The thesis that I was tired after finishing/writing was long

Semantics aids in processing and acceptability of syntactically ungrammatical sentences

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Abstract

A fundamental question in linguistics considers how the human brain processes language. I contrast two key models for semantic and syntactic composition: a two-phase model and a parallel model. Frazier and Fodor (1978) posit that linguistic processing relies on constraints imposed by syntactic information. Following this model, semantics is derived from the successful derivation of syntax. Therefore, the two-phase model adopts the view that if syntactic rules are violated, semantic structure cannot be built successfully. On the other hand, through a parallel framework, Jackendoff (2007) argues that the linguistic processor builds linguistic information in parallel, with syntactic and semantic structure built separately and simultaneously. In this model, semantics is built alongside syntax, and semantic structure can be built even if the syntactic structure is infelicitous.

This thesis compares these models by studying processing of syntactically ungrammatical sentences in English, focusing on sentences that violate the Adjunct Condition in GAP-filling. Sentences with varying levels of semantic support were presented to fifty participants, who completed self-paced reading and acceptability judgment tasks. Sentences were also presented in the presence of extra context to study a different form of semantic enrichment. A two-phase processing model predicts that all experimental stimuli should be unacceptable, even in the presence of semantic support. A parallel processing model predicts that semantic support can ameliorate the ungrammaticality of sentences violating the Adjunct Condition. My results support the theory that an increase in semantic support decreases the processing time of a syntactically ungrammatical sentence. My results also support the theory that sentences with semantic support are significantly more acceptable than sentences with less semantic support. This study provides evidence for a parallel processing model of language, where semantic composition occurs alongside syntax, not as a result of it.

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AdjP	Adjective Phrase
CP	Complementizer Phrase
DP	Determiner Phrase
NP	Noun Phrase
OP	Operator
PP	Prepositional Phrase
PredP	Predicate Phrase
TP	Tense Phrase
VP	Verb Phrase
SPR	Self-Paced Reading

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Chapter 1

Introduction

1.1 Where This Idea Began

I first began considering these ideas as a sophomore in Spring 2022, while simultaneously enrolled in Neurolinguistics and Syntax II. I was lucky enough to learn about the Adjunct Condition while I was also thinking about priming and a parallel language processor. This study is a culmination of questions I asked after comparing and combining my conclusions from those two courses. This thesis follows a pilot study I completed in Neurolinguistics, studying acceptability judgements of similar stimuli.

1.2 Background

In theoretical syntax, extensive literature exists regarding constraints on WH-movement, specifically in relative clauses (e.g. Ross 1967, Chomsky 1977, Szabolcsi and Lohndal 2017). My thesis seeks to compare claims from syntactic theory to models describing language in the brain.

Theoretical syntax tells us that sentence (1a), repeated with its simplified syntactic structure as (1b), is ungrammatical because it violates the Adjunct Island Condition, defined in

(2). Sentence (1) is ungrammatical according to the Adjunct Island Condition because the PP [$_{PP}$ after destroying GAP] is not subcategorized by the adjective *sad*, so the PP is an adjunct.

(1) a. * The book that I was sad after destroying was long.

b. [$_{TP}$[$_{DP}$ The book$_i$ [$_{CP}$ that [$_{TP}$ I was [$_{PredP}$[$_{AdjP}$ sad [$_{PP}$ after destroying GAP$_i$]]]]]] was long.]

(2) **Adjunct Island Condition**: Wh-extraction from inside an adjunct is prohibited.

adapted from Chomsky (1986:217)

This is presented visually in Figure 1.1, where the operator leaves the adjunct and moves into spec CP, violating the Adjunct Condition. Note that in the figure, the prepositional phrase is adjoined to the predicate phrase.

Similarly, sentence (3) is ungrammatical because it also violates the Adjunct Condition; in fact, the only difference between sentences (1) and (3) is that (1) includes the lexical item *destroying* and (3) includes the lexical item *reading*. However, some English speakers (anecdotally) have a gut instinct that sentence (3) is more acceptable than sentence (1). Because the syntax of these two sentences is identical, this anecdotal discrepancy implies that information beyond syntax is involved in processing these sentences.

(3) *?* The book that I was sad after reading was long.

In considering these two sentences, I noticed that the lexical item *reading* seems to be more semantically related to *book* than *destroying* is. It therefore seems that the semantic relationship between the PP verb and the intended GAP may play a role in the ease of processing these sentences.

My informal pilot study showed that twenty Yale College students did judge sentences like sentences (1) and (3) differently (Holubkov 2022). This result was critical because it implied that the semantic content of these sentences impacted their relative acceptability, and that syntax was not the only type of information driving successful processing. The goal of this thesis is to replicate these results, and to delve deeper and attempt to understand why this discrepancy exists.

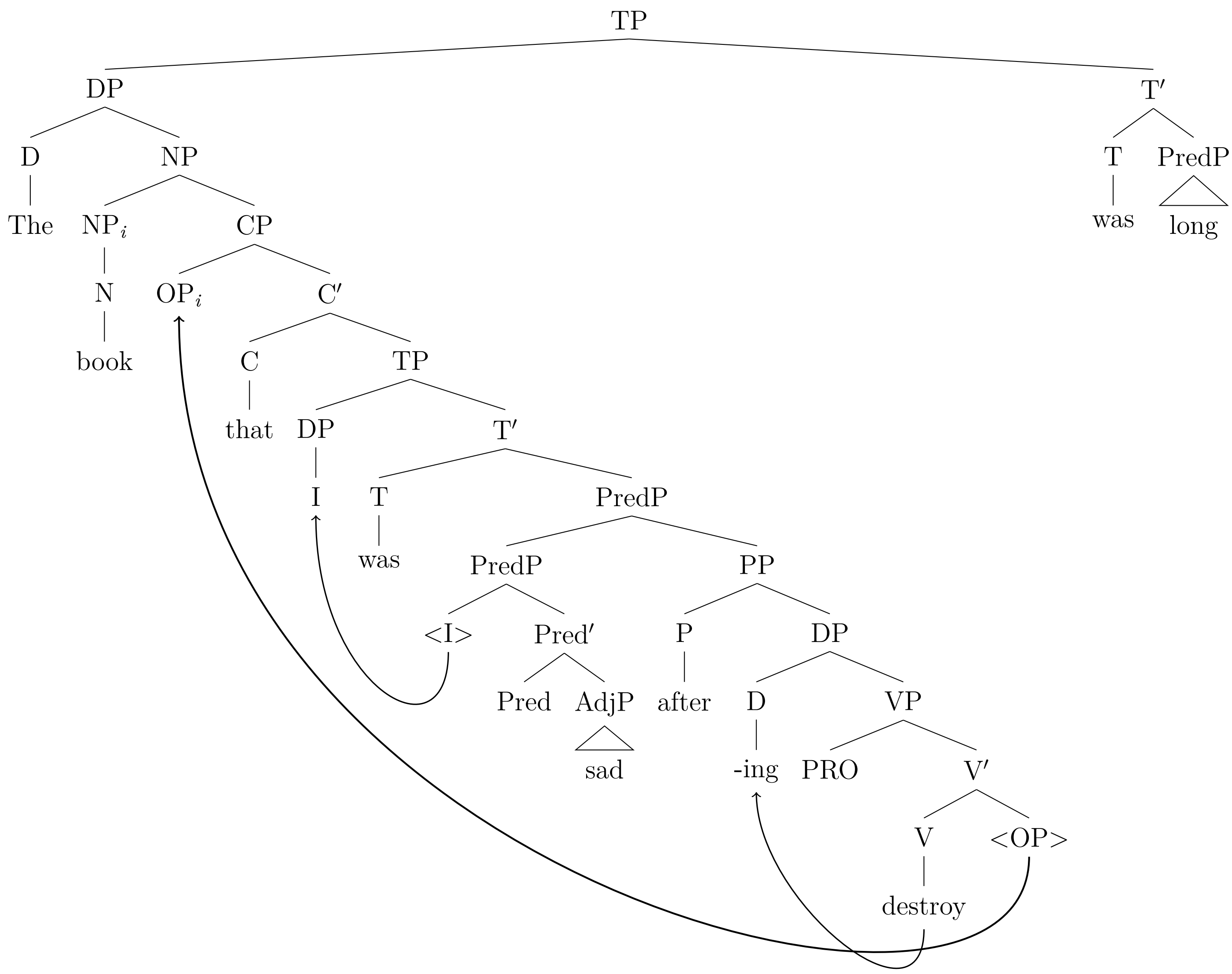

Figure 1.1: Syntax Tree Representation of Sentence (1)

1.3 Two Models for Processing

At its core, this thesis compares two fundamental models for syntactic and semantic composition in the brain: a two-phase processor and a parallel processor.

1.3.1 The Two-Phase Processor

The Two-Phase Processor was affectionately coined as the "Sausage Machine" in Frazier and Fodor (1978). In this paper, Frazier and Fodor outline a model in which the processor begins with the "sausage machine," which retains around seven words in its working memory and assigns them to "phrasal packages," essentially phrases defined by low-level nodes. Following this, the processor moves these packages to the Sentence Structure Supervisor, which connects these packages to higher nodes. Crucially, the foundation of this processing model is the development of syntactic nodes, implying that syntactic information is the bedrock of the processor.

Frazier and Fodor's work and the implications it carries have been central to a main perspective on syntax and semantics: that syntax *drives* semantics, and that semantic structure cannot be developed without syntactic structure. At its core, this viewpoint believes that meaning is built in *two phases*: (1) the processor builds the underlying syntactic structure of the sentence and (2) the syntactic structure motivates the sentence's semantic structure.

This view on the relationship between syntax and semantics is deeply embedded in linguistic study, and Frazier and Fodor's paper, and their central claim, have been referenced for decades. For example, see Frazier and Rayner (1982), applying this view to structurally ambiguous sentences; Ferreira and Clifton (1986), claiming that initial structural analysis relies only on syntactic modules; Konieczny et al. (1997), assuming that this view is true and studying the role lexical heads play in it; Darzhinova and Luk (2024), using this perspective as a foundation for the study of relative clauses in Russian.

Under this framework, the Adjunct Condition and syntactic rules like it are rigid *rules*.

Violations of the Adjunct Condition are an impediment to the development of syntactic structure. Faced with imperfect or unacceptable syntax, the processor will also flounder in developing meaning because syntax motivates semantics. Therefore, the listener will find any sentence that violates the Adjunct Condition to be infelicitous.[1]

1.3.2 The Parallel Processor

Hickok (1993) concludes from his work on garden-path sentences that the linguistic processor constructs syntactic representations in parallel. He suggests that in processing sentences with ambiguous syntactic structures, the processor builds multiple possible syntactic structures before "pruning" contextually inappropriate structures and selecting the best one. He notes in his discussion that during this process, semantic interpretation also takes place (Hickok 1993:248). This implies that semantic interpretation takes place before a syntactic representation for the sentence is fully formed.

This view is solidified by Jackendoff (2007) in a culmination of his previous work on the Parallel Architecture framework. Under this framework, semantic units are different from syntactic units and therefore must be constructed separately.[2] Lexical items are stored in long-term memory and working memory is only involved in *applying* the syntactic and semantic information stored in each lexical item. Crucially, as each lexical item is processed, syntactic structure and semantic structure are built simultaneously and in parallel, of their

[1]Other interpretations and variations of Adjunct Condition violations in this processing model have been proposed in the field. Chomsky (1977:72) suggests that thematic relationships are embedded into syntactic deep structure and extended into Logical Form (LF) after transformations of deep structure are complete. From this framework, Brown (2015) argues that semantically supported adjuncts have a different structure than semantically unsupported adjuncts, and therefore do not violate syntactic constraints. Another perspective argues that because island violations can be repaired via mechanisms such as sluicing, island constraints apply to the phonetic form (PF) and not to deep structure. For discussions of this view, see for example Merchant (1999), Nakao (2009). My framing of the Two-Phase Processor model in this thesis takes a less nuanced view to operationalize and emphasize differences between the two hypotheses for experimental purposes. Specifically, I assume that semantically supported adjuncts are syntactically identical to semantically unsupported adjuncts. I also assume that the Adjunct Condition is a syntactic constraint, and not a PF constraint.

