Tipping the Balance: The Modulation of ERP Effects at the Syntax--Semantics Interface

Les Sikos
University of Colorado at Boulder, lsikos@gmail.com

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TIPPING THE BALANCE:
THE MODULATION OF ERP EFFECTS AT THE
SYNTAX-SEMANTICS INTERFACE

by

LES SIKOS

B.A., University of Florida, 1989
M.A., California Institute of Integral Studies, 2000
M.A., University of Colorado, 2008

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written by Les Sikos
has been approved for the Department of Linguistics
and the Institute of Cognitive Science

________________________________________
Dr. Laura Michaelis-Cummings

_____________________________________
Dr. Albert Kim

Date________________________

The final copy of this thesis has been examined by the signatories,
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Tipping the Balance: The Modulation of ERP Effects at the Syntax-Semantics Interface
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Abstract

This thesis uses event-related brain potential (ERP) methods to explore the hypothesis that syntactic and semantic cues are processed via parallel and fully-interactive processing streams. This hypothesis offers an alternative to a longstanding and influential view that language comprehension is accomplished by independent, stage-based mechanisms wherein syntactic analysis precedes and guides semantic interpretation (e.g., Frazier, 1978, 1989). I describe results from four ERP experiments that each pit syntactic cues against semantic cues. Experiments 1 and 2 manipulated the relative "strength" of those cues and found that the conflict's outcome is determined by cue strength: when semantic cues are stronger, well-formed syntactic cues are perceived as anomalous, eliciting P600 effects; when syntactic cues are stronger, the anomaly is perceived as being semantic in nature, resulting in enhanced N400; when cues are evenly matched, anomalies elicit a left-anterior negativity (LAN). Experiments 3 and 4 manipulated contextual information and found that sentences with local semantic anomalies elicited N400 effects when preceded by a "no-mention" context, but the same anomalies elicited P600 effects when preceded by a "previous-mention" context. This suggests that discourse activates structured event-representations within semantic knowledge that can similarly "tip the balance" between syntactic and semantic processing streams, thereby influencing the outcome of the conflict.

Taken together, these findings suggest that syntactic and semantic information are processed in parallel streams that are fully-interactive, wherein the strength of cues
influences the conflict’s outcome and determines which level is most affected by the conflict. Under normal conditions, streams converge on a single representation. However, during conflict streams can vie for interpretive dominance — sometimes tipping in favor of semantic reanalysis (N400), sometimes toward structural reprocessing (P600), and occasionally caught between the two (LAN). These findings provide insights into issues in linguistic theory and psycholinguistic models of language processing, and advance our understanding of how people make sense of conflicting information during language comprehension.
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Chapter 1 · Introduction

Human language comprehension is rapid and outwardly seamless. A core feature of the comprehension system is its ability to quickly incorporate incoming information at a variety of linguistic levels (phonological, syntactic, semantic, contextual, etc.) and form a coherent mental representation of the intended meaning. Under most normal circumstances these linguistic cues support each other and converge on a single representation. Quite frequently, however, the language we hear and read contains novel concepts, ambiguity, unfamiliar words, production errors, and disfluencies, all of which may put linguistic cues at odds with one another. How the comprehension system identifies and resolves local conflicts “on-line” has been a productive yet controversial topic in psycholinguistic research.

Event-related brain potentials (ERPs) are particularly useful for exploring this question because they provide a high-temporal-resolution, multi-dimensional index of brain activity elicited by cognitive operations. More specifically, ERP studies of sentence processing have found a strong correlation between brain responses and different levels of language processing. Semantically anomalous or improbable words embedded within a sentence modulate the N400 component, a negative voltage deflection from baseline that peaks around 400 ms after onset of the anomalous word (Kutas & Hillyard, 1980). The amplitude of the N400 has been robustly correlated with the difficulty of retrieving conceptual knowledge associated with a word (or other meaningful stimuli) and/or integrating the current word into the preceding context (Brown & Hagoort, 1993; Kutas & Federmeier, 2000). In contrast, syntactic anomalies elicit a P600 component, a positive-going shift that begins around 600 ms after onset (e.g., Hagoort, Brown & Groothusen,
1993; Osterhout & Holcomb, 1992). P600 effects are generally thought to reflect structural processing difficulty of some kind, although models vary in their characterization of that difficulty. For example, it has been described as an index of difficulty in assigning the preferred structure to the input (Hagoort et al., 1993), a late, non-automatic process of syntactic re-analysis or repair (Friederici, Hahne & Mecklinger, 1996), syntactic integration difficulty (Kaan, Harris, Gibson & Holcomb, 2000), or simply reflecting general linguistic parsing difficulties (Münte, Heinze, Matzke, Wieringa & Johannes, 1998).

A number of recent ERP studies suggest that linguistic cues are processed by separable, parallel streams, which can vie for interpretative dominance, with different cues “winning” under different circumstances. Among these are findings that some semantically anomalous predications (combinations of a noun and verb) elicit P600 rather than classic N400 effects (Hoeks, Stowe & Doedens, 2004; Kim & Osterhout, 2005; Kim & Sikos, 2011; Kolk, Chwilla, Van Herten & Oor, 2003; Kuperberg, Sitnikova, Caplan & Holcomb, 2003; Nieuwland & Van Berkum, 2005). For instance, sentences like “The hearty meal was devouring...” elicit P600 effects at the verb, relative to well-formed controls (Kim & Osterhout, 2005), even though the syntactic cues are well-formed. Although the syntactic cues unambiguously signal a semantically anomalous interpretation (meal as the Agent of the devouring event), no N400 enhancement occurs. Consequently, these findings have been dubbed the “semantic P600” effect (Van Herten, Kolk & Chwilla, 2005). Kim & Osterhout (2005) interpret these P600 effects in terms of a powerful “semantic attraction” between meal and the Theme role of devour because meals are highly plausible things to devour. This strong attraction to a semantically-driven interpretation opposes and overwhelms the given syntactic cues, thereby causing the well-formed syntax to appear ill-
formed (*devouring* should be *devoured*). In other words, semantics “wins” a competition between processing streams, and the P600 effects are consistent with structural reprocessing in response to the perception of syntactic anomaly. In support of this hypothesis, a follow-up study found that syntactically similar sentences that lacked semantic attraction (e.g., “The sealed envelopes were *devouring* …”; *envelopes* is not a plausible Agent or Theme for *devour*) elicited classic N400 enhancement rather than P600 effects (Kim & Osterhout, 2005; but see Kuperberg, Kreher, Sitnikova, Caplan & Holcomb, 2007). Thus, in the absence of semantic attraction to a particular interpretation, the syntactic processing stream wins and interpreters appear to pursue the syntactically valid but semantically implausible analysis.

Several alternative explanations have also been proposed for these so-called semantic P600 effects (see Kuperberg, 2007 and Bornkessel-Schlesewsky & Schlesewsky, 2008 for reviews). Most of these accounts propose a language comprehension model that contains some form of parallel processing architecture, wherein syntactic and semantic analyses occur in partially independent systems that interact in a potentially adversarial relationship. These proposals depart from a longstanding and influential view within psycholinguistic theory that syntactic analysis precedes and guides semantic interpretation (Frazier, 1987), raising fundamental questions about the architecture of the language comprehension system.

### 1.1 · Outstanding Questions

The eliciting conditions for semantic P600 effects are not well understood and seemingly contradictory results have been reported in the literature. Some researchers
suggest that there is no single trigger for semantic P600s, but rather that a number of interacting factors contribute to producing the effect, including lexico-semantic association, animacy violation, thematic structure violation, semantic-thematic fit (semantic attraction), and context (Kuperberg, 2007; see also Kim & Sikos, 2011). Furthermore, many questions remain about the nature of interactions between the system(s) serving language processing and their functional relationship to the N400 and P600 components of the ERP. Consequently, further research focusing on the online comprehension of semantically anomalous predications may help shed light on a number of outstanding questions and inform us about the interaction between syntactic and semantic information at the syntax-semantics interface.

Q1: What is the fundamental architecture of the language comprehension system?

Psycholinguistic research on language comprehension has long focused on the construction of syntactic representations (Altmann & Steedman, 1988; Ferreira & Clifton, 1986; Osterhout, Holcomb & Swinney, 1994; Rayner, Carlson & Frazier, 1983; Tanenhaus, Spivey-Knowlton, Eberhard & Sedivy, 1995; Trueswell, Tanenhaus & Garnsey, 2002) which imply that an accurate interpretation of an utterance is dependent on an initial syntactic parse. However, recent research has challenged this “syntax first” view by focusing on the ability of semantic processing to independently pursue analyses that challenge syntactic cues (Hoeks et al., 2004; Kim & Osterhout, 2005; Kuperberg et al., 2003; Kolk et al., 2003). A key question that this research tries to address is whether the architecture of language processing system can best be characterized as stage-based or parallel?
Q2: How are cues weighted?

If the language comprehension system has a parallel, streams-based architecture, then a series of complementary questions become relevant: What is the nature of each stream and what are the interactions between them? Is the parallel processing system syntactocentric, semanto-centric, or non-centric? What is the role of syntactic cues in allowing challenges from other cue systems? Can "semantic attraction" be overcome by the strengthening of syntactic cues?

Q3: How do world-knowledge and discourse context modulate lexico-semantic information?

A large body of psycholinguistic studies show that the brain rapidly and incrementally integrates incoming words into a wider contextual representation, shaping the interpretations assigned to those words (Altmann & Kamide, 1999; Hess, Foss & Carroll, 1995; Marslen-Wilson, 1975; Marslen-Wilson & Tyler, 1980; Sedivy, Tanenhaus, Chambers & Carlson, 1999; Van Petten, Coulson, Rubin, Plante & Parks, 1999). However, it is not clear how general world knowledge and/or discourse context serves to influence the interpretation of information at the syntax-semantics interface in real time. Specifically, can the interpretation of anomalous predications be redeemed by manipulating contextual information?

1.2 · Goals of Dissertation Research

The overarching goal of the proposed dissertation research is to extend and clarify our understanding of the brain’s response to conflict between syntactic and semantic cues during sentence processing. The research project proposed here will address each of the
questions raised above in a series of neurophysiological experiments of on-line sentence processing utilizing event-related potential (ERP) methods.

The remainder of this thesis is organized as follows. Chapter 2 provides 1) a brief overview of psycholinguistic models of language comprehension, 2) an overview of ERP methods and language-related ERP effects, and 3) an outline of relevant findings from previous research. Chapter 3 describes two ERP experiments that pit syntactic cues against semantic cues. An anomaly paradigm is employed, a standard technique for studying sentence comprehension in language-related ERP research. This methodology exposes participants to sentences that contain an anomaly which can be interpreted as either syntactic or semantic. We then measure brain responses to those conflicts, revealing processing commitments participants make when identifying and attempting to resolve the conflict. This technique allows us to manipulate the relative "strength" of syntactic and semantic cues while participants remain largely unaware of the manipulations. Chapter 4 describes two ERP experiments that also pit syntactic cues against semantic cues in an anomaly paradigm. However, here we hold constant the syntactic cues within critical sentences while embedding them in discourse contexts that manipulate the expectation for certain thematic role assignments within an overall event-representation. This method allows us to investigate the role of contextual information on participants’ processing commitments during instances of syntax-semantics conflict. Finally, Chapter 5 synthesizes the results of these experiments and presents conclusions.
Chapter 2 · Theoretical Background

2.1 · On-Line Language Comprehension

The investigation of real-time language processing has been a fundamental and controversy-fraught challenge in psycholinguistic research for decades. Most current psycholinguistic models of language comprehension assume three core levels of processing within the linguistic system: form (phonology/orthography), grammar (syntax), and conceptual meaning (semantics) (Jackendoff, 2003). As the linguistic input unfolds, information at each of these levels must be rapidly retrieved from long-term memory (the mental lexicon) and combined into larger and more complex mental representations of the utterance.

Stage-based models. One longstanding and influential view within psycholinguistic theory emphasizes the independence of syntactic and semantic processing. For example, Frazier and colleagues argue that syntactic analysis is served by a fast, modular system, which precedes and guides semantic interpretation (Frazier, 1987; 1989). Many of these proposals incorporate Fodor’s (1983) modularity hypothesis to explain the speed at which language processing occurs. The notion of modularity assumes that cognition is compartmentalized into separate processors that are each dedicated to specific, narrowly defined inputs or tasks; modules are thought to be informationally encapsulated such that they are largely insensitive to the overall goals of other modules or the system as a whole. Such specialization, it is proposed, results in rapid, automatic processing because each module only processes a restricted portion of the input.
On this account, incoming information is processed in a cascading, stage-based fashion. First, a single rudimentary syntactic representation is computed via “parsing” mechanisms — the application of abstract, algorithmic rules which operate at the level of word categories (e.g., nouns, verbs) and phrase structures. Lexically-specific knowledge (e.g., lexical semantics, lexical frequency, verb-argument structure) or contextual information (e.g., world knowledge, discourse context) is not consulted at this stage. Therefore, if multiple phrase structure analyses are consistent with the input, a single analysis is selected using only a small set of syntactic processing principles. For instance, the Minimal Attachment principle selects the “simplest” structural representation (i.e., fewest phrasal nodes in a partial parse tree).

This single syntactic parse is then passed on to the semantic processing module, which retrieves lexically-specific semantic representations and contextual information from long-term memory. If lexical information conflicts with the initial syntactic analysis, the syntactic parse is revised.

The core ideas of the stage-based model — that the early stages of syntactic processing precede and are immune to semantic moderation — have been one of the most dominant ideas in psycholinguistic theory. Consequently, this family of proposals has been labeled the “syntax first” model of language comprehension.

*Constraint-based lexicalist models.* Another highly influential, but somewhat less dominant, view challenges the syntax-first account by emphasizing the role of lexical knowledge (e.g., Trueswell & Tanenhaus, 1994; MacDonald, Pearlmutter & Seidenberg 1994). These constraint-based lexicalist (CBL) models propose a language comprehension architecture that contains parallel, interactive streams of processing.
On this account, syntactic processing involves probabilistic constraint satisfaction (cf. McClelland, 1987) in which parsing decisions can be influenced by detailed semantic knowledge. These proposals incorporate a connectionist perspective of information processing, in which the processing at one level of representation can be influenced by the processing at another. As words are encountered, they are recognized and resolved into specific word senses and their corresponding structural representation. This is accomplished via the activation of rich lexico-syntactic information that is driven by a combination of language-wide frequency effects as well as local contextual information. Consequently, selection of the appropriate structural representation for each word in a sentence accomplishes much of the information-processing task performed by a syntactic parser in stage-based models.

Although CBL models assume that there is no syntax-first stage (semantic constraints are available immediately to constrain syntactic decisions) they nevertheless contain an implicit syntacto-centric assumption. These models predict that during instances of conflict between syntactic and semantic cues, unambiguous syntactic cues should control interpretation. In other words, it is only when multiple syntactic analyses exist (e.g., due to ambiguity) that semantic information plays a key role in determining the syntactic parse.

*Fully-interactive, parallel processing.* A number of more recent proposals have extended constraint-based proposals to parallel architectures in which syntactic and semantic analysis occur in partially-independent but fully-interactive processing streams, which can interact in a potentially adversarial relationship (e.g., Kim & Osterhout, 2005; Kuperberg, 2007; Kolk & Chwilla, 2007; Bornkessel & Schlesewsky, 2006; Ferreira, 2003).
One key source of data driving these proposals is the growing set of semantic P600 findings discussed above. Before looking at some of these findings in more detail, let’s first review the essentials of ERP methodology in sentence processing.

**2.2 · ERP Methodology**

Event-related potentials are particularly useful for exploring interactions at the syntax- semantics interface because they provide a non-invasive index of brain activity elicited by cognitive operations (Luck, 2005; Osterhout, McLaughlin & Bersick, 1997; Rugg & Coles, 1996). ERPs are obtained by recording post-synaptic electrical activity at multiple electrodes on the scalp via electroencephalography (EEG). The raw EEG reflects thousands of simultaneous brain processes. Thus, the brain response to a single stimulus or event of interest is rarely visible in the EEG. However, by time-locking the brain’s activity to the onset of a particular stimulus (e.g., an anomalous word embedded in a sentence), we can then average together the brain’s response to a large number of stimuli of a particular type, thereby filtering out unrelated brain activity. The result is a highly replicable ERP waveform, a patterned series of voltage deflections that reflect the flow of information through the brain. Peaks and troughs in the ERP waveform are called “components,” and are thought to reflect the brain activation associated with one or more mental operations. In contrast to behavioral measures such as reaction times and error rates, ERPs are multi-dimensional. Components vary in polarity (negative or positive potentials), amplitude, latency, and scalp distribution. Consequently, ERPs can be used to distinguish and identify psychological processes involved in complex cognitive, motor, or perceptual tasks. Furthermore, unlike many other neuroimaging methods (e.g., fMRI), ERPs have a
millisecond level temporal resolution, which is ideal for capturing the speed at which language comprehension occurs.

ERP studies of sentence processing usually present subjects with a large number of stimuli of various conditions, either visually or auditorily. For example:

1a. The cats won’t eat their food.  Control
1b. The cats won’t bake their food.  Semantic Anomaly
1c. The cats won’t eating their food.  Syntactic Anomaly

Notice that the example stimuli are identical up to the critical word (underlined), where the ERP is measured. Therefore, the remaining portion of the sentence word does not impact the brain activity at the critical word. ERP studies of sentence processing have found a strong correlation between brain responses and different levels of language processing. For example, all words elicit an N400 component during comprehension, a negative deflection from baseline that peaks around 400 ms after onset of the word (Kutas & Hillyard, 1980). However, semantically improbable or anomalous words embedded within a sentence significantly enhance the amplitude of the N400, referred to as an “N400 effect” (Kutas & Hillyard, 1980; Figure 2.1A). In contrast, dispreferred syntactic structures and outright syntactic anomalies elicit a P600 component, a positive-going shift that begins around 600 ms after onset of the word (Hagoort et al., 1993; Osterhout & Holcomb, 1992) (Figure 2.1B).
2.3 · Language-Related ERPs

*N400*. The N400 component is a broad, negative deflection from baseline that is typically peaks at approximately 400 ms and is largest over centro-parietal electrodes (Kutas et al., 2006). N400s are elicited by most meaningful stimuli, including isolated words (Bentin, McCarthy & Wood, 1985; Rugg, 1985), pseudowords (Bentin, et al., 1985, Rugg & Nagy, 1987), pictures (Barrett & Rugg, 1990; Holcomb & McPherson, 1994; Ganis, Kutas & Sereno, 1996), and faces (Barrett, Rugg & Perett, 1988; Barrett & Rugg, 1989). Although the N400 effect (an increase in amplitude elicited by one condition relative to another) is most commonly associated with semantic anomaly, the functional significance
of the N400 remains a debated issue. Two proposals form the core of the debate. On the one hand, some researchers suggest that the N400 effect is correlated with the difficulty of retrieving conceptual knowledge associated with a stimulus from semantic memory (Kutas & Federmeier, 2000; Federmeier and Laszlo, 2009). This lexical-access account proposes that the N400 indexes the activation of semantic features associated with a word (or other meaningful stimulus) from long-term mental representations (Kutas & Federmeier, 2000; Federmeier, 2007). Many findings are consistent with this hypothesis: repeated words result in reduced N400s upon second presentation (Rugg, 1985; Smith & Halgren, 1987; Rugg, 1990), low-frequency words reliably elicit larger N400s than high-frequency words (Van Petten & Kutas, 1990; Allen, Badecker & Osterhout, 2003), and pseudowords result in larger N400s than words (Holcomb & Neville, 1990; Holcomb, 1993; Bentin, Mouchetant-Rostaing, Glard, Ecallier & Pernier, 1999).\(^1\) In short, anything that facilitates lexical access should also reduce N400 amplitude.

On the other hand, many findings suggest that the N400 reflects processing costs associated with integrating semantic information into a preceding context (Brown & Hagoort, 1993; Hagoort, 2003). Contexts that semantically “support” a target word, from word pairs in a priming paradigm (e.g., “coffee – ___” vs. “chair – tea”) to sentential contexts (e.g., “I like my coffee with cream and socks/sugar.”), reliably lead to smaller N400 amplitudes (Kutas & Hillyard, 1980; Rugg, 1985). Moreover, N400 amplitude is sensitive to more than just the degree of anomaly or frequency. Both prediction and semantic

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\(^1\) One explanation for this effect is that pseudowords result in an “endless search.” Although they are word-like, they are not real words, and therefore have no associated semantic representation.

\(^2\) Until recently, the P600 effect was sometimes labeled the syntactic positive shift (SPS). The field now appears to have converged on the more general term, P600.

\(^3\) The unusually low accuracy for Control stimuli was surprising. However, exit interviews suggested that
relatedness also appear to play key roles. In the sentence frame “I like my coffee with cream and ...”, honey would elicit a larger N400 than sugar even though both are equally plausible and frequent. Furthermore, socks would elicit a larger N400 than salt, because salt is semantically related to the highly predicted sugar (Kutas & Hillyard, 1984; Federmeier & Kutas, 1999). These findings suggest that the N400 reflects combinatorial semantic processes that occur after lexical access is already accomplished (Sereno, Rayner & Posner, 1998; Hauk, Davis, Ford, Pulvermuller & Marslen-Wilson, 2006).

Although the functional significance of the N400 effect remains a debated issue, with some evidence supporting the lexical-access view and other findings supporting semantic integration, there is a clear consensus that the N400 is sensitive to semantic difficulty during semantic processing.

P600. The P600 is a late, long-lasting, positive deflection of the ERP that can vary substantially in its presentation. Although it typically peaks between 500-800 ms and has a centro-parietal focus, it can sometimes onset as early as 200 ms, often has no clear peak, and can have a more anterior focus (Kutas, Van Petten & Kluender, 2006). The functional significance of the P600 effect\(^2\) is also a debated issue. It has been elicited by a wide variety of syntactic violation types, including subject-verb agreement (e.g., “The spoiled child \textit{throw} the toys on the floor”; Hagoort et al., 1993), verb subcategorization (Osterhout, 1997; Osterhout et al., 1994), phrase structure (Friederici et al., 1996; Neville, Nicol, Barss, Forster & Garrett, 1991), and higher-level syntactic constraints like word order (“The expensive \textit{very} tulip”; Hagoort et al., 1993). Beyond outright syntactic anomaly, the P600 is

\(^2\) Until recently, the P600 effect was sometimes labeled the syntactic positive shift (SPS). The field now appears to have converged on the more general term, P600.
also elicited by syntactically ambiguous structures, including well-formed sentences containing dispreferred structures (e.g., garden path sentences; “The broker persuaded to sell the stock was sent to jail”; Osterhout & Holcomb, 1992; Osterhout et al., 1994; Van Berkum, Brown & Hagoort, 1999). The P600 also appears to be modulated by syntactic complexity (e.g., long distance dependencies) (Kaan et al., 2000). Functional accounts for P600 include an index of difficulty in assigning the predicted structure to the input (Hagoort et al., 1993), a result of general linguistic parsing difficulties (Münte et al., 1998), a late, non-automatic process of syntactic re-analysis or repair (Friederici et al., 1996; Friederici, 2002), the result of syntactic integration difficulty (Kaan et al., 2000), and as a reflection of competition between alternative syntactic unification options (Hagoort, 2003).

P600 effects do not seem to be modulated by lexical frequency (Allen et al., 2003).

As with the N400, although the functional significance of the P600 effect remains controversial, there is nonetheless a strong consensus that the P600 is related to the processing of structural/syntactic information.

2.4 · “Semantic P600s”

Until recently, N400 and P600 effects have been taken as evidence that the brain “respects” the theoretical distinction between semantics and syntax (Kuperberg, 2007; Hagoort, 2003). In other words, N400 was seen as an index of semantic processing and P600 was related to syntactic processing. However, in an apparent deviation from earlier findings, recent studies report that some semantically anomalous predications elicit P600 rather than classic N400 effects (Hoeks et al., 2004; Kim & Osterhout, 2005; Kolk et al., 2003; Kuperberg et al., 2003; Nieuwland & Van Berkum, 2005). These findings have called
into question the clean mapping of ERP effects to semantic and syntactic processes, and will therefore be particularly relevant to Experiments 1 and 2 (Chapter 3).

For instance, in a study that artificially put syntactic cues at odds with semantic cues, sentences like (2b) elicited P600 effects at the verb in relation to control sentences (2a) even though the syntactic cues are well-formed (Kim & Osterhout, 2005):

- 2a. The hearty meal was devoured ...
- 2b. The hearty meal was devouring ...
- 2c. The sealed envelopes were devouring ...

Control
Semantic Attraction
No Attraction

What is interesting here is that despite unambiguous syntactic information that signals a semantically anomalous interpretation (i.e., meal as Agent of the devouring event), no N400 enhancement occurs. Instead, processing appears to be dominated by a strong “semantic attraction” between meal and the Theme role of devour because meals are highly plausible things to devour. Kim and Osterhout (2005) argue that this semantic attraction opposes and overshadows the syntactic cues, thereby causing the well-formed syntactic cues to appear ill-formed (devouring should be devoured). In other words, the semantically-driven interpretation “wins” out over the syntactically-licensed interpretation. However, sentences like (2c) elicited classic N400 effects rather than an enhanced P600, despite having similar syntax. Kim & Osterhout (2005) suggest that this is due to the fact that these sentences lacked semantic attraction — envelopes is not a plausible Agent or Theme for devour (but see Kuperberg et al., 2007). Thus, in the absence of semantic attraction to a particular interpretation, the syntactic interpretation wins and comprehenders appear to pursue the syntactically signaled but semantically implausible analysis. These findings suggest that the P600 effect is triggered by structural reprocessing in response to the perception of a syntactic anomaly. Kim and Osterhout (2005) interpret these results in
terms of partially independent semantic and syntactic “streams” of combinatory processing, which can pursue conflicting analyses during sentence processing.

A growing number of ERP studies have found similar results, wherein the P600 component of the ERP waveform (which is thought to be correlated with grammatical anomaly) is elicited by sentences in which semantic cues signal interpretations that conflict with unambiguous syntactic cues (e.g., Kolk et al., 2003; Kuperberg et al., 2003). Thus, these findings have been loosely labeled “semantic P600” effects. Kuperberg et al. (2003, 2007) found semantic P600s for anomalous verbs in sentences like, “Every morning at breakfast the eggs would eat ...”. Two Dutch research groups also found similar semantic P600 effects at anomalous verbs. Kolk et al. (2003) presented participants with sentences like, “De vos die op de stropers joeg...” / “The fox that hunted the poachers...”, and Hoeks et al. (2004) elicited semantic P600s in Dutch stimuli like, “De speer heeft de atleten geworpen.” / “The javelin has thrown the athletes.”

In summary, all of these studies utilize stimuli wherein the semantically anomalous predications are made up of content words that, in and of themselves, can be combined to form “plausible scripts” (Kos, Vosse, Van den Brink & Hagoort, 2010). Thus, this paradigm differs from typical N400 eliciting conditions, in which the semantically anomalous words are implausible (e.g., “I like my coffee with cream and socks.”; Kutas & Hillyard, 1980). Instead, these semantic P600 stimuli pit plausible semantic cues against well-formed syntactic structures that signal an implausible Agent of the verb. The fact that this paradigm results in P600 effects for apparent semantic anomalies has raised fundamental questions about the nature of the language comprehension system, as well as the functional
interpretation of language-related ERP components that are thought to index to the processes involved in comprehension.

Processing accounts. All the studies outlined above interpret their results as an indication that semantic cues can sometimes drive interpretive commitments, even in the face of direct opposition from well-formed syntactic cues. In other words, they emphasize the role of non-syntactic processing mechanisms in the combinatorial analysis of sentences. Besides the semantic attraction hypothesis described above (Kim & Osterhout, 2005), several other language processing models have also been proposed: the Monitoring Theory (Kolk et al., 2003; Van Herten et al., 2005; Van Herten, Chwilla & Kolk, 2006; Van de Meerendonk et al., 2009, 2010), the continued analysis account (Kuperberg, 2007; Kuperberg et al., 2007), the processing competition account (Hagoort et al., 2009), and the extended Argument Dependency Model (eADM; Bornkessel & Schlesewsky, 2006; Bornkessel-Schlesewsky & Schlesewsky, 2008, 2009). All these models assume that language comprehension is served by two or more processing streams, and that conflict between these streams results in P600 effects. However, the accounts differ widely concerning the kinds of information processed by each stream, the inherent dominance of one or more streams over others, and the degree to which context plays a role. Furthermore, although some kind of interaction between processing streams is assumed in all the models, the nature of their interaction is often left unexplained.

Of these competing accounts, the eADM maintains the closest ties with the long-standing and influential syntacto-centric models discussed above, as it is the only model that contains an explicit syntax-first component. In this cascading, stage-based account, Bornkessel and colleagues propose that an initial syntactic processing stage identifies basic
word categories (e.g., noun, verb) and constituents, and then quickly feeds that information forward into one of two processing routes: 1) a “compute prominence” mechanism for noun phrases, and 2) a “compute linking” mechanism for verbs. Once a verb is encountered, previously encountered noun phrases are assigned thematic roles based on a restricted set of language-specific features (e.g., linear order, case marking, animacy, definiteness). A critical assumption in this model is that the linking mechanism operates independently of lexico-semantic associations and/or world knowledge. Instead, a parallel and largely independent “plausibility processing” step selects the most plausible verb-argument combination from those generated by the prominence/linking stage. The relationship between streams is thought to be asymmetrical, such that prominence/linking can block the plausibility step. However, plausibility processing cannot influence prominence/linking processing. Finally, these processes are integrated within a “generalized mapping” stage, where integration difficulty generates P600 effects. In the case of examples like, “The hearty meal was devouring …”, the resulting P600 may reflect conflict encountered at the generalized mapping stage between the plausibility of meal as the Theme of devouring and the output of the compute prominence/linking step, where strong linear order constraints in English drive an Agent assignment.

The Monitoring Theory also assumes that plausibility is processed in a parallel but separate stream from algorithmic syntactic analysis. Kolk and colleagues propose that a plausibility heuristic pursues the most plausible thematic relationship between content words. If this heuristic conflicts with the syntactic analysis, a general cognitive monitoring process is triggered. P600 effects are therefore thought to reflect the system’s attempt to resolve the conflict by checking the memory trace of the input for possible processing
errors (i.e., “Did I read that correctly?”, Kolk et al., 2003, p. 31). Although this model is not explicitly syntax-first, it still maintains a syntacto-centric stance as the syntactic stream is considered to be a full-fledged analysis, while conflicting semantic information is processed via a heuristic.

Kuperberg and colleagues continued analysis account assumes that language comprehension is served by at least two interactive but dissociable processing streams: 1) a semantic memory-based system that compares lexical associations and categorical relationships between content words with long-term semantic memory, and 2) one or more combinatorial streams that are sensitive to morphosyntactic information as well as semantic and thematic constraints. Conflict between the output of these streams results in a continued combinatorial analysis, reflected in P600. This implies that there is no single trigger for semantic P600s. Rather, a number of interacting factors contribute to producing the effect, including lexico-semantic association, animacy violation, thematic structure violation, semantic-thematic fit (semantic attraction), and relevant contextual information.

The processing competition account of Hagoort and colleagues (Hagoort, 2003, 2005; Hagoort et al., 2009) overlaps considerably with the semantic attraction hypothesis (Kim & Osterhout, 2005). In this account, the language processing system is fully interactive and parallel, such that both syntactic and semantic constraints are taken into consideration simultaneously. Therefore, information from one stream can influence the processing at other levels. A critical prediction of this model is that during times of conflict between streams, the processing level with the strongest cues imposes an extra processing load at the level with the weaker cues. Hagoort et al. (2009) describes the competition between semantic and syntactic streams as a “loser takes all” principle: “[I]f the semantic cues are
stronger than the syntactic cues, the effect will appear at the level of syntactic unification (P600)” (p. 14). Importantly, both the processing competition account and the semantic attraction hypothesis maintain the classic distinction between the N400 and P600, as indices of semantic processing and structural processing, respectively.

2.5 · Importance of Context and Prediction

Contextual information is crucial for understanding language. The meaning of red in *red fire truck, red hair, or red sunset* depends on the words it is combined with. Beyond interpreting the meaning of individual words within a local context, general world knowledge is also brought to bear in language comprehension, often providing a foundation for logical inferences that are not explicitly stated in the linguistic input. Consider the following, for example:

3. The astronomy student observed the night sky through a telescope.  
   She was looking at a particularly radiant planet.

By juxtaposing these two sentences in a discourse context, we can infer that the pronoun *she* is co-referenced with *student* and that the *telescope* is the Instrument of both *observed* as well as *looking*. In short, linguistic input is often quite underspecified and contextual information frequently helps to fill in the gaps — often without the listener even noticing the lack of explicit information.

The influence of discourse context on semantic and syntactic processing has been demonstrated in a large body of psycholinguistic studies showing that the brain rapidly and incrementally integrates incoming words into a wider contextual representation, shaping the interpretations assigned to those words (Altmann & Kamide, 1999; Hess et al., 1995; Marslen-Wilson, 1975; Marslen-Wilson & Tyler, 1980; Sedivy et al., 1999; Van Petten et al.,
Altmann argues that linguistic knowledge can be operationalized as the ability to predict how language will subsequently unfold (e.g., conscious and/or subconscious expectations of what a particular word means or what word is likely to occur next) given the current linguistic and nonlinguistic contexts (Altmann, 1999; Altmann & Mirković, 2009). Prediction is key in utilizing contextual information to bridge the gaps in linguistic input and make the necessary inferences. Federmeier sums up the essential role of prediction and ties it to an important form of neural computation, pattern recognition: “The brain is an amazing pattern recognition device, and this is perhaps nowhere more apparent than in the domain of language comprehension” (Federmeier, 2007, p. 491).

However, in spite of the clear role of context in interpretation, its impact is often not addressed in ERP sentence-processing experiments. ERP research on language comprehension has instead largely focused on the processing of individual words or sentences in the absence of preceding context. Only recently have studies begun to illuminate the wide-ranging effects of discourse context on sentence processing (see Van Berkum, 2008 and Van Berkum, Brown, Zwitserlood, Kooijman & Hagoort, 2005 for reviews). For example, Nieuwland & Van Berkum (2006) presented participants with auditory short stories in Dutch where an inanimate noun comes alive in a cartoon-like world (“The peanut was singing about a girl he had just met...”). Classic N400 effects to the animacy violation quickly decreased as the story progressed, consistent with the hypothesis that contextual information constrains the interpretation of local linguistic cues. Furthermore, in the story-final sentence (“The peanut was in love / salted...”) a word that was locally-appropriate (salted) elicited an N400 effect with respect to the more discourse-
appropriate in love. This evidence suggests that contextual information can, at least in some cases, influence the outcome of conflicts between cues processing streams.

These potentially significant effects of discourse context will become especially relevant for Experiments 3 and 4 (Chapter 4).

2.6 · Research Overview

The overarching goal of the proposed research is to extend and clarify our understanding of the brain’s response to conflict between syntactic and semantic cues during sentence processing. More specifically, I have been working with Professor Albert Kim and the Cognitive Neuroscience of Language Laboratory to conduct four ERP experiments that attempt to tease apart the contributions of different types of information in the real-time processing of semantically anomalous predications.

Experiments 1 and 2 pit syntactic cues against semantic cues in an anomaly paradigm, a standard technique for studying sentence comprehension in language-related ERP research. This methodology exposes participants to sentences that contain an anomaly which can be interpreted as either syntactic or semantic. We then measure brain responses to those conflicts, revealing processing commitments participants make when identifying and attempting to resolve the conflict. This technique allows us to manipulate the relative “strength” of syntactic and semantic cues while participants remain largely unaware of the manipulations.

Experiments 3 and 4 also pit syntactic cues against semantic cues in an anomaly paradigm, but here critical sentences are preceded by discourse contexts that manipulate the expectation for certain thematic role assignments within the comprehender’s overall
event-representation. This method allows us to investigate the role of contextual information on participants’ processing commitments during instances of syntax-semantics conflict to test whether processing can be modulated by discourse.

To assess the outcomes of these manipulations, I will follow Kim & Osterhout (2005) and use ERP effects as “diagnostic” of processing outcomes. In other words, I will interpret P600 effects as indicating that conflicting cues ultimately resulted some form of syntactic or structural processing difficulty. Conversely, I will interpret N400 effects as an indication that the conflict triggered processing difficulty within the semantic stream.
Chapter 3 · Manipulating the “strength” of syntactic cues

This chapter reports two ERP studies examining the first issue of concern in this dissertation: whether the outcome of syntax-semantics conflicts can be influenced by modulating the “strength” of competing cues. To answer this question, Experiments 1 and 2 investigated whether putatively unambiguous syntactic cues vary in their susceptibility to challenges from opposing “semantic attraction” effects (Kim & Osterhout, 2005). We examined whether well-formed syntactic cues are more vulnerable to opposition from semantic attraction when those cues are partially consistent with a semantically attractive interpretation. As discussed above, Kim & Osterhout (2005) speculated that the ability of semantic attraction to control interpretation of sentences like (4b) was facilitated by the ease with which apparently defective syntactic cues might be “repaired.”

4a. The hearty meal was devoured ... Control
4b. The hearty meal was devouring ... Single-Edit-Repair
4c. The hearty meal would devour ... Multiple-Edit-Repair

Semantic attraction can be accommodated in (4b) with a single morphosyntactic edit (devouring → devoured), resulting in an interpretation of the anomaly as a passive predication. This semantically attractive meal = Theme analysis may be strengthened by its partial consistency with the syntactic cues (a single morphosyntactic edit away), generating a compelling challenge to the syntactically licensed analysis.

3.1 · Experiment 1

In Experiment 1, we examined whether syntactic cues can be made more resistant to challenge from semantic attraction when the partial consistency between syntactic cues and an alternate semantic interpretation is reduced. We compared brain responses to
sentences like (4b) and (4c), in which the former requires a single morphosyntactic change to become plausible (Single-Edit-Repair) while the latter requires two morphosyntactic changes (Multiple-Edit-Repair). For Single-Edit-Repair sentences, we predicted that the anomaly would elicit continued combinatory processing that would be reflected in P600 effects (replicating Kim & Osterhout, 2005). For Multiple-Edit-Repair sentences, on the other hand, we predicted that syntactic cues would resist an alternative combinatory analysis, thereby reducing the P600. We further predicted that Multiple-Edit-Repair sentences would enhance the N400, reflecting the ability of repair-resistant syntactic cues to support the syntactically licensed but implausible interpretation (meal=Agent). In other words, in the Multiple-Edit-Repair conditions, syntax may “win” the conflict with opposing semantic cues.

3.1.1 Methods

Participants. Fifty-five students from the University of Colorado at Boulder participated in the experiment for course credit. Fifteen participants were not included in the statistical analyses due to excessive electrophysiological artifacts (nine) or for behavioral response accuracy below an 85% threshold (six). The remaining 40 participants (20 females) ranged in age from 18 to 25 (mean = 19.0 years). All participants were right-handed (eight reported ambidextrous abilities) native English-speakers with normal or corrected-to-normal vision.

Stimuli. Ninety-six stimulus items were created, each in three forms, which were labeled Control, Single-Edit-Repair, and Multiple-Edit-Repair (4a–c). The full stimulus set is listed in the Appendix (Table A.1). Control (4a) and Single-Edit-Repair (4b) sentences were
identical to the Control and Semantic Attraction Violation conditions from Kim & Osterhout (2005), Experiment 1. Multiple-Edit-Repair sentences (4c) contained the same content words as Single-Edit-Repair sentences but altered the syntactic cues. In both Single-Edit-Repair and Multiple-Edit-Repair stimuli, the syntactic cues unambiguously signaled an Agent interpretation of the initial noun phrase, which was highly implausible. The noun phrase was highly attractive, however as Theme for the verb. Single-Edit-Repair stimuli could be repaired to a well-formed and plausible sentence by changing the verb's inflection (–ing to –ed). Multiple-Edit-Repair stimuli could also be repaired but required more morphosyntactic changes: adding the verb be and adding the inflection –ed to the verb.

Three counterbalanced stimulus lists were created using these materials. Each list contained 32 stimulus items from each of the three experimental conditions (4a-c). Stimuli were rotated through condition assignments such that each item occurred only once per list. Lists were then pseudo-randomly mixed with 160 filler stimuli. Of these, 16, 16, and 128 were semantically anomalous (e.g., “This old blender doesn’t beg ice cubes anymore.”), syntactically anomalous (e.g., “The angry driver will honks the horn at pedestrians.”), and well-formed and plausible (e.g., “The soup and salad were prepared by a famous chef.”), respectively. Thus, each list contained 256 sentences in total, with 62.5% well-formed and 37.5% anomalous. To control for any unintended priming effects across stimuli, an additional three lists were created by reversing the presentation order of the original lists. Participants were randomly assigned to one of these six lists. Therefore, each participant saw all 96 experimental stimulus items, but no item in more than one condition.

Procedure. Participants were tested in a single session lasting about 90 minutes, including 30 minutes of experiment preparation. Each participant was randomly assigned
to one stimulus list and seated in a comfortable chair in front of a LCD monitor in a darkened, sound-attenuated booth. The participant was instructed to read normally and to try to understand the sentences. The instructions indicated that most of the sentences would be normal sentences of English, but others may contain unexpected words or grammatical markings.

Each trial consisted of the following events: A fixation cross appeared in the center of the screen for 650 ms, after which a stimulus sentence appeared one word at a time in the center of the screen via rapid serial visual presentation (RSVP). Each word appeared for 500 ms, followed by a 100 ms blank screen. Every sentence was followed by a screen asking participants to determine whether the preceding sentence was a normal sentence of English. Participants were instructed to respond “Normal” if they felt they might conceivably hear or read that sentence produced by a native English speaker (who has not just made speaking error). Otherwise, they were instructed to respond “Not Normal.” This screen remained up until one of two buttons on a button-box (“Yes” or “No”) was pressed. Participants used their thumbs to respond, with half the participants using their right thumb to answer “Yes”. Behavioral responses were followed by a “Continue?” prompt, appearing on screen until either button was pressed. A random-length blank-screen interval of 500-1000 ms followed each trial.

Data Acquisition. Continuous EEG was recorded from 64 sintered Ag/Ag-Cl electrodes embedded in an elastic cap (Neuroscan QuikCaps) arranged according to the extended 10-20 system (Figure 3.1). Vertical eye movements and blinks were monitored with two electrodes placed above and below the left eye, and horizontal eye-movements were monitored by electrodes placed at the outer canthi of each eye. EEG was also recorded over
left and right mastoid sites. EEG was referenced on-line to a vertex electrode and later re-referenced to an average of the left and right mastoid channels. Impedances were maintained below 10 kΩ.

![Figure 3.1. 64-channel scalp-electrode array. Gray shading indicates the six channel-groups used for statistical analysis: left-anterior, left-posterior, right-anterior, right-posterior, midline-anterior, midline-posterior.](image)

EEG was amplified and digitized at a sampling frequency of 1000 Hz (Neuroscan Systems). After recording, data was down-sampled to 250Hz and filtered with a bandpass of 0.1 to 30 Hz. ERPs were averaged off-line within each experimental condition (Control, Single-Edit-Repair, Multiple-Edit-Repair) for each subject at each electrode site in epochs spanning -200 to 1000 ms relative to the onset of the target verb. After baseline correcting to a 200 ms pre-target-word interval, epochs were automatically screened for any remaining eye movements, electrode drifting, amplifier blocking or excessive muscle
artifact using a +/- 100 μV criterion; this led to rejection of 4.7% of trials overall, with no asymmetry across conditions: Control (5.2%), Single-Edit-Repair (4.8%), and Multiple-Edit-Repair (4.0%).

ERP components of interest were identified based on visual inspection of ERPs and topographic maps, as well as prior findings. Voltages were averaged for analysis within six channel-groups (Figure 3.1): left-anterior (F3, F5, F7, FT7, FC5), left posterior (CP3, CP5, P3, P5, TP7), right-anterior (F4, F6, F8, FT8, FC6), right-posterior (CP4, CP6, P4, P6, TP8), midline-anterior (FZ, FC1, FCZ, FC2, CZ), midline-posterior (CPZ, P1, PZ, P2, POZ). For each of these channel-groups, we quantified ERPs for analysis as mean voltages within windows of 300-600 ms (capturing a broad negativity) and 650-900 ms (capturing a broad positivity) after stimulus onset. We also analyzed voltages in the 50-150 ms window (N1) and 150-300 ms window (P2) to test for experimental effects on earlier components. These dependent measures were analyzed with repeated measures analyses of variance (ANOVA). ANOVAs were conducted separately at midline channel-groups (midline-posterior and midline-anterior) and lateral channel-groups (left/right anterior and left/right posterior). For the midline analysis, the factors were condition (Control, Single-Edit-Repair, Multiple-Edit-Repair) and position (anterior, posterior). For the lateral sites analysis, factors were condition, position, and hemisphere (left, right). The Greenhouse-Geisser (1959) correction for inhomogeneity of variance was applied to all ANOVAs with greater than one degree of freedom in the numerator. In such cases, the corrected p-value is reported.
3.1.2 · Results

Acceptability Judgments. Participants' judgments of target sentence acceptability agreed with the intended judgments at the following rates: Controls were judged to be normal: 94.8% (range: 86.0-100.0%), while Single-Edit-Repair and Multiple-Edit-Repair stimuli were judged to be unusual: 96.4% (range: 87.0-100.0%) and 97.0% (range: 88.0-100.0%), respectively.

ERPs. Grand-averaged ERP waveforms for target verbs in each of the three experimental conditions are displayed in Figure 3.2 for the six channel-groups used in the statistical analysis (see Appendix, Figure A.1 for grand-averaged ERPs at all 30 individual channels included in the data analysis). Figure 3.3 shows the scalp distribution of the Single-Edit-Repair condition (Figure 3.3A) and Multiple-Edit-Repair condition (Figure 3.3B) at six contiguous 100 ms time windows from 300-900 ms (voltage averaged within each time window). All waveforms showed a clear negative-positive complex in the first 300 ms following word-onset (the “N1-P2” complex), followed by a negative-going component peaking around 400 ms (N400; Figure 3.2). Single-Edit-Repair waveforms diverged from Control at about 650 ms, resulting in a large positive shift that was maximal at centro-parietal channels and continued through the end of the epoch (P600; Figures 3.2, 3.3A). Multiple-Edit-Repair waveforms did not contain this positive shift and instead diverged from Control from approximately 300 to 600 ms, resulting in a widely distributed negativity that was maximal at left anterior channels, but was also visible over centro-parietal channels (Figures 3.2, 3.3B).
**Figure 3.2.** Experiment 1: Grand-averaged ERP waveforms for target verbs in each of the three experimental conditions at six channel-groups used in data analyses. Positive voltage is plotted down. Onset of the target verbs is indicated by the vertical bar (0 ms). Waveforms are filtered (12 Hz high cutoff) for presentation purposes only.
Figure 3.3. Experiment 1: Topographic maps of voltage-differences between (A) Single-Edit-Repair and Control and between (B) Multiple-Edit-Repair and Control stimuli. Each plot shows average voltage differences at six consecutive 100 ms time windows, starting at 300 ms.

ANOVA in early latency windows (50-150; 150-300 ms) showed no significant effect of condition.

**Broad Negativity (300-600 ms).** In the 300-600 ms window, voltages in the Multiple-Edit-Repair condition were more negative than in the Control condition, reflected in a main effect of condition at all channel-groups [midline: $F(2, 78) = 3.48, p < 0.05$; lateral: $F(2, 78) = 4.35, p < 0.05$]. Pairwise comparisons showed that the Multiple-Edit-Repair condition was more negative-going than the Control [midline: $F(1, 39) = 9.78, p < 0.01$; lateral: $F(1, 39) = 11.83, p < 0.01$] but that the Single-Edit-Repair condition did not differ from Control [$F$s <
This effect was left-lateralized, reflected in an interaction between Hemisphere (left/right) and Condition at the lateral channel-groups \(F(2, 78) = 3.35, p < 0.05\). This interaction was driven by an effect of Condition at left hemisphere channels \(F(2, 78) = 6.20, p < 0.01\) but not right hemisphere channels \((F < 2)\). The effect was furthermore focused at left-anterior channels, reflected in an interaction between Position (anterior/posterior), Hemisphere, and Condition for the lateral channel-groups \(F(2, 78) = 7.23, p < 0.01\). Examining each of the lateral channel-groups individually, the Multiple-Edit-Repair condition was more negative than control at all lateral channel-groups except the right anterior [left-anterior: \(F(1, 39) = 12.05, p < 0.01\); left-posterior: \(F(1, 39) = 10.00, p < 0.01\); right-posterior \(F(1, 39) = 6.10, p < 0.05\)]. The Single-Edit-Repair condition did not differ from control at any channel-groups \((Fs < 2.5)\). Table 3.1 provides an overview of the statistical analyses.

**Table 3.1.** Experiment 1: ANOVAs of mean ERP amplitudes in the 300-600 ms time window.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Omnibus</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>2, 78</td>
<td>3.48</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Condition x Position</td>
<td>2, 78</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td>Lateral</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>2, 78</td>
<td>4.35</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Condition x Hemi</td>
<td>2, 78</td>
<td>3.35</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Condition x Position</td>
<td>2, 78</td>
<td>1.36</td>
<td></td>
</tr>
<tr>
<td>Condition x Hemi x Position</td>
<td>2, 78</td>
<td>7.23</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Left hemisphere</td>
<td></td>
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<tr>
<td>Condition</td>
<td>2, 78</td>
<td>6.20</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Condition x Position</td>
<td>2, 78</td>
<td>3.97</td>
<td>&lt;0.05</td>
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<tr>
<td>Right hemisphere</td>
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<tr>
<td>Condition</td>
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</tr>
<tr>
<td>Condition x Position</td>
<td>2, 78</td>
<td>1.20</td>
<td></td>
</tr>
</tbody>
</table>
**Pairwise Comparisons**

**Midline**
- Single-Edit vs Control: 1, 39 1.20
- Multi-Edit vs Control: 1, 39 9.78 <0.01
- Single-Edit vs Multi-Edit: 1, 39 1.90

**Lateral**
- Single-Edit vs Control: 1, 39 0.48
- Multi-Edit vs Control: 1, 39 11.83 <0.01
- Single-Edit vs Multi-Edit: 1, 39 4.06 0.05

**Left-anterior**
- Single-Edit vs Control: 1, 39 0.19
- Multi-Edit vs Control: 1, 39 12.05 <0.01
- Single-Edit vs Multi-Edit: 1, 39 10.21 <0.01

**Right-anterior**
- Single-Edit vs Control: 1, 39 0.26
- Multi-Edit vs Control: 1, 39 1.46
- Single-Edit vs Multi-Edit: 1, 39 0.22

**Left-posterior**
- Single-Edit vs Control: 1, 39 0.89
- Multi-Edit vs Control: 1, 39 10.00 <0.01
- Single-Edit vs Multi-Edit: 1, 39 3.31 0.08

**Right-posterior**
- Single-Edit vs Control: 1, 39 2.45
- Multi-Edit vs Control: 1, 39 6.10 <0.05
- Single-Edit vs Multi-Edit: 1, 39 0.99

*P600 (650-900 ms).* In the 650-900 ms window, voltages in the Single-Edit-Repair condition were more positive than in the Control and Multiple-Edit-Repair conditions, reflected in a main effect of Condition at both midline and lateral channel-groups [midline: \( F(2, 78) = 19.93, p < 0.001 \); lateral: \( F(2, 78) = 13.66, p < 0.001 \)]. Pairwise comparisons showed that the Single-Edit-Repair condition was more positive-going than both the control [midline: \( F(1, 39) = 23.96, p < 0.001 \); lateral: \( F(1, 39) = 15.30, p < 0.001 \)] and the Multiple-Edit-Repair condition [midline: \( F(1, 39) = 22.76, p < 0.001 \); lateral: \( F(1, 39) = 17.60, p < 0.001 \)]. The Multiple-Edit-Repair condition was marginally more positive than control at midline [\( F(1, 39) = 3.50, p = 0.07 \)] but not lateral sites [\( F < 1 \)]. The P600 effect was larger over posterior than anterior channels, reflected in an interaction between
position (anterior/posterior) and condition [midline: $F(2, 78) = 5.24, p < 0.01$; lateral: $F(2, 78) = 3.77, p < 0.05$].

Examining each of the channel-groups individually revealed that the Single-Edit-Repair condition was more positive than control at all channel-groups [left-anterior: $F(1, 39) = 6.00, p < 0.05$; midline-anterior: $F(1, 39) = 11.78, p < 0.01$; right-anterior: $F(1, 39) = 5.37, p < 0.05$; left-posterior: $F(1, 39) = 24.38, p < 0.001$; midline-posterior: $F(1, 39) = 30.27, p < 0.001$; right-posterior $F(1, 39) = 13.11, p < 0.001$]. The Multiple-Edit-Repair condition was marginally more positive than control at the midline-posterior channel-group only [$F(1, 39) = 3.99, p = 0.05$]. The Single-Edit-Repair condition was also more positive than the Multiple-Edit-Repair condition at all channel-groups except right-anterior [left-anterior: $F(1, 39) = 13.79, p < 0.001$; midline-anterior: $F(1, 39) = 10.76, p < 0.01$; left-posterior: $F(1, 39) = 28.43, p < 0.001$; midline-posterior: $F(1, 39) = 28.12, p < 0.001$; right-posterior $F(1, 39) = 15.70, p < 0.001$]. Table 3.2 displays a statistical overview for the P600 time window.

**Table 3.2.** Experiment 1: ANOVAs of mean ERP amplitudes in the 650-900 ms time window.

<table>
<thead>
<tr>
<th>Source</th>
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<td>19.93</td>
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</tr>
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<td>Condition</td>
<td></td>
<td>2, 78</td>
<td>5.24</td>
<td>&lt;0.01</td>
</tr>
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<td>2, 78</td>
<td>13.66</td>
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<td>Lateral</td>
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<td></td>
</tr>
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<tr>
<td><strong>Midline</strong></td>
<td>Single-Edit vs Control</td>
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<td></td>
<td>Multi-Edit vs Control</td>
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<td>Single-Edit vs Multi-Edit</td>
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<td><strong>Lateral</strong></td>
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<td></td>
<td>Multi-Edit vs Control</td>
<td>0.16</td>
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<td>Single-Edit vs Multi-Edit</td>
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<tr>
<td><strong>Left hemisphere</strong></td>
<td>Single-Edit vs Control</td>
<td>17.54</td>
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<tr>
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<td>Multi-Edit vs Control</td>
<td>0.29</td>
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<td>Single-Edit vs Multi-Edit</td>
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<td><strong>Right hemisphere</strong></td>
<td>Single-Edit vs Control</td>
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<td>Multi-Edit vs Control</td>
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<td>Multi-Edit vs Control</td>
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<td>Single-Edit vs Multi-Edit</td>
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<td>Multi-Edit vs Control</td>
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<td>Single-Edit vs Multi-Edit</td>
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<td>&lt;0.01</td>
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<tr>
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<td>Multi-Edit vs Control</td>
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<td>Single-Edit vs Multi-Edit</td>
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<td>Multi-Edit vs Control</td>
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<tr>
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<td>Single-Edit vs Multi-Edit</td>
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<td><strong>Midline-posterior</strong></td>
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<td>39</td>
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<td>Multi-Edit vs Control</td>
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<td></td>
<td>Single-Edit vs Multi-Edit</td>
<td>28.12</td>
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<td><strong>Right-posterior</strong></td>
<td>Single-Edit vs Control</td>
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<td>0.36</td>
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<tr>
<td></td>
<td>Single-Edit vs Multi-Edit</td>
<td>15.70</td>
<td>39</td>
<td>&lt;0.001</td>
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</table>

3.1.3 · Discussion

Experiment 1 investigated whether syntactic cues can be made more resistant to challenge from semantic attraction when the partial consistency between syntactic cues and an alternate semantic interpretation is reduced. We recorded ERPs elicited by two
types of sentences in which syntactic and semantic cues signaled incompatible analyses. The results show that stimuli that could be resolved with a single morphological edit (4b; *devouring* → *devoured*) were weak enough to be overcome by a more semantically attractive interpretation (i.e., *meal* as Theme of *devouring*), and therefore resulted in a robust P600 effect at the verb, replicating Kim & Osterhout (2005). This finding is consistent with the hypothesis that semantic processing can pursue interpretations that conflict with the syntactically licensed analysis of a sentence (Kim & Osterhout, 2005; see also Kuperberg et al., 2003; Kolk et al., 2003). On the other hand, semantically anomalous sentences that required more than a single morphosyntactic edit to repair (4c; *devour* → *be devoured*) did not elicit reliable P600 effects and instead elicited a broad negativity, 300-600 ms post stimulus onset, which was maximal over left anterior channels. The P600 effect observed for Single-Edit-Repair sentences is consistent with the hypothesis that semantic processing can pursue interpretations that conflict with the syntactically licensed analysis of a sentence (Kim & Osterhout, 2005; see also Kuperberg et al., 2003; Kolk et al., 2003). Furthermore, the qualitative reduction of P600 in the Multiple-Edit-Repair condition is consistent with the additional conclusion that the outcome of conflict between syntactic and semantic analyses is modulated by the susceptibility of the syntactic cues to alternative analyses.

However, we originally predicted that Multiple-Edit-Repair stimuli would elicit N400 effects, based on with the hypothesis that stronger syntactic cues would drive processing costs at the level of semantic processing, and would therefore enhance N400. One outstanding question is whether the resulting negativity in the 300-600 ms window is best categorized as a non-standard N400 effect (i.e., more anterior and temporally extended
than typical N400 effects)? Or can it better be characterized as some other ERP component (e.g., left anterior negativity (LAN))? One possibility is that Multiple-Edit-Repair stimuli may be strong enough to compete with the semantically attractive interpretation, but not sufficiently strong enough to win the competition. The conflict may therefore result in an impasse between the processing streams, wherein neither the syntactic interpretation nor semantic interpretation are strong or stable enough to overcome the other. This irreconcilable conflict may recruit working memory resources and/or selectional mechanisms, both of which have been speculatively linked to LAN effects (Kim & Sikos, 2011). We will return to this question in the General Discussion below.

An alternative explanation for the differences in brain response to Single-Edit-Repair versus Multiple-Edit-Repair conditions could potentially lie in processing differences triggered by the auxiliaries (e.g., was vs. would), which may then affect the downstream processing of the anomalous verb. In other words, it may be the case that the system entertains a different set of options immediately following was (e.g., privileging the passive interpretation) versus would (e.g., privileging an active, future tense interpretation), based on the combinatoric frequency of words in the language. In addition to potential language-wide regularities that may influence processing outcomes, experiment-specific expectations may also be built up over the course of the study. For example, it is possible that participants became primed for a passive interpretation following was (or were) because all Control trials are passive sentences containing was (or were). In contrast, would never leads to a passive in the current stimulus items. This asymmetry could lead to different processing tendencies for would/was, above and beyond language-wide
expectations. Consequently, it is possible that the modulation of P600 in Experiment 1 was due to this difference in auxiliaries. Experiment 2 was designed to address this question.

3.2 · Experiment 2

Experiment 2 was designed to replicate Experiment 1 while controlling for potential differences due to the processing of different auxiliary verbs.

3.2.1 · Methods

Participants. Thirty-eight students from the University of Colorado at Boulder participated in the experiment for course credit. Three participants were not included in the statistical analyses due to mean accuracy rates on experimental conditions below 80%, one participant was excluded due to excessive electrophysiological artifacts, and three were excluded because their behavioral data were not recorded due to experimenter error. The remaining 31 participants (7 females) ranged in age from 18 to 27 (mean = 19.3 years). All participants were right-handed (one reported ambidextrous abilities) native English-speakers with normal or corrected-to-normal vision.

Stimuli. Ninety-six stimulus items were created, each in three forms, which were labeled Control, Single-Edit-Repair, and Multiple-Edit-Repair (5a-c). The full stimulus set is listed in the Appendix (Table A2).

5a. The hearty meal would be devoured ... Control
5b. The hearty meal would be devouring ... Single-Edit-Repair
5c. The hearty meal would devour ... Multiple-Edit-Repair

Multiple-Edit-Repair stimuli were identical to those used in Experiment 1. However, Single-Edit-Repair and Control stimuli were modified by replacing the auxiliaries was and
were with *would be, could be, might be, or should be*, such that each modal auxiliary occurred in 24 stimulus items. Therefore, as in Experiment 1, Multiple-Edit-Repair sentences (5c) contained the same content words as Single-Edit-Repair sentences but altered the syntactic cues. In both Single-Edit-Repair and Multiple-Edit-Repair stimuli, the syntactic cues unambiguously signaled a highly implausible Agent interpretation of the initial noun phrase, and the noun phrase was highly attracted to the Theme role of the verb. As above, Single-Edit-Repair stimuli could be repaired to a well-formed and plausible sentence by changing the verb's inflection (*–ing to –ed*), while Multiple-Edit-Repair stimuli required more morphosyntactic changes: adding the verb *be* and adding the inflection *–ed* to the verb. In contrast to Experiment 1, however, all critical words were now preceded by a modal auxiliary (e.g., *would* or *would be*).

Each list also contained 110 filler sentences. Of these, 25 were syntactically anomalous (e.g., “The angry driver will *honks* the horn at pedestrians.”), and 25 were well-formed and plausible (e.g., “The swimmers were *diving* into the pool.”). An additional set of 60 filler stimuli were part of a separate experimental design that is reported elsewhere (Oines & Kim, in preparation). However, it is worth noting that this subset of filler stimuli contained somewhat more complex sentence structure than the current experimental items, and may have had minor effects on participants’ acceptability judgments (see Results below). Of these fillers, 20 contained a “semantic attraction” between an initial noun phrase and a subsequent target verb, which rendered the Agent of that verb semantically implausible (e.g., “The artist figured that the engineer was *painting* a portrait.”), 20 contained no attraction between either noun phrase and the verb (e.g., “The gunman remembered that the academic was *serving* dessert.”); although neither noun phrase was a highly likely Agent
of the action), and 20 were well-formed and plausible (e.g., "We saw that the fisherman was catching tons of crab."), respectively. As in Experiment 1, the experimental design was fully factorial. Experimental conditions were pseudo-randomly mixed with the filler items to create 6 counterbalanced lists. Thus, each list contained 206 sentences in total, with 47.1% well-formed and 52.9% anomalous.

The same procedure and data acquisition methods were used as in Experiment 1, except as noted below.

Procedure. The rapid serial visual presentation (RSVP) timing was subtly modified from the parameters used in Experiment 1. This was done primarily because a substantial amount of alpha activity was encountered in several participants' raw EEG in Experiment 1, resulting in grand-averaged waveforms that appear to contain some summated alpha activity (Figure 3.2). An added benefit to utilizing jitter is that it renders the stimulus presentation somewhat more natural. Each trial began with a fixation cross that appeared in the center of the screen for 750 ms, followed by a random-length blank-screen interval of 400-600 ms. The RSVP contained a variable inter-stimulus interval, such that non-target words were presented for 380 ms and followed by an inter-stimulus interval proportional to word length (20 ms/character). Critical verbs were presented for 380 ms and followed by a fixed inter-stimulus interval of 140 ms.

An unintended side effect of using a variable inter-stimulus interval, however, was that the duration of the inter-stimulus interval following pre-target words varied across conditions. Therefore, a -150 to +150 ms baseline correction interval was utilized prior to rejecting epochs characterized by eye blinks or excessive muscle artifact, in order to maximally align ERPs going into the critical verb (see Baseline Correction below). An
average of 6.0% of trials were rejected, with no asymmetry across conditions: Control (5.6%), Single-Edit-Repair (6.3%), and Multiple-Edit-Repair (6.2%).

ERP voltages were averaged for analysis within the same six channel-groups and time windows as Experiment 1. Mean voltages for each time window were then submitted to repeated measures ANOVAs, conducted separately at midline and lateral channel-groups.

3.2.2 · Results

Acceptability Judgments. Participants’ judgments of target sentence acceptability agreed with the intended judgments at the following rates: Controls were judged to be normal: 80.8 % (range: 56.0-100.0 %)\(^3\), while Single-Edit-Repair and Multiple-Edit-Repair stimuli were judged to be unusual: 96.6 % (range: 79.0-100.0 %) and 95.5 % (range: 72.0-100.0 %), respectively.

ERPs. Grand-averaged ERPs are shown in Figure 3.4 for the six channel-groups used in the statistical analysis (see Appendix, Figure A.2 for grand-averaged ERPs at all 30 individual channels included in the data analysis). Figure 3.5 shows the scalp topography of the Single-Edit-Repair vs. Control (Figure 3.5A) and Multiple-Edit-Repair vs. Control (Figure 3.5B) effects at six contiguous 100 ms time windows from 300-900 ms (voltages averaged within each window). All waveforms showed a clear negative-positive complex in the first 300 ms following word-onset (the “N1-P2” complex), followed by a negative-going component peaking around 400 ms (N400; Figure 3.4). As in Experiment 1, Single-Edit-Repair waveforms showed a large positive shift, relative to Control, which was maximal at

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\(^3\)The unusually low accuracy for Control stimuli was surprising. However, exit interviews suggested that this may have been due to the somewhat more complex subset of filler conditions, as discussed below.
centro-parietal channels. This positivity began around 650 ms and continued through the end of the epoch (P600; Figures 3.4, 3.5B). Multiple-Edit-Repair waveforms did not contain this positive shift and instead contained a widely distributed negativity at 300-600 ms, which was maximal at left anterior channels (Figures 3.4, 3.5A). Unlike Experiment 1, however, this negativity was not visible over centro-parietal channels.

Figure 3.4. Experiment 2: Grand-average ERP waveforms at six channel-groups used in data analyses. Positive voltage is plotted down. Onset of the target verbs is indicated by the vertical bar (0 ms). Waveforms are filtered (12 Hz high cutoff) for presentation purposes only.
Figure 3.5. Experiment 2: Topographic maps of voltage-differences between (A) Single-Edit-Repair and Control and between (B) Multiple-Edit-Repair and Control stimuli. Each plot shows average voltage differences at six consecutive 100 ms time windows, starting at 300 ms.

Early Latency Windows (N1, P2). In the 50-150 ms window, ANOVAs showed that voltages in the Multiple-Edit-Repair condition were more positive than in the control and Single-Edit-Repair conditions, reflected in a main effect of condition at all channel-groups [midline: $F(2, 74) = 19.47, p < 0.001$; lateral: $F(2, 74) = 24.29, p < 0.001$]. Pairwise comparisons showed that the Multiple-Edit-Repair condition was more positive-going than both Control [midline: $F(2, 74) = 25.27, p < 0.001$; lateral: $F(2, 74) = 29.40, p < 0.001$] and Single-Edit-Repair condition [midline: $F(2, 74) = 25.45, p < 0.001$; lateral: $F(2, 78) = 32.16$, $p < 0.001$.}
$p < 0.001$. The Single-Edit-Repair condition did not differ from control at any channel-groups ($F < 2$). Table 3.3 shows an overview of the statistical analyses.

**Table 3.3.** Experiment 2: ANOVAs of mean ERP amplitudes in the 50-150 ms time window.

<table>
<thead>
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<th>Source</th>
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<tbody>
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<tr>
<td>Midline</td>
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<tr>
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<td>Single-Edit vs Multi-Edit</td>
<td>1, 37</td>
<td>32.16</td>
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</table>

In the 150-300 ms window, ANOVAs suggested that voltages in the Multiple-Edit-Repair condition were more positive than in the control at posterior channel-groups. This was reflected in an interaction between condition and position (anterior/posterior) that was marginal at midline but reliable at lateral channel-groups [midline: $F(2, 74) = 2.85, p = 0.06$; lateral: $F(2, 74) = 4.68, p < 0.05$]. Pairwise comparisons revealed that this interaction was driven by interactions between the Multiple-Edit-Repair condition and Position at both midline and lateral channel-groups [midline: $F(1, 37) = 5.39, p < 0.05$; lateral: $F(1, 37) = 7.22, p < 0.05$]. Table 3.4 displays a statistical overview for the 150-300 ms time window.
Table 3.4. Experiment 2: ANOVAs of mean ERP amplitudes in the 150-300 ms time window.

<table>
<thead>
<tr>
<th>Source</th>
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<tr>
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<tr>
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<td>Single-Edit vs Control</td>
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<td>5.39</td>
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<td>Single-Edit vs Multi-Edit</td>
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<td>1.07</td>
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<tr>
<td>Single-Edit vs Multi-Edit x Position</td>
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<td>1.64</td>
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<tr>
<td>Single-Edit vs Control</td>
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<td>2.07</td>
<td></td>
</tr>
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<td>Multi-Edit vs Control</td>
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<tr>
<td>Single-Edit vs Multi-Edit x Position</td>
<td>1, 37</td>
<td>5.57</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

Broad Negativity (300-600 ms). In the 300-600 ms window, voltages in the Multiple-Edit-Repair condition were more negative than in the Control condition at anterior channel-groups, reflected in an interaction of Condition and Position that was marginal at midline but reliable at lateral channel-groups [midline: \(F(2, 74) = 2.39, p = 0.10\); lateral: \(F(2, 74) = 4.96, p < 0.01\)]. Holding Position constant revealed that this effect was focus at left-anterior channel-groups, reflected in a main effect of Condition at anterior channels \(F(2, 74) = 3.82, p < 0.05\] and a marginal interaction between Condition and Hemisphere at posterior channel-groups \(F(4, 148) = 2.07, p = 0.09\]. Pairwise comparisons at individual channel-groups showed that the interaction was driven by the Multiple-Edit-Repair
condition being more negative-going than the control at the left-anterior channel-group
\( [F(1, 37) = 10.09, p < 0.01] \), and marginally more negative at the other anterior channel-
groups [midline-anterior: \( F(1, 37) = 3.59, p = 0.07 \); right-anterior: \( F(1, 37) = 3.47, p = 0.07 \)].
The Single-Edit-Repair condition did not differ from Control \( [Fs < 1] \) at any channel-group.
Table 3.5 shows an overview of the statistical analyses.

\textit{Table 3.5.} Experiment 2: ANOVAs of mean ERP amplitudes in the 300-600 ms time window.

<table>
<thead>
<tr>
<th>Source</th>
<th>300-600 ms</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<td></td>
<td>df</td>
<td>( F )</td>
<td>( p )</td>
</tr>
<tr>
<td>Omnibus</td>
<td></td>
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<td>Condition x Position</td>
<td>2, 74</td>
<td>2.39</td>
<td>0.1</td>
</tr>
<tr>
<td>Lateral</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>2, 74</td>
<td>1.90</td>
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<tr>
<td>Condition x Hemi</td>
<td>2, 74</td>
<td>2.30</td>
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<td>Condition x Position</td>
<td>2, 74</td>
<td>4.96</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Condition x Hemi x Position</td>
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<td>1.46</td>
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</tr>
<tr>
<td>Anterior</td>
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<tr>
<td>Condition</td>
<td>1, 37</td>
<td>3.82</td>
<td>&lt;0.05</td>
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<tr>
<td>Condition x Hemi</td>
<td>1, 37</td>
<td>0.89</td>
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<td>Posterior</td>
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<td>0.09</td>
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<td>Pairwise Comparisons</td>
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</tr>
<tr>
<td>Left-anterior</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-Edit vs Control</td>
<td>1, 37</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>Multi-Edit vs Control</td>
<td>1, 37</td>
<td>10.09</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Single-Edit vs Multi-Edit</td>
<td>1, 37</td>
<td>5.57</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Midline-anterior</td>
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<tr>
<td>Single-Edit vs Control</td>
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<td>0.41</td>
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<tr>
<td>Multi-Edit vs Control</td>
<td>1, 37</td>
<td>3.59</td>
<td>0.07</td>
</tr>
<tr>
<td>Single-Edit vs Multi-Edit</td>
<td>1, 37</td>
<td>2.18</td>
<td></td>
</tr>
</tbody>
</table>
**P600 (650-900 ms).** In the 650-900 ms window, voltages in the Single-Edit-Repair condition were more positive than in the control and Multiple-Edit-Repair conditions, reflected in a main effect of Condition at both midline and lateral channel-groups [midline: $F(2, 74) = 10.16, p < 0.001$; lateral: $F(2, 74) = 4.67, p < 0.05$]. Pairwise comparisons showed that the Single-Edit-Repair condition was more positive-going than both the Control [midline: $F(1, 37) = 13.26, p < 0.001$; lateral: $F(1, 37) = 6.63, p < 0.05$] and the Multiple-Edit-Repair condition [midline: $F(1, 37) = 22.78, p < 0.001$; lateral: $F(1, 37) = 10.04, p < 0.01$]. The Multiple-Edit-Repair condition did not differ from control [$Fs < 1$]. The P600 effect was larger over posterior than anterior channels, reflected in an interaction between position and condition [midline: $F(2, 74) = 6.42, p < 0.01$; lateral: $F(2, 74) = 9.22, p < 0.001$]. Table 3.6 displays an overview of the statistical analyses for the P600 ms time window.
Table 3.6. Experiment 2: ANOVAs of mean ERP amplitudes in the 650-900 ms time window.

<table>
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<th>p</th>
</tr>
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<td>650-900 ms</td>
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<td></td>
</tr>
<tr>
<td><strong>Omnibus</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Midline</td>
<td>2, 74</td>
<td>10.16</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Condition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition x Position</td>
<td>2, 74</td>
<td>6.42</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Lateral</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>2, 74</td>
<td>4.67</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Condition x Hemi</td>
<td>2, 74</td>
<td>2.42</td>
<td>0.10</td>
</tr>
<tr>
<td>Condition x Position</td>
<td>2, 74</td>
<td>9.22</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Condition x Hemi x Position</td>
<td>2, 74</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
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</tr>
<tr>
<td>Midline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-Edit vs Control</td>
<td>1, 37</td>
<td>13.26</td>
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<tr>
<td>Multi-Edit vs Control</td>
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<td>0.43</td>
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<td>&lt;0.001</td>
</tr>
<tr>
<td>Lateral</td>
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<tr>
<td>Single-Edit vs Control</td>
<td>1, 37</td>
<td>6.63</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Multi-Edit vs Control</td>
<td>1, 37</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>Single-Edit vs Multi-Edit</td>
<td>1, 37</td>
<td>10.04</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Left-anterior</td>
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<td>Single-Edit vs Control</td>
<td>1, 37</td>
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<td></td>
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<td>1, 37</td>
<td>3.29</td>
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<td>1, 37</td>
<td>6.68</td>
<td>&lt;0.05</td>
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<tr>
<td>Single-Edit vs Multi-Edit</td>
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<td>1.15</td>
<td></td>
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<td>Left-posterior</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Single-Edit vs Control</td>
<td>1, 37</td>
<td>10.69</td>
<td>&lt;0.01</td>
</tr>
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<td>Multi-Edit vs Control</td>
<td>1, 37</td>
<td>0.59</td>
<td></td>
</tr>
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<td>Single-Edit vs Multi-Edit</td>
<td>1, 37</td>
<td>12.27</td>
<td>&lt;0.01</td>
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<td>Midline-posterior</td>
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<td></td>
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<tr>
<td>Single-Edit vs Control</td>
<td>1, 37</td>
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<td>22.82</td>
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<tr>
<td>Right-posterior</td>
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<tr>
<td>Single-Edit vs Multi-Edit</td>
<td>1, 37</td>
<td>9.69</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
3.2.3 · Discussion

Experiment 2 largely replicated the findings of Experiment 1. Stimuli that could be resolved with a single morphological edit (5b; *would be devouring* → *would be devoured*) were weak enough to be overcome by a more semantically attractive interpretation (i.e., *meal* as Theme of *devouring*), and therefore resulted in a robust P600 effect at the verb. Furthermore, as in Experiment 1, stimuli that required multiple edits (5c; *would devour* → *would be devoured*) elicited a widely-distributed negativity in the 300-600 ms window, with a strong left anterior focus. Therefore, we can rule out differences between auxiliary verbs as a critical factor in modulating the ERP effects between conditions. In contrast to Experiment 1, however, the negativity elicited by the Multiple-Edit-Repair condition in Experiment 2 did not resemble typical N400 effects with regard to latency or scalp distribution. Instead, the extended duration and left anterior focus suggest that LAN may be a better characterization of the negativities found in both Experiment 1 and 2. We will return to the potential functional significance of LAN in the General Discussion.

**Baseline Correction.** As mentioned above, introducing jitter via a variable inter-stimulus interval led to an unintended side effect: the duration of inter-stimulus intervals just prior to target words varied systematically across conditions and led to baseline correction issues. In the Multiple-Edit-Repair condition, the pre-target word was one of four modal auxiliaries, each presented for 380 ms and followed by an inter-stimulus interval of 20 ms/character (*would, could, might*: 100 ms; *should*: 120 ms). Conversely, the pre-target word in both the Single-Edit-Repair and Control conditions was *be*, which was presented for 380 ms and followed by an inter-stimulus interval of 40 ms. These timing differences are summarized in columns 1-4 of Table 3.7.
Table 3.7. Experiment 2: Timing differences due to pre-target words. Columns 1-4 show the pre-target word, duration, and inter-stimulus interval by condition (measured in ms). Columns 5-9 show the approximate onset of pre-target words and their component peak timings by condition (measured in ms with respect to onset of verb).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Pre-target Word</th>
<th>Duration</th>
<th>ISI</th>
<th>Onset</th>
<th>N1</th>
<th>P2</th>
<th>N400</th>
<th>P600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-Edit</td>
<td>Modal</td>
<td>380</td>
<td>100/120</td>
<td>-500</td>
<td>-330</td>
<td>-250</td>
<td>-10</td>
<td>250</td>
</tr>
<tr>
<td>Single-Edit</td>
<td><em>be</em></td>
<td>380</td>
<td>40</td>
<td>-420</td>
<td>-270</td>
<td>-190</td>
<td>50</td>
<td>250</td>
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<tr>
<td>Control</td>
<td><em>be</em></td>
<td>380</td>
<td>40</td>
<td>-420</td>
<td>-270</td>
<td>-190</td>
<td>50</td>
<td>250</td>
</tr>
</tbody>
</table>

In sentence processing studies, inter-stimulus intervals are often kept short (<2 sec) in order to make the stimuli more natural. Therefore, ERP responses from successive stimuli overlap. The timing differences described above led to both systematic differences in the latency of ERP components elicited by pre-target words across conditions, as well as differences in their subsequent overlap with ERPs elicited by the target words themselves. Columns 5-9 of Table 3.7 show the approximate onset of pre-target words and the resulting timing of their associated ERP components. In the Multiple-Edit-Repair condition, the onset of modals was approximately 500 ms prior to the onset of the verb. The subsequent peaks of the ERP components elicited by modals had the following approximate latencies with respect to the onset of the verb: N1 (-330 ms), P2 (-250 ms), N400 (-10 ms), and P600 (250 ms). On the other hand, in both Single-Edit-Repair and Control conditions, the onset of *be* was 420 ms prior to the onset of the verb. Thus, the peaks of the ERP components elicited by *be* had the following approximate latencies with respect to the onset of the verb: N1 (-270 ms), P2 (-190 ms), N400 (50 ms), and P600 (250 ms).

Comparing grand averaged ERPs across conditions requires the selection of an appropriate baseline or zero point. Luck (2005) recommends subtracting the average
voltage in the 200 ms prior to target words as the baseline (as we have done in Experiments 1, 3, and 4) because it is assumed that the voltage in this period is unaffected by the target stimulus. If the pre-target activity differs across conditions, as in Experiment 2, differences in measured amplitudes between conditions could potentially be due to pre-target differences rather than due to the target word itself (Luck, 2005). Therefore, to compensate for pre-target differences, we chose a baseline correction interval that: 1) was longer than the standard 200 ms in order to maximally align the ERPs going into the critical verb, 2) included both pre-target-onset and post-target-onset voltages (-150 to 150 ms), and 3) did not include late potentials elicited by the target-word (N400, P600).

The statistically significant differences between the mean ERP amplitudes for target words across conditions during the early time windows (N1 and P2) can therefore be clearly attributed to the difference in onset of pre-target words across conditions. However, these differences between conditions were resolved by 250 ms after the onset of the target word (the waveforms for all conditions converge), suggesting that the baseline correction interval was appropriate. Finally, although the choice of -150 to 150 ms baseline for Experiment 2 lead to a striking replication of Experiment 1, further studies are needed to confirm the findings. We are currently planning a follow-up experiment in which pre-target inter-stimulus intervals are held constant across all experimental conditions.
3.3 · General Discussion

3.3.1 · P600 and Syntactic Cues

The modulation of P600 found in Experiments 1 and 2 can be understood in terms of varying the strength of syntactic cues, such that those cues vary in their consistency with an alternative semantic analysis. When syntactic cues are nearly consistent with semantic attraction to a syntactically unlicensed analysis (Single-Edit-Repair), the combination of strong semantic plausibility and partial syntactic support generates an analysis that challenges the syntactically licensed analysis, reflected in P600. When syntactic cues are more distinct from a configuration that would accommodate the semantic attraction (Multiple-Edit-Repair), they can resist the alternative combinatory analysis, eliminating the P600 effect. In other words, in situations involving conflict between a semantically attractive interpretation and putatively unambiguous syntactic cues, the syntactic cues can vary in their ability to “resist” or “surrender” to challenge from semantics.

3.3.2 · Negativity (300-600 ms)

We originally predicted that Multiple-Edit-Repair anomalies would enhance N400, reflecting the ability of syntactic cues to resist an alternative combinatory analysis and support the highly implausible meal = Agent interpretation. However, the left-anterior focus of the negativity at 300-600 ms contrasts with the central-parietal distribution typical of semantic anomaly N400s. The absence of a typical N400 effect may reflect the strength of semantic attraction; even when the syntactic cues resist repair, they cannot force through the semantically unattractive meal = Agent interpretation.
We offer here a speculative interpretation of the left anterior negativity (LAN) effect elicited by the multiple-edit repair condition. It is possible that the LAN reflects participants’ pursuit of an interpretation that simultaneously satisfies the syntactic and semantic cues, with *meal* serving as Theme of *devour* and as syntactic subject. This might resemble the middle-construction, in which a verb that typically takes a direct-object Theme occurs with a subject Theme (e.g., “This book reads well”). This analysis requires a thematic grid (Carlson & Tanenhaus, 1988)\(^4\), which is not typically associated with the verb, and may engage controlled retrieval processes in order to access this grid. We do not know whether a functional relationship exists between the LAN effect here and similar ERP effects elicited by morphosyntactic violations (Osterhout & Mobley, 1995; Gunter, Friederici & Schriefers, 2000; Coulson, King & Kutas, 1998) and by syntactically complex sentences (King & Kutas, 1995; Fiebach, Schlesewsky, Friederici, 2002). However, it is conceivable that LAN reflects working memory resources recruited in all of these situations: controlled retrieval of atypical lexical senses, syntactically complex sentences, and some types of morphosyntactic anomaly. Further work is needed to test this speculation.

3.3.3 · P600 and Syntax-Semantics Interactions

We have previously proposed that language comprehension is served by partially independent but highly interactive streams of semantic and syntactic processing (Kim &

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\(^4\) Carlson & Tanenhaus (1988) propose that recognition of a verb includes the selection of a single thematic grid, which represents the number and type of thematic roles assigned by the verb. For instance a grid characterized by \{Agent, Theme\} would assign an Agent and Theme (e.g., “the boy ate the apple” or “the apple was eaten by the boy”), while \{Theme\} would assign only a Theme role (e.g., “this book reads well”).
In previous statements, we focused on cases of clear semantic attraction to an interpretation that is inconsistent with the syntactic cues, where morphosyntactic editing could render the sentence plausible (e.g., Hoeks et al., 2004; Kim & Osterhout, 2005; Kolk et al., 2003). However, several studies find that such “global” semantic attraction is not necessary for P600 to occur, as in the case of some animacy violations, where no morphosyntactic edit can render the sentence plausible (e.g., Kuperberg et al., 2007). Furthermore, the current findings indicate that semantic attraction is not always sufficient to elicit P600. Here, we briefly elaborate and extend our theoretical view and address some of the diversity in the syntax-semantics interactions leading to P600 effects.

The lexico-syntactic stream. We envision the syntactic stream as a mechanism that incrementally analyzes the words in a sentence, retrieving an informationally rich lexico-syntactic category, or “treelet”, for each word, based on the word’s identity and local context. Treelets encode much of the syntactic environment of a given word, such as the position and number of a verb’s arguments (Kim, Srinivas & Trueswell, 2002; Srinivas & Joshi, 1999; see Hagoort, 2005 for a similar perspective on lexico-syntactic contributions to language comprehension). We further propose that treelets encode the thematic role associated with each syntactic position. For instance, different treelets are required for the verbs in “The man slept” and “The soup simmered”, in which the subject noun is an Experiencer and a Theme, respectively. We do not distinguish between an initial stage of basic category level (e.g., noun, verb) and finer-grained syntactic analyses (as in, e.g.,

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5 In some models, ‘independence’ is used to mean non-interaction with other systems (e.g., Frazier, 1987). Here we take independence to imply that two or more systems compute distinct representations, and that neither is completely determined by the other. These distinct representations may be correlated and the two systems may interact constantly, with each providing constraints that guide the other.
Recognition of the appropriate treelet for each word in a sentence accomplishes much of the information-processing task performed by a more conventional syntactic parser, because treelets are highly restricted in their combinatorial possibilities (far more than basic grammatical categories; Srinivas & Joshi, 1999). The computations of the lexico-syntactic stream are modulated by local context and may be modeled by a simple recurrent neural network (SRN), in which re-entrant feedback of previous activation states allows maintenance of information over time (Elman, 1990).

*The semantic stream and semantic attraction.* The semantic stream activates structured, generalized knowledge representations about events and their participants, which are acquired through real world and linguistic experience (Hare, Jones, Thomson, Kelly & McRae, 2009; Boland, Tanenhaus, Garnsey & Carlson, 1995; Altmann, 1999). Activity within the semantic stream is constantly modulated by input from lexico-syntactic treelets. We further propose that event-representations can be activated via “direct” associations with individual words (e.g., Hare et al., 2009), with especially robust activation when multiple words within a sentence associate with the same event. For instance, a *devour-a-meal* event-representation receives multiple sources of direct activation from “The hearty meal was devouring”. This is the basis of what we have termed “semantic attraction” (Kim & Osterhout, 2005). This description of the semantic stream does not require that all event-representations activated during sentence comprehension are stored representations of previously experienced events. Event-representations of novel events like *devour-a-rutabaga* will also be accessible. We expect such event representations to have strong overlap with representations of more frequent events (e.g., interpretation by
analogy). We expect access of novel event representations to be constrained by lexico-syntactic cues. Furthermore, weaker forms of semantic attraction should exist, even for novel events; for instance, the inanimacy of *rutabaga* may generate attraction to the Theme role of a *devouring* event, given knowledge about devouring events in general.

**Syntactic fragility.** We propose that lexico-syntactic representations are generally “fragile”, such that they are prone to reprocessing, reflected in P600, when they do not integrate with some (at least moderately) plausible event-representation within the semantic stream\(^6\). Such fragility does not preclude profound lexico-syntactic influences on semantic interpretation. For instance, lexico-syntactic cues drive very different semantic interpretations of “The thief recognized the cop” and “The cop recognized the thief”. Here, *thief* and *cop* are each plausible as Agent and Theme for *recognized*, and syntactic analysis determines which interpretation emerges. However, when lexico-syntactic analyses directly conflict with semantic processing (e.g., “The meal was *devouring* …”), lexico-syntactic analyses will often undergo reprocessing, manifest in P600.\(^7\)

Several factors may modulate the degree of fragility in lexico-syntactic analysis. One factor, explored in Experiments 1 and 2, is the nature of the syntactic cues. We suggest that sentence and discourse context may be another factor, which can tax the processing resources required to maintain syntactic representations, rendering syntactic representations vulnerable to alternative analyses. We further propose that processing within the semantic stream includes pattern completion of event-representations, which

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\(^6\) Ferreira, Bailey & Ferraro (2002) have also described syntactic representations as fragile, with a related but somewhat different interpretation, in which syntactic representations decay rapidly (Sachs, 1967) without reinforcement from semantic representations.

\(^7\) We do not assume that such reprocessing always succeeds in finding an alternative syntactic analysis; only that it attempts to do so.
activates plausible but *unmentioned* thematic role assignments (e.g., Hare et al., 2009). Such pattern completion may be another source of syntax-semantics conflicts that generate P600. The notions of context-induced fragility and pattern completion processes may help resolve a potential contradiction in the literature. They are the focus of Experiments 3 and 4 (Chapter 4).

3.3.4 · Conclusions

Experiments 1 and 2 manipulated the strength of syntactic cues in sentences containing conflicts between syntactic and semantic information. The results showed that when well-formed syntactic cues are nearly consistent with a strong semantic attraction to a syntactically unlicensed analysis (Single-Edit-Repair), the syntactic cues are “fragile” — they are weak enough to be overcome by the combination of semantic plausibility and partial syntactic support. Such instances are perceived as syntactic anomalies and therefore result in P600 effects. On the other hand, when syntactic cues are “strengthened” by making them less consistent with the semantically attractive interpretation (Multiple-Edit-Repair), they can better “resist” the challenge from semantic attraction. Such instances elicited a LAN effect, suggesting that there was an impasse between syntactic and semantic representations. In sum, in situations involving conflict between a semantically attractive interpretation and putatively unambiguous syntactic cues, the syntactic cues can vary in their ability to resist challenge from semantics.

These findings are consistent with the following conclusions: 1) the architecture of language processing system is fully interactive and parallel, such that both syntactic and semantic constraints are taken into consideration simultaneously, 2) contrary to syntacto-
centric models, semantic processing can pursue interpretations that diverge from the syntactically licensed analyses of a sentence, 3) the outcome of conflict between syntactic and semantic analyses is modulated by the strength of each kind of cue, and 4) the comprehension system can occasionally reach an impasse where neither stream “wins.” Crucially, this semantic attraction account maintains the classic distinction between the N400 as an index of semantic processing and P600 as reflecting structural processing.
Chapter 4 · Manipulating the “strength” of semantic cues

Many questions still remain about the nature of interactions between the systems serving language processing and their functional relationship to the P600. One outstanding issue is the role of context (Kuperberg, 2007). The semantic attraction proposal outlined in Chapter 3 argues that global context (i.e., world knowledge) plays a crucial role in the incremental interpretation of an utterance. For example, our experience in the world with things like meals and events like devouring, influences the outcome of conflicts between syntactic and semantic information in sentences like “The meal was devouring...”). At least some semantic P600 effects seem to occur when lexico-syntactic cues collapse in the face of strong semantic associations.

However, the semantic attraction account may also be somewhat too narrow; it encounters difficulty explaining apparently similar semantic P600 effects that are elicited in the absence of strong semantic associations. For example, Kuperberg et al. (2007) found P600s at verbs in sentences like, “Every morning at breakfast the eggs would plant...” (eggs and plant are not semantically attracted), and Van Herten et al. (2006) found P600 for Dutch sentences like, “Jan zag dat de olifanten de bomen snoeiden ...” / “John saw that the elephants the trees pruned ...” (anomalies contain only partial semantic attraction: trees are often pruned, but usually not by elephants).

A primary motivation for Experiments 3 and 4 is to explain these apparently contradictory findings by extending the semantic attraction hypothesis. Perhaps potentially weaker forms of semantic association (e.g., word associations based on prior discourse context) could sufficiently bias the outcome of competition between processing streams, and result in semantic P600 effects.
4.1 · Discourse Context and Event-Representations

A potential way to extend the notion of semantic attraction beyond entrenched lexical-semantic associations between a specific verb and its arguments is to consider schema-levels of analysis. It is conceivable that the critical semantic processing event may not be the activation of a specific thematic role assignment (that then opposes a syntactically-signaled analysis), but rather the activation of a schema-level interpretation in which the lexical items within the anomalous sentence appear to “belong” together, but for which the syntactic cues do not provide a plausible interpretations.

This idea is consistent with recent psycholinguistic models that have emphasized the online activation of structured event-representations within semantic knowledge during language comprehension (McRae, Spivey-Knowlton & Tanenhaus, 1998). We hypothesize that once an event-representation becomes active, it can strongly constrain the combinatorial analysis of subsequent words in the sentence and potentially lead to conflicts with local syntactic cues (Kim & Sikos, 2011; Kim & Osterhout, 2005). Furthermore, we suggest that deeply entrenched event-representations can be richly activated by as few as one or two words via semantic pattern completion processes, while novel event representations may require more extended discourse. At one end of this continuum, semantic attraction can be understood as the result of a few, highly associated words like meal and devouring incrementally activating a rich devour-a-meal event-representation based on world knowledge about meals and devouring events. As the semantic features of devouring integrate within the developing event-representation, the semantic system

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8 Event-representations and related theoretical notions like semantic frames (Fillmore, 1985) or situation models (Zwaan & Radvansky, 1998) share the idea that language comprehension activates more than just individual lexical items.
adheres to the event-representation and assigns *meal* to the Theme role of *devour*, independently of well-formed grammatical cues that signal otherwise.

Towards the other end of the continuum lies discourse context. The role of context in constraining the interactions between the parallel systems serving language processing remains an open question (Kuperberg, 2007), but some recent ERP evidence is suggestive. For instance, Kuperberg and colleagues (Kuperberg et al., 2003; 2007) found P600 effects at the verb for sentences like, “Every morning at breakfast the eggs would *eat*...”. However, Experiments 1 and 2 find LAN effects for sentences that contained similar anomalies (e.g., “The hearty meal would *devour*...”) without a lead-in context (e.g., “Every morning at breakfast”) (Kim & Sikos, 2011). It is possible that information contained in a lead-in context can modulate the interaction between syntactic and semantic processing streams during such anomalies. We hypothesize here that discourse-driven event-representations can also control interpretation of the sentence in the face of opposition from syntactic cues. Specifically, discourse-driven event-representations may establish expectations about specific words and lead to fast thematic role commitments for those words when they are subsequently encountered, possibly independently of the available syntactic cues. If lexical-syntactic cues conflict with such discourse-driven commitments, the language processing system may “blame” the problem on the structural representation of the event rather than attempting a difficult semantic integration signaled by the syntactic cues. In other words, syntactic analysis may collapse and trigger structural reprocessing manifest in P600 effects. We will refer to this hypothesis as the “discourse-expectedness” hypothesis. In sum, the discourse-expectedness hypothesis assumes a parallel-streams-of-processing architecture and predicts that 1) event-representations can control interpretation of the
sentence in the face of opposition from syntactic cues, 2) event-representations can be strongly activated by a small number of words via semantic pattern completion processes, and 3) P600 effects can occur when lexico-syntactic cues fail to unify with an entrenched event-representation (Kim & Sikos, 2011; Kim & Osterhout, 2005).

Recent ERP findings are compatible with this proposal. Nieuwland & Van Berkum (2005) report that animacy-violating nouns (the Dutch equivalent of “The woman told the suitcase...”) elicited P600 effects when preceded by a rich discourse context that previously mentioned both suitcase and the woman behind the check-in counter (the antecedent of the woman) in plausible sentences. The discourse-expectedness hypothesis suggests that the anomalous word suitcase is rapidly recognized and linked to an event-representation driven by the prior discourse. Specifically, prior to the anomaly, discourse establishes thematic relationships for suitcase as the Theme of bring, open, and weigh. Consequently, the comprehension system integrates the anomalous instance of suitcase in a way that is consistent with the current event-representation, but which is inconsistent with the (well-formed) syntactic cues. In such cases, the discourse-expectedness hypothesis predicts that conflict between discourse-driven constraints and syntactic cues should result in the collapse of the syntactic analysis and lead to combinatorial reprocessing manifest in P600. Moreover, no N400 enhancement should be elicited, even though the syntactic cues clearly signal an implausible interpretation, because the event-representation is not compatible with the implausible interpretation.

Although Nieuwland and Van Berkum (2005) find suggestive evidence that discourse context is critical for eliciting this P600-without-N400 effect (the authors briefly discuss data from a separate study with null context in which the same anomalous words enhanced
N400 rather than P600), they suggest an account that is different from the one proposed here. Nieuwland and Van Berkum (2005) argue that discourse context leads to a temporary failure to register suitcase as anomalous because it provides a “good-enough” match to the strongly anticipated tourist and therefore does not enhance N400. This finding is compared to “semantic illusion” phenomena wherein subjects do not notice a semantically anomalous word because it bears certain semantic relationships to the contextually appropriate word (e.g., “When an airplane crashes on a border with debris on both sides, where should the survivors be buried?”; survivors should be victims) (Barton & Sanford, 1993; Sanford & Garrod, 1998; Sanford & Sturt, 2002). Although this account explains the lack of N400 effects at the anomalous word (e.g., suitcase), it does not explain the subsequent P600. Nieuwland and Van Berkum (2005) suggest a possible explanation for the P600 effect: it may involve comprehenders quickly recovering from the temporary semantic illusion to ultimately recognize that something is wrong with the sentence, and then “put the blame on syntax” (e.g., by considering the possibility of an incorrect phrase ordering) (699). However, it does not specify whether the P600 effect reflects processing difficulty due to selectional restrictions of the verb (i.e., animacy violation and/or implausibility), or due to a conflict between discourse-driven event-representation and unambiguous syntactic cues.

In Experiments 3 and 4, we tested whether discourse-expectedness can modulate processing outcomes even when the unfolding event-representation is not entrenched within world knowledge. We recorded the brain activity elicited by semantically anomalous predications, while manipulating the discourse-expectedness of the critical verb (Table 4.1). Target sentence subject nouns were paired with verbs that were not only
anomalous, but were also semantically unassociated prior to discourse. Experiment 3 specifically manipulated the “richness” of discourse context in order to maximize the possibility of eliciting robust context-related effects. Experiment 4, on the other hand, maintained the discourse-expectedness manipulation but equated the richness of contexts (i.e., both contexts contained approximately the same number of words) in order to rule out the possibility that any ERP modulation was due to the richness of context alone.
Table 4.1. Sample experimental items by condition for Experiments 3 and 4. Critical verbs are underlined and repeated nouns are in italics.

Experiment 3

Control Conditions

No-Mention Context + Control
1a. A moon orbited the planet.
2a. The planet was glowing brightly in a distant solar system.

Mention Context + Control
1b. The astronomy student searched the night sky through a telescope. She was looking for a particular planet.
2a. The planet was glowing brightly in a distant solar system.

Anomalous Conditions

No-Mention Context + Anomaly
1a. A moon orbited the planet.
2b. The planet was searching for the constellation.

Mention Context + Anomaly
1b. The astronomy student searched the night sky through a telescope. She was looking for a particular planet.
2b. The planet was searching for the constellation.

Experiment 4

Control Conditions

No-Mention Context + Control
3a. The astronomy student observed the night sky through a telescope. She was looking at a particularly radiant planet.
4a. The planet was glowing brightly in a distant solar system.

Mention Context + Control
3b. The astronomy student carried the heavy telescope outside. She was looking for a particular planet.
4a. The planet was glowing brightly in a distant solar system.

Anomalous Conditions

No-Mention Context + Anomaly
3a. The astronomy student observed the night sky through a telescope. She was looking at a particularly radiant planet.
4b. The planet was carrying the constellation.

Mention Context + Anomaly
3b. The astronomy student carried the heavy telescope outside. She was looking for a particular planet.
4b. The planet was carrying the constellation.
4.2 · Experiment 3

In Experiment 3, we recorded the brain activity elicited by semantically anomalous predications (e.g., “The planet was searching ...”; Table 4.1, 2b) and plausible control sentences (e.g., “The planet was glowing ...”; Table 4.1, 2a). Furthermore, we manipulated the discourse-expectedness of the anomalous critical verb (searching) via prior context. No-Mention Contexts (e.g., “A moon orbited the planet.”; Table 4.1, 1a) were minimal and did not create any thematic role expectations for the subsequent anomalous critical verb. Therefore, we predicted that the anomaly would be treated like an outright semantic violation. In other words, the unambiguous syntactic cues would be honored and the anomalous critical verb would trigger integration difficulty, resulting in an enhanced N400 amplitude relative to well-formed controls. In contrast, Mention Contexts (e.g., “The astronomy student searched the night sky through a telescope. She was looking for a particular planet.”; Table 4.1, 1b) contained rich discourse that included a felicitous use of the anomalous critical verb with an animate subject/Agent. Here we had a two-part prediction. First, the comprehension system would recognize the subsequent anomalous use of the critical verb as the previously encountered word and would therefore generate a reduced N400 effect (due to lexical repetition effects, as discussed in Chapter 2). Second, the implausible lexico-syntactic analysis of the target sentence (e.g., planet as Agent of searching) would be contradicted by an active event-representation already containing a more plausible thematic role assignment for the critical verb (student as Agent of searching). We predicted that, under such conditions of conflict between discourse-driven
constraints and syntactic cues, syntactic analysis would collapse into reprocessing and elicit P600 effects.

4.2.1 · Methods

Participants. Forty students (21 female) from the University of Colorado at Boulder participated in the experiment for course credit. Participants ranged in age from 18 to 28 (mean = 19.9 years). All participants were right-handed native English-speakers with normal or corrected-to-normal vision.

Stimuli. One hundred twenty short stories of two to three sentences were created, each in four versions that resulted from manipulating the plausibility of the critical verb within the story-final target sentence (Anomaly vs. Control) and the nature of the prior context (No-Mention vs. Mention of the anomalous critical verb) (Table 4.1). The full stimulus set is listed in the Appendix (Table A.3). Story-final target sentences began with an inanimate subject noun (planet) followed by a critical verb that was either plausible (glowing) or anomalous (carrying). No-Mention Contexts (1a) contained a single sentence that introduced the target sentence subject (planet). Mention Contexts (1b) contained two sentences, one introducing the target sentence subject noun and the other introducing the Anomalous target sentence's critical verb (carrying), used with a highly plausible Agent/Subject (student). Importantly, in order to minimize the possibility that ERP effects at the critical verb would be driven by prior lexical association (such as semantic attraction relationships), we paired target sentence subject nouns with verbs that were not only
anomalous, but were also semantically unassociated (mean LSA cosine = 0.10).\textsuperscript{9} Mention Contexts varied as to whether the sentence introducing the target sentence subject noun or critical verb came first (noun first = 48.3%; verb first = 51.7%). Anomalous (2b) and Control (2a) target sentences were identical up to the verb. Anomalous verbs were animacy violations while Control verbs were plausible. In sum, the crucial manipulation in this study is found in the Mention Context, which creates an expectation for thematic role assignments (student as Agent of searching) that then contradict the syntactically-signalated assignment found in the Anomalous target sentence (planet as Agent of searching).

Four counterbalanced stimulus lists were created using these materials. Each list contained 30 stories from each of the four experimental conditions in Table 4.1. Stories were rotated through condition assignments such that each story occurred only once per list. Lists were then pseudo-randomly mixed with 120 filler stories, of which 30 had semantically anomalous target sentences, 30 had syntactically anomalous target sentences, and 60 had well-formed and plausible target sentences. Thus, each list contained 240 stories in total (50% well-formed, 50% anomalous). To control for any unintended priming effects across stories, an additional four lists were created by reversing the presentation order of the original lists. Participants were randomly assigned to one of these eight lists. Therefore, each participant saw all 120 experimental stories, but no story in more than one condition.

\textsuperscript{9} Semantic association was confirmed via latent semantic analysis (LSA; Landauer & Dumais, 1997). LSA measures co-occurrence relationships between pairs of words in a large corpus of written texts and has been shown to detect subtle differences in semantic relatedness between words beyond simple lexical association (Chwilla & Kolk, 2005). The meaning of a word is defined as a vector in semantic space and the semantic relatedness of two words can be determined by calculating the cosine between their vectors. The more semantically related two words are, the higher their cosine. The analysis for the current study utilized the “General Reading up to First Year of College” topic space.
Procedure. Participants were tested in a single session lasting approximately 120 minutes, including 30 minutes of experiment preparation. Participants were seated in a comfortable chair in front of a LCD monitor in a darkened, sound-attenuated booth and were instructed to read normally and to try to understand the stories. The experiment began with five practice trials to ensure that the participant understood the instructions. Each trial consisted of the following events: No-Mention and Mention Contexts were presented in full (to reduce total time of experiment) under the heading “Background” and stayed on screen until the participant pressed a button to continue to the target sentence (Figure 4.1a). Anomalous and Control target sentences were presented one word at a time in the center of the screen via rapid serial visual presentation (RSVP) (Figure 4.1b). A fixation cross appeared in the center of the screen for 1100 ms. Non-critical words were presented for 380 ms and followed by an inter-stimulus interval proportional to word length (20 ms/character); this variable inter-stimulus interval was used to reduce alpha activity as well as to make the stimulus presentation more natural. Critical verbs were presented for 380 ms and followed by a fixed inter-stimulus interval of 140 ms, ensuring that ERPs were not affected by the variable inter-stimulus interval. Participants were asked to avoid blinks and eye movements during the RSVP but encouraged to blink at any other time. Approximately every third story was followed by a comprehension task clearly identified as “Quiz” (Figure 4.1c). Participants were asked to judge whether a paraphrase statement was consistent with the previous story. The statement varied as to whether it paraphrased a context sentence or target sentence. However, the paraphrase never referred to a semantic anomaly. This quiz remained on screen until one of two buttons on a button-box (“True” or “False”) was pressed. Participants used their thumbs to respond,
with half the participants using their right thumb to answer “True”. Behavioral responses were followed by a “Continue?” prompt, appearing on screen until either button was pressed. A “Go to Story X?” prompt followed each trial.

Figure 4.1. Stimulus presentation sequence (Experiment 3). (A) Self-paced context. (B) Rapid serial visual presentation of critical sentence. Red indicates target verb where ERPs were measured. (C) Comprehension task.

Data Acquisition and Analysis. EEG recording and analysis methods were identical to Experiments 1 and 2, except as follows. ERPs were averaged off-line within each
experimental condition (No-Mention Context + Anomaly, No-Mention Context + Control, Mention Context + Anomaly, Mention Context + Control) for each subject at each electrode site in epochs spanning -200 to 1000 ms relative to the onset of the critical verb. Following ocular artifact reduction and baseline correction to a 200 ms pre-target-word interval, the following percentage of epochs per condition were rejected due to remaining artifacts: No-Mention Context + Anomaly (5.9%), No-Mention Context + Control (5.4%), Mention Context + Anomaly (6.5), and Mention Context + Control (5.8%). The remaining EEG segments were averaged per participant and per condition.

ERP components of interest were identified based on visual inspection of ERPs and topographic maps, as well as prior findings. For each channel-group (Figure 3.1), we quantified ERPs for analysis as mean voltages within an early window of 350-550 ms (N400) and a late window of 650-900 ms (P600) after stimulus onset. These windows were based upon visual analysis and depended upon the time interval in which maximal differences between conditions were obtained. We also analyzed voltages in 50-150 ms (N1), 150-300 ms (P2) windows to test for experimental effects on earlier components. Repeated measures ANOVAs were conducted separately at midline (midline-posterior and midline-anterior) and lateral (left/right anterior and left/right posterior) channel-groups to examine distributional differences across the scalp in both the left-right and anterior-posterior dimensions. For the midline analysis, the factors were Context (No-Mention, Mention), Completion (Anomalous, Control), and Position (anterior, posterior). For the lateral sites analysis, factors were Context, Completion, Hemisphere (left, right) and Position. We also analyzed planned pairwise ANOVAs by holding Context constant (No-Mention Context + Anomaly vs. No-Mention Context + Control, Mention Context + Anomaly vs. Mention Context + Control, Mention Context + Control vs. No-Mention Context + Control).
vs. Mention Context + Control, No-Mention Context + Anomaly vs. Mention Context + Anomaly) as we had specific a priori hypotheses for each of these comparisons.

4.2.2 · Results

ERPs. Figure 4.2 shows the grand-average waveforms for anomalous verbs vs. controls at the midline-posterior channel-group (where the effects were largest) following both No-Mention Context (4.2A) and Mention Context (4.2B), as well as the topographical distribution of these effects (see Appendix, Figure A.3 for ERPs at all six channel-groups used for data analysis).

(A) No-Mention Context
The smell of bacon was overwhelming.
The bacon was leaving...  
The bacon was trying...

(B) Mention Context
The kids woke up to the smell of bacon and coffee. Their dad was already leaving for work.
The bacon was leaving...  
The bacon was trying...

Figure 4.2. Experiment 3: Grand-average waveforms for ERPs elicited by Anomalous verbs (dashed lines) and Control verbs (solid black lines) at midline-posterior channel-group, and scalp distribution of ERP effects (Anomaly minus Control) as mean voltage difference within designated time windows. (A) Anomaly vs. Control following No-Mention Context. (B) Anomaly vs. Control following Mention Context. Positive voltage is plotted down. Onset of the target verbs is indicated by the vertical bar (0 ms). Waveforms are filtered (12 Hz high cutoff) for presentation purposes only. Dotted black rectangle indicates time windows used for analysis.
All waveforms showed a clear negative-positive complex in the first 300 ms following word-onset (the “N1-P2” complex), followed by a negative-going component peaking around 400 ms. Following No-Mention Context, waveforms for Anomalous verbs showed a widely distributed negative shift between 350-550 ms that was maximal at midline-posterior channels, relative to waveforms for Control verbs (N400; Figure 4.2A). Following Mention Context, waveforms for Anomalous verbs did not show this negative enhancement and instead contained a widely distributed positivity that began at 650 ms, continued through the end of the epoch, and was maximal at posterior channels (P600; Figure 4.2B).

ANOVAs in early latency windows (50-150; 150-300 ms) showed no significant effect of condition.

**N400 (350-550 ms).** In the N400 window, ERPs to both anomalous and control verbs were more negative following No-Mention Contexts than following Mention Contexts, reflected in a main effect of Context at midline but not lateral channel-groups [midline: $F(1, 39) = 4.56, p < 0.05$; lateral: $F < 1.1$]. ERPs elicited by anomalous completions were somewhat more negative than control completions, irrespective of Context, reflected in a marginal effect of Completion at lateral channels only [midline: $F < 2$; lateral: $F(1, 39) = 3.79, p = 0.06$]. Contrary to predictions, there was no reliable interaction between Context and Completion in the N400 window [$Fs < 2.3$]. However, numerical differences suggest a trend toward an interaction. Figure 4.3 shows interaction plots of mean voltages at midline and lateral channel groups during the 350-550 ms window, which suggest that anomalies were more negative following No-Mention Contexts than Mention Contexts at both midline and lateral channel-groups. This is supported by pair-wise comparisons holding Context constant. Following No-Mention Contexts, semantically anomalous words elicited a larger
negativity in the N400 window than the Control words at both midline and lateral channel-groups [midline: $F(1, 39) = 5.81, p < 0.05$; lateral: $F(1, 39) = 5.06, p < 0.05$]. Following Mention Contexts, anomalous words did not differ from control words at the N400 [$F$s < 0.8]. Directly comparing the anomalous completions in No-Mention and Mention Contexts showed that anomalous words elicited larger N400s following No-Mention than Mention Contexts at midline but not lateral channel-groups [midline: $F(1, 39) = 6.21, p < 0.05$; lateral: $F < 1.2$]. Directly comparing control completions in No-Mention and Mention Contexts showed that controls did not differ at the N400 [$F$s < 0.4].

![Figure 4.3](image)

*Figure 4.3. Experiment 3: Interaction plots showing mean voltages at (A) midline and (B) lateral channel groups (right) for anomalous and control completions following No-Mention Contexts (left) and Mention Contexts (right) during the N400 time window (350-550 ms).*

Following Mention Contexts there was a Completion x Hemisphere x Position interaction in the lateral channel-groups [$F(1, 39) = 7.71, p < 0.01$]. This reflected a marginally significant negativity in the left-anterior channel group [$F(1, 39) = 3.05, p <
which did not occur at other channel groups. Table 4.2 summarizes the statistical analysis for the N400 time window.

Table 4.2. Experiment 3: ANOVAs of mean ERP amplitudes in the 350-550 ms time window.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Midline</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Context</td>
<td>1, 39</td>
<td>4.56</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Completion</td>
<td>1, 39</td>
<td>1.78</td>
<td></td>
</tr>
<tr>
<td>Context x Completion</td>
<td>1, 39</td>
<td>2.28</td>
<td></td>
</tr>
<tr>
<td>Context x Completion x Position</td>
<td>1, 39</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td><strong>Lateral</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Context</td>
<td>1, 39</td>
<td>1.02</td>
<td></td>
</tr>
<tr>
<td>Completion</td>
<td>1, 39</td>
<td>3.79</td>
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<td>Context x Completion</td>
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<tr>
<td>Context x Completion x Hemi</td>
<td>1, 39</td>
<td>0.02</td>
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<tr>
<td>Context x Completion x Position</td>
<td>1, 39</td>
<td>1.79</td>
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<tr>
<td>Context x Completion x Hemi x Position</td>
<td>1, 39</td>
<td>1.93</td>
<td></td>
</tr>
<tr>
<td><strong>Following No-Mention Contexts</strong></td>
<td></td>
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**Left-Anterior**

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**Left-Posterior**

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**Right-Posterior**

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**P600 (600-900 ms).** ANOVAs revealed a main effect of Context at both midline and lateral channel-groups during the P600 window, indicating that ERPs to both semantically anomalous and control verbs were more positive following Mention Contexts than following No-Mention Contexts [midline: \(F(1, 39) = 15.37, p < 0.001\); lateral: \(F(1, 39) = 9.14, p < 0.01\)]. However, anomalous target words were significantly more positive then controls
when following Mention Contexts, reflected in an interaction between Context and Completion at midline channel-groups [midline: $F(1, 39) = 6.43, p < 0.05$] The P600 effect following Mention Contexts was larger over posterior than anterior channels, reflected in a Context x Completion x Position interaction at lateral channel-groups [$F(1, 39) = 9.03, p < 0.01$].

These differences can be seen more clearly by holding Context constant. ANOVAs revealed that following Mention Contexts, semantically anomalous words elicited a larger positivity in the P600 window than Control words at midline but not lateral channel-groups [midline: $F(1, 39) = 4.23, p < 0.05$; lateral: $F < 1.5$]. This effect was focused at posterior channels, reflected in a Completion x Position interaction at both midline and lateral channel-groups [midline: $F(1, 39) = 9.98, p < 0.01$; lateral: $F(1, 39) = 21.93, p < 0.001$]. Following No-Mention Contexts, anomalous words did not differ from the control condition at the P600 [$F_s < 2.75$]. Directly comparing the anomalous sentences in No-Mention and Mention Contexts showed that anomalous words elicited larger P600s following Mention Contexts at both midline and lateral channel-groups [midline: $F(1, 39) = 16.39, p < 0.001$; lateral: $F(1, 39) = 7.80, p < 0.01$]. Directly comparing control completions in No-Mention and Mention Contexts showed that controls did not differ at the P600 [$F_s < 1.6$]. Table 4.3 provides an overview of the statistical analysis.

Table 4.3. Experiment 3: ANOVAs of mean ERP amplitudes in the 650-900 ms time window.

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### Right-Anterior
- **Following No-Mention**: 1, 39, 0.49
- **Following Mention**: 1, 39, 0.17
- **Directly Comparing Anomalies**: 1, 39, 0.97
- **Directly Comparing Contexts**: 1, 39, 0.41

### Left-Posterior
- **Following No-Mention**: 1, 39, 0.01
- **Following Mention**: 1, 39, 11.06, <0.01
- **Directly Comparing Anomalies**: 1, 39, 13.02, <0.001
- **Directly Comparing Contexts**: 1, 39, 0.84

### Midline-Posterior
- **Following No-Mention**: 1, 39, 0.88
- **Following Mention**: 1, 39, 10.92, <0.01
- **Directly Comparing Anomalies**: 1, 39, 29.96, <0.001
- **Directly Comparing Contexts**: 1, 39, 2.01

### Right-Posterior
- **Following No-Mention**: 1, 39, 0.02
- **Following Mention**: 1, 39, 11.88, <0.01
- **Directly Comparing Anomalies**: 1, 39, 21.52, <0.001
- **Directly Comparing Contexts**: 1, 39, 0.41

### 4.2.3 · Discussion

Experiment 3 investigated the influence of discourse context on the processing of semantically-anomalous predcations. Models of language processing that assume unambiguous syntactic cues always dominate semantic cues predict that the anomalous verbs in our experimental stimuli will elicit semantic processing difficulty (manifest in N400 effects), regardless of prior discourse context. In contrast, the discourse-expectedness hypothesis predicts that the anomalous verb should be processed differently following No-Mention vs. Mention Contexts.

The results are consistent with the discourse-expectedness hypothesis. Although the Context x Completion interaction was not statistically reliable in the N400 window, pairwise comparisons holding Context constant suggest a strong trend toward interaction. Figure 4.4 highlights the midline-posterior channel group and shows that the mean magnitude of the N400 effect (anomalous completion minus control completion; blue bars)
was larger following No-Mention Contexts than when the same anomalous and control sentences followed Mention Contexts. Conversely, the mean magnitude of the P600 effect (red bars) was larger following Mention Contexts than when the same anomalous and control sentences followed No-Mention Contexts.

![Figure 4.4](image)

*Figure 4.4. Experiment 3: Anomaly effects (Anomaly minus Control) at midline-posterior channel-group. (A) Following No-Mention Context. (B) Following Mention Context. Error bars indicate standard error.*

These analyses suggest that ERP effects at the semantically anomalous verb were modulated by discourse context such that anomalies enhanced N400 relative to control when following No-Mention Contexts, while the same anomalies enhanced P600 when following Mention Contexts. The findings are consistent with the hypothesis that event-representations which establish thematic relations between content words (even in the absence of semantic attraction) can bias the comprehension system to interpret locally anomalous combinations of those words in ways that are plausible given the event-representation. The system therefore attempts to resolve the conflict via structural reprocessing instead of attempting a difficult semantic integration, thereby eliciting P600 rather than N400 effects.
An alternative explanation, however, could also account for the modulation of P600 effects. Experiment 3 manipulated the richness of context in order to ensure that the conditions were divergent enough to engender different brain responses to the same anomalous predication. A result of this manipulation was that Mention Contexts were considerably longer (mean length of 21.0 words) than No-Mention Contexts (mean length of 6.9 words). Previous research has linked syntactic and/or conceptual complexity with enhanced P600 (Fiebach et al., 2002; Friederici, Hahne & Saddy, 2002; Kaan & Swaab, 2003; Kaan et al., 2000). Thus, it is possible that the modulation of P600 in Experiment 3 was due to the difference in the amount of contextual information across conditions.

We conducted a follow-up experiment to 1) replicate the Context x Completion interactions in both N400 and P600 windows, and 2) to rule out whether the P600 modulation was due to differences in amount of context.

4.3 · Experiment 4

Experiment 4 was designed to replicate Experiment 3 while controlling for the length of context. No-Mention Contexts were expanded in order to become equally as rich as Mention Contexts (see Stimuli below for details).

4.3.1 · Methods

Participants. Thirty-seven students from the University of Colorado at Boulder participated in the experiment for course credit. Three participants were excluded from the statistical analyses due to excessive electrophysiological artifacts, three participants were excluded for mean accuracy rates below 80%, and one participant was excluded for both
artifact and accuracy. The remaining 30 participants (12 female) ranged in age from 18 to 24 (mean = 20.1 years). All participants were right-handed native English-speakers with normal or corrected-to-normal vision.

**Stimuli.** One hundred twenty short stories of three sentences were created, each in four versions that resulted from manipulating the plausibility of the critical verb within the story-final target sentence (Anomaly vs. Control) and the nature of the prior context (No-Mention vs. Mention of the critical verb from the target sentence) (Table 4.1). The full stimulus set is listed in the Appendix (Table A.4). Story-final target sentences (e.g., Table 4.1, 4a/b) began with an inanimate subject noun (planet) followed by a critical verb that was either plausible (glowing) or anomalous (carrying). Mention Contexts (e.g., Table 4.1, 3b) contained two sentences, one introducing the subject noun of the target sentence and the other introducing the Anomalous target sentence’s critical verb (carrying). No-Mention Contexts (e.g., Table 4.1, 3a) also contained two sentences, one of which introduced the target sentence subject (planet); the target sentence verb was not mentioned in these contexts. The number of words were equated across both types of context (mean word count: No-Mention Context = 23.0, Mention Context = 22.0). As in Experiment 3, the subject noun and critical verb of the anomalous target sentence had minimal prior semantic association (mean LSA cosine = 0.09). Mention Contexts varied as to whether the sentence introducing the target sentence noun or critical verb came first (noun first = 45%; verb first = 55%). Mention Contexts also introduced a highly-plausible Agent for the target sentence anomalous verb. Control (4a) and Anomalous (4b) target sentences were identical up to the verb. Anomalous verbs were animacy violations while Control verbs were plausible. As in Experiment 3, the crucial manipulation was found in the Mention Context, which created an
expectation for specific thematic role assignments for the content words that occur in the semantically anomalous predication.

Stimuli for Experiment 4 were largely based on those from Experiment 3. However, in addition to equating the contexts for richness, some additional modifications were made based on a post-hoc analysis of the original stimuli. A review of the Anomalous target sentences found that 8 items (6.7%) could be interpreted as reversal anomalies (e.g., “The planet was searching...”, “The computer was plugging...”), 14 items (11.7%) contained weak semantic associations that were not evident in the LSA analysis (e.g., “The flag was cheering...”, “The weapons were marching...”), and 3 items (2.5%) had conceivable continuations that were not anomalous (e.g., “The strawberries were swimming ... [in cream.]”). A highly conservative assessment concludes that 20.8% (25 out of 120) of the Anomalous target sentences from Experiment 3 were less than ideal. The stimuli for Experiment 4 resolved these issues.

An additional 120 filler stories with 2-sentences contexts were created. Thirty filler stories had semantically anomalous target sentences, 30 had syntactically anomalous target sentences, and 60 were well-formed and plausible.

As in Experiment 3, the experimental design was fully factorial. Experimental conditions were pseudo-randomly mixed with the filler stories to create 8 counterbalanced lists. Each list contained 240 stories in total (50% well-formed, 50% anomalous).

Procedure. The same general procedure was used as in Experiment 3, however an acceptability judgment task was added such that 50% of stories were followed by a comprehension task and 50% were followed by an acceptability judgment task. This second task was included for two reasons: 1) We wanted to ensure that participants were
processing both the contextual information and target sentences as deeply as possible, and
2) to increase the amplitude of ERP effects elicited by the experimental manipulation.
Although comprehension questions are well-suited to assessing the depth of processing of
well-formed stimuli, acceptability judgments have been shown to elicit larger P600 effects
than comprehension tasks (Friedman, Simson, Ritter and Rapin, 1975; Kuperberg, 2007),
presumably due to a greater allocation of attention or controlled top-down processing.
Thus, each trial in Experiment 4 was followed by either a comprehension task or an
acceptability judgment task. This increased the proportion of trials followed by behavioral
judgments from 33% in Experiment 3 to 100% in Experiment 4.

In the comprehension task participants were asked to determine whether a
paraphrase statement was consistent with the background information in the previous
story. The quiz remained on screen until one of two buttons on a button-box (“True” or
“False”) was pressed. In the acceptability judgment task, participants judged whether the
target sentence was “Normal” or “Not Normal”. Participants used their thumbs to respond
to both tasks. The assignment of “True/False” and “Normal/Not Normal” to the left and
right buttons was counterbalanced across participants. Behavioral responses were
followed by a “Continue?” prompt, appearing on screen until either button was pressed. A
“Go to Story X?” prompt followed each trial. Experiment 4 began with eight practice trials
to ensure that the participant understood the instructions and both tasks.

*Data Acquisition and Analysis.* The same methods and parameters were used as in
Experiment 3. Artifact rejection led to the exclusion of approximately 2.3 % of trials, with
no asymmetry across conditions: No-Mention Context + Anomaly (2.3%), No-Mention
ERP components of interest were identified based on visual inspection of ERPs and topographic maps, as well as prior findings. In addition to the time windows used for analysis in Experiment 3, mean voltages from a 350-1000 ms time were submitted to repeated measures ANOVA to analyze an unexpected negativity that was widely distributed and sustained over time (see Broad Frontal Negativity below).

4.3.2 · Results

Comprehension Task. Participants’ judgments of paraphrase acceptability by condition (No-Mention Context + Anomaly, No-Mention Context + Control, Mention Context + Anomaly, Mention Context + Control) agreed with the intended judgments at the following rates: 91.7, 89.3, 91.4, and 92.4 %, respectively.

Acceptability Judgments. Participants’ judgments of target sentence acceptability by condition (No-Mention Context + Anomaly, No-Mention Context + Control, Mention Context + Anomaly, Mention Context + Control) agreed with the intended judgments at the following rates: 95.0, 91.6, 96.9, and 92.1 %, respectively.

ERPs. Figure 4.5 shows the grand-average waveforms for anomalous verbs vs. controls at the midline-posterior channel-group following both No-Mention Context (4.5A) and Mention Context (4.5B), as well as the topographical distribution of these effects (see Appendix, Figure A.4 for ERPs at all six channel-groups used for data analysis).
Figure 4.5. Experiment 4: Grand-average waveforms for ERPs elicited by Anomalous verbs (dashed lines) and Control verbs (solid black lines) at midline-posterior channel-group, and scalp distribution of ERP effects (Anomaly minus Control) as mean voltage difference within designated time windows. (A) Anomaly vs. Control following No-Mention Context. (B) Anomaly vs. Control following Mention Context. Positive voltage is plotted down. Onset of the target verbs is indicated by the vertical bar (0 ms). Waveforms are filtered (12 Hz high cutoff) for presentation purposes only. Dotted black rectangle indicates time windows used for analysis.

All waveforms showed a clear negative-positive complex in the first 300 ms following word-onset (the “N1-P2” complex), followed by a negative-going component peaking around 400 ms. Following No-Mention Context, waveforms for Anomalous verbs showed a widely distributed negative shift between 350-550 ms that was maximal at midline-posterior and left-posterior channels, relative to waveforms for Control verbs (N400; Figures 4.5A). Following Mention Context, waveforms for Anomalous verbs did not show this negative enhancement and instead contained a widely distributed positivity that began at approximately 650 ms and continued through the end of the epoch (P600; Figures 4.5B).
In addition, a negativity elicited by Anomalous verbs following No-Mention Context appeared sustained over time and became increasingly more anterior throughout the epoch, relative to Control verbs following No-Mention Context (Figure 4.6A). This was unpredicted. ERPs for anomalous verbs following Mention Context did not show this sustained negativity (Figure 4.6B).

![Figure 4.6](image)

*Figure 4.6. Experiment 4: Scalp distribution of ERP effects (Anomaly minus Control) as mean voltage difference within designated time windows. (A) Anomaly vs. Control following No-Mention Context. (B) Anomaly vs. Control following Mention Context.*

ANOVA in the 50-150 ms (N1) window indicate a condition X position interaction at lateral channel groups \[F(1, 29) = 4.84, p<.05\], which is likely to be spurious. ANOVA in the 150-300 ms window showed no significant effect of condition.
**N400 (350-550 ms).** In the N400 window, ERPs to both anomalous and control verbs were more negative following No-Mention Contexts than following Mention Contexts, reflected in a main effect of Context both midline and lateral channel-groups [midline: \(F(1, 29) = 7.04, p < 0.05\); lateral: \(F(1, 29) = 6.36, p < 0.05\)]. Irrespective of Context, ERPs elicited by anomalous completions were more negative than control completions, reflected in a main effect of Completion [midline: \(F(1, 29) = 14.49, p < 0.001\); lateral: \(F(1, 29) = 25.03, p < 0.001\)]. However, ERPs to semantically anomalous target words were more negative in the N400 window when following No-Mention Contexts, reflected in an interaction between Context and Completion. This can be seen more clearly by holding Context constant. Following No-Mention Contexts, semantically anomalous words elicited a larger negativity in the 350-550 ms window than the Control words [midline: \(F(1, 29) = 18.19, p < 0.001\); lateral: \(F(1, 29) = 25.49, p < 0.001\)]. Following Mention Contexts, anomalous words at the N400 did not differ from control words at midline but were marginally more negative than control words at lateral [midline: \(F < 1.7\); lateral: \(F(1, 29) = 3.58, p = 0.07\)]. Directly comparing the anomalous sentences in No-Mention and Mention Contexts showed that anomalous words elicited larger N400s following No-Mention than Mention Contexts [midline: \(F(1, 29) = 12.97, p < 0.01\); lateral: \(F(1, 29) = 15.78, p < 0.001\)]. Directly comparing control completions in No-Mention and Mention Contexts showed that controls did not differ at the N400 [Fs < 0.4]. Table 4.4 provides an overview of the statistical analyses.
Table 4.4. Experiment 4: ANOVAs of mean ERP amplitudes in the 350-550 ms time window.

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<td>&lt;0.001</td>
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<td>1, 29</td>
<td>3.57</td>
<td>0.07</td>
</tr>
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**P600 (650-900 ms).** ERPs to both semantically anomalous and control verbs were somewhat more positive following Mention Contexts than following No-Mention Contexts, reflected in a main effect of Context at midline but not lateral channel-groups [midline: $F(1, 29) = 4.21, p < 0.05$; lateral: $F < 2$]. However, anomalous target words were more positive than controls when following Mention Contexts, reflected in a marginal interaction between Context and Completion at lateral channel-groups but not at midline [midline: $F < 2.2$; lateral: $F(1, 29) = 3.00, p = 0.09$] as well as a marginal Context x Completion x Hemisphere x Position interaction at lateral channel-groups [$F(1, 29) = 3.49, p = 0.07$]. Holding position constant revealed that this effect was driven by posterior channel-groups,
reflected in a marginal Context x Completion interaction at posterior but not anterior channel-groups [anterior: $F < 1.9$; posterior: $F(1, 29) = 3.17, p = 0.09$].

The P600 effect becomes more clear by holding Context constant. Following Mention Contexts, semantically anomalous words elicited a marginally larger positivity in the 650-900 ms window than control words at midline but did not differ at lateral channel groups [midline: $F(1, 29) = 3.28, p = 0.08$; lateral: $F < 1.6$]. Directly comparing the anomalous sentences in No-Mention and Mention Contexts showed that anomalous words were more positive following Mention Contexts than No-Mention Contexts [midline: $F(1, 29) = 6.15, p < 0.05$; lateral: $F(1, 29) = 5.24, p < 0.05$]. Directly comparing control completions in No-Mention and Mention Contexts showed that controls did not differ at the P600 [Fs < 0.2].

The P600 effect following Mention Contexts was larger over posterior than anterior channels, reflected in an Completion x Position interaction [midline: $F(1, 29) = 8.92, p < 0.01$; lateral: $F(1, 29) = 24.84, p < 0.001$]. This reflected significant positivities at all posterior channel groups [left-posterior: $F(1, 29) = 13.08, p < 0.01$; midline-posterior: $F(1, 29) = 8.66, p < 0.01$; right-posterior: $F(1, 29) = 9.52, p < 0.01$]. Furthermore, this positivity appears to reverse polarity at left anterior channels (Anomalous words were more negative then Control following Mention Context [$F(1, 29) = 4.20, p < 0.05$]), reflected in an Completion x Hemisphere x Position interaction [lateral: $F(1, 29) = 5.20, p < 0.05$].

Following No-Mention Contexts, anomalous words elicited an anterior negativity relative to controls in the P600 window. This is reflected in an interaction between Completion and Position at both midline and lateral channel-groups [midline: $F(1, 29) = 6.80, p < 0.05$; lateral: $F(1, 29) = 17.84, p < 0.001$], which was driven by significant negativities at both left and right anterior channel-groups [left-anterior: $F(1, 29) = 7.45, p <
right-anterior: $F(1, 29) = 13.02, p < 0.01$. Table 4.5 provides an overview of the statistical analyses

**Table 4.5. Experiment 4: ANOVAs of mean ERP amplitudes in the 650-900 ms time window.**

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<td>5.20</td>
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</table>
### Directly Comparing Anomalies

- **Midline**
  - Context: $F(1, 29) = 6.15, p < 0.05$
  - Context x Position: $F(1, 29) = 0.11$

- **Lateral**
  - Context: $F(1, 29) = 5.24, p < 0.05$
  - Context x Hemi: $F(1, 29) = 0.42$
  - Context x Position: $F(1, 29) = 0.79$
  - Context x Hemi x Position: $F(1, 29) = 0.98$

### Directly Comparing Controls

- **Midline**
  - Context: $F(1, 29) = 0.12$
  - Context x Position: $F(1, 29) = 0.00$

- **Lateral**
  - Context: $F(1, 29) = 0.09$
  - Context x Hemi: $F(1, 29) = 0.14$
  - Context x Position: $F(1, 29) = 0.17$
  - Context x Hemi x Position: $F(1, 29) = 1.45$

### Left-Anterior

- Following No-Mention: $F(1, 29) = 7.45, p < 0.05$
- Following Mention: $F(1, 29) = 4.20, p < 0.05$
- Directly Comparing Anomalies: $F(1, 29) = 0.92$
- Directly Comparing Contexts: $F(1, 29) = 0.00$

### Midline-Anterior

- Following No-Mention: $F(1, 29) = 1.90$
- Following Mention: $F(1, 29) = 0.22$
- Directly Comparing Anomalies: $F(1, 29) = 4.46, p < 0.05$
- Directly Comparing Contexts: $F(1, 29) = 0.07$

### Right-Anterior

- Following No-Mention: $F(1, 29) = 13.02, p < 0.01$
- Following Mention: $F(1, 29) = 0.21$
- Directly Comparing Anomalies: $F(1, 29) = 3.62, p = 0.07$
- Directly Comparing Contexts: $F(1, 29) = 0.25$

### Left-Posterior

- Following No-Mention: $F(1, 29) = 0.34$
- Following Mention: $F(1, 29) = 13.08, p < 0.01$
- Directly Comparing Anomalies: $F(1, 29) = 4.41, p < 0.05$
- Directly Comparing Contexts: $F(1, 29) = 0.15$

### Midline-Posterior

- Following No-Mention: $F(1, 29) = 0.24$
- Following Mention: $F(1, 29) = 8.66, p < 0.01$
- Directly Comparing Anomalies: $F(1, 29) = 5.68, p < 0.05$
- Directly Comparing Contexts: $F(1, 29) = 0.16$

### Right-Posterior

- Following No-Mention: $F(1, 29) = 0.21$
- Following Mention: $F(1, 29) = 9.52, p < 0.01$
- Directly Comparing Anomalies: $F(1, 29) = 6.49, p < 0.05$
- Directly Comparing Contexts: $F(1, 29) = 0.25$
Broad frontal negativity (350-1000ms). In the 350-1000 ms window, ANOVAs revealed a main effect of Context at both midline and lateral channel-groups [midline: $F(1, 29) = 5.65, p < 0.05$; lateral: $F(1, 29) = 3.00, p = 0.09$] and a main effect of Completion at lateral channel-groups only [midline: $F < 0.2$; lateral: $F(1, 29) = 4.63, p < 0.05$]. However, ANOVAs also showed that anomalous completions elicited an unpredicted, broad, and long-lasting frontal negativity relative to controls when following No-Mention Contexts. This effect was reflected in a marginal Context x Completion interaction at lateral but not at midline channel-groups [midline: $F < 2.5$; lateral: $F(1, 29) = 3.11, p = 0.09$], as well as a marginal Context x Completion x Hemisphere x Position interaction at lateral channel-groups [lateral: $F(1, 29) = 3.05, p = 0.09$].

Holding Context constant makes the picture more clear. Following No-Mention Contexts, semantically anomalous words elicited a larger negativity in the 350-1000 ms window than the control words at lateral but not midline channel groups [midline: $F < 2$; lateral: $F(1, 29) = 7.41, p < 0.05$]. This negativity was larger over anterior than posterior channel-groups, reflected in a Completion x Position interaction at lateral channel-groups only [midline: $F < 2.5$; lateral: $F(1, 29) = 6.37, p < 0.05$]. Following Mention Contexts, anomalous words did not differ from control words in this time window [$F < 0.7$]. Directly comparing the anomalous sentences in No-Mention and Mention Contexts showed that anomalous words elicited a larger negativity following No-Mention than Mention Contexts [midline: $F(1, 29) = 8.07, p < 0.01$; lateral: $F(1, 29) = 7.55, p < 0.05$]. Directly comparing control completions in No-Mention and Mention Contexts showed that controls did not differ at the P600 [$Fs < 0.25$]. Table 4.6 provides an overview of the statistical analyses.
Table 4.6. Experiment 4: ANOVAs of mean ERP amplitudes in 350-1000 ms time window.

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### Left-Anterior
- Following No-Mention: 1,29, 11.58, <0.001
- Following Mention: 1,29, 4.95, <0.05
- Directly Comparing Anomalies: 1,29, 2.15
- Directly Comparing Contexts: 1,29, 0.10

### Midline-Anterior
- Following No-Mention: 1,29, 4.08, 0.05
- Following Mention: 1,29, 0.00
- Directly Comparing Anomalies: 1,29, 5.63, <0.05
- Directly Comparing Contexts: 1,29, 0.19

### Right-Anterior
- Following No-Mention: 1,29, 11.71, <0.01
- Following Mention: 1,29, 0.61
- Directly Comparing Anomalies: 1,29, 4.33, <0.05
- Directly Comparing Contexts: 1,29, 0.02

### Left-Posterior
- Following No-Mention: 1,29, 1.13
- Following Mention: 1,29, 4.11, 0.05
- Directly Comparing Anomalies: 1,29, 9.14, <0.01
- Directly Comparing Contexts: 1,29, 0.03

### Midline-Posterior
- Following No-Mention: 1,29, 0.45
- Following Mention: 1,29, 2.18
- Directly Comparing Anomalies: 1,29, 7.61, <0.01
- Directly Comparing Contexts: 1,29, 0.22

### Right-Posterior
- Following No-Mention: 1,29, 0.91
- Following Mention: 1,29, 1.89
- Directly Comparing Anomalies: 1,29, 6.23, <0.05
- Directly Comparing Contexts: 1,29, 0.02

### 4.3.3 Discussion

The goal of Experiment 4 was to replicate the effects of discourse context on the processing of semantically-anomalous predications while controlling for length of context. The results were consistent with the findings of Experiment 3: Anomalies following Mention Contexts elicited a P600 effect, while the same anomalies following No-Mention Contexts elicited a widespread negativity relative to control within the N400 window. These findings suggest that the trend towards an interaction between Context and Completion in Experiment 3 was genuine. Moreover, amount of context was not the critical factor in modulating the ERP effect across conditions in Experiment 3.
The results from Experiment 4 are consistent with the discourse-expectedness hypothesis. Figure 4.7 highlights the midline-posterior channel group and shows that the mean magnitude of the N400 effect (anomalous completion minus control completion; blue bars) was larger following No-Mention Contexts than when the same anomalous and control sentences followed Mention Contexts. Conversely, the mean magnitude of the P600 effect (red bars) was larger following Mention Contexts than when the same anomalous and control sentences followed No-Mention Contexts.

![Figure 4.7](image_url)

**Figure 4.7.** Experiment 4: Anomaly effects (Anomaly minus Control) at midline-posterior channel-group. (A) Following No-Mention Context. (B) Following Mention Context. Error bars indicate standard error.

The P600 effect elicited by Anomalies following Mention Context was accompanied by a concurrent negativity at left anterior channels. Both of these effects had similar temporal properties but opposite polarities (Figure 4.6B). Thus, it possible that they reflect two sides of a single dipole generator. Further studies are needed to confirm this hypothesis.

Following No-Mention Context, Anomalous words elicited a negativity that was significantly sustained over time and became increasingly anterior as the epoch progressed.
(Figure 4.6A). This result was not predicted. We do not know how this frontal negativity may be related to other similar findings. One possibility is that it is related to sustained frontal negativity effects found for referentially ambiguous nouns or pronouns (Van Berkum, Koornneef, Otten & Nieuwland, 2007). We will return to this idea below.

4.4 · General Discussion

We conducted two ERP studies to test the hypothesis that discourse-driven event-representations generate predictions about possible upcoming words, including the thematic role assignments those words will participate in, even in the absence of strong semantic attraction. Subjects read short stories that varied in context and concluded with either (1) a well-formed and plausible control sentence (e.g., “The planet was glowing …”) or (2) a sentence containing an animacy violation that set discourse-driven constraints against syntactic cues (e.g., “The planet was carrying …”). The semantically anomalous target sentences elicited P600 effects relative to controls when the critical word was expected in the discourse (Mention Context). In this situation, the prior discourse activated an event-representation that predicted, and could therefore easily integrate, the new word, but required a structural configuration different from that signaled by the syntactic cues (planet should be a Theme and carrying should take an animate Agent, specifically the student previously mentioned in the discourse). However, the same sentences elicited N400 effects when the discourse did not generate a prediction for the critical word (No-Mention Context).
4.4.1 · Language Comprehension Architecture

Our findings suggest that discourse-driven event-representations which establish thematic relations between content words may bias the comprehension system to interpret locally anomalous combinations of those words in ways that are plausible given the event-representation. In such cases, the system attempts to resolve the conflict between parallel processing streams via structural reprocessing instead of attempting a difficult semantic integration, thereby eliciting P600 rather than N400 effects. Here we outline how discourse might influence the interpretation of semantically anomalous predications in the current study via the building of event-representations. The essential ideas are (1) each sentence in a discourse incrementally elaborates an unfolding event-representation, and (2) event-representations retain their activation over the following discourse and thereby exert an anticipatory impact on upcoming input (see Nieuwland & Van Berkum, 2006 for a similar proposal). Consider Anomalous completions following Mention Context in Experiment 4 (Table 4.1). Here, the unfolding discourse establishes specific thematic role assignments for the content words that will later appear in the target sentence. In the first context sentence, semantic and syntactic cues conspire to establish a carry event-representation in which student is the Agent. The key outcome of the second sentence is that planet is assigned as Theme of looking. Processing of the third sentence begins without difficulty because planet is already given information and can be rapidly integrated into the current event-representation. However, the verb carrying does introduce processing difficulty. The system can potentially respond to this word in at least two ways. On the one hand, the syntactic cues indicate that planet is doing the carrying. Although planets can carry things (e.g., an atmosphere, life forms), planet is not an ideal Agent for this verb and should
therefore lead to a processing cost manifest in enhanced N400 if the semantic integration was pursued. Our results, however, suggest that semantic integration is not attempted.

An alternate explanation for this lack of N400 effect is that low-level semantic priming leads to a reduction in N400. This hypothesis would be consistent with a large number of studies that indicate word-elicited N400 effects are reduced by prior presentation of semantic associates or outright repetitions (e.g., Rugg, 1985; Anderson & Holcomb, 1995). Given that our target words were repeated within the Mention Context conditions, semantic priming could explain the reduction in N400 found for Anomaly completions following Mention Context. However, we emphasize that semantic priming may be subsumed by the discourse-expectedness hypothesis. We consider the event-representations discussed above to be the source of priming, encompassing both repetition and semantic priming.

Returning to the discourse-expectedness hypothesis, our findings suggest that instead of attempting semantic integration, the discourse-driven event-representations cause carrying to be rapidly recognized as an instantiation of the previously established carried-a-telescope event (Figure 4.7a), in which student has already been established as the Agent of carried (Figure 4.7b). Once carrying is recognized as such an instantiation, the event-representation influences the range of plausible thematic role assignments available for the word. More specifically, the previously established thematic role assignments are active in working memory and therefore compete against any alternative interpretations, such as the syntactically signaled assignment of planet as Agent (Figure 4.7c). We propose that in such cases of conflict, the syntactic representation is prone to collapse. Recall the previous discussion of syntactic cues being “fragile”, such that when they signal a thematic role
assignment that faces opposition from an established event-representation, the syntactic representation is interpreted as anomalous and thereby triggers structural reprocessing manifest in P600 (Kim & Sikos, 2011). In sum, the discourse-expectedness hypothesis is not only able to account for the modulation of N400, but also for the P600 findings, as well as for the tradeoff between these two ERP components and the processes underlying them. Semantic priming alone, on the other hand, does not account for the robust modulation of P600 effects found here.

Figure 4.7. Experiment 2: Conflicts between discourse-driven and syntactically-assigned thematic role assignments in semantically anomalous predications following Mention Context. Legend:

- **Verb** to **Verb** Co-indexing within event-representation
- **Noun** to **Verb** Strong thematic role assignment
- **Noun** to **Verb** Weak thematic role assignment

In equally rich discourse contexts that do not generate competition against the syntactically-signaled interpretation (i.e., No-Mention Contexts; Table 4.1), the unfolding event-representation is elaborated somewhat differently. Here, the first sentence establishes student as Agent of observed. The following sentence provides specific details that elaborate the event: she is coreferenced with student and looking is unified with

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observed — they are the same event. As above, the target sentence becomes problematic at
the anomalous word since planet is not a prototypical Agent for carrying. However,
contrary to the Mention Context, there is no specific sense of carrying that is currently
active. Therefore, although “The planet was carrying...” is a relatively difficult semantic
integration, there is no better alternative to pursue. In this case, the syntactic cues
successfully support the evaluation of an implausible interpretation (planet as Agent of
carrying), and the system attempts the difficult semantic integration that manifests in
N400.

Influence of Prediction. The parallel streams language comprehension architecture
proposed here is consistent with models of comprehension that incorporate a high degree
of prediction at multiple levels of representational abstraction during sentence processing,
and where context is crucial for anticipation and interpretation of upcoming semantic,
thematic, and syntactic content (Altmann, 1999; Altmann & Mirković, 2009; Elman, 1990).
Altmann and Mirković (2009) argue that thematic role assignments emerge from
prediction based on the interaction of world knowledge and the current discourse: “As a
sentence unfolds, conceptual entitles ‘receive’ event-specific roles only to the extent that
they are anticipated to take part in the event that the unfolding language describes” (600).
This is the result of pattern completion mechanisms that anticipate specific semantic
properties that are likely to characterize upcoming input (Altmann, 1999; Altmann &
Mirković, 2009; DeLong, Urbach & Kutas, 2005). Although the influence of context is
acknowledged in most constraint-based lexicalist models, it is often considered secondary
to lexical information; comprehension is thought to be “contextually constrained but
lexically dominated” (MacDonald, Pearlmutter & Seidenberg, 1994). The current results
extend the role of context in interpreting lexical information in constraint-based approaches.

4.4.2 · Semantic P600 Effects

The results of the current study may be related to so-called “semantic P600” findings, wherein semantic violations between verbs and their arguments elicit a P600 effect in relation to well-formed controls. Kuperberg (2007) suggests that there may be multiple triggers for semantic P600 effects, including the syntactic assignment of thematic roles that violates the verb’s selectional restrictions (e.g., animacy violation), the presence of semantic associations between a verb and its arguments that suggest an alternative combination to the one assigned by syntax (i.e., semantic attraction), and/or the presence of a discourse context that supports a representation of the predication that conflicts with syntactic cues. Kuperberg (2007) further proposes that a single trigger may be sufficient to elicit a P600 effect in some cases, while in others, multiple interacting factors may be required. The P600 elicited in the current study cannot be attributed to animacy violation or semantic association alone because each was held constant across anomalous conditions (No-Mention Context + Anomaly, Mention Context + Anomaly) and still resulted in a robust modulation of the P600. Instead, we manipulated expectations for thematic role assignments via contextual information alone. This does not necessarily entail, however, that factors like animacy do not exert an influence over the elicitation of P600 effects. It may be the case that a combination of animacy violation and discourse-driven prediction is 

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10 Our view is that animacy is a specific, particularly informative dimension of semantic attraction within a multidimensional semantic space. While the strongest form of semantic attraction occurs between a predicate and a prototypical role-filler (e.g., between ‘devour’ and ‘meal’), semantic attraction can also occur along the animacy dimension alone. Inanimate entities are generally more attractive Themes than Agents.
required for the system to respond to the semantically anomalous predications in the current study via structural reprocessing. For example, although our anomalous verbs (e.g., *carrying*) have strong preferences for animate Agents, this animacy violation only leads to P600 following Mention contexts. Therefore, it is possible the animacy violation leads the system to map the inanimate noun (e.g., *planet*) to the Theme role in both conditions, but that this prediction may need to be supported with additional discourse-driven expectations in order to collapse the local syntactic analysis and elicit P600. We leave it as an open question whether discourse expectedness without animacy violation is equally sufficient.

Apparently Conflicting Results. The proposed influence of context on the processing of semantically-anomalous predications might help explain some discrepancies in recent semantic P600 findings. Kuperberg et al. (2007) found that sentences like “Every morning at breakfast the eggs would *eat...*” elicit a P600 effect at the anomalous verb, while Experiments 1 and 2 finds that seemingly similar semantic anomalies (“The hearty meal would *devour...*”) elicit a left anterior negativity (LAN; Kim & Sikos, 2011). One potentially important difference between these studies is the amount of lead-in context. While the stimuli in Experiments 1 and 2 contained very little lead-in context prior to the anomaly, the Kuperberg stimuli included varying amounts of lead-in context, which may establish sufficient discourse expectations for biasing thematic role assignments. “Every morning at breakfast” may activate a salient semantic frame, which drives elaboration of a *breakfast-with-eggs* event-representation, including partial, predictive activation of likely thematic role assignments (e.g., *eggs* as a Theme of *eating* or *cooking*). When the syntactic cues in the subsequent clause assign *eggs* as Agent of *eat*, the prediction is violated, the syntactic
analysis collapses, and the system commits to structural reprocessing. Consistent with this hypothesis, Kuperberg (2007) mentions preliminary data indicating that removing the lead-in context resulted in no P600 effect at the anomalous verb. In a second condition which directly manipulated semantic attraction, sentences like “Every morning at breakfast, the eggs would plant ...” also elicited P600 effects (Kuperberg et al., 2007). The discourse-expectedness hypothesis can also account for this effect. When the syntactic analysis signals that eggs is the Agent of plant, it fails to integrate with the predicted breakfast-with-eggs event-representation and collapses. We predict that in a null context (e.g., “The eggs would plant...”), the event-representation would be less elaborated and therefore the lexico-syntactic analysis would face less semantic opposition. This may trigger semantic integration difficulty and lead to a classic N400 effect.

Stroud and Phillips (2011) report another apparent discrepancy in semantic P600 findings. They manipulated semantic attraction in Spanish and found that both Semantic Attraction stimuli (e.g., Spanish equivalent of “The warning was declaring...”) and No-Attraction stimuli (e.g., Spanish equivalent of “The apartment was declaring...”) elicited a P600-without-N400 effect pattern in relation to well-formed controls (e.g., Spanish equivalent of “The fireman was declaring...”). These results contradict the findings of Experiment 2 from Kim and Osterhout (2005), in which Semantic Attraction stimuli (e.g., “The hearty meal was devouring...”) elicited P600 effects while No-Attraction stimuli (e.g., “The dusty tabletops were devouring...”) elicited N400. Thus, the authors conclude that semantic attraction does not play a role in the resolution of such anomalies. However, each of the target sentences in Stroud and Phillips (2001) was preceded by a rich context sentence (e.g., Spanish equivalent of “After the fire, the fireman prepared a warning to
forbid entrance into the burnt apartment.”). The intended goals of embedding the target sentences into such context were 1) to increase naturalness, and 2) to reduce the contribution of lexical accessibility and lexical expectation on N400. However, this contextual information may have contributed to an unintended result — the establishment of discourse expectations for thematic role assignments. Therefore, like the Kuperberg et al. (2007) results and the current findings for anomalous predications following Mention-Context, the Stroud and Phillips (2001) findings are consistent with the discourse-expectedness hypothesis.

4.4.3 · Sustained Frontal Negativity

The sustained frontal negativity elicited by Anomalous target sentence verbs following No-Mention Contexts in Experiment 4 was unpredicted. It is not immediately clear how this frontal negativity may be related to other anterior negativities observed in language processing studies (Coulson et al., 1998; Fiebach et al., 2002; Gunter et al., 2000; King & Kutas, 1995; Osterhout & Mobley, 1995). One possibility is that it is related to recent work finding that sustained frontal negativity effects for referentially ambiguous nouns or pronouns (Nref) (Van Berkum et al., 2007; Nref effect; e.g., “David shot at John as he…”). They suggest that under such circumstances the Nref reflects an attempt to co-reference the ambiguous word (he) with one of two competing antecedents (David or John).

In Experiment 4, No-Mention Contexts contained a salient and Agentive noun (astronomy student). When the system subsequently encounters the syntactically-signaled but anomalous role assignment in the target sentence (planet as Agent of carrying), astronomy student may potentially act as a viable competitor (Figure 4.8). The system may
consequently attempt to reanalyze the anomaly in a way that is analogous to the referential ambiguity resolution reflected in Nref. In Experiment 3, on the other hand, No-Mention Contexts did not contain an animate noun. Thus, no prototypically Agentive noun is active in the event-representation to serve as a competitor to *planet* when the anomalous verb is encountered. Consequently, the system appears to take the anomaly at face value and instead pursues the unusual semantic integration (reflected in N400).

**No-Mention Context**

The [[astronomy student] observed] the night sky through a telescope. She was looking at a particularly radiant [[planet].

The [planet] was (carrying)...

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*Figure 4.8.* Experiment 2: Potential co-reference ambiguity in semantically anomalous predications following Mo-Mention Context. Legend:

- [verb] → [verb] Co-indexing within event-representation
- [noun] → [verb] Strong thematic role assignment
- [noun] → [verb] Weak thematic role assignment

Finally, as discussed above, Mention Contexts in both Experiment 3 and 4 clearly establish *astronomy student* as the Agent of the anomalous verb (*carrying*). Therefore, when syntactic cues subsequently assign *planet* as Agent, *planet* cannot compete with the discourse-established assignment, and the most efficient resolution to the conflict may be to treat it as combinatorily anomalous (reflected P600).
4.4.4 · Conclusions

The findings from Experiment 3 and 4 show that the processing of semantically-anomalous predications can be modulated by discourse context. Crucially, our manipulation involved creating contexts which pit discourse-driven constraints against syntactic cues. Anomalies elicited P600 effects relative to controls when they followed Mention Contexts (indicative of structural processing difficulty), but the same anomalies enhanced N400 when they followed No-Mention Contexts (suggesting semantic processing difficulty). Therefore, the results can be clearly attributed to the dynamic effects of discourse on word interpretation, such that each sentence in a discourse incrementally elaborates an unfolding event-representation and makes it more specific, thereby constraining the interpretation of subsequent input. These findings are consistent with previous research indicating that discourse context interacts with local linguistic cues. Furthermore, the results extend the research on semantic P600 effects and suggest that discourse-driven event-representations which establish thematic relations between content words may bias the comprehension system to interpret locally anomalous combinations of those words in ways that are plausible given the event-representation. The system therefore attempts to resolve the conflict via structural reprocessing instead of attempting a difficult semantic integration, thereby eliciting P600 rather than N400 effects. To our knowledge, this is the first direct evidence of semantic P600 effects being modulated by discourse context within subjects.

We have proposed an architecture in which language comprehension is served by multiple, partially independent yet interactive streams of processing that vie for influence over interpretation (Kim & Osterhout, 2005; Kim & Sikos, 2011) and in which context plays
an important constraining role. Earlier, related models have also argued for independent but interactive semantic and syntactic streams (MacDonald et al., 1994; Trueswell & Tanenhaus, 1994). However, these models assume that syntactically unambiguous cues dominate semantic cues (see Kim & Osterhout, 2005), and that lexical information dominates contextual constraints (MacDonald et al., 1994). The framework proposed here and elsewhere (Kuperberg, 2007; Altmann & Mirkovic, 2009) argues that syntactic and semantic processing often interact collaboratively but may conflict and vie for influence over interpretation. Several critical aspects of the view proposed here differ from previous constraint-based accounts: (1) there is a high degree of prediction at multiple levels of representational abstraction during sentence processing, (2) context is crucial for anticipation and interpretation of upcoming semantic, thematic, and syntactic content, and (3) the semantic stream may be privileged such that syntactic cues have a propensity to collapse in the face of direct opposition. Further research is needed to test and extend these hypotheses.
Chapter 5 · Overall Conclusions

We conducted four ERP studies to extend and clarify our understanding of the brain’s response to conflict between syntactic and semantic cues during sentence processing. Experiments 1 and 2 pit syntactic cues against semantic cues and manipulated the relative “strength” of those cues. The results indicate that the conflict’s outcome is determined by cue strength: when semantic cues are stronger, well-formed syntactic cues are perceived as anomalous, eliciting P600 effects; when syntactic cues are stronger, the anomaly is perceived as being semantic in nature, resulting in enhanced N400; when cues are evenly matched, anomalies elicit significantly reduced P600 effects (indicating the “resistance” of syntactic cues to reprocessing) and a robust left-anterior negativity (LAN), suggesting the recruitment of prefrontal executive control mechanisms.

Experiments 3 and 4 manipulated contextual information to test whether discourse activates structured event-representations within semantic knowledge. Results indicated that ERP effects elicited by critical verbs in semantically anomalous predications can be modulated by discourse context: sentences with local semantic anomalies elicited enhanced N400 when preceded by a “no-mention” context but P600 effects when preceded by a “previous-mention” context. These findings suggest that discourse activates structured event-representations within semantic knowledge that can "tip the balance" between syntactic and semantic processing streams, thereby influencing the outcome of the conflict.

Taken together, these findings suggest that syntactic and semantic information are processed in parallel streams that are fully-interactive, wherein the strength of cues influences the conflict’s outcome and determines which level is most affected by the conflict. Under normal conditions, streams converge on a single representation. However,
during conflict streams can vie for interpretive dominance — sometimes tipping in favor of semantic reanalysis (N400), sometimes toward structural reprocessing (P600), and occasionally caught between the two (LAN).

5.1 · Alternate Explanations

Although the results of this dissertation research are consistent with the parallel-streams model of language comprehension described above, other accounts might also explain these findings. Chapter 2 outlined several alternative explanations for “semantic P600” findings. How might they account for the current results?

5.1.1 · “Syntax-first” accounts

Arguably, the most dominant and influential model of language processing within psycholinguistic theory remains the view that syntactic analysis precedes and guides semantic interpretation (Frazier, 1987; 1989). On this account, incoming linguistic information is first parsed into a single rudimentary syntactic representation based on algorithmic rules that operate at the level of word categories and phrase structures only. The single syntactic parse is then passed on to the semantic processing module, which retrieves both lexically-specific semantic representations and contextual information, and plugs them into the syntactic parse. If there is a conflict between the syntactic analysis and lexical information, the syntactic parse is revised to some less frequent or dispreferred parse that is nevertheless consistent with the surface form (e.g., a garden path sentence).

Consequently, the syntax-first model incorrectly predicts that both Single-Edit-Repair (e.g., The hearty meal was devouring...) and Multiple-Edit-Repair (e.g., The hearty meal
would *devour*...) conditions in Experiments 1 and 2 should be processed in the same way, eliciting identical brain responses at the anomalous verb. Since both conditions are syntactically well-formed, they should not elicit any processing difficulty during the initial parsing stage. However, during the semantic processing stage, lexically-specific information is retrieved for *devour/devouring* and results in a conflict: the verb’s selectional restrictions require that its Agent must be animate. This would presumably elicit an enhanced N400 due to the increased semantic processing difficulty of attempting to interpret *meal* as Agent of the *devouring* event. Subsequently, on this account, the system might attempt to find a revised parse that is consistent with the surface form of the input. This increased processing load may be sufficient to elicit P600 effects. However, few syntax-first theories allow for well-formed syntactic cues to be completely overridden by conflicting semantic information. Consequently, one might argue that such an attempt would be “blocked” by the syntactic processing module, and therefore no P600 effects should be elicited in this model. In sum, most syntax-first models would predict N400 effects at the anomalous verb, while some might predict an initial N400 followed by a P600 effect. Contrary to either of these predictions, the results of Experiments 1 and 2 show that the Single-Edit-Repair and Multiple-Edit-Repair conditions engender qualitatively different brain effects: the Single-Edit-Repair condition enhances P600 only, while the Multiple-Edit-Repair condition elicits LAN only. Neither condition enhances N400.

For Experiments 3 and 4, the syntax-first account incorrectly predicts that anomalous completion sentences should be processed identically (at least initially) regardless of which discourse context precedes the anomaly. For example, in Experiment 3, sentences like, “The bacon was *leaving*...” are syntactically well-formed and should therefore cause no
processing difficulty in the initial parsing stage. However, subsequent semantic processing leads to a conflict because of the animacy violation (i.e., *leaving* requires an animate Agent). As in Experiments 1 and 2, the anomaly should therefore elicit N400 effects in both contexts because of increased semantic processing of attempting to interpret *bacon* as an animate Agent. Since contextual information is incorporated within the semantic processing module, some syntax-first models may predict subsequent differences in brain effects due to Mention vs. No-Mention contexts (possibly predicting P600 for Mention context). However, as discussed above, most syntax-first models would not allow for discourse information to override well-formed syntactic cues and would therefore predict no P600 effects for either context. Contrary to these predictions, the results of Experiments 3 and 4 show that Anomalies following Mention Contexts do not elicit N400. Instead, they enhance P600 only. In short, discourse context modulates the processing of anomalous completions, engendering qualitatively different brain effects.

More subtle syntax-first models (e.g., eADM; Bornkessel & Schlesewsky, 2006; Bornkessel-Schlesewsky & Schlesewsky, 2008, 2009) lead to somewhat different predictions, but nevertheless fail to account for the current results. According to the eADM account, a “compute prominence/linking” stage determines the verb’s argument structure and assigns thematic roles to sentential arguments (independently of lexical-semantic associations, contextual information, or world knowledge), while a parallel “plausibility processing” stream computes the most likely verb-argument combination. Problems within either of these streams are thought to elicit N400 effects. In a subsequent stage of processing, the outputs from each stream are integrated in a “generalized mapping” process, wherein a conflict between outputs leads to enhanced P600 effects. Note that this
explanation suggests that the eliciting conditions for P600 effects should include phenomena beyond structural processing difficulty.

This account would incorrectly predict that both the Single-Edit-Repair and Multiple-Edit-Repair conditions in Experiments 1 and 2 should elicit P600 effects, rather than the qualitatively different brain effects found here (P600 and LAN, respectively). This is due to the fact that both conditions contain identical content words and identical prominence/linking information (resulting in a meal = Agent interpretation), which would then conflict with the most plausible thematic role assignment (meal = Theme) during the subsequent generalized mapping stage.

The eADM also makes incorrect predictions for Experiments 3 and 4. On this account, anomalous completion sentences should elicit N400 regardless of the preceding discourse context because planet and carrying do not form a plausible combination of open class words. Furthermore, the output of the plausibility stage would conflict with the thematic role assignments computed in the parallel prominence/linking stage, leading to P600 effects following both contexts. The findings described in Chapter 4 contradict these predictions.

5.1.2 · Alternate parallel-streams accounts

The Monitoring Theory (Kolk et al., 2003; Van Herten et al., 2005, 2006; Van de Meerendonk et al., 2009, 2010) suggests that a plausibility heuristic pursues the most plausible thematic relationship between content words in a parallel but separate stream from algorithmic syntactic analysis. Conflicts between these streams (or between other types of information; e.g., semantic vs. orthographic representations) are thought to trigger
a general cognitive monitoring process reflected in P600 effects. Therefore, the Monitoring Theory also makes incorrect predictions: both the Single-Edit-Repair and Multiple-Edit-Repair conditions in Experiments 1 and 2 should elicit P600 effects, since they both contain conflicts between a plausible combination of content words (*meal, devour/devouring*) and the thematic roles assigned by the well-formed syntactic cues. However, more recent formulations of this account suggest that such monitoring processes are only triggered by “strong conflicts”; “weaker” conflicts are thought to be resolved via semantic integration, reflected in N400 (Van de Meerendonk et al., 2010). While it is possible that the strength of conflict between streams differed across conditions in Experiments 1 and 2, thereby modulating the current ERP effects, it could be argued that the Multiple-Edit-Repair condition created a stronger conflict than the Single-Edit-Repair condition. Therefore, more recent versions of the Monitoring Theory might predict that the Multiple-Edit-Repair condition should elicit P600 effects, while the Single-Edit-Repair condition should enhance N400. The results from Experiment 1 and 2, however, show that the Single-Edit-Repair condition enhanced P600, while the Multiple-Edit-Repair condition elicits LAN. Neither condition enhances N400. Similarly, the Monitoring Theory predicts that anomalous completion sentences in Experiments 3 and 4 should elicit P600 effects, regardless of prior context, because the output of the plausibility heuristic (*bacon* is not an appropriate Agent for *leaving*) conflicts with the thematic role assignment driven by the syntactic analysis (*bacon* = Agent). Again, the findings described in Chapter 4 contradict these predictions.

The continued analysis account (Kuperberg, 2007; Kuperberg et al., 2008), on the other hand, does a better job accounting for the current results. In this model, language comprehension is served by a semantic memory-based stream that computes lexical
associations between content words, and one or more combinatorial streams that process morphosyntactic information as well as semantic and thematic constraints. Conflict between the output of these streams results in a continued combinatorial analysis, reflected in P600. Since a number of interacting factors can contribute to producing P600 effects in this account (including lexico-semantic association, animacy violation, thematic structure violation, semantic attraction, and contextual information), many of the current findings can be accounted for.

In the Single-Edit-Repair condition in Experiments 1 and 2, strong lexical associations between content words (e.g., meal, devour/devouring) lead to thematic role mappings within the semantic memory-based system that conflict with the mappings driven by morphosyntactic information in the combinatorial stream. This results in continued combinatorial analysis and elicits P600. However, this model does not account for differences in strength of syntactic cues and therefore does not explain the LAN effects found for the Multiple-Edit-Repair condition.

The results of Experiments 3 and 4, on the other hand, can be accounted for by the continued analysis account. Contextual information, including discourse context, is thought to be incorporated as quickly as syntactic and/or semantic information. Therefore, Mention Contexts can influence the processing of semantic anomalies (e.g., The bacon was leaving...) in at least two ways. First, Mention Contexts might lead to semantic associations between bacon and leaving that increases the likelihood that the system registers a conflict between the thematic roles assigned by syntactic cues and those established by discourse. Second, context can introduce sufficient syntactic complexity to "bias participants away from assigning thematic roles on the basis of syntactic rules and towards paying relatively more
attention to coherent semantic associative relationships” (Kuperberg, 2007, p. 36). Both of these circumstances would increase the likelihood of conflict between representations, resulting in P600. Since No-Mention Contexts do not create such semantic associations between bacon and leaving, they should not lead to conflicts between streams. Therefore, the well-formed syntactic cues are honored, resulting in a difficult semantic integration and leading to N400 effects.

Finally, the processing competition account (Hagoort, 2003, 2005; Hagoort et al., 2009) overlaps considerably with both the semantic attraction hypothesis (Kim & Osterhout, 2005) and the discourse-expectedness hypothesis (Kim & Sikos, 2011) that served as a theoretical foundation for the research presented here. In all these account, the language processing system is 1) fully interactive and parallel, 2) information from one stream can influence the processing at other levels, and 3) the processing level with the strongest cues imposes an extra processing load at the level with the weaker cues. Therefore, the current data can be best explained by fully-interactive models of language processing. Alternative explanations that assume stage-based, syntax-first processing, monitoring processes, or continued analysis either make predictions that are inconsistent with the data presented here, or they do not fully account for all the findings. Furthermore, these fully-interactive models have the added benefit that they maintain the classic distinction between the N400 and P600 as indices of semantic processing and structural processing, respectively.
5.2 · Summary

These findings provide insights into issues in linguistic theory and psycholinguistic models of language processing, and advance our understanding of how people make sense of conflicting information during language comprehension.

Taken together, the results of these four experiments can be synthesized into conclusions that are relevant for interactions at the syntax-semantics interface. “Semantic attraction” and “discourse attraction” may each activate event-representations with strong expectations for thematic role assignments. Consequently, if the comprehension system is faced with well-formed syntactic cues that conflict with the unfolding event-representation based on either world knowledge (e.g., “The hearty meal was devouring...”) and/or the current discourse context (e.g., “The planet was carrying...”), it appears that the system will privilege the predicted role assignments and treat the syntax as anomalous. In other words, in both semantic attraction and discourse attraction, we can blame the problem on the structural representation of the event, and can repair the problem by exchanging the implausible argument with a highly plausible argument in our immediately active set of players.

The cumulative findings of this dissertation are consistent with the hypothesis that language comprehension involves multiple, parallel processing streams that interact incrementally. Under normal conditions, streams converge on a single representation. However, streams can vie for dominance during conflict — sometimes tipping in favor of semantic reanalysis (N400), sometimes toward structural reprocessing (P600), and occasionally caught between the two (LAN). These findings also suggest that the “semantic P600” label is a misnomer. Instead, it appears that when strong semantic cues are at odds
with well-formed syntactic cues, the comprehension system often perceives the structural cues as being anomalous, thereby triggering P600 effects.

These findings extend our understanding of the complex interaction between various forms of information during on-line sentence processing and suggest a model that differs from previous accounts in several critical respects: 1) prediction plays a key role at multiple levels of representational abstraction, 2) no stream is dominant over another except insofar as one is more predictive in a given situation, 3) syntactic cues may have a propensity to “surrender” in the face of strong opposition, 4) context is crucial for anticipation and interpretation of upcoming linguistic content. In conclusion, the brain appears to strive continuously to find the best articulation of the current input, the context that is relevant at that moment, and world knowledge and experience, in order to form intelligent and evolving generalizations across rich knowledge stores in real time.
References


Figure A.1. Experiment 1. Grand-average ERPs at 30 selected channel locations for control (black), Single-Edit-Repair (red), and Multiple-Edit-Repair sentences (blue). Positive voltage is plotted down. Onset of the target verbs is indicated by the vertical bar (0 ms). Waveforms are filtered (12 Hz high cutoff) for presentation purposes only.
Figure A.2. Experiment 2. Grand-average ERPs at 30 selected channel locations for control (black), Single-Edit-Repair (red), and Multiple-Edit-Repair sentences (blue). Positive voltage is plotted down. Onset of the target verbs is indicated by the vertical bar (0 ms). Waveforms are filtered (12 Hz high cutoff) for presentation purposes only.
Figure A.3. Experiment 3. Grand-average ERPs at six channel-groups used in data analysis. (Top) ERPs at critical verbs following No-Mention Context: control (black), anomaly (blue). (Bottom) ERPs at critical verbs following Mention Context: control (black), anomaly (red). Positive voltage is plotted down. Onset of the target verbs is indicated by the vertical bar (0 ms). Waveforms are filtered (12 Hz high cutoff) for presentation purposes only.
Figure A.4. Experiment 4. Grand-average ERPs at six channel-groups used in data analysis. (Top) ERPs at critical verbs following No-Mention Context: control (black), anomaly (blue). (Bottom) ERPs at critical verbs following Mention Context: control (black), anomaly (red). Positive voltage is plotted down. Onset of the target verbs is indicated by the vertical bar (0 ms). Waveforms are filtered (12 Hz high cutoff) for presentation purposes only.
<table>
<thead>
<tr>
<th>Table A.1. Experimental stimuli for Experiment 1.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. Cleopatra’s beauty was admired always.</td>
</tr>
<tr>
<td>1b. Cleopatra’s beauty was admiring many people.</td>
</tr>
<tr>
<td>1c. Cleopatra’s beauty would admire many people.</td>
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<tr>
<td>2a. The winning lottery numbers had been announced by the TV news.</td>
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<tr>
<td>2b. The winning lottery numbers had been announcing the TV news.</td>
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<tr>
<td>2c. The winning lottery numbers would announce the TV news.</td>
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<tr>
<td>3a. Frank’s loan application had been approved anyways.</td>
</tr>
<tr>
<td>3b. Frank’s loan application had been approving by the bank.</td>
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<tr>
<td>3c. Frank’s loan application would approve by the bank.</td>
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<tr>
<td>4a. The library books had been borrowed by the graduate student.</td>
</tr>
<tr>
<td>4b. The library books had been borrowing the graduate student.</td>
</tr>
<tr>
<td>4c. The library books would borrow the graduate student.</td>
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<tr>
<td>5a. The simple coffin was buried at the church.</td>
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<tr>
<td>5b. The simple coffin was burying the villagers.</td>
</tr>
<tr>
<td>5c. The simple coffin should bury the villagers.</td>
</tr>
<tr>
<td>6a. Carrie’s morning meeting was canceled by the boss.</td>
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<tr>
<td>6b. Carrie’s morning meeting might cancel as expected.</td>
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<tr>
<td>6c. Carrie’s morning meeting might cancel as expected.</td>
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<tr>
<td>7a. The roast lamb had been carved by a servant.</td>
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<tr>
<td>7b. The roast lamb had been carving by a servant.</td>
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<tr>
<td>7c. The roast lamb might carve by a servant.</td>
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<tr>
<td>8a. The Queen’s 80th birthday was celebrated by thousands of people.</td>
</tr>
<tr>
<td>8b. The Queen’s 80th birthday was celebrating expensively.</td>
</tr>
<tr>
<td>8c. The Queen’s 80th birthday would celebrate expensively.</td>
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<tr>
<td>9a. The bubblegum had been chewed by the boy.</td>
</tr>
<tr>
<td>9b. The bubblegum had been chewing by the boy.</td>
</tr>
<tr>
<td>9c. The bubblegum should chew by the boy.</td>
</tr>
<tr>
<td>10a. The firewood had been chopped by Jen’s grandfather.</td>
</tr>
<tr>
<td>10b. The firewood had been chopping poorly.</td>
</tr>
<tr>
<td>10c. The firewood could chop poorly.</td>
</tr>
<tr>
<td>11a. Billy’s unruly hair was combed by his mother to one side.</td>
</tr>
<tr>
<td>11b. Billy’s unruly hair was combing his mother to one side.</td>
</tr>
<tr>
<td>11c. Billy’s unruly hair should comb his mother to one side.</td>
</tr>
<tr>
<td>12a. The musical piece was composed in a dream.</td>
</tr>
<tr>
<td>12b. The musical piece was composing by Beethoven in 1799.</td>
</tr>
<tr>
<td>12c. The musical piece would compose by Beethoven in 1799.</td>
</tr>
<tr>
<td>13a. A tiny spy camera was concealed by the agent inside a flowerpot.</td>
</tr>
<tr>
<td>13b. A tiny spy camera was concealing by the agent inside a flowerpot.</td>
</tr>
<tr>
<td>13c. A tiny spy camera would conceal by the agent inside a flowerpot.</td>
</tr>
<tr>
<td>14a. The sin had been confessed on Sunday.</td>
</tr>
<tr>
<td>14b. The sin had been confessing by the repentant Catholic.</td>
</tr>
<tr>
<td>14c. The sin would confess by the repentant Catholic.</td>
</tr>
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<td>15a. The girl’s disease was cured by a simple treatment.</td>
</tr>
<tr>
<td>15b. The girl’s disease was curing a simple treatment.</td>
</tr>
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<td>15c. The girl’s disease should cure a simple treatment.</td>
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<td>16b. The pizza had been delivering once more.</td>
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<td>19b. The hearty meal was devouring by the kids.</td>
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The homicide case had been investigating diligently.

The homicide case had been investigated by the FBI.

The useful new gadget had been invented by a bored waiter.

The useful new gadget could invent by a bored waiter.

The homicide case had been investigated by the FBI.

The homicide case should investigate diligently.
Ten new trees might plant on the hillside.

Ten new trees had been planting on the hillside.

The men’s faces could photograph by a security camera.

The men’s faces had been photographing by a security camera.

The men’s faces had been photographed by a security camera.

A faint light was perceived underwater.

Thirty pounds of potatoes had been peeling by the cooks.

Thirty pounds of potatoes had been peeling carefully.

The portrait of Napoleon had been painted by a Dutch artist.

The portrait of Napoleon could paint by a Dutch artist.

The phone bill might pay his roommate.

The phone bill might have paid quickly.

The portrait of Napoleon had been painting by a Dutch artist.

The portrait of Napoleon could paint by a Dutch artist.

Three more martinis would order by Laurie’s sister.

Three more martinis would be ordering by Laurie’s sister.

The rare bird’s behavior was observed by the biologists.

The rare bird’s behavior was observing by the biologists.

The rare bird’s behavior would observe by the biologists.

The sealed envelope would open the judge.

The sealed envelope was opening the judge.

The sealed envelope would be opened without permission.

The sealed envelope was opening without permission.

The portrait of Napoleon had been painted by a Dutch artist.

The portrait of Napoleon could paint by a Dutch artist.

The phone bill had been paid quickly.

The phone bill had been paying his roommate.

The portrait of Napoleon had been painting by a Dutch artist.

The portrait of Napoleon could paint by a Dutch artist.

Olson’s bulging suitcase had been packed for the trip.

Olson’s bulging suitcase had been packing his assistant.

Olson’s bulging suitcase could pack his assistant.

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Thirty pounds of potatoes might peel by the cooks.

A faint light was perceived underwater.

A faint light was perceiving by the rescue workers.

A faint light could perceive by the rescue workers.

The men’s faces had been photographed by a security camera.

The men’s faces could photograph by a security camera.

The men’s faces had been photographing by a security camera.

Ten new trees had been planted by the Forestry Service.

Ten new trees had been planting on the hillside.

Ten new trees might plant on the hillside.
<p>| | |</p>
<table>
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<tr>
<td>61c.</td>
<td>A new medication could prescribe the physician.</td>
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<tr>
<td>62a.</td>
<td>The elevator button had been pressed by the attendant.</td>
</tr>
<tr>
<td>62b.</td>
<td>The elevator button had been pressing slowly.</td>
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</tr>
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<td>65a.</td>
<td>The tragic mistake was regretted years later.</td>
</tr>
<tr>
<td>65b.</td>
<td>The tragic mistake was regretting by Erika for many years.</td>
</tr>
<tr>
<td>65c.</td>
<td>The tragic mistake might regret by Erika for many years.</td>
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<td>66a.</td>
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<td>66b.</td>
<td>Wilson's unreasonable proposal was rejecting by the boss.</td>
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<td>Martin's tonsils had been removed at the hospital.</td>
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<td>The tangled part of the wood was sanded by the carpenter.</td>
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<td>An appointment was scheduled by the secretary.</td>
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<td>72a.</td>
<td>Larry's note had been scribbled with haste.</td>
</tr>
<tr>
<td>72b.</td>
<td>Larry's note had been scribbling his wife.</td>
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<td>Larry's note should scribble his wife.</td>
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<td>73a.</td>
<td>The grimy pots and pans had been scrubbed by the dishwashers.</td>
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<td>74a.</td>
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<td>An urgent message had been sent again.</td>
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<tr>
<td>75b.</td>
<td>An urgent message had been sending by the ambassador to the President.</td>
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<td>76a.</td>
<td>The appetizers had been served before the meal.</td>
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<tr>
<td>79a.</td>
<td>A drawing of the house had been sketched again.</td>
</tr>
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<td>A drawing of the house had been sketching again.</td>
</tr>
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96b. Tamara's birthday gift had been wrapped yesterday.
95b. The murder could witness by the three bystanders.
94b. An illegal weapon had been smuggled only once.
93b. Janet's houseplants watering too much.
92b. The alarm clock had been unlocking late at night.
91b. The overgrown shrubs were trimming regularly.
90b. The alarm clock was unplug accidently.
89b. The overgrown shrubs were being trimmed by a gardener.
88b. The new snowball had been tossed in anger.
87b. The unpleasant cough syrup was swallowed by the boy.
86b. The unpleasant cough syrup could swallow the boy.
85b. The unpleasant cough syrup was swallowing the boy.
84b. The unpleasant cough syrup was swallowed by the boy.
83b. The strange mystery had been solved at the station.
82b. The strange mystery had been solving the detectives.
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80a. The strange mystery had been solved by the detectives.
Table A.2. Experimental stimuli for Experiment 2.

1a. Cleopatra's beauty would be admired always. Control
1b. Cleopatra's beauty would be admiring many people. Single-Edit-Repair
1c. Cleopatra's beauty would admire many people. Multiple-Edit-Repair
2a. The winning lottery numbers would be announced on the TV news. Control
2b. The winning lottery numbers would be announcing the TV news. Single-Edit-Repair
2c. The winning lottery numbers would announce the TV news. Multiple-Edit-Repair
3a. Frank's loan application would be approved anyways. Control
3b. Frank's loan application would be approving by the bank. Single-Edit-Repair
3c. Frank's loan application would approve by the bank. Multiple-Edit-Repair
4a. The library books would be borrowed by the graduate student. Control
4b. The library books would be borrowing the graduate student. Single-Edit-Repair
4c. The library books would borrow the graduate student. Multiple-Edit-Repair
5a. The simple coffin should be buried at the church. Control
5b. The simple coffin should be burying the villagers. Single-Edit-Repair
5c. The simple coffin should bury the villagers. Multiple-Edit-Repair
6a. Carrè's morning meeting might be canceled by the boss. Control
6b. Carrè's morning meeting might be canceling as expected. Single-Edit-Repair
6c. Carrè's morning meeting might cancel as expected. Multiple-Edit-Repair
7a. The roast lamb might be carved by a servant. Control
7b. The roast lamb might be carving by a servant. Single-Edit-Repair
7c. The roast lamb might carve by a servant. Multiple-Edit-Repair
8a. The Queen's 80th birthday would be celebrated by thousands of people. Control
8b. The Queen's 80th birthday would be celebrating expensively. Single-Edit-Repair
8c. The Queen's 80th birthday would celebrate expensively. Multiple-Edit-Repair
9a. The bubblegum should be chewed carefully. Control
9b. The bubblegum should be chewing carefully. Single-Edit-Repair
9c. The bubblegum should chew carefully. Multiple-Edit-Repair
10a. The firewood should be chopped before bringing it inside. Control
10b. The firewood should be chopping before bringing it inside. Single-Edit-Repair
10c. The firewood should chop before bringing it inside. Multiple-Edit-Repair
11a. Billy’s unruly hair could be combed by his mother. Control
11b. Billy’s unruly hair could be combing his mother. Single-Edit-Repair
11c. Billy’s unruly hair could comb his mother. Multiple-Edit-Repair
12a. The musical piece would be composed in a dream. Control
12b. The musical piece would be composing by Beethoven in 1799. Single-Edit-Repair
12c. The musical piece would compose by Beethoven in 1799. Multiple-Edit-Repair
13a. A tiny spy camera could be concealed by the agent inside a flowerpot. Control
13b. A tiny spy camera could be concealing by the agent inside a flowerpot. Single-Edit-Repair
13c. A tiny spy camera could conceal by the agent inside a flowerpot. Multiple-Edit-Repair
14a. The sin would be confessed on Sunday. Control
14b. The sin would be confessing by the repentant Catholic. Single-Edit-Repair
14c. The sin would confess by the repentant Catholic. Multiple-Edit-Repair
15a. The girl's disease should be cured by a new treatment. Control
15b. The girl's disease should be curing a new treatment. Single-Edit-Repair
15c. The girl's disease should cure a new treatment. Multiple-Edit-Repair
16a. The pizza could be delivered by Antonio himself. Control
16b. The pizza could be delivering once more. Single-Edit-Repair
16c. The pizza could deliver once more. Multiple-Edit-Repair
17a. The embarrassing allegations might be denied by the mayor. Control
17b. The embarrassing allegations might be denying by the mayor. Single-Edit-Repair
17c. The embarrassing allegations might deny by the mayor. Multiple-Edit-Repair
18a. The sleek new building would be designed by a team of German architects. Control
18b. The sleek new building would be designing a team of German architects. Single-Edit-Repair
18c. The sleek new building would design a team of German architects. Multiple-Edit-Repair
19a. The hearty meal could be devoured with gusto. Control
19b. The hearty meal could be devouring by the kids. Single-Edit-Repair
19c. The hearty meal could devour by the kids. Multiple-Edit-Repair
The homicide case should be investigated by the FBI.

A useful new gadget could be invented by the bored waiter.

Hathaway's gigantic fortune might be inherited by his daughters.

Poisonous fumes could be inhaled by the firefighters.

The noises in the attic might hear nightly.

The wheat crops would be harvesting by the local farmers.

Several important topics would be discussed despite the weather.

Lisa's phone could be disconnected next month.

A man's signature could be forging the lawyers.

Several important topics would be discussing despite the weather.

The movie would be directed professionally.

The final exams should be graded at school.

The value of the jewels could be estimated by the dealer.

A hedgehog could be running in front of the house.

The noises in the attic might be heard by the boys.

The leaves would be floating in the river.

The left over food would be discarded wastefully.

The noises in the attic might be heard nightly.

The wheat crops would be harvested after the rain.

The noises in the attic might be heard by the boys.

The leave would be floating in the river.

The noises in the attic might be heard nightly.

The leaves would be floating in the river.

The noises in the attic might be heard by the boys.

The leaves would be floating in the river.

The leave would be floating in the river.

The noises in the attic might be heard nightly.

The leaves would be floating in the river.

The noises in the attic might be heard nightly.
40a. Mark’s wrinkly shirts should be ironed by his mother.  
40b. Mark’s wrinkly shirts should be ironing by his mother.  
40c. Mark’s wrinkly shirts should iron by his mother.  
41a. An important lesson could be learned in space.  
41b. An important lesson could be learning in space.  
41c. An important lesson could learn in space.  
42a. The cheap products would be manufactured by a Chinese firm.  
42b. The cheap products would be manufacturing a Chinese firm.  
42c. The cheap products would manufacture a Chinese firm.  
43a. The height of the bookcase should be measured incorrectly.  
43b. The height of the bookcase should be measuring by a carpenter.  
43c. The height of the bookcase should measure by a carpenter.  
44a. The vocabulary list would be memorized well.  
44b. The vocabulary list would be memorizing well.  
44c. The vocabulary list would memorize well.  
45a. The bathroom floor would be mopped regularly in the future.  
45b. The bathroom floor would be mopping by a janitor.  
45c. The bathroom floor would mop by a janitor.  
46a. Mother Theresa’s death should be mourned by millions of people.  
46b. Mother Theresa’s death should be mourning millions of people.  
46c. Mother Theresa’s death should mourn millions of people.  
47a. Patty’s overgrown lawn should be mowed this week.  
47b. Patty’s overgrown lawn should be mowing the boy next door.  
47c. Patty’s overgrown lawn should mow the boy next door.  
48a. Several spelling errors should be noticed by the careful editor.  
48b. Several spelling errors should be noticing the careful editor.  
48c. Several spelling errors should notice the careful editor.  
49a. The rare bird’s behavior would be observed by the biologists.  
49b. The rare bird’s behavior would be observing by the biologists.  
49c. The rare bird’s behavior would observe by the biologists.  
50a. The sealed envelope could be opened without permission.  
50b. The sealed envelope could be opening the judge.  
50c. The sealed envelope could open the judge.  
51a. Three more martinis should be ordered repeatedly.  
51b. Three more martinis should be ordering by Laurie’s sister.  
51c. Three more martinis should order by Laurie’s sister.  
52a. Their secret conversation might be overheard by a nosey neighbor.  
52b. Their secret conversation might be overhearing by a surprised neighbor.  
52c. Their secret conversation might overhear by a surprised neighbor.  
53a. Olson’s bulging suitcase could be packed for the trip.  
53b. Olson’s bulging suitcase could be packing his assistant.  
53c. Olson’s bulging suitcase could pack his assistant.  
54a. The phone bill might be paid quickly.  
54b. The phone bill might be paying his roommate.  
54c. The phone bill might pay his roommate.  
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55b. The portrait of the president might be painting by a Dutch artist.  
55c. The portrait of the president might paint by a Dutch artist.  
56a. Thirty pounds of potatoes might be peeled carefully.  
56b. Thirty pounds of potatoes might be peeling by the cooks.  
56c. Thirty pounds of potatoes might peel by the cooks.  
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65b. The tragic mistake might be regretting by Erika for many years.  
65c. The tragic mistake might regret by Erika for many years.  
66a. Wilson’s unreasonable proposal should be rejected at the hospital.  
66b. Wilson’s unreasonable proposal should be rejecting by the boss.  
66c. Wilson’s unreasonable proposal should reject by the boss.  
67a. Martin’s tonsils could be removed at the hospital.  
67b. Martin’s tonsils could be removing at the hospital.  
67c. Martin’s tonsils could remove at the hospital.  
68a. The broken television could be repaired by the technician.  
68b. The broken television could be repairing the technician.  
68c. The broken television could repair the technician.  
69a. The bank might be robbed repeatedly.  
69b. The bank might be robbing two masked men.  
69c. The bank might rob two masked men.  
70a. The rough part of the wood could be sanded by the carpenter.  
70b. The rough part of the wood could be sanding to perfection.  
70c. The rough part of the wood could sand to perfection.  
71a. An appointment could be scheduled by the secretary.  
71b. An appointment could be scheduling by the secretary.  
71c. An appointment could schedule by the secretary.  
72a. Larry’s note should be scribbled with haste.  
72b. Larry’s note should be scribbling his wife.  
72c. Larry’s note should scribble his wife.  
73a. The grimy pots and pans should be scrubbed by the dishwashers.  
73b. The grimy pots and pans should be scrubbing the dishwashers.  
73c. The grimy pots and pans should scrub the dishwashers.  
74a. The stolen artwork might be seized by the border police.  
74b. The stolen artwork might be seizing without warning.  
74c. The stolen artwork might seize without warning.  
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75b. An urgent message could be sending by the ambassador to the President.  
75c. An urgent message could send by the ambassador to the President.  
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76b. The appetizers should be serving before the meal.  
76c. The appetizers should serve before the meal.  
77a. The man’s beard could be shaved twice a day.  
77b. The man’s beard could be shaving twice a day.  
77c. The man’s beard could shave twice a day.  
78a. The legal contract would be signed by the family.  
78b. The legal contract would be signing falsely.  
78c. The legal contract would sign falsely.  
79a. A drawing of the house might be sketched again.  
79b. A drawing of the house might be sketching again.  
79c. A drawing of the house might sketch again.
80a. The fresh warm bread should be sliced with love.
80b. The fresh warm bread should be slicing by the baker into halves.  
80c. The fresh warm bread should slice by the baker into halves.  
81a. An illegal weapon might be smuggled only once.  
81b. An illegal weapon might be smuggling only once.  
81c. An illegal weapon might smuggle only once.  
82a. The old lady’s purse might be snatched with speed.  
82b. The old lady’s purse might be snatching a kid.  
82c. The old lady’s purse might snatch a kid.  
83a. The strange mystery might be solved at the station.  
83b. The strange mystery might be solving the detectives.  
83c. The strange mystery might solve the detectives.  
84a. All of her money would be spent before the wedding.  
84b. All of her money would be spending before the wedding.  
84c. All of her money would spend before the wedding.  
85a. The unpleasant cough syrup could be swallowed by the boy.  
85b. The unpleasant cough syrup could be swallowing the boy.  
85c. The unpleasant cough syrup could swallow the boy.  
86a. A wet snowball might be tossed in anger.  
86b. A wet snowball might be tossing by the girls through the window.  
86c. A wet snowball might toss by the girls through the window.  
87a. The overgrown shrubs should be trimmed by a gardener.  
87b. The overgrown shrubs should be trimming regularly.  
87c. The overgrown shrubs should trim regularly.  
88a. The car door would be unlocked by the child.  
88b. The car door would be unlocking late at night.  
88c. The car door would unlock late at night.  
89a. The alarm clock should be unplugged accidentally.  
89b. The alarm clock should be unplugging accidentally.  
89c. The alarm clock should unplug accidentally.  
90a. The club’s rules would be violated only twice.  
90b. The club’s rules would be violating Richard.  
90c. The club’s rules would violate Richard.  
91a. The popular amusement park could be visited daily.  
91b. The popular amusement park could be visiting by millions of tourists each year.  
91c. The popular amusement park could visit by millions of tourists each year.  
92a. Wendy’s muddy car should be washed wearily.  
92b. Wendy’s muddy car should be washing the boys.  
92c. Wendy’s muddy car should wash the boys.  
93a. Janet’s houseplants would be watered by her neighbor.  
93b. Janet’s houseplants would be watering too much.  
93c. Janet’s houseplants would water too much.  
94a. The dusty tabletops would be wiped thoroughly.  
94b. The dusty tabletops would be wiping thoroughly.  
94c. The dusty tabletops would wipe thoroughly.  
95a. The murder might be witnessed even in the dark.  
95b. The murder might be witnessing by the three bystanders.  
95c. The murder might witness by the three bystanders.  
96a. Tamara’s birthday gift should be wrapped yesterday.  
96b. Tamara’s birthday gift should be wrapping yesterday.  
96c. Tamara’s birthday gift should wrap yesterday.
### Table A.3. Experimental stimuli for Experiment 3.

<table>
<thead>
<tr>
<th></th>
<th>Context and Anomaly</th>
<th>Mention Context +</th>
<th>No-Mention Context +</th>
<th>Anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Jenny broke her reading glasses this morning. She couldn’t see the funny cartoon I came across in the paper. The cartoon was seeing the refugees.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>1b</td>
<td>A cartoon appeared in the paper today. The cartoon was seeing the refugees.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>1c</td>
<td>Jenny broke her reading glasses this morning. She couldn’t see the funny cartoon I came across in the paper. The cartoon was mocking local politicians.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Control</td>
</tr>
<tr>
<td>1d</td>
<td>A cartoon appeared in the paper today. The cartoon was mocking local politicians.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Control</td>
</tr>
<tr>
<td>2a</td>
<td>Chris had to meet an important client first thing in the morning. He got up early and made a hearty breakfast. The breakfast was meeting with the board of directors.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>2b</td>
<td>Breakfast was served at 7 am. The breakfast was meeting with the board of directors.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>2c</td>
<td>Chris had to meet an important client first thing in the morning. He got up early and made a hearty breakfast. The breakfast was steaming hot.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>2d</td>
<td>Breakfast was served at 7 am. The breakfast was steaming hot.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>3a</td>
<td>The children were playing outside. Clouds were forming but the kids stayed out until it started to rain. The clouds were playing endlessly.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>3b</td>
<td>Clouds lined the horizon. The clouds were playing endlessly.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>3c</td>
<td>The children were playing outside. Clouds were forming but the kids stayed out until it started to rain. The clouds were building all afternoon.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>3d</td>
<td>Clouds lined the horizon. The clouds were building all afternoon.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>4a</td>
<td>The journalist used a tiny video camera to record the horrible conditions in the sweatshop factory. Children as young as eight were making shoes for $2 an hour. The shoes were recording the scene in amazing detail.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>4b</td>
<td>The factory produces shoes. The shoes were recording the scene in amazing detail.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>4c</td>
<td>The journalist used a tiny video camera to record the horrible conditions in the sweatshop factory. Children as young as eight were making shoes for $2 an hour. The shoes were coming off the production line with name brand labels.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>4d</td>
<td>The factory produces shoes. The shoes were coming off the production line with name brand labels.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>5a</td>
<td>Kristen was waiting for the moon to come up. She stepped out onto the balcony to watch it rise. The moon was stepping over the mountains.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>5b</td>
<td>It was a full moon. The moon was stepping over the mountains.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>5c</td>
<td>Kristen was waiting for the moon to come up. She stepped out onto the balcony to watch it rise. The moon was rising over the mountains.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>5d</td>
<td>It was a full moon. The moon was rising over the mountains.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>6a</td>
<td>The chef was deciding which vegetables to use in his new soup. Herbs fresh from the garden were simmering in a broth. The soup was deciding what to do.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>6b</td>
<td>The restaurant serves fresh soup daily. The soup was deciding what to do.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>6c</td>
<td>The chef was deciding which vegetables to use in his new soup. Herbs fresh from the garden were simmering in a broth. The soup was boiling on the stove.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>6d</td>
<td>The restaurant serves fresh soup daily. The soup was boiling on the stove.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>7a</td>
<td>Last weekend we visited my grandmother. She was waiting for us on a rickety antique bench on the front porch. The bench was visiting from Italy.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>7b</td>
<td>The antique bench was covered with junk. The bench was visiting from Italy.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Anomaly</td>
</tr>
<tr>
<td>7c</td>
<td>Last weekend we visited my grandmother. She was waiting for us on a rickety antique bench on the front porch. The bench was sagging and looked like it might collapse.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Control</td>
</tr>
<tr>
<td>7d</td>
<td>The antique bench was covered with junk. The bench was sagging and looked like it might collapse.</td>
<td>Mention Context +</td>
<td>No-Mention Context +</td>
<td>Control</td>
</tr>
</tbody>
</table>
8a. A cool breeze was blowing through the tall grass. Hidden out of sight, a silent team of soldiers was preparing for their attack. The grass was preparing for battle.

8b. Tall grass surrounded the property. The grass was preparing for battle.

8c. A cool breeze was blowing through the tall grass. Hidden out of sight, a silent team of soldiers was preparing for their attack. The grass was swaying gently in the breeze.

8d. Tall grass surrounded the property. The grass was swaying gently in the breeze.

9a. A deer was racing away from the hunters. The forest was thick, providing excellent cover. The forest was racing desperately to save its life.

9b. There were good hiding spots in the thick forest. The forest was racing desperately to save its life.

9c. A deer was racing away from the hunters. The forest was thick, providing excellent cover. The forest was darkening rapidly as the sun set on the horizon.

9d. There were good hiding spots in the thick forest. The forest was darkening rapidly as the sun set on the horizon.

10a. The people that live upstairs are always making noise. Yesterday I had to listen to them play basketball in their apartment. The ball was bouncing all afternoon.

10b. Basketball is popular during recess time. The ball was bouncing all afternoon.

10c. The people that live upstairs are always making noise. Yesterday I had to listen to them play basketball in their apartment. The ball was listening to the noise.

10d. Basketball is popular during recess time. The ball was listening to the noise.

11a. At the roadside cafe, dozens of tired drivers sat drinking cup after cup of strong coffee. A waitress was singing along to a song on the radio. The coffee was singing off key.

11b. A pot of hot coffee was sorely needed. The coffee was singing off key.

11c. At the roadside cafe, dozens of tired drivers sat drinking cup after cup of strong coffee. A waitress was singing along to a song on the radio. The coffee was brewing behind the counter.

11d. A pot of hot coffee was sorely needed. The coffee was brewing behind the counter.

12a. Firefighters were battling a fire on Fifth Avenue. Black smoke was pouring out the doors and windows. The smoke was battling into the night sky.

12b. Smoke poured from the fire. The smoke was battling into the night sky.

12c. Firefighters were battling a fire on Fifth Avenue. Black smoke was pouring out the doors and windows. The smoke was pouring into the night sky.

12d. Smoke poured from the fire. The smoke was pouring into the night sky.

13a. The cliff along the river was huge. Joey found it hard to believe that flowing water alone could carve its way through miles of stone. The cliff was flowing into the river.

13b. A huge cliff bordered the river. The cliff was flowing into the river.

13c. The cliff along the river was huge. Joey found it hard to believe that flowing water alone could carve its way through miles of stone. The cliff was towering over head.

13d. A huge cliff bordered the river. The cliff was towering over head.

14a. Sue’s new dress was way too small. After arriving home she had to change into something more comfortable. The dress was arriving with her friends.

14b. The dress was too small. The dress was arriving with her friends.

14c. Sue’s new dress was way too small. After arriving home she had to change into something more comfortable. The dress was splitting at the seams.

14d. The dress was too small. The dress was splitting at the seams.

15a. The Carlson’s chopped down the old tree by the river. We used to jump into the water from its highest branches. The tree was jumping into the water.

15b. The old tree had to be chopped down. The tree was jumping into the water.
15c. The Carlson's chopped down the old tree by the river. We used to jump into the water from its highest branches. The tree was blocking their view of the river.
15d. The old tree had to be chopped down. The tree was blocking their view of the river.
16a. Danny rushed out the door to catch the school bus. When he got to the corner he realized that he had forgotten his wallet. The wallet was rushing out the door.
16b. The wallet fell out of the bag. The wallet was rushing out the door.
16c. Danny rushed out the door to catch the school bus. When he got to the corner he realized that he had forgotten his wallet. The wallet was laying on the kitchen table.
16d. The wallet fell out of the bag. The wallet was laying on the kitchen table.
17a. One of my favorite things is fresh squeezed orange juice. It reminds me of vacationing in Florida as a kid. The oranges were vacationing near Disneyworld.
17b. Fresh oranges are the best. The oranges were vacationing near Disneyworld.
17c. One of my favorite things is fresh squeezed orange juice. It reminds me of vacationing in Florida as a kid. The oranges were falling from the trees in the orchard.
17d. Fresh oranges are the best. The oranges were falling from the trees in the orchard.
18a. Keith brought Carmen lots of presents for her birthday. She gave him a big kiss and put them all on the table in the living room. The presents were kissing in the corner.
18b. The dining room was filled with presents. The presents were kissing in the corner.
18c. Keith brought Carmen lots of presents for her birthday. She gave him a big kiss and put them all on the table in the living room. The presents were covering the entire table.
18d. The dining room was filled with presents. The presents were covering the entire table.
19a. The brothers were relaxing in the living room on a chilly Saturday afternoon. They were watching TV. The television was relaxing in the corner.
19b. A TV was on in the living room. The television was relaxing in the corner.
19c. The brothers were relaxing in the living room on a chilly Saturday afternoon. They were watching TV. The television was showing a funny commercial.
19d. A TV was on in the living room. The television was showing a funny commercial.
20a. Everyone sought shelter from the blizzard in the house. A huge pot of soup was bubbling on the stove. The blizzard was bubbling over.
20b. A blizzard hit the small town. The blizzard was bubbling over.
20c. Everyone sought shelter from the blizzard in the house. A huge pot of soup was bubbling on the stove. The blizzard was raging throughout the entire night.
20d. A blizzard hit the small town. The blizzard was raging throughout the entire night.
21a. The poet was really good with words. Everyone was weeping as he read his new poem. The words were weeping endlessly.
21b. The poem’s words were very fitting. The words were weeping endlessly.
21c. The poet was really good with words. Everyone was weeping as he read his new poem. The words were engaging the entire audience.
21d. The poem’s words were very fitting. The words were engaging the entire audience.
22a. An old-fashioned barber was expertly shaving the distinguished professor. The next customer was waiting patiently by the door. The door was shaving the next customer.
22b. There was a knock at the door. The door was shaving the next customer.
22c. An old-fashioned barber was expertly shaving the distinguished professor. The next customer was waiting patiently by the door. The door was opening as more people came in.
22d. There was a knock at the door. The door was opening as more people came in.
23a. Fred borrowed his friend’s pickup truck to haul some garbage to the dump. When he started the truck, the steering wheel seemed stuck. The steering wheel was hauling a heavy load.

23b. The old truck had a problematic steering wheel. The steering wheel was hauling a heavy load.

23c. Fred borrowed his friend’s pickup truck to haul some garbage to the dump. When he started the truck, the steering wheel seemed stuck. The steering wheel was turning very slowly.

23d. The old truck had a problematic steering wheel. The steering wheel was turning very slowly.

24a. The flag was raised during the national anthem. Everyone cheered as the games began. The flag was cheering loudly.

24b. The new national flag was yellow with a single blue star. The flag was cheering loudly.

24c. The flag was raised during the national anthem. Everyone cheered as the games began. The flag was waving for all to see.

24d. The new national flag was yellow with a single blue star. The flag was waving for all to see.

25a. The gardener was whistling while she worked in the greenhouse. She watered and fertilized the plants. The plants were whistling while they grew.

25b. Plants grow better if they are taken care of properly. The plants were whistling while they grew.

25c. The gardener was whistling while she worked in the greenhouse. She watered and fertilized the plants. The plants were spreading faster than expected.

25d. Plants grow better if they are taken care of properly. The plants were spreading faster than expected.

26a. The hummingbird flapped its wings rapidly as it flew from flower to flower. It darted toward a blossom full of nectar. The nectar was flapping through the air.

26b. The blossom was full of nectar. The nectar was dripping from the petals.

26c. The hummingbird flapped its wings rapidly as it flew from flower to flower. It darted toward a blossom full of nectar. The nectar was dripping from the petals.

26d. The blossom was full of nectar. The nectar was dripping from the petals.

27a. On his way to work Alex passed a construction crew demolishing an old church. He couldn’t help but think about the old building on the long ferry ride down the river. The river was demolishing the steeple.

27b. The river was very calm and peaceful. The river was demolishing the steeple.

27c. On his way to work Alex passed a construction crew demolishing an old church. He couldn’t help but think about the old building on the long ferry ride down the river. The river was winding through the countryside.

27d. The river was very calm and peaceful. The river was winding through the countryside.

28a. Frank bought new paddles for the big canoe trip with his sons. He had to juggle a lot in his schedule to make it to the store in time. The paddles were juggling the boys during the whole trip.

28b. The canoe paddles were made of cheap plywood. The paddles were juggling the boys during the whole trip.

28c. Frank bought new paddles for the big canoe trip with his sons. He had to juggle a lot in his schedule to make it to the store in time. The paddles were banging together in the back of the truck on the way home.

28d. The canoe paddles were made of cheap plywood. The paddles were banging together in the back of the truck on the way home.

29a. The band was blaring their new hit single on a brightly lit stage. As I listened I looked into the night sky and saw fireflies flashing along to the beat. The fireflies were blaring loudly.

29b. The night sky was filled with fireflies. The fireflies were blaring loudly.
29c. The band was blaring their new hit single on a brightly lit stage. As I listened I looked
into the night sky and saw fireflies flashing along to the beat. The fireflies were blinking
brightly.
29d. The night sky was filled with fireflies. The fireflies were blinking brightly.
30a. Karen couldn't find her sunglasses before she biked home from work. The sun was so
strong she could hardly see anything. The sun was biking too fast.
30b. The sun was blinding. The sun was biking too fast.
30c. Karen couldn't find her sunglasses before she biked home from work. The sun was so
strong she could hardly see anything. The sun was setting on the horizon.
30d. The sun was blinding. The sun was setting on the horizon.
31a. The kids went to the video store to get a movie. After looking for almost an hour they
finally rented Harry Potter. The movie was looking for a star.
31b. There was an horror movie on TV. The movie was looking for a star.
31c. The kids went to the video store to get a movie. After looking for almost an hour they
finally rented Harry Potter. The movie was scaring the younger children.
31d. There was an horror movie on TV. The movie was scaring the younger children.
32a. The boss sat impatiently in his chair. He watched intently as the consultant presented a
new proposal. The chair was presenting the project.
32b. There was a chair behind the desk. The chair was presenting the project.
32c. The boss sat impatiently in his chair. He watched intently as the consultant presented a
new proposal. The chair was rocking back and forth.
32d. There was a chair behind the desk. The chair was rocking back and forth.
33a. Drew was studying for a chemistry exam but was distracted by his roommates. Bill and
Cynthia were playing darts in the other room. The darts were studying the game.
33b. Playing darts can be dangerous. The darts were studying the game.
33c. Drew was studying for a chemistry exam but was distracted by his roommates. Bill and
Cynthia were playing darts in the other room. The darts were flying everywhere.
33d. Playing darts can be dangerous. The darts were flying everywhere.
34a. Philip carried in the logs he had just chopped. He stacked the wood high in the
fireplace. The wood was carrying the logs.
34b. There was a stack of wood in the fireplace. The wood was carrying the logs.
34c. Philip carried in the logs he had just chopped. He stacked the wood high in the
fireplace. The wood was blazing strongly after a few minutes.
34d. There was a stack of wood in the fireplace. The wood was blazing strongly after a few
minutes.
35a. Mom sat on the edge of the bathtub. She couldn't answer the phone because she was
watching little Tami. The bathtub was answering as the water flowed out the faucet.
35b. Water lapped at the edge of the bathtub. The bathtub was answering as the water
flowed out the faucet.
35c. Mom sat on the edge of the bathtub. She couldn't answer the phone because she was
watching little Tami. The bathtub was filling with warm water.
35d. Water lapped at the edge of the bathtub. The bathtub was filling with warm water.
36a. My sister graduated today and had to wear a cap and gown. At the formal ceremony an
usher directed us to our seats. The gown was directing the graduates where to sit.
36b. It was a long black gown. The gown was directing the graduates where to sit.
36c. My sister graduated today and had to wear a cap and gown. At the formal ceremony an
usher directed us to our seats. The gown was covering Alisha's casual clothes.
36d. It was a long black gown. The gown was covering Alisha's casual clothes.
37a. The shower broke this morning and flooded the bathroom. I used all the spare towels to clean it up. The towels were breaking outside.
37b. The towels soaked up the water spill. The towels were breaking outside.
37c. The shower broke this morning and flooded the bathroom. I used all the spare towels to clean it up. The towels were drying outside.
37d. The towels soaked up the water spill. The towels were drying outside.

38a. We went dancing Friday night. On our way home we were hungry so we stopped at the supermarket. The supermarket was dancing all night long.
38b. There was a supermarket on the corner. The supermarket was dancing all night long.
38c. We went dancing Friday night. On our way home we were hungry so we stopped at the supermarket. The supermarket was closing when we got there.
38d. There was a supermarket on the corner. The supermarket was closing when we got there.

39a. The rain-soaked warriors marched into camp. Each one had to clean their weapon before resting. The weapons were marching in the rain.
39b. After battle the weapons were cleaned. The weapons were marching in the rain.
39c. The rain-soaked warriors marched into camp. Each one had to clean their weapon before resting. The weapons were gleaming after the thorough inspection.
39d. After battle the weapons were cleaned. The weapons were gleaming after the thorough inspection.

40a. The office was a mess ever since the technician came to fix the cooling system. Jerry couldn’t find the folder he needed for his meeting. The folder was cooling in the refrigerator.
40b. A folder was missing from the cabinet. The folder was cooling in the refrigerator.
40c. The office was a mess ever since the technician came to fix the cooling system. Jerry couldn’t find the folder he needed for his meeting. The folder was lying on the conference table.
40d. A folder was missing from the cabinet. The folder was lying on the conference table.

41a. Rick stepped out the front door and tripped over the Sunday paper. He dropped his tea in the bushes as he fell. The tea was tripping out of his hands.
41b. A cup of tea spilled. The tea was tripping out of his hands.
41c. Rick stepped out the front door and tripped over the Sunday paper. He dropped his tea in the bushes as he fell. The tea was seeping into the ground.
41d. A cup of tea spilled. The tea was seeping into the ground.

42a. My mother gave us a new blanket for the baby. It had been so cold at night that the baby would not stop crying. The blanket was crying every hour.
42b. The blanket was made of fleece. The blanket was crying every hour.
42c. My mother gave us a new blanket for the baby. It had been so cold at night that the baby would not stop crying. The blanket was keeping the baby warm.
42d. The blanket was made of fleece. The blanket was keeping the baby warm.

43a. The rescue crew located a shipwreck survivor clinging to a floating log. A helicopter quickly lowered a rope down to the victim. The rope was locating the victims.
43b. A rope was lowered from above. The rope was locating the victims.
43c. The rescue crew located a shipwreck survivor clinging to a floating log. A helicopter quickly lowered a rope down to the victim. The rope was swinging towards the man’s outstretched arms.
43d. A rope was lowered from above. The rope was swinging towards the man’s outstretched arms.

44a. The recent Autumn storm had blown lots of leaves into the yard. Jake looked in the garage for an old rake. The rake was blowing across the yard.
44b. The old rake was in the garage. The rake was blowing across the yard.
44c. The recent Autumn storm had blown lots of leaves into the yard. Jake looked in the garage for an old rake. The rake was leaning against the back wall.
44d. The old rake was in the garage. The rake was leaning against the back wall.
45a. Dad and Uncle Steve went fishing on the small lake. Brian waited for them on shore, skipping stones on the smooth surface of the water. The stones were fishing for trout.
45b. Round polished stones skip across water the best. The stones were fishing for trout.
45c. Dad and Uncle Steve went fishing on the small lake. Brian waited for them on shore, skipping stones on the smooth surface of the water. The stones were sinking to the bottom.
45d. Round polished stones skip across water the best. The stones were sinking to the bottom.
46a. By the last week of school all the teachers were falling behind in their grading. They decided to order a pizza and work through lunch. The pizza was grading the exams one by one.
46b. Pizza is always a good choice for lunch. The pizza was grading the exams one by one.
46c. By the last week of school all the teachers were falling behind in their grading. They decided to order a pizza and work through lunch. The pizza was cooling on the desk as everyone worked.
46d. Pizza is always a good choice for lunch. The pizza was cooling on the desk as everyone worked.
47a. Janet brought fresh strawberries to the picnic. She watched as the kids swam in the pond before eating lunch. The strawberries were swimming in the pond.
47b. The container of strawberries looked very fresh. The strawberries were swimming in the pond.
47c. Janet brought fresh strawberries to the picnic. She watched as the kids swam in the pond before eating lunch. The strawberries were chilling in the cooler.
47d. The container of strawberries looked very fresh. The strawberries were chilling in the cooler.
48a. The cable guy was three hours late. Then he blamed the downed service on high winds. The winds were blaming the service provider.
48b. High winds were blowing from the west. The winds were blaming the service provider.
48c. The cable guy was three hours late. Then he blamed the downed service on high winds. The winds were gusting over sixty miles an hour.
48d. High winds were blowing from the west. The winds were gusting over sixty miles an hour.
49a. The carpenter carefully sanded down the table to a smooth finish. He then applied a special paint. The paint was sanding the table even further.
49b. The table was coated in a special paint. The paint was sanding the table even further.
49c. The carpenter carefully sanded down the table to a smooth finish. He then applied a special paint. The paint was hiding any imperfections in the wood.
49d. The table was coated in a special paint. The paint was hiding any imperfections in the wood.
50a. Kim’s new kitten accidentally scratched her on the arm. She cleaned the cut with a damp tissue. The tissue was scratching the kitten.
50b. A tissue covered the wound. The tissue was scratching the kitten.
50c. Kim’s new kitten accidentally scratched her on the arm. She cleaned the cut with a damp tissue. The tissue was absorbing the blood.
50d. A tissue covered the wound. The tissue was absorbing the blood.
51a. The technician was troubleshooting a problem with the new computer. He first made sure all the wires were completely plugged in. The computer was plugging the cords into the outlet.
51b. After a small mishap the computer was working again. The computer was plugging the cords into the outlet.
51c. The technician was troubleshooting a problem with the new computer. He first made sure all the wires were completely plugged in. The computer was displaying the startup screen.
51d. After a small mishap the computer was working again. The computer was displaying the startup screen.
52a. If you leave your bike unlocked, someone might take it. Mine was stolen last week. The bike was stealing equipment from the shop.
52b. The bike had a flat tire. The bike was stealing equipment from the shop.
52c. If you leave your bike unlocked, someone might take it. Mine was stolen last week. The bike was standing on the sidewalk in front of the house.
52d. The bike had a flat tire. The bike was standing on the sidewalk in front of the house.
53a. Dr. Branson examined Sally’s rash and determined it was just an allergic reaction. He prescribed an over the counter antihistamine. The rash was prescribing Benadryl tablets once a day.
53b. The allergic reaction caused a horrible rash. The rash was prescribing Benadryl tablets once a day.
53c. Dr. Branson examined Sally’s rash and determined it was just an allergic reaction. He prescribed an over the counter antihistamine. The rash was itching terribly.
53d. The allergic reaction caused a horrible rash. The rash was itching terribly.
54a. Jennifer and I saw the new Broadway show that debuted last night. We got free tickets from my boss. The tickets were debuting at the theater.
54b. Tickets for the show had to be picked up in person. The tickets were debuting at the theater.
54c. Jennifer and I saw the new Broadway show that debuted last night. We got free tickets from my boss. The tickets were waiting at the will call counter.
54d. Tickets for the show had to be picked up in person. The tickets were waiting at the will call counter.
55a. The kitchen staff was busily chopping vegetables. The grand opening of the new restaurant had been marked on the calendar for weeks. The calendar was chopping carrots into the salad.
55b. The grand opening had been on the calendar for weeks. The calendar was chopping carrots into the salad.
55c. The kitchen staff was busily chopping vegetables. The grand opening of the new restaurant had been marked on the calendar for weeks. The calendar was hanging on the wall in the break room.
55d. The grand opening had been on the calendar for weeks. The calendar was hanging on the wall in the break room.
56a. Commuters traveled into the city every day on the new train. In the back a businessman was skimming the New York Times. The train was skimming a novel about arctic exploration.
56b. A train approached. The train was skimming a novel about arctic exploration.
56c. Commuters traveled into the city every day on the new train. In the back a businessman was skimming the New York Times. The train was slowing as it entered the station.
56d. A train approached. The train was slowing as it entered the station.
57a. The offshore oil well exploded and sank. Rescue ships were deployed to the area immediately. The oil was deploