive structure. This is because the early intermediate phrase boundary aligns with a completed syntactic constituent (i.e., the S-bar) in the intransitive structure. In contrast, the intermediate phrase boundary is only licensed in the transitive structure if an additional boundary follows an upcoming direct object.

It is difficult to know how much weight the prosodic representation adds to the intransitive structure relative to the transitive structure. Indeed, one weakness of any constraint-based model is its ability to adjust the relative influence of constraints so freely that the model cannot be falsified. The current work does not provide a way to estimate the strength of the goodness-of-fit constraint; it leaves that topic as an area for future research. The results of Experiment 3 do suggest, however, that the early intermediate phrase boundary adds enough support to the intransitive structure to allow verb bias to influence the attachment of an implausible direct object NP into the direct object structure. No similar effect was observed in the no boundary condition, presumably
because the prosodic representation added little, if any, support to the intransitive structure. In the no boundary condition, the acceptability of the implausible NP as a direct object or main clause subject predicted naming times.

When an intonation phrase boundary follows the verb, as in Figure 10.2, the boundary tone triggers semantic and syntactic wrap-up. Although the intransitive structure is initially weaker than the one with a direct object, the weaker intransitive structure is selected. This is because the weaker structure corresponds to the current lexical input. At the same time that the syntactic processor undertakes syntactic wrap-up, the semantic processor commits to its thematic structure: the one that involves assigning a theme. Because the wrap-up processes happen simultaneously and independently, the syntactic and semantic representations end up conflicting. The prosodic and lexical properties that accompany further input influence the resolution process.

10.3 Future work

The results reported here provide robust evidence that intonation boundaries have immediate effects on syntactic and semantic processing. In conjunction with Kjelgaard and Speer (1999), there can be little question of the effects. That said, this is the first study to show semantic and syntactic wrap-up to representations that conflict in terms of transitivity during spoken language comprehension. Ideally other studies will attempt to replicate the effect, and in doing so, perhaps test the claims regarding reanalysis that were proposed in the discussion of Experiment 1.

More specifically, reanalysis seemed to be constrained in part by the status of independent syntactic and semantic representations. Given commitment to structure and meaning (i.e., because of an intonation boundary), reanalysis of a dominant
representation seemed to be preferred to reanalysis of a subordinate representation. This conflicted with accounts in which thematic relations reflect the favored structure and only trigger reanalysis if a more plausible set of relations exists (e.g., Frazier, 1990; Frazier & Clifton, 1996). In short, studies that manipulate and control the relative dominance of representations would provide a better understanding of reanalysis during spoken language processing.

As mentioned in the previous section, additional studies are also needed to better understand the role of intermediate phrases in syntactic processing. While there is little question that such phrases are used in reanalysis and play a role in final structures and interpretations, more online work is needed to detect additional effects on initial representations.

More work is also needed to estimate how much weight intermediate phrase boundaries add to competing syntactic alternatives and to understand what the contributing factors are. As mentioned in Chapter 9, goodness-of-fit probably comprises two components: the quality of fit between the prosody and the syntactic alternatives, and the likelihood of the prosody for each syntactic alternative.

In theory, one way to test for effects of prosodic likelihood might be to compare two prosodic representations that have a high goodness-of-fit with the syntactic structures, but which differ in frequency. Consider the conditions in (1a)-(1d).

(1a) Patricia likes bakeries (no boundary, high frequency)
(1b) Patricia likes bakeries that (no boundary, low frequency)
(1c) Patricia likes bakeries (intermediate phrase, low frequency)
(1d) Patricia likes bakeries that (intermediate phrase, high frequency)
Auditory fragments would end at the verb in one of two boundary conditions (no boundary, intermediate boundary). The visual target for naming, which is underlined, would either be a bare direct object (e.g., *bakeries*) or the direct object plus the word *that*. Because *that* signals a heavy NP object, a preceding intermediate phrase boundary should be more likely than no boundary. Conversely, a preceding intermediate phrase boundary should be less likely than no boundary for a bare direct object.²

If the likelihood of the boundary influences processing, naming times should be slower in the low frequency conditions than in the high frequency conditions. If intermediate phrases uniformly reduce prosodic visibility and delay syntactic attachment (Schafer, 1997), then naming times in the boundary conditions should be slower than naming times in the no boundary condition. If both factors influence syntactic processing, effects of frequency should be larger in the intermediate phrase conditions.

Unfortunately, it is not clear that enough spoken corpora exist to verify intuitions regarding the boundary manipulation. Furthermore, because the results of Experiments 2 and 3 suggest that effects of intermediate phrasing are especially subtle, even when syntactic alternatives compete, it is unclear whether effects would emerge in syntactically unambiguous structures.³

The current experiments and those in Kjelgaard and Speer (1999) investigated prosodic phrasing and the resolution of one particular closure ambiguity. In addition, that ambiguity involved an argument relation. Thus, it remains to be seen whether the

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² If the relative frequencies for a no boundary, intermediate boundary, and intonation boundary condition could be determined, there could actually be a three-way comparison of boundary.

³ Perhaps an additional memory task (e.g., one in which participants remember a string of numbers presented between each trial and report those numbers at various intervals) could increase processing load enough to reveal effects.
processing mechanisms related to intonation and intermediate boundaries adequately account for processing in other constructions, such as other argument ambiguities, adjunct ambiguities, and unambiguous utterances. While the processing mechanisms seem general enough (i.e., wrap-up always applies), the generality of these mechanisms deserves to be tested empirically. In addition, in the absence of ambiguity, other processing effects could well emerge (i.e., prosodic frequency effects).

Finally, and perhaps most importantly, the generality of these processing mechanisms needs to be tested cross-linguistically.
APPENDIX A

STIMULI: EXPERIMENTS 1 AND 2

The 12 sets of critical sentence fragments from Experiments 1 and 2 are listed below. The order of verb bias in each set is (a) transitive, (b) equi, and (c) intransitive. The numbers following each verb indicate the transitivity-bias score as calculated from the Connine, Ferreira, Jones, Clifton, and Frazier (1984) sentence completion data. Negative numbers indicate more frequent intransitive use. The numbers following the final noun indicate the written frequency of each noun as taken from Francis and Kucera (1982).

The auditory stimuli contained intonation boundaries (Experiment 1) or intermediate boundaries (Experiment 2) that were located either before or after the structurally ambiguous noun phrase (e.g., *the plane* in the first example fragment). The visual targets in both experiments were the words *it’s* and *is*. 
1.  
(a) If the man saves (17.0) the bill (143)  
(b) If the man starts (3.7) the class (207)  
(c) If the man flies (-8.8) the plane (114)  

2.  
(a) Whenever the teen imitates (15.3) the squad (18)  
(b) Whenever the teen babysits (n/a) the pet (8)  
(c) Whenever the teen continues (-15.3) the trick (15)  

3.  
(a) Every time the boy paints (10.9) the fence (30)  
(b) Every time the boy leaves (9.0) the chair (66)  
(c) Every time the boy walks (-10.8) the trail (31)  

4.  
(a) If the girl buys (14.8) the poster (4)  
(b) If the girl plays (-1.2) the fiddle (2)  
(c) If the girl jumps (-10.3) the puddle (1)  

5.  
(a) When the woman describes (15.0) the group (390)  
(b) When the woman performs (-5.8) the act (283)  
(c) When the woman debates (-8.5) the point (395)  

6.  
(a) Whenever the lady loads (7.0) the car (274)  
(b) Whenever the lady checks (9.2) the room (383)  
(c) Whenever the lady moves (-9.2) the door (312)
7.
(a) When the kid kicks (10.8) the mud (32)
(b) When the kid cleans (7.8) the track (38)
(c) When the kid tries (-15.8) the lock (23)

8.
(a) When the animal kills (5.3) the cat (23)
(b) When the animal strikes (-1.7) the dirt (43)
(c) When the animal swims (-8.5) the creek (14)

9.
(a) Every time the person visits (13.4) the nation (139)
(b) Every time the person studies (-5.7) the picture (162)
(c) Every time the person guesses (-10.8) the answer (152)

10.
(a) Every time the friend pulls (9.0) the sheet (45)
(b) Every time the friend deals (n/a) the deck (23)
(c) Every time the friend fights (-6.8) the crowd (53)

11.
(a) If the couple reads (7.5) the verse (28)
(b) If the couple sings (-3.7) the tune (10)
(c) If the couple knows (-4.1) the scheme (33)

12.
(a) Whenever the parent asks (9.1) the question (257)
(b) Whenever the parent phones (8.7) the number (472)
(c) Whenever the parent cheats (-7.3) the system (416)
The 12 sets of critical sentence fragments from Experiment 3 are listed below. The order of verb bias in each set is (a) transitive, (b) equi, and (c) intransitive. The numbers following each verb indicate the transitivity-bias score as calculated from the Connine, Ferreira, Jones, Clifton, and Frazier (1984) sentence completion data. Negative numbers indicate more frequent intransitive use.

Auditory fragments in Experiment 3 ended at the verb in one of three boundary conditions: no boundary, intermediate boundary, or intonation boundary. Noun phrases that were either plausible or implausible as direct objects for the verb were used as visual targets. The set of 36 plausible noun phrases were reassigned to other verbs in the implausible condition. The noun phrases following each verb below indicate the visual targets. Plausible direct objects are listed first along with the mean written frequency of the nouns as taken from Francis and Kucera (1982). The frequency counts following plural nouns reflect frequency in the singular.
1.
(a) If the man saves (17.0) his job (238) his fear
(b) If the man starts (3.7) his trip (81) his dog
(c) If the man flies (-8.8) the plane (114) the show

2.
(a) Whenever the teen imitates (15.3) the buzzer (n/a) her shoulder
(b) Whenever the teen babysits (n/a) the infant (11) the story
(c) Whenever the teen continues (-15.3) the story (153) the teacher

3.
(a) Every time the boy paints (10.9) the wall (160) his job
(b) Every time the boy leaves (9.0) the couch (12) his trip
(c) Every time the boy walks (-10.8) his dog (75) the van

4.
(a) If the girl buys (14.8) the car (274) the clerk
(b) If the girl plays (-1.2) the tune (10) the stream
(c) If the girl jumps (-10.3) the stream (51) the noise

5.
(a) When the woman describes (15.0) the noise (37) the words
(b) When the woman performs (-5.8) the show (287) the plane
(c) When the woman debates (-8.5) the issue (152) the infant

6.
(a) Whenever the lady loads (7.0) the van (32) the sun
(b) Whenever the lady checks (9.2) the weather (69) the IRS
(c) Whenever the lady moves (-9.2) her elbow (10) the weather
7.  
(a) When the kid kicks (10.8) the chair (66) the tune  
(b) When the kid cleans (7.8) the hallway (n/a) the bully  
(c) When the kid tries (-15.8) the soup (16) the price  

8.  
(a) When the animal kills (5.3) the ducks (9) the creek  
(b) When the animal strikes (-1.7) her shoulder (61) the answer  
(c) When the animal swims (-8.5) the creek (14) the ducks  

9.  
(a) Every time the person visits (13.4) the teacher (80) her elbow  
(b) Every time the person studies (-5.7) the sun (112) the couch  
(c) Every time the person guesses (-10.8) the answer (152) the buzzer  

10.  
(a) Every time the friend pulls (9.0) the rope (15) the soup  
(b) Every time the friend deals (n/a) the cards (26) the song  
(c) Every time the friend fights (-6.8) the bully (4) the hallway  

11.  
(a) If the couple reads (7.5) the words (274) the chair  
(b) If the couple sings (-3.7) the song (70) the car  
(c) If the couple knows (-4.1) his fear (127) the wall  

12.  
(a) Whenever the parent asks (9.1) the price (108) the rope  
(b) Whenever the parent phones (8.7) the clerk (34) the cards  
(c) Whenever the parent cheats (-7.3) the IRS (n/a) the issue


PSY: A Program for Contrast Analysis (Bird, Hadzi-Pavlovic, & Isaac; www.psy.unsw.edu.au/research/PSY.htm)