[2]Jackendoff also goes into a very interesting discussion about phonological units and their divergence from syntax, which unfortunately will not be discussed in this thesis.

respective units. The processing of lexical items also results in predictions about what can follow – the information stored in long-term memory includes knowledge about what types of lexical items come together, whether due to their semantic relationship, their lexical categories, and/or phonotactic constraints. For example, the long-term memory might store that the lexical item *student* is semantically related to the lexical items *school* and *teacher*. This means that processing a lexical item also results in the priming of lexical items that are likely to follow. Syntactic and semantic structures can work in tandem to resolve ambiguity, but semantic structure does not have to "wait" for syntax to be completely built before it can develop (Piñango et al. 1999).

This perspective, while newer, is also well-cited in the literature. For example, see Bastiaansen and Hagoort (2015), using this framework as a basis for an EEG study of segregation of syntactic and semantic processes in the brain; Piñango et al. (2016), relying on theories fundamental to Parallel Architecture to study processing of long-distance dependencies using fMRI; Wagley and Booth (2021), studying how meaning and grammar work together to support language competence in young children; Hendriks et al. (2022), considering how contextual knowledge facilitates processing.

Taking this one step further, under a parallel processing model, the Adjunct Condition is a *suggestion*, not a rule. Violations of the Adjunct Condition are a violation of the syntactic structure, but because semantics is built separately, the processor still develops a semantic structure for the utterance in the presence of the Adjunct Condition violation. The listener is therefore able to ultimately understand the utterance, even if the syntactic violation causes some hesitation.

1.4 Specifics of this Study

This thesis seeks to confirm anecdotes that certain sentences violating the Adjunct Condition are more acceptable than others. The study collects acceptability judgments to formalize these anecdotes into concrete evidence. It also takes this goal one step further by collecting self-paced reading (SPR) data to additionally study the processing load of reading these sentences, attempting to visualize in real time whether sentences with increased semantic information are easier to process than sentences without it. Ultimately, I seek to use these two types of data to bring ideas from theoretical syntax into experimental work and compare my results to existing models of linguistic processing.

1.4.1 Semantic Support

This thesis defines the term "semantic support" as the semantic relationship between the relative clause's verb and its intended GAP object.[3] The strength of this support is determined by the strength of the semantic relationship.

This thesis does not attempt to model a spectrum for semantic support, but rather operationalizes semantic support as a binary of semantic support versus no semantic support for testing purposes,[4] as outlined in Section 3.1.1. In this thesis, semantic relationships are determined using the support of a corpus, specifically the Corpus of Contemporary American English (COCA). When using COCA, I define the presence of semantic support as a close semantic relationship between two words, and I take two words to be closely related (exhibiting semantic support) if one is a collocate[5] of the item I search in the corpus. If the two words are not collocates, I take them to be less closely related, and therefore to not exhibit semantic support.

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[3]"Semantic support" is defined similarly, as "relatedness," by Sharps and Antonelli (1997). Other studies use the term "semantic support" similarly, though often not with an explicit definition. See, for example, Hsieh et al. (2009), Hsieh and Boland (2015). "Semantic support" is also differently defined and used in fields such as communications monitoring, business models, and quantitative research processing.

[4]See 3.1.1, Footnote 1 for discussion of why *no semantic support* is imperfect, but still used in this thesis.

[5]A collocate is a lexical item that co-occurs with a search term, with a frequency greater than chance. For each search term, COCA lists eight collocates each for Noun, Verb, Adjective, and Adverb, providing thirty-two top collocates in total for a search term. I focused on the Noun collocates because I was considering the relationship between the relative clause verb and its intended GAP object (always a noun in my stimuli).

1.5 Road Map

Chapter 2 of this thesis outlines the hypotheses for this study, rooted in existing models of linguistic processing. Chapter 3 describes the methods of this study, including experimental design and the development of stimuli. Chapter 4 describes the participants in this study, including their recruitment. Chapter 5 presents predicted results based on the study's hypotheses. Chapter 6 describes statistical analyses used in this thesis. Chapter 7 presents the results of the study. Chapter 8 discusses the results within the framework of the presented hypotheses. Chapter 9 concludes.

1.6 Key Findings

The acceptability judgment data from this experiment show that semantic support significantly increases acceptability of syntactically ungrammatical sentences. The SPR data show that semantic support decreases processing time of those sentences. A mixed model analysis of the SPR data shows that semantic support and additional context both decrease processing time, and that these variables interact to shape the time course of their influence. Overall, my data provide support for a parallel processing model of language over a two-phase model.

Chapter 2

The Two Hypotheses

2.1 Hypothesis 1: The Two-Phase Processor

The first hypothesis for this thesis adopts the two-phase perspective. In adopting this view, the first hypothesis predicts that increased semantic support should have no effect on linguistic processing of syntactically ungrammatical sentences.[1]

Under the two-phase processor, the development of semantic structure depends on the successful development of syntactic structure. When faced with a violation, the processor is forced to give up or to build an infelicitous syntactic structure. The semantic structure is also necessarily flawed because it is built from an infelicitous syntactic structure. Therefore, whether or not semantic support exists, the foundation of the semantic structure is unsound, and processing the sentence is a strenuous task.

This hypothesis carries some implications: Semantic processes are embedded in syntactic processes and cannot be separated from them. If this hypothesis holds, we should not be able to manipulate semantic processes separately from syntactic structure, and we should not see differences in processing behavior after attempting to change semantic information.

[1] Again, this view of the Two-Phase Processor is less nuanced than some views to highlight how it differs from the Parallel Processor and contrast the two models.

Therefore, differences in semantic information will not correlate with changes in acceptability judgments, reading time, or other types of experimental data.

2.2 Hypothesis 2: The Parallel Processor

The second hypothesis for this thesis adopts a parallel view of the language processor. In adopting this view, the second hypothesis predicts that increased semantic support facilitates linguistic processing of syntactically ungrammatical sentences.

Under a parallel processor, as each lexical item is uttered or read, the processor builds a semantic structure for the utterance in parallel with the syntactic structure. Therefore, even if there is a syntactic violation, semantic structure can still be built. While the syntactic violation may make the sentence less felicitous, the sentence's meaning can be understood because the semantic structure is possible.

Via the parallel perspective, increased semantic support can facilitate the building of semantic structure. Two lexical items (let's call them A and B) with a strong semantic relationship are linked to each other by the semantic information each carries in the long-term memory. When lexical item A is uttered, this linkage primes lexical item B in the working memory, and the processor expects it. Lexical item A's semantic information also includes some of B's information due to their linkage. Therefore, when lexical item B is eventually uttered, some of B's semantic information is already encoded into the semantic structure and the structure is easily completed.

On the other hand, if two other lexical items (let's call them C and D), do not exhibit a strong semantic relationship, this facilitation is not observed. When C is uttered, it does not prime D in the working memory, and C's semantic information is not linked to D's. Therefore, when D is uttered, its semantic information is not already encoded into the semantic structure and must be processed from scratch. The semantic structure therefore takes more effort to complete if semantic support is not present.

This hypothesis predicts that semantic processes occur separately from syntactic processes. If this is the case, by manipulating semantic information in a setting where syntactic structure is held constant, we should be able to identify differences in processing behavior. This may result in changes in acceptability and reading time, as well as in other behavior, such as eye movement and lexical decision tasks.

Chapter 3

Methods

3.1 Design

3.1.1 Conditions

The two hypotheses of this thesis have different implications for the relationship between syntactic and semantic processing. The Two-Phase Processor Hypothesis predicts that semantic processing cannot be observed separately from syntactic processing. The Parallel Processor Hypothesis predicts that it can.

To tease out this difference, the experimental conditions for this thesis compared sentences exhibiting semantic support versus no semantic support,[1] referred to respectively as the *Semantic Support* and *No Semantic Support* conditions. Examples of these conditions are presented respectively as sentences (4) and (5), where bolding is added for emphasis.[2]

[1] In truth, this condition is poorly named. A more accurate name would be *Less* Semantic Support, as it's not possible to say that there is *no* semantic relationship between lexical items like *destroy* and *book*. The name No Semantic Support is used as a shorthand to emphasize the difference between the two semantic support conditions and to operationalize semantic support for testing purposes, not to imply that there is no semantic relationship between the verb and the object GAP.

[2] These words were not bolded when presented to participants.

(4) **The book** that I was sad after **reading** was long.

(5) **The book** that I was sad after **destroying** was long.

Note that in (4) *book* is a collocate of the verb *read*, per COCA, while in (5) *book* is not a collocate of the verb *destroy*.

Comparing these two conditions allows us to get to the heart of this thesis's contributions. (4) and (5) share the same syntactic structure, but contain differing semantic content. By manipulating semantics while keeping syntax constant, we can see if and how speakers' processing behavior provides support for the hypotheses presented.

However, we cannot draw conclusive inferences without comparing these experimental results to well-understood controls. To that end, the study also included three types of controls: *Emotional Predicate*, *Negative Control*, and *Acceptable Control*. These are outlined in Section 3.2.1.

Presence of Context

Stimuli were presented both with and without plausible contexts. For example, (4) and (5) were presented alone, or in context, such as in (6) and (7).

(6) Today, I read some books at the library. Some of the books I read were quite short. The book that I was sad after reading was long.

(7) Today, I ruined some books at the library. Some of the books I destroyed were quite short. The book that I was sad after destroying was long.

We can think about an absence of context as a further layer of semantic impoverishment – by introducing a plausible context to frame the target sentence, the target sentence is semantically enriched. Therefore, the presence of context was considered to be a condition of extra semantic support. These plausible contexts were thus designed to introduce an implied contrast between the subject of the target sentence (e.g. the book in question) and other objects (e.g. other books in the library) to encourage successful semantic processing.

Presenting the target sentence in context also reflects the fact that language users encounter utterances in the real world not as bare sentences, but in the context of other utterances, the environment, speakers' relationships, and a host of other factors.

3.1.2 Task

Participants were asked to complete a self-paced reading (SPR) task, with an acceptability judgment question following each stimulus item.

Self-Paced Reading

Stimuli were presented word by word, with each word appearing individually in the center of the screen. Participants advanced to the next word by pressing the space bar. Stimuli were presented word by word instead of in a masked setup to avoid effects of context – in a masked setup, a participant would see a longer masked sentence with context than without context, which could introduce a confounding variable.

Acceptability Judgments

After reading each stimulus, participants were asked to indicate their acceptance of the target sentence. When the sentence was presented without context, the instructions indicated, "Please rate the sentence you just read," without showing the entire sentence. When the sentence was presented with context, the instructions indicated, "Please rate this sentence:" and repeated the full target sentence.

Acceptability judgments were presented on a Likert scale with five points, where each point was presented with a sentence summarizing what that point represented. The meaning of each point was presented every time participants were asked to rate a stimulus. This was to ensure that participants were considering the correct sentence when providing their judgment. An example of this is shown in (8).

(8) **SPR Screen (presented one word at a time):** Last summer, I bought lots of clothes. Some of the clothes I wore were quite used. The clothes that I felt happy after wearing were new.

Acceptance Screen: Please rate this sentence: The clothes that I felt happy after wearing were new.

The ratings and their meanings were adapted from Sanchez-Alonso (2018), and they are reproduced in Table 3.1.

Table 3.1: Acceptability Judgement Options and Their Meanings

Acceptability	**What this choice reflects**
1	A native speaker of English would definitely not say this sentence. The sentence sounds weird, and I do not understand its meaning.
2	A native speaker of English would not say this sentence. The sentence sounds weird, although I understand its meaning.
3	I am not sure. The sentence sounds good, but a native speaker would not say it.
4	A native speaker of English would say this sentence. I understand its meaning, but I could or could not say it in this way.
5	A native speaker of English would definitely say this sentence. I understand its meaning, and I myself would say it in this way.

3.2 Materials

3.2.1 Development of Stimuli

Stimuli were developed in multiple quintuplets, as the survey considered five conditions, with the additional layer of context versus no context. An example of a quintuplet can be found in Table 3.2. Beyond the two experimental conditions, three control conditions were used.

The *Emotional Predicate* condition was designed as a filler and positive control for participants. In this condition, the predicate was followed by the word *about* instead of the word *after*, as in sentence (9).

(9) The book that I was sad **about reading** was long.

Some research suggests that emotions with a cause (reflected in phrases such as *sad about*) are a separate semantic category from so-called "bare emotions," such as *sad* on its own (Johnson-Laird and Oatley 1989:100). *Sad* does not select for an event; it merely selects for an argument (such as a person) that is in a state (of sadness), represented in (10).

(10) SYNTAX: $[_{\text{IP}}$ NP [PredP/VP V $[_{\text{AdjP}}$ **Adj**]]]

SEMANTICS: [predicate [**state**, argument]]

On the other hand, in a caused emotional predicate (*sad about*), the emotion selects for a causative event, namely the event that has caused sadness, shown in (11).

(11) SYNTAX: $[_{\text{IP}}$ NP [PredP/VP V $[_{\text{AdjP}}$ **Adj** $[_{\text{PrepP}}$ **Prep** $[_{\text{IP}}$]]]]]

SEMANTICS: [predicate [$\textbf{state}_{\textbf{j}}$, [$_{\textbf{CAUS}}$ $\text{argument}_{\text{j}}$, $\text{argument}_{\text{w}}$]]]

By changing the semantic categories of the sentence so that the predicate selects for a causal event, the *Emotional Predicate* condition provides participants with an acceptable semantic structure. Participants should therefore be more likely to accept stimuli from this condition.

The *Acceptable Control* condition was designed as a filler for participants to alleviate the "weirdness" of the sentences they were faced with, and to ensure that they understood the task. Sentences in this condition contained relative clauses, but were designed so that they did not violate the Adjunct Condition, as presented in (12), and with a syntax tree representation in Figure 3.1.

(12) a. The book that I read **when I was sad** was long.

b. $[_{\text{CP}}[_{\text{DP}}$The book_i $[_{\text{CP}}$ that $[_{\text{IP}}$ I $[_{\text{VP}}$ read GAP_i $[_{\text{CP}}$ when $[_{\text{IP}}$ I was sad]]]]]] was long.]

Note that in Figure 3.1 the movement of *the book* does not violate the Adjunct Condition, unlike in Figure 1.1. Sentences in this condition should be very acceptable to readers no matter which hypothesis is supported, as there is no syntactic violation.

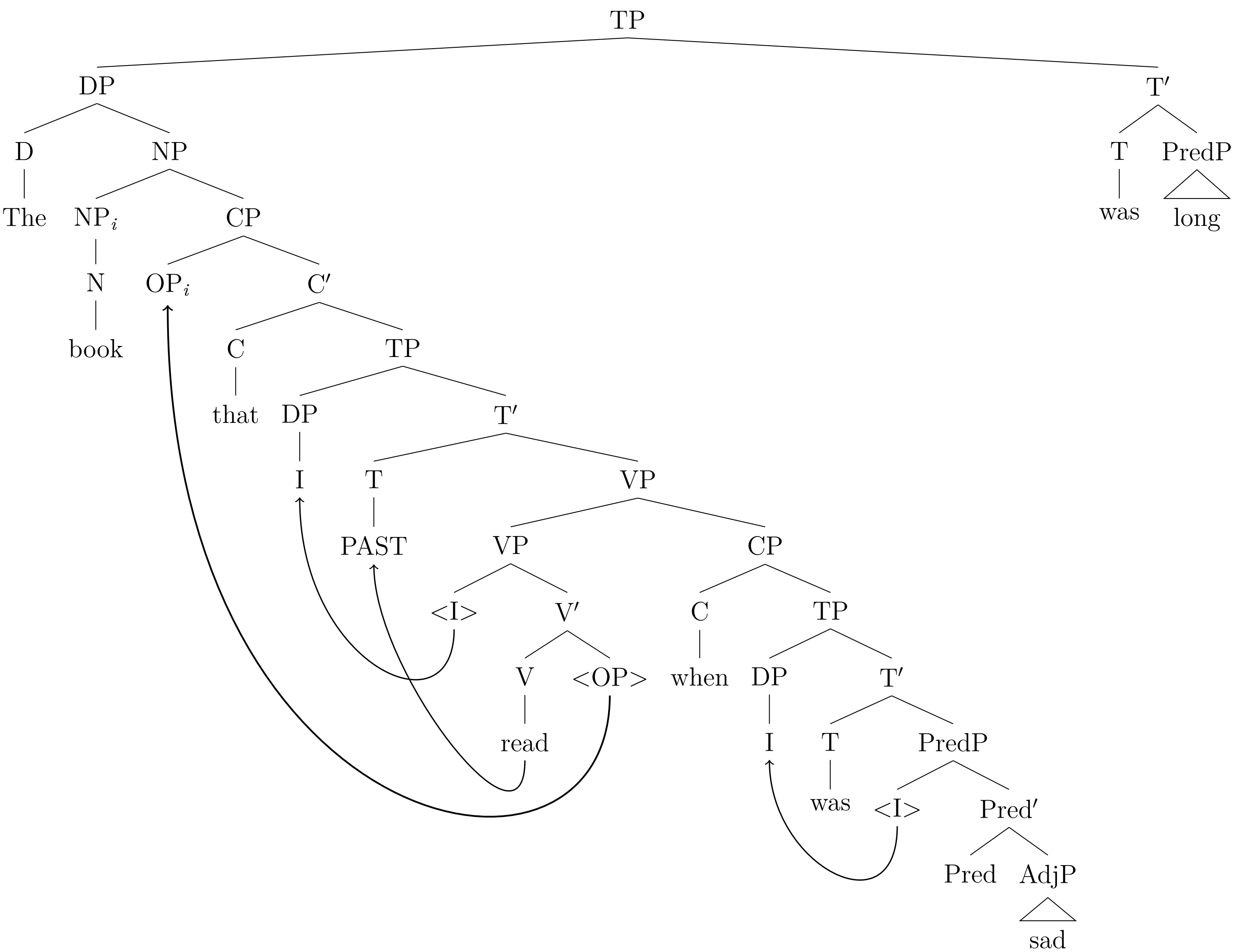

Figure 3.1: Syntax Tree Representation of Sentence (9)

The *Unacceptable Control* was also designed as a filler and to ensure that the experiment was behaving as expected, but as a negative control. Sentences in this condition contained relative clauses where the object had moved out of the GAP, but a noun still remained there, as in (13).

(13) * The **book** that I was sad after reading **book** was long.

This is such an egregious syntactic violation that no matter which hypothesis is supported, native English speakers should judge this condition as unacceptable if the experiment is set up correctly and the participant is focused and understands the task.

Table 3.2: Example Quintuplet without Context

Condition	**Example**
Semantic Support	The book that I was sad after reading was long.
No Semantic Support	The book that I was sad after destroying was long.
Emotional Predicate	The book that I was sad about reading was long.
Acceptable Control	The book that I read when I was sad was long.
Unacceptable Control	The book that I was sad after reading book was long.

Table 3.3: Example Quintuplet with Context

Contextual Condition	**Example**
Semantic Support	Today, I read some books at the library. Some of the books I read were quite short. The book that I was sad after reading was long.
No Semantic Support	Today, I ruined some books at the library. Some of the books I destroyed were quite short. The book that I was sad after destroying was long.
Control	Today, I read some books at the library. Some of the books I read were quite short. The book that I was sad about reading was long.
Acceptable Filler	Today, I read some books at the library. Some of the books I read were quite short. The book that I read when I was sad was long.
Unacceptable Filler	Today, I read some books at the library. Some of the books I read were quite short. The book that I was sad after reading book was long.

In total, there were ten quintuplets, presented with and without context for a total of 100 stimuli. The breakdown of the number of stimuli for each condition is in Table 3.4. All stimuli can be found listed in Appendix A.

Table 3.4: Breakdown of Stimuli by Condition

Condition	Number of sentences
Semantic Support, No Context	10
No Semantic Support, No Context	10
Emotional Predicate, No Context	10
Acceptable, No Context	10
Unacceptable, No Context	10
Semantic Support, Context	10
No Semantic Support, Context	10
Emotional Predicate, Context	10
Acceptable, Context	10
Unacceptable, Context	10
Total	100

3.3 Procedure

The experiment was designed and carried out in Gorilla (`app.gorilla.sc`). Participants consented to taking place in the study and then completed an Autism Quotient survey. Then, the task began. Participants were initially presented with two practice sentences to familiarize themselves with the SPR setup. These sentences included relative clauses so that participants would be accustomed to seeing relative clauses in the stimuli. The sentences are presented below as (14) and (15).

(14) The library I visited yesterday was full of people.

(15) The Fourth of July Parade I attended was very crowded.

Following this, participants were presented with a 100-sentence script containing the ten total conditions (five with context and five without). The stimuli were pseudorandomized to avoid showing participants consecutive sentences from the same group. To avoid order effects, stimuli were manually pseudorandomized into five different orders, and participants were randomly assigned one of the five versions when completing the task.

Chapter 4

Participants

4.1 Recruitment

Participants were recruited via Prolific (`www.prolific.com`) and directed to the Gorilla task. 54 participants were recruited across approximately two days. 4 participants were removed from the study for taking more than two hours to complete the study or for failing to complete the task. 50 participants' data were retained for analysis. Participants were compensated for their participation and took around half an hour to complete the task, on average.

4.1.1 Recruitment Criteria

To avoid impact on processing behavior by English speakers who learned English later in life or in non-natural settings, participation was limited to native English speakers only. To avoid impact of dialect, participation was also limited to participants in the United States. Both of these requirements were applied using filters provided by Prolific. Participants were also asked to indicate if they spoke any "non-standard" dialects of American English, including but not limited to Chicano English, African-American Vernacular English (AAVE), Pennsylvania Dutch, and Miami English. Answering in the affirmative to this question did not preclude a participant from participating in the study.

Additionally, participation was limited to individuals who had graduated from college or who are currently in college, in the age range of 18-24. These limitations were imposed to avoid introducing effects due to age or education.

Because this study focused on the processing of the brain, which is affected by biological sex (Ruigrok et al. 2014), the study considered participants' biological sex instead of their gender identity. Participants were given the option to indicate if they were male, female, or intersex. When asking about race, options similar to census options were provided: Native American/Alaska Native, Black/African-American, Asian/Pacific Islander, Hispanic, White/Caucasian, Multiracial, and Other.

These criteria may have failed to consider impacts of individual upbringing as opposed to possible effects of race and ethnicity. These criteria also do not consider the fact that transgender individuals are found to have unique neuroanatomical phenotypes (Flint et al. 2020; Kurth et al. 2022). However, the purpose of the chosen restrictions was to collect broad demographic data from participants while limiting confounding variables as much as possible. Future work could focus on narrower and more detailed considerations of the impact of demographics, identity, and lived experience on Adjunct Condition processing.

4.2 Demographics

Of the 50 participants retained, 21 indicated that they were females, and 29 indicated that they were males. Zero participants indicated that they were intersex. The mean age of the participants was 21.66, with a minimum age of 19 and a maximum age of 24.

Participants' racial breakdown is presented in Table 4.1, and their educational breakdown is presented in Table 4.2. Just over half of the participants identified as White/Caucasian, and more than three quarters of participants had completed some college at the time of participating in the survey. This survey therefore provides an account of college students' processing behavior, but may paint an under-representative picture of processing behavior across racial groups.[1]

46 of the participants indicated that English was their first language, and 4 participants indicated that they had started speaking English when they started school.[2] All 50 identified as native English speakers according to Prolific. 24 of the participants indicated that they spoke languages other than English. A description of their languages spoken is available in Appendix B. One participant indicated that they spoke AAVE, and one indicated that they spoke Miami English. The other 48 participants did not indicate any usage of "non-standard" American English dialects.

Table 4.1: Racial Identification of Participants

Race	**Number of Participants**
White/Caucasian	27
Asian/Pacific Islander	9
Hispanic	8
Black/African-American	4
Multiracial	2

Table 4.2: Education Level of Participants

Education Level	**Number of Participants**
Some college	38
Bachelor's degree	9
Some graduate school	2
Master's or other grad degree	1

[1]Section 4.1.1 discusses why the study controlled for education level, and possible future steps for considering the impact of demographics on Adjunct Condition processing.

[2]Participants did not provide an age at which they started school, but all had identified themselves as native English speakers to Prolific.

Chapter 5

Predictions

Acceptability judgment and SPR time values are arbitrary in predictions figures. The focus of figures in this section is on the difference, or lack thereof, between conditions.

5.1 Acceptability Judgments

The Two-Phase Processor Hypothesis

The Two-Phase Processor Hypothesis predicts that there will be no significant difference in acceptability between the *Semantic Support* and *No Semantic Support* conditions. This hypothesis also does not predict a significant difference between the *Unacceptable* condition and the experimental conditions because this framework predicts that semantics cannot be built without a satisfactory syntactic structure. The experimental conditions and the *Unacceptable* condition each prevent formation of a syntactic structure, but in different ways. [1]

This hypothesis does not predict any changes in acceptability when additional context is

[1] This hypothesis also does not posit ”levels” of syntactic violations, so the hypothesis does not predict that the *Unacceptable* control has a “worse” syntactic violation than the experimental conditions. Any graph showing otherwise would require a discussion of levels of syntactic violation, which is outside the scope of this thesis.

given because under this framework, semantic enrichment does not impact acceptability of a syntactically unacceptable sentence.

These predictions are presented in Figure 5.1.

The Parallel Processor Hypothesis

The Parallel Processor Hypothesis predicts a significant difference in acceptability judgments between the *Semantic Support* and *No Semantic Support* conditions, where *Semantic Support* sentences are rated higher.[2] This hypothesis also predicts that in the presence of additional context, all conditions should be rated higher than without context. This trend is predicted because under this framework, increased semantic enrichment leads to greater support for semantic structure, which in turn facilitates processing. However, there should still be significantly higher ratings for the *Semantic Support* condition, as this condition is most semantically enriched. These predictions are presented in Figure 5.2.

[2]To emphasize that semantic support is not a binary, the *No Semantic Support* condition is rated slightly higher than the *Unacceptable* condition to reflect that the verb and its intended object may have a weak semantic relationship, resulting in a slight increase in acceptability compared to the *Unacceptable* control. Again, see 3.1.1 for discussion.

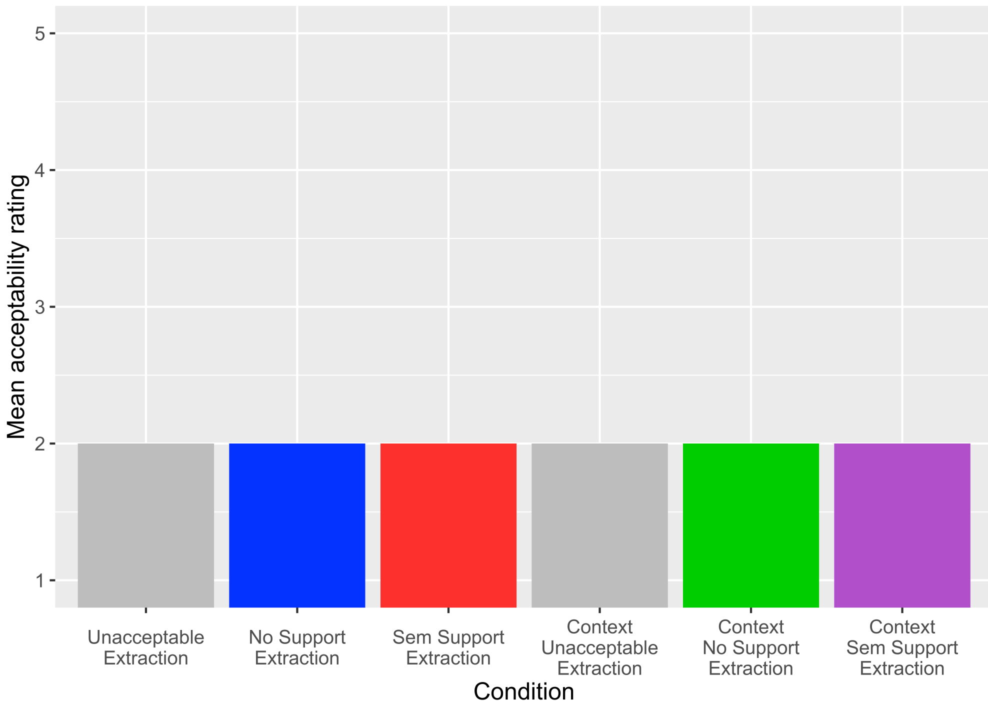

Figure 5.1: Predicted Acceptability Judgments under a Two-Phase Processing Model

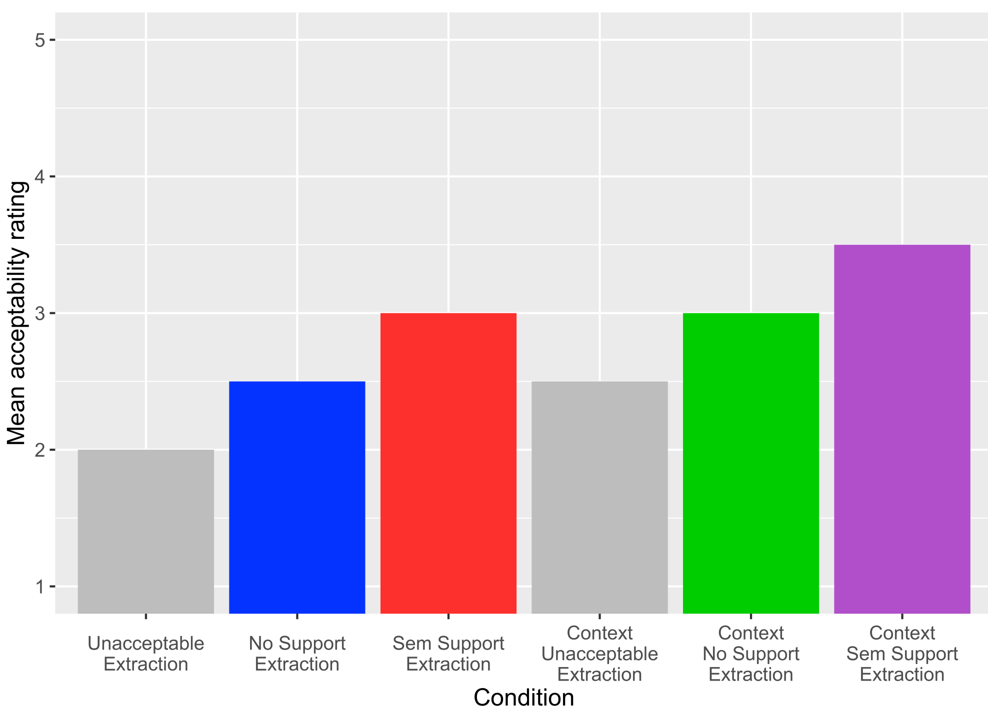

Figure 5.2: Predicted Acceptability Judgements under a Parallel Processing Model

5.2 Self-Paced Reading Times

The Two-Phase Processor Hypothesis

The Two-Phase Processor Hypothesis predicts that the presence of semantic support should not impact reading time following the GAP. There should be no difference between reading times across the *Semantic Support* and *No Semantic Support* conditions. This is presented visually in Figure 5.3.

This hypothesis does not predict any changes in reading time when additional context is given because via this perspective, semantic enrichment does not impact processing behavior of a syntactically unacceptable sentence. This is presented in Figure 5.5 to contrast against the predictions of the other hypothesis.

The Parallel Processor Hypothesis

The Parallel Processor Hypothesis predicts that the presence of semantic support should ameliorate the GAP-filling process, leading to a decrease in reading time following the GAP. Sentences in the *Semantic Support* condition should therefore have a lower reading time than sentences in the *No Semantic Support* condition after the GAP. This is presented visually in Figure 5.4.

Under this hypothesis, the present of context, or semantically enrichment to the processor, should also aid in the building of semantics. Therefore, under this framework, the presence of context should lower reading times across all conditions as processing is expedited due to the bolstering of semantics. However, semantic support should still significantly decrease the processing time after the GAP, compared to sentences without semantic support. This is presented in Figure 5.6.

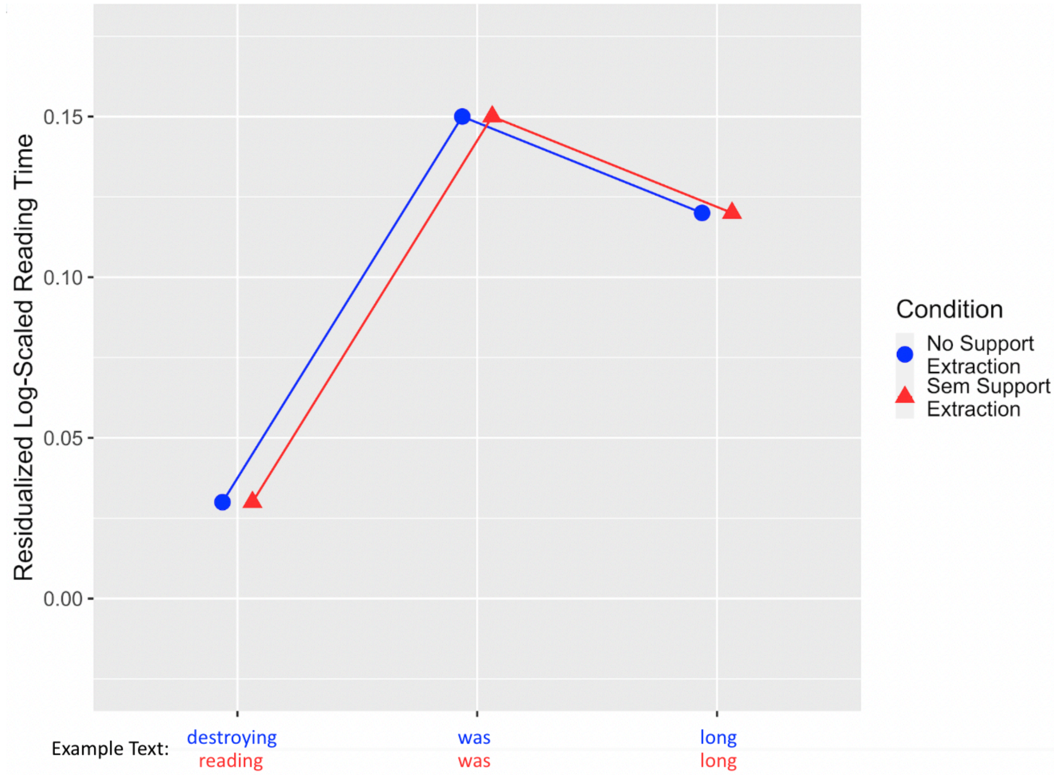

Figure 5.3: Predicted SPR Times sans Context under a Two-Phase Processing Model

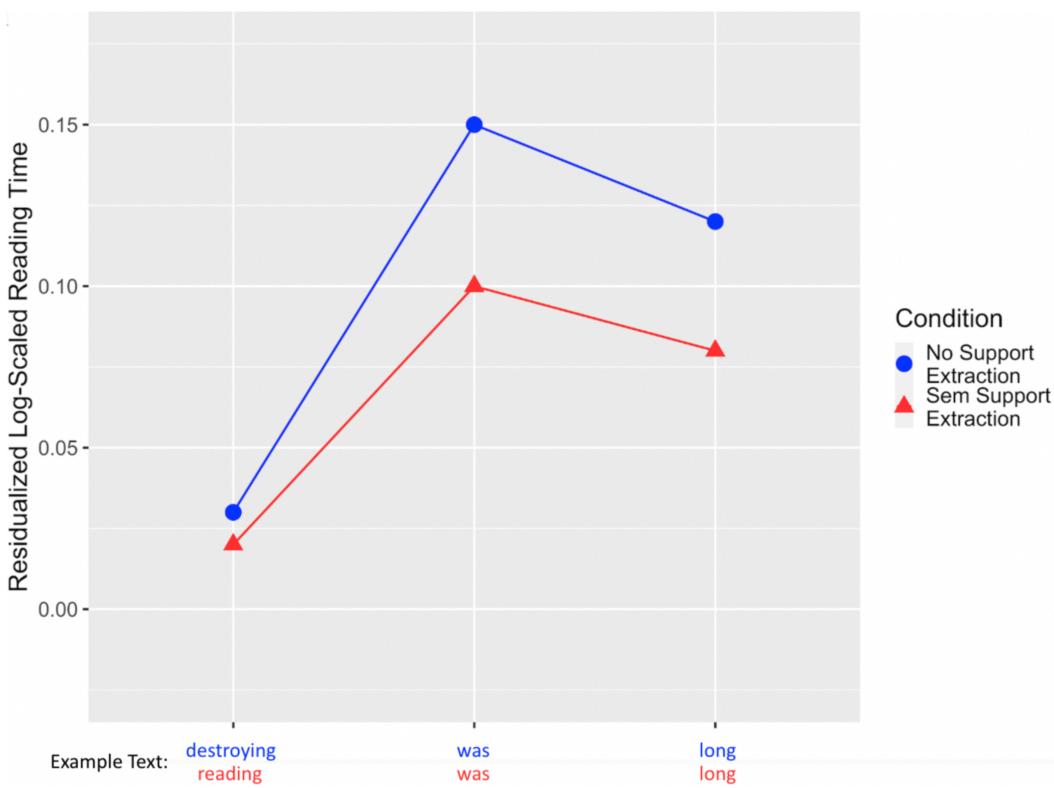

Figure 5.4: Predicted SPR Times sans Context under a Parallel Processing Model

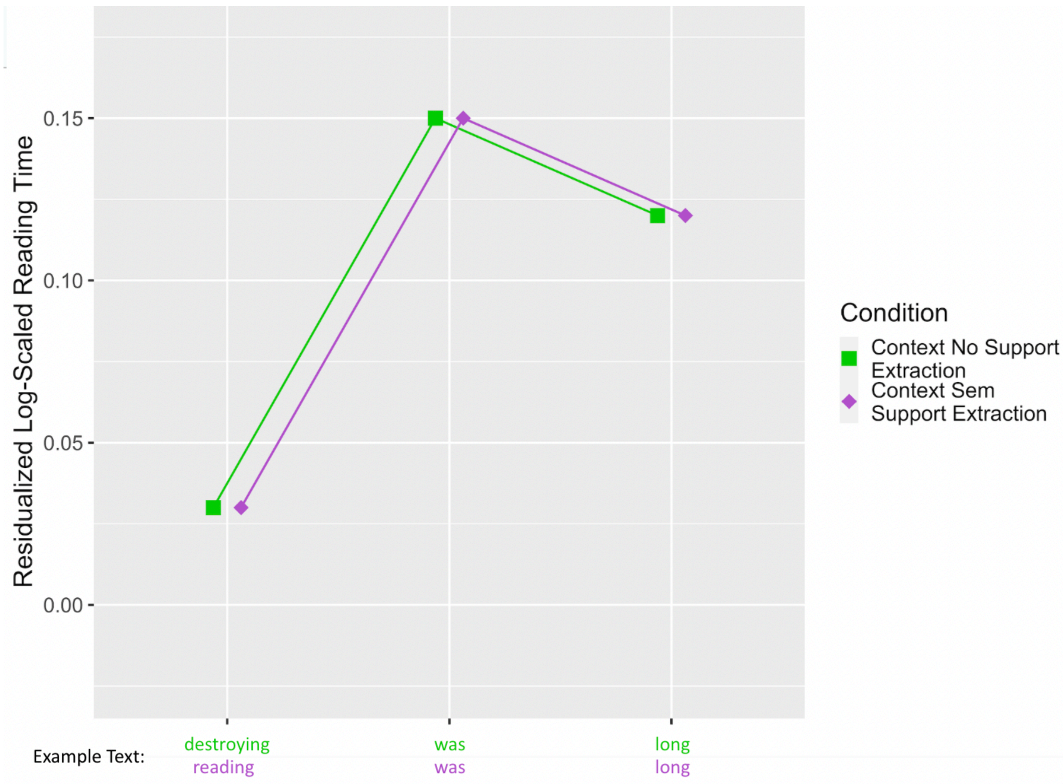

Figure 5.5: Predicted SPR Times with Context under a Two-Phase Processing Model

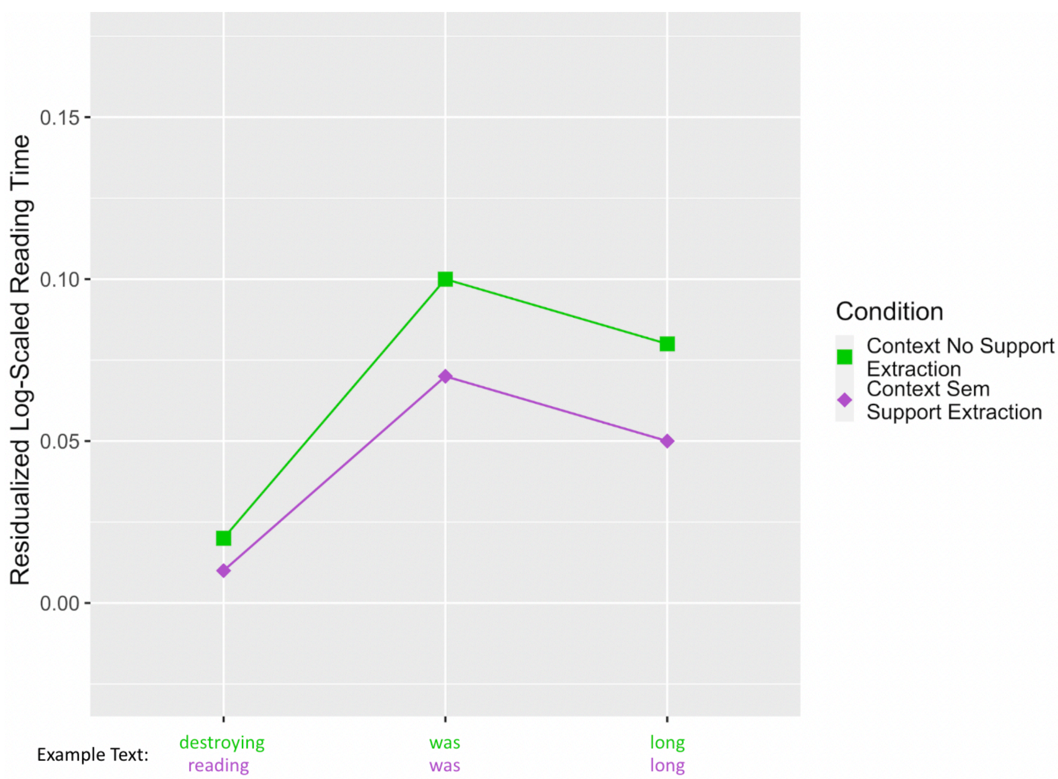

Figure 5.6: Predicted SPR Times with Context under a Parallel Processing Model

Chapter 6

Statistical Analysis

All analyses were performed using R Statistical Software (R Core Team 2023).

6.1 Acceptability Judgments

Acceptability judgments were scaled by participant, then averaged by condition.[1]

6.2 Self-Paced Reading

Reading times were scaled by participant, then reading time data for individual words were removed if the word's reading time was outside 2.5 standard deviations for that participant. This resulted in the removal of 752 words across the experiment, or 0.80% of single-word SPR trials.

The number of characters in each word, the reading time of the previous word, and the number of trials participants had read prior to reading the word were scaled. Then, reading

[1]There is some controversy as to whether ordinal data, such as acceptability judgments, can be treated using parametric statistics. However, review of this controversy shows that parametric tests are sufficiently robust to analyze Likert scale ratings (Sullivan and Artino 2013). While the mean values of acceptability judgments cannot be assigned to exact meanings as presented in Table 3.1, conclusions will be drawn from the difference between mean acceptability judgments, not the meaning of the individual mean values.

times were residualized with respect to these three scaled variables.

6.3 Further Analysis

Mixed-effects models were run *only* on the experimental conditions (*Sem Support* and *No Sem Support*, with and without context) to study the impact of context and semantic support on residualized SPR times.[2] These models were created using the lme4 package in R (Bates et al. 2015). These models included context, semantic support, and the interaction between the two as fixed variables.

The models were run on three target words: the verb before the object GAP ("Verb"), the critical word immediately following the GAP ("Critical"), and the word following the critical word ("Next"). Examples of these words are presented in Table 6.1.

Table 6.1: Example Target Words for Mixed-Effects Model Analysis

Condition	**Non-Target Words**	**Verb**	**Critical**	**Next**
Sem Support	The book that I was sad after	reading	was	long.
No Sem Support	The book that I was sad after	destroying	was	long.

A two-way ANOVA was run on each model to compare the effect of context, semantic support, and their interaction on residualized reading times. P values were determined using Wald chi-squares. Anova tests were run using the car package in R (Fox and Weisberg 2019).

[2]These models relied on SPR times that were residualized as described in Section 6.2.

Chapter 7

Results

In all figures, error bars represent a 95% confidence interval. This indicates that any values without confidence interval overlap are significantly different ($p < 0.05$).

7.1 Acceptability Judgments

Acceptability judgment data are presented for the experimental conditions (*No Semantic Support* and *Semantic Support*[1]), alongside the *Unacceptable* condition. The *Unacceptable* condition was selected as the contrastive control in these data representations because it was highly ungrammatical, and therefore should have elicited a very low rating from native English speakers. Participants did rate *Unacceptable* stimuli as unacceptable across context conditions, indicating that participants understood the task presented. Recall that participants were presented with a 1-5 Likert scale when asked to judge stimuli.

Table 7.1 summarizes participants' mean acceptability judgments across experimental conditions and the *Unacceptable* condition.[2] These data are also presented visually in Figure 7.1.

[1]These conditions are presented in figures as No Support Extraction and Sem Support Extraction, respectively.

[2]A table of more precise values, across all conditions, can be found in Appendix C.

Stimuli with context were not rated significantly differently from stimuli without context. *Semantic Support* stimuli were rated as significantly more acceptable than *No Semantic Support* stimuli across both context conditions ($p < 0.05$).

Condition	**Mean Judgment**	**95% C.I. Width**
Unacceptable	2.33	0.101
No Support	3.53	0.112
Semantic Support	3.84	0.0916
Context Unacceptable	2.26	0.0946
Context No Support	3.48	0.108
Context Semantic Support	3.75	0.0983

Table 7.1: Mean Acceptability Judgments

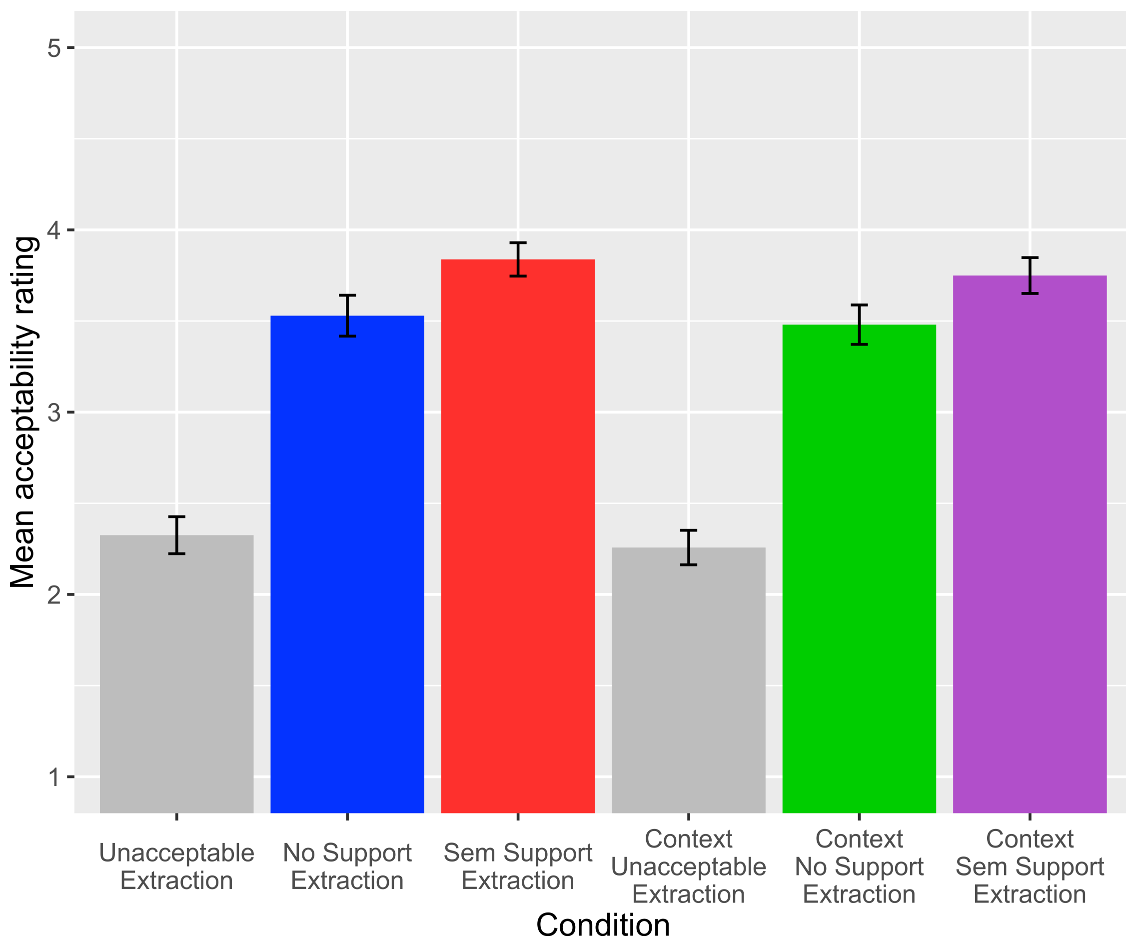

Figure 7.1: Mean Acceptability Judgments of Stimuli across Conditions

7.2 Self-Paced Reading Times

SPR data are presented for the experimental conditions (*No Semantic Support* and *Semantic Support*). Figures and tables show residualized reading times for the target words in each stimulus.[3] Examples of target words are presented in each table and along the X-axis of each figure. A description of the residualization methodology can be found in Section 6.2.

7.2.1 Self-Paced Reading, without Context

Table 7.2 summarizes participants' mean residualized SPR times at each target word, without context. These data are presented visually in Figure 7.2.

When not given additional context, participants read the Critical target word significantly more slowly when reading *No Semantic Support* stimuli than when reading *Semantic Support* stimuli ($p < 0.05$). There was no significant difference in reading time at the Verb target word or the Next target word.

7.2.2 Self-Paced Reading, with Context

Table 7.3 summarizes participants' mean residualized reading times at each target word, with context. These data are presented visually in Figure 7.3.

When the stimuli were presented with additional context, participants read the Verb target word significantly more slowly when reading *No Semantic Support* stimuli than when reading *Semantic Support* stimuli ($p < 0.05$). There was no significant difference in reading time at the Critical target word or the Next target word.

[3] A table of more precise values, across all conditions, can be found in Appendix D.

Condition	Target Word	Example Text	SPR Time (logms)	95% C.I. Width (logms)
Semantic Support	Verb	*reading*	0.0267	0.0369
	Critical	*was*	0.107	0.0326
	Next	*long*	0.159	0.0384
No Semantic Support	Verb	*destroying*	0.0401	0.0337
	Critical	*was*	0.177	0.0368
	Next	*long*	0.148	0.0407

Table 7.2: Log-Transformed SPR Times for Target Words, without Context

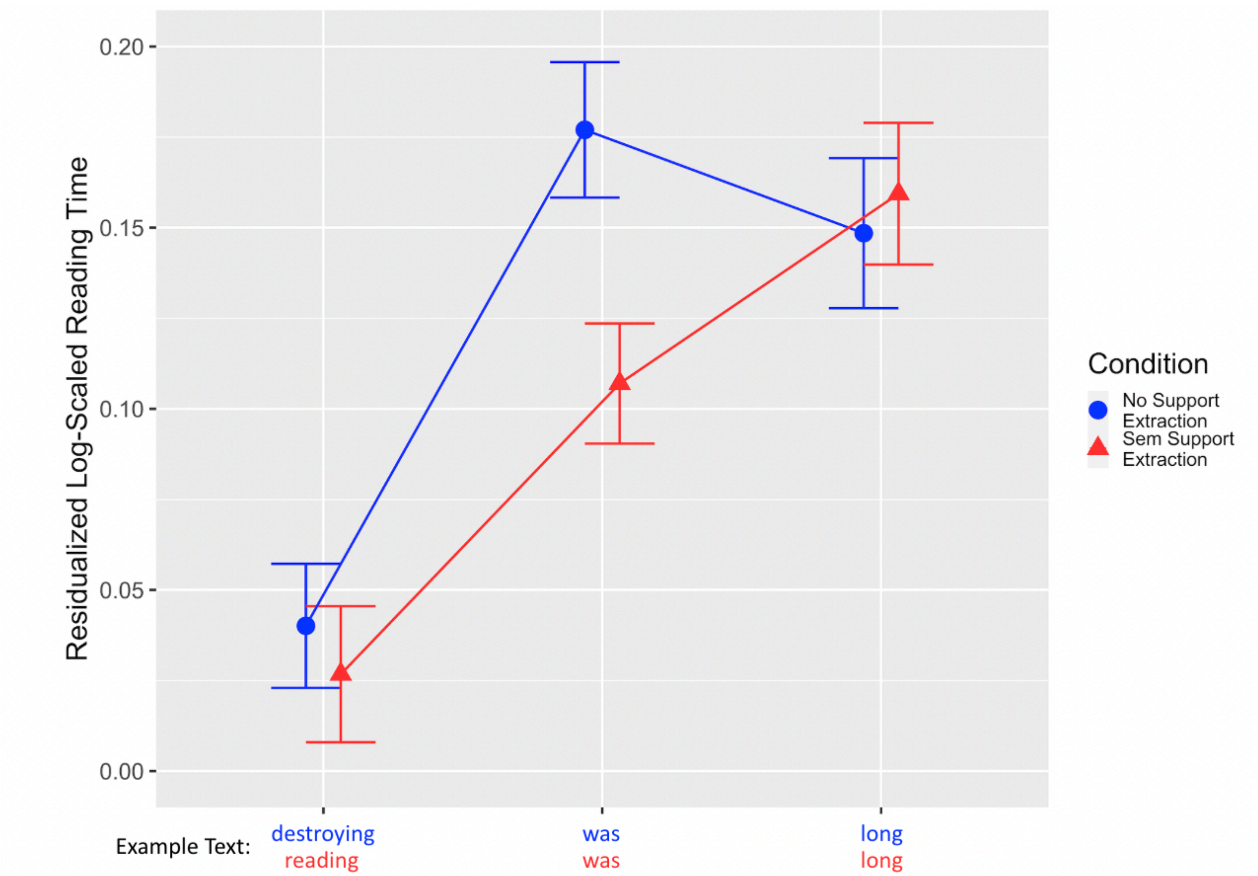

Figure 7.2: Log-Transformed SPR Times for Target Words, without Context

Condition	Target Word	Example Text	SPR Time (logms)	95% C.I. Width (logms)
Context Semantic Support	Verb	*reading*	-0.0128	0.0461
	Critical	*was*	0.0802	0.0428
	Next	*long*	0.113	0.0416
Context No Semantic Support	Verb	*destroying*	0.0362	0.0447
	Critical	*was*	0.0855	0.0468
	Next	*long*	0.0989	0.0502

Table 7.3: Log-Transformed SPR Times for Target Words, with Context

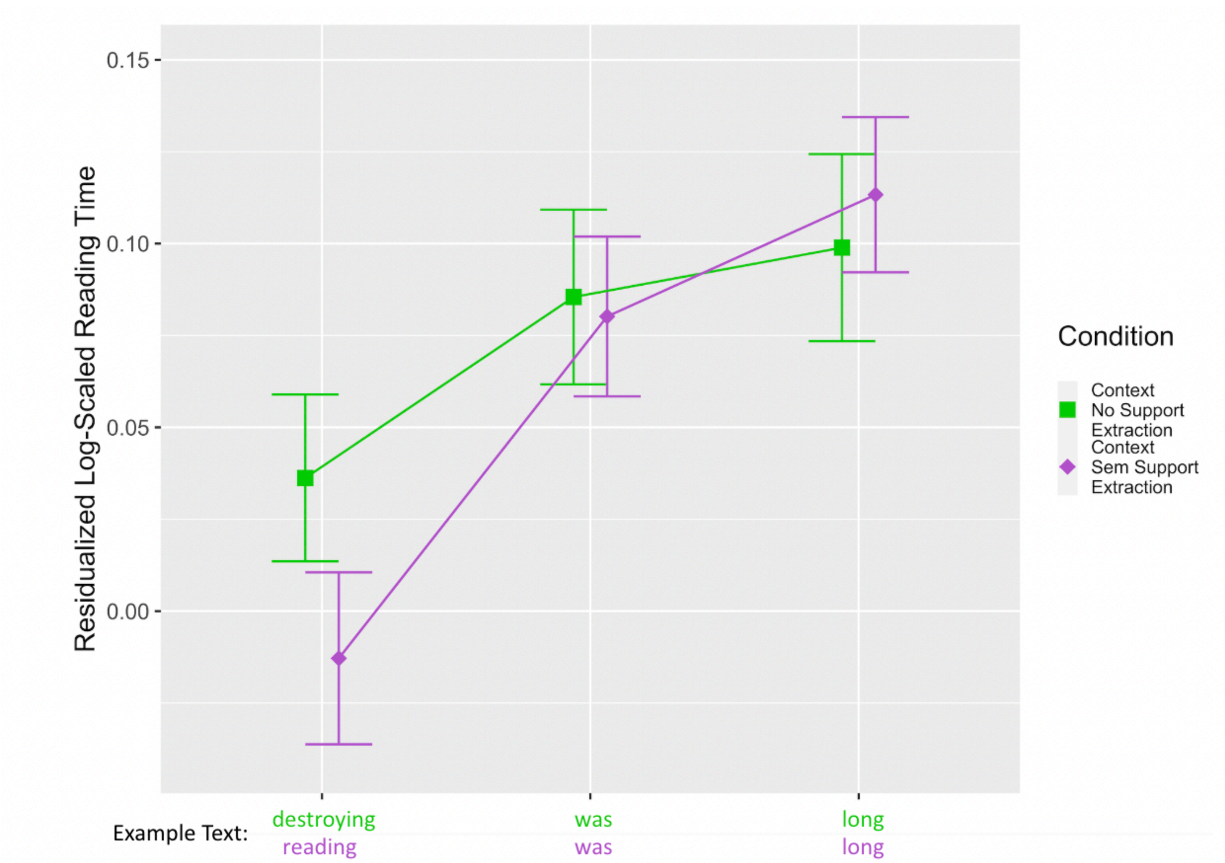

Figure 7.3: Log-Transformed SPR Times for Target Words, with Context

7.3 Mixed-Model Analysis

The mixed model analyses compared the *No Semantic Support* and *Semantic Support* conditions with and without context, at each target word. These four conditions are presented together in Figure 7.4.

The mixed model for the Verb target word preceding the object GAP (e.g.*reading/destroying*) showed no evidence for impact of context (p=0.31), no evidence for impact of semantic support (p=0.19), and no evidence for impact of their interaction (p=0.40) on residualized SPR times.

The mixed model for the Critical target word following the object GAP (e.g.*was*) showed evidence for impact of context (p=0.012), evidence for impact of semantic support (p=0.014) and evidence for impact of their interaction (p=0.087) on residualized SPR times. Specifically, the model provides evidence that context and semantic support each individually significantly decrease reading time at the Critical target word.

The mixed model for the Next target word (e.g. *long*) showed evidence for impact of context (p=0.012), but showed no evidence for impact of semantic support (p=0.73) and no evidence for impact of their interaction (p=0.94) on residualized SPR times. Specifically, the model provides evidence that context decreases reading time at the Next target word.

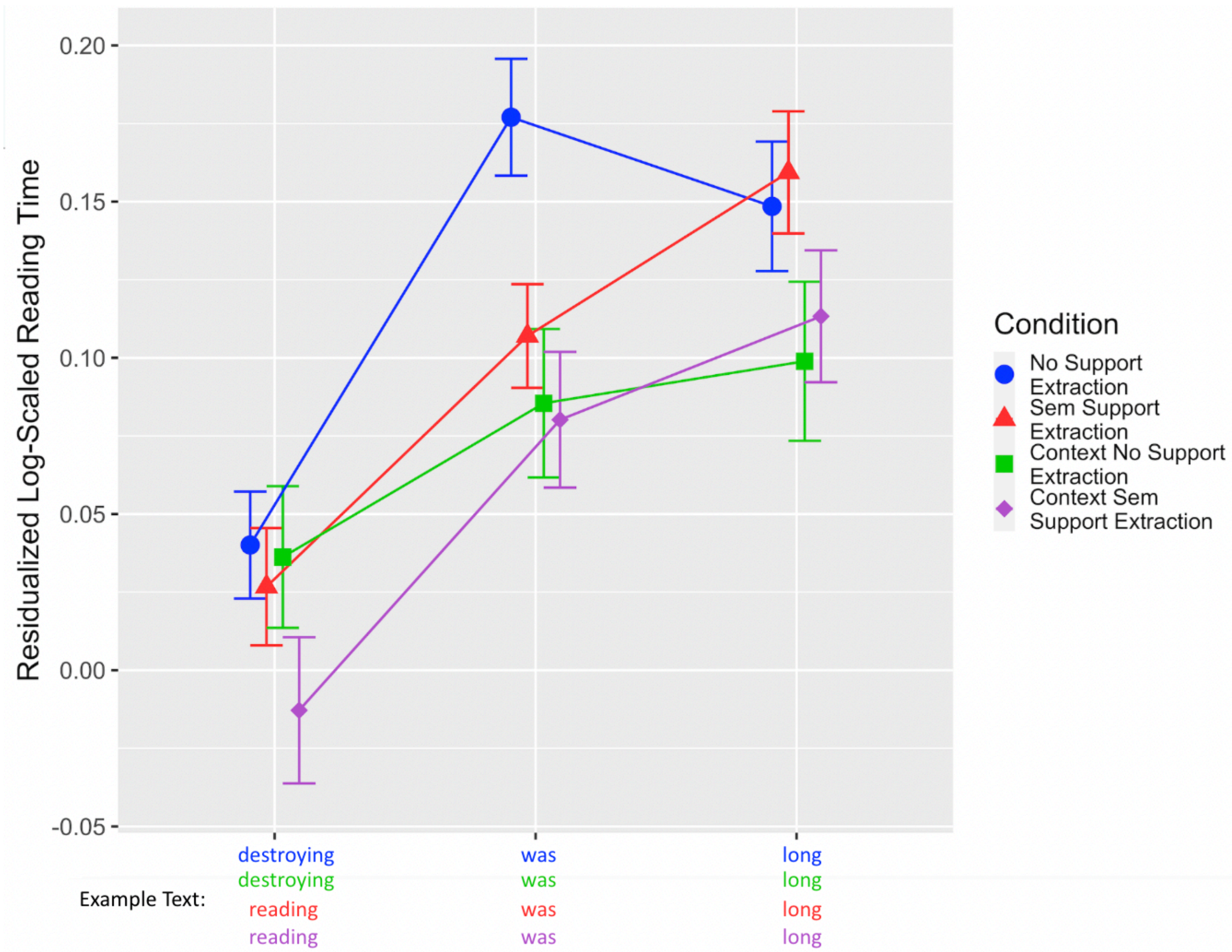

Figure 7.4: Log-Transformed SPR Times for All Experimental Conditions

Chapter 8

Discussion

8.1 Implications for The Hypotheses

The acceptability judgment data show that when we manipulate semantic information without changing syntactic structure, native English speakers judge sentences with semantic support more favorably than sentences without it. These data support the Parallel Processor Hypothesis because they provide evidence that semantic information contributes to processing of a sentence outside of syntactic processes.

However, the data do not seem to show an impact of context – which I take to be analogous to further semantic enrichment – on acceptability judgments. A possible explanation for context's lack of influence is that there is some sort of ceiling effect for acceptability judgments in the experimental conditions without additional context. While these sentences were judged more acceptably than the *Unacceptable* condition, they do still contain a syntactic violation, which would at least cause hesitation under either processing hypothesis. Therefore it is possible that there is a limit to the extent to which semantic enrichment can ameliorate this syntactic violation effect, and that this is reflected in the acceptability judgements across context conditions. However, there are not enough data to definitively draw this conclusion, and more experimentation is required here.

The SPR data show a clear difference between the *Semantic Support* and *No Semantic Support* conditions, across both context conditions. Taken together, the SPR data also provide support for the Parallel Processor Hypothesis.

Let us begin with the no-context conditions. When stimuli were presented without context, there was evidence for a significant difference between the semantic support conditions at the critical word. Across both conditions, there was a jump in reading time following the GAP, reflecting the process during which the GAP is filled. The jump in SPR time was significantly lower when the sentence included semantic support, providing evidence that semantic support ameliorates the processing time of GAP-filling. While there was no evidence for an impact of semantic support on either of the other target words, the impact of semantic support at the critical word provides evidence that semantic support plays a role in facilitating the GAP-filling process. On a larger scale, a change in semantic information has an effect on processing behavior. This provides support for the Parallel Processor Hypothesis.

Next, we turn to the context conditions. When stimuli were presented with context, there was evidence for a significant SPR difference between the semantic support conditions at the verb word. The residualized reading time at the verb word was significantly shorter when there was semantic support. To understand this, it's important to remember that the participant has read quite a bit of context before reading the verb word – this context is shown in (16) and (17), with the verb word italicized.

(16) **Semantic Support:** Today, I read some books at the library. Some of the books I read were quite short. The book that I was sad after *reading* was long.

(17) **No Semantic Support:** Today, I ruined some books at the library. Some of the books I destroyed were quite short. The book that I was sad after *destroying* was long.

After reading this context, in both conditions the reader knows that this scenario is about books. Per COCA, *read* is a collocate of *book*, but *destroy* is not, so as the reader considers books, reading the word *destroying* is less expected than reading the word *reading*. Therefore, there is a shorter residualized reading time for the collocate verb than the non-collocate verb, indicating that semantic support may cause this discrepancy. However, this is a different impact of semantic support because the intended object *book* seems to be shaping the reading of the verb, whereas, without context, at the critical word the verb seems to shape processing of the intended object. Therefore, context seems to guide the time at which semantic support plays a role in processing behavior.

Additionally, when context is provided, there is no difference between reading times at the critical word following the GAP, implying that after the initial impact of semantic support at the verb, semantic support does not have a significant impact on processing time. Again, these results are supportive of the theory that context has an effect on the time course of semantic support effects. The mixed-effects model also provides evidence for an interaction between context and semantic support at the critical word, indicating that the presence of context does seem to influence the impact of semantic support.

The mixed-effects model provides even further evidence for the impact of context on processing time course. The model shows that there is an impact of context at the word following the critical word, but that there is no impact of semantic support at that point. The model therefore supports the theory that while both context and semantic support have an effect at the critical word, context continues to have an impact once the reader reaches the next word, while semantic support's impact wears off by that point. Taken together, these time course results may indicate that semantic support and context are different types of semantic enrichment. We could infer that while both ameliorate processing cost of syntactically ungrammatical sentences, semantic support on its own plays a short-term role at the critical word. On the other hand, the presence of context plays a longer term role across the clause – both before the GAP, by shaping the influence of semantic support, and after it, shaping processing behavior on its own. These time course impacts make sense given how I defined semantic support and context from the start – semantic support is a small difference within the sentence, while context is a larger, broader, form of meaning that forms the environment of a sentence. Stepping back to see the big picture, these nuances can be summarized as indicating that manipulating semantic enrichment, separately from syntactic structure, impacts processing behavior. This conclusion supports the Parallel Processing Hypothesis.

8.2 Implications for Future Work

While this thesis provides more precise and detailed evidence than my pilot study, there are many more methods beyond SPR to study GAP-filling and the influence of semantic support. Incredibly exciting work, including in Piñango et al. (2016), shows that fMRI can be used to observe real-time GAP-search and GAP-filling in regions of the brain. It would be fascinating to run a similar experiment to understand whether (and if so, by what mechanism and to what extent) semantic support impacts these observations.

Additionally, it would be interesting to run a lexical decision task after the GAP using these same stimuli. Semantic support among collocates seems to necessarily imply some sort of priming effect between the verb and the intended object. The semantic support effects seen in my study could potentially be explained by this simple priming effect – the lexical item deemed semantically most connected to the preceding word is "ripe for picking" from the lexicon as the processor attempts to fill the GAP. A lexical decision task could confirm if such a priming effect exists and provide more detailed insight into how exactly semantic support facilitates processing of these stimuli.

While my participants indicated their demographics and took an Autism Quotient test, this experiment did not study the influence of identity, lived experience, and AQ scores on processing behavior. Future work in the Adjunct Condition should take these factors into account, allowing us to draw conclusions about how identity, experience, and context sensitivity influence the brain's linguistic processing of these types of sentences.

In Chapter 8, I note that context and semantic support seem to impact each other and shape processing behavior in different ways. Continued experimentation is necessary to tease out the differences between these two seemingly different types of semantic enrichment, to better understand how they work together and separately to shape processing behavior.

Finally, this thesis seems to provide substantial evidence in support of a Parallel Processor hypothesis over a Two-Phase hypothesis. I am hopeful that the field as a whole will continue studying and comparing models for the linguistic processor, and that this thesis may contribute to that body of work.

8.2.1 Suggestions for Improvement

Due to technical errors with Gorilla, two stimuli (or approximately 2% of single word SPR trials) were not shown to a fifth of participants, and one stimulus (or approximately 0.5% of single-word SPR trials) was not shown to a separate fifth of participants.[1] While this was a very small percentage and most likely did not significantly influence my results, the study and its conclusions would be more robust had these errors not occurred.

Additionally, the *Acceptable* condition was rated much lower than expected, even lower than the *Semantic Support* condition when context was present (see Appendix C). It is unclear why these sentences were not highly acceptable to participants. The *Acceptable* stimuli were not included in my pilot study (Holubkov 2022), so were not robustly screened before implementation of this study. These surprising results may indicate that these sentences should be studied to understand why they are marked for native English speakers. Additionally, if my study is replicated, the *Acceptable* control stimuli should be rewritten and tested in a separate pilot study to ensure that they are judged highlyas expected.

Finally, the non-experimental conditions in this experiment only used semantically supported verbs, such as *reading*, and not semantically unsupported verbs, such as *destroying*.

[1] All stimuli were viewed by at least forty participants, and an items analysis indicated that no individual set of stimuli had a significant impact on experimental results.

Ideally, if this experiment were to be replicated, the control conditions would include both types of verbs to create more minimal pairs, allowing for more robust conclusions.

8.2.2 Other Perspectives

Other perspectives on language processing could differently frame the relevance of my results. For example, one view posits that semantic units in syntax render "semantic support" adjuncts (to use my terminology) as syntactically different from "no semantic support" adjuncts, avoiding violation of the Adjunct Condition (de Vos 2005, Wiklund 2008, Brown 2015). If this perspective is accurate, my experiment does not manipulate semantics of adjuncts in syntactically identical environments. A new experimental design would therefore be required to compare how semantic differences impact processing. Another perspective argues that constraints such as the Adjunct Condition constrain PF, not syntax, as evidenced by phenomena such as sluicing (Merchant 1999, Nakao 2009). If this is accurate, my experiment might provide support for models comparing PF and semantics, instead of semantics and syntax.

While a wide variety of views exist in linguistics with regard to the Adjunct Condition and language processing, my thesis assumes that the Adjunct Condition is a syntactic constraint, not a PF constraint. I also assume that semantically supported adjuncts are syntactically identical to semantically unsupported adjuncts. Under these assumptions and the framing of my two hypotheses, the evidence from this study support a parallel processing model over a two-phase model. Future work could – and should – study these types of stimuli under other models and frameworks, beyond those I present, to pinpoint the framework that is best supported by my results.

Chapter 9

Conclusion

9.1 What did I find?

This thesis provides evidence that native English speakers judge syntactically identical sentences differently when the sentences show different levels of semantic enrichment; namely, an increase in semantic support leads to more favorable judgment of a sentence containing a syntactic violation. There is also evidence that semantic enrichment ameliorates the process of GAP-filling, and that semantic enrichment takes at least two forms: semantic support and broader context. Statistical analysis of the thesis data shows that semantic support and context work individually and in tandem at different times in relative clauses to decrease processing time, and that context may alter the time course of semantic impact on processing. Taken together, these data suggest that a parallel model for semantic and syntactic processing is more accurate than a two-phase model.

9.2 Why does it matter?

It seems incredibly niche to create sentences that violate the Adjunct Condition, then manipulate those sentences to include varying levels of semantic support, and maybe even silly to think about those sentences for two years. But the specificity of these sentences is exactly what allows them to provide insight into linguistic processing. We obviously cannot gain an understanding of linguistic processing by opening a skull and dissecting the brain itself. Through precise and minimal manipulation, followed by the study of speakers' reaction to these changes, these kinds of sentences provide insight into linguistic processing that is impossible to access otherwise.

This study compares two essential models of linguistic processing, a two-phase model and a parallel model. By providing evidence that semantics aids in the processing of sentences that violate syntactic rules, and further, that semantic composition occurs *alongside* syntactic composition, not *because* of it, this thesis hopes to push the field closer to a model that comprehensively and accurately describes linguistic behavior, and accounts for our ability to understand sentences with structures we've never encountered before, even when they are structured imperfectly. In doing so, this thesis contributes to our understanding of the processor that we use every single day (even in reading this paper!), and of language, an instrument that takes what is in our minds and allows us to share it with the world.

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Appendices

Appendix A: Stimuli for Experiment

All stimuli are presented with context included, with the target sentence bolded.

Set 1

Semantic Support: Today, I read some books at the library. Some of the books I read were quite short. **The book that I was sad after reading was long.**

No Semantic Support: Today, I ruined some books at the library. Some of the books I destroyed were quite short. **The book that I was sad after destroying was long.**

Emotional Predicate: Today, I read some books at the library. Some of the books I read were quite short. **The book that I was sad about reading was long.**

Acceptable Control: Today, I read some books at the library. Some of the books I read were quite short. **The book that I read when I was sad was long.**

Unacceptable Control: Today, I read some books at the library. Some of the books I read were quite short. **The book that I was sad after reading book was long.**

Set 2

Semantic Support: Last summer, I bought lots of clothes. Some of the clothes I wore were quite used. **The clothes that I felt happy after wearing were new.**

No Semantic Support: Last summer, I destroyed lots of clothes. Some of the clothes I burned were quite used. **The clothes that I felt happy after burning were new.**

Emotional Predicate: Last summer, I bought lots of clothes. Some of the clothes I wore were quite used. **The clothes that I felt happy about wearing were new.**

Acceptable Control: Last summer, I bought lots of clothes. Some of the clothes I wore were quite used. **The clothes that I wore when I was happy were new.**

Unacceptable Control: Last summer, I bought lots of clothes. Some of the clothes I wore were quite used. **The clothes that I felt happy after wearing clothes were new.**

Set 3

Semantic Support: Yesterday, I made cookies. Some of the cookies I baked were quite dry. **The cookie that I was happy after baking was delicious.**

No Semantic Support: Yesterday, I purchased cookies. Some of the cookies I bought were quite dry. **The cookie that I was happy after buying was delicious.**

Emotional Predicate: Yesterday, I made cookies. Some of the cookies I baked were quite dry. **The cookie that I was happy about baking was delicious.**

Acceptable Control: Yesterday, I made cookies. Some of the cookies I baked were quite dry. **The cookie that I baked while I was happy was delicious.**

Unacceptable Control: Yesterday, I made cookies. Some of the cookies I baked were quite dry. **The cookie that I was happy after baking cookie was delicious.**

Set 4

Semantic Support: Today, I saw many dogs at the dog park. Some of the dogs I pet were quite wild. **The dog that I was excited after petting was well-trained.**

No Semantic Support: Today, I noticed many dogs at the dog park. Some of the dogs I saw were quite wild. **The dog that I was excited after seeing was well-trained.**

Emotional Predicate: Today, I saw many dogs at the dog park. Some of the dogs I pet were quite wild. **The dog that I was excited about petting was well-trained.**

Acceptable Control: Today, I saw many dogs at the dog park. Some of the dogs I pet were quite wild. **The dog that I pet while I was excited was well-trained.**

Unacceptable Control: Today, I saw many dogs at the dog park. Some of the dogs I pet were quite wild. **The dog that I was excited after petting dog was well-trained.**

Set 5

Semantic Support: Yesterday, I created paintings for my living room. Some of the paintings I painted were quite plain. **The painting that I felt joy after painting was beautiful.**

No Semantic Support: Yesterday, I selected paintings for my living room. Some of the paintings I chose were quite plain. **The painting that I felt joy after choosing was beautiful.**

Emotional Predicate: Yesterday, I created paintings for my living room. Some of the paintings I painted were quite plain. **The painting that I felt joy about painting was beautiful.**

Acceptable Control: Yesterday, I created paintings for my living room. Some of the paintings I painted were quite plain. **The painting that I painted while I was joyful was beautiful.**

Unacceptable Control: Yesterday, I created paintings for my living room. Some of the paintings I painted were quite plain. **The painting that I felt joy after painting painting was beautiful.**

Set 6

Semantic Support: Yesterday, I cleaned my kitchen and did my dishes. Some of the dishes I washed were quite gross. **The dishes that I felt content after washing were clean.**

No Semantic Support: Yesterday, I cleaned my kitchen and inspected my dishes. Some of the dishes I observed were quite gross. **The dishes that I felt content after observing were clean.**

Emotional Predicate: Yesterday, I cleaned my kitchen and did my dishes. Some of the dishes I washed were quite gross. **The dishes that I felt content about washing were clean.**

Acceptable Control: Yesterday, I cleaned my kitchen and did my dishes. Some of the dishes I washed were quite gross. **The dishes that I washed while I was content were clean.**

Unacceptable Control: Yesterday, I cleaned my kitchen and did my dishes. Some of the dishes I washed were quite gross. **The dishes that I felt content after washing dishes were clean.**

Set 7

Semantic Support: Today, I composed several assignments for my English class. Some of the papers I wrote were quite bare. **The paper that I felt stressed after writing was complex.**

No Semantic Support: Today, I completed several assignments for my English class. Some of the papers I finished were quite bare. **The paper that I felt stressed after finishing was complex.**

Emotional Predicate: Today, I composed several assignments for my English class. Some of the papers I wrote were quite bare. **The paper that I felt stressed about writing was complex.**

Acceptable Control: Today, I composed several assignments for my English class. Some of the papers I wrote were quite bare. **The paper that I wrote while I was stressed was complex.**

Unacceptable Control: Today, I composed several assignments for my English class. Some of the papers I wrote were quite bare. **The paper that I felt stressed after writing paper was complex.**

Set 8

Semantic Support: Today, I was thirsty and heated some water to drink. Some of the water I boiled was quite stale. **The water that I felt excited after boiling was refreshing.**

No Semantic Support: Today, I was thirsty and purchased some water to drink. Some of the water I bought was quite stale. **The water that I felt excited after buying was refreshing.**

Emotional Predicate: Today, I was thirsty and heated some water to drink. Some of the water I boiled was quite stale. **The water that I felt excited about boiling was refreshing.**

Acceptable Control: Today, I was thirsty and heated some water to drink. Some of the water I boiled was quite stale. **The water that I boiled when I was excited was refreshing.**

Unacceptable Control: Today, I was thirsty and heated some water to drink. Some of the water I boiled was quite stale. **The water that I felt excited after boiling water was refreshing.**

Set 9

Semantic Support: Yesterday, for my acting class, I had to peck several people on the mouth. Some of the lips I kissed were quite chapped. **The lips that I felt happy after kissing were soft.**

No Semantic Support: Yesterday, for my drawing class, I had to draw several people's mouths. Some of the lips I drew were quite chapped. **The lips that I felt happy after drawing were soft.**

Emotional Predicate: Yesterday, for my acting class, I had to peck several people on the mouth. Some of the lips I kissed were quite chapped. **The lips that I felt happy about kissing were soft.**

Acceptable Control: Yesterday, for my acting class, I had to peck several people on the mouth. Some of the lips I kissed were quite chapped. **The lips that I kissed while I was happy were soft.**

Unacceptable Control: Yesterday, for my acting class, I had to peck several people on the mouth. Some of the lips I kissed were quite chapped. **The lips that I felt happy after kissing lips were soft.**

Set 10

Semantic Support: Today, I played my grandfather's favorite movies. Some of the movies I watched were quite simple. **The movie that I felt sad after watching was confusing.**

No Semantic Support: Today, I tried my grandfather's favorite movies. Some of the movies I borrowed were quite simple. **The movie that I felt sad after borrowing was confusing.**

Emotional Predicate: Today, I played my grandfather's favorite movies. Some of the movies I watched were quite simple. **The movie that I felt sad about watching was confusing.**

Acceptable Control: Today, I played my grandfather's favorite movies. Some of the movies I watched were quite simple. **The movie that I watched while I was sad was confusing.**

Unacceptable Control: Today, I played my grandfather's favorite movies. Some of the movies I watched were quite simple. **The movie that I felt sad after watching movie was confusing.**

Appendix B: Languages Spoken by Participants

Language	Number of Speakers
Cantonese	1
French	3
German	1
Hebrew	1
Japanese	1
Korean	2
Mandarin	1
Saraiki	1
Shangainese	1
Spanish	11
Swedish	1
Tagalog	1
Urdu	1
Vietnamese	3

Appendix C: Mean Acceptability Judgments and Confidence Intervals for All Conditions

Without Context		
Condition	**Mean Judgment**	**C.I. Width**
Unacceptable	2.325000	0.10148338
No Support	3.529167	0.11219431
Sem Support	3.838000	0.09156262
Emotional Predicate	4.052083	0.09377755
Acceptable	3.768750	0.10727752
With Context		
Condition	**Mean Judgment**	**C. I. Width**
Unacceptable	2.257367	0.09458232
No Support	3.480000	0.10806459
Sem Support	3.749491	0.09829902
Emotional Predicate	3.994000	0.08768752
Acceptable	3.519565	0.10876835

Appendix D: Log-Scaled Residualized SPR Times of Target Words for All Conditions

All values are residualized with regard to word length, trial number, and reading time of the previous word. All values are in log milliseconds.

Without Context						
Condition	**Verb word**		**Critical word**		**Next word**	
	SPR Time	**C.I. Width**	**SPR Time**	**C.I. Width**	**SPR Time**	**C.I. Width**
Unacceptable	0.076114698	0.0330900	0.108183514	0.0355288	0.194448606	0.0333453
No Support	0.040090525	0.0336502	0.177008495	0.0367758	0.148479529	0.0407219
Sem Support	0.026736234	0.0369162	0.106992421	0.0326161	0.159369686	0.0384207
Emotional Predicate	0.051038104	0.0304527	0.100729512	0.0355207	0.132378512	0.0331715
Acceptable	-0.021000599	0.0287021	-0.013326167	0.0272104	0.028023548	0.0250492
Without Context						
Condition	**Verb**		**Critical Word**		**Following Word**	
	SPR Time	**C.I. Width**	**SPR Time**	**C.I. Width**	**SPR Time**	**C.I. Width**
Unacceptable	-0.008431109	0.0370366	0.071304360	0.0461069	0.187780141	0.0617923
No Support	0.036237717	0.0446941	0.085467596	0.0468183	0.098901071	0.0501708
Sem Support	-0.012829313	0.0461024	0.080171089	0.0428044	0.113298385	0.0415854
Emotional Predicate	0.035849858	0.0492750	0.080062897	0.0461314	0.068390719	0.0507446
Acceptable	0.001953375	0.0396300	-0.000142940	0.0351936	0.048729871	0.0395392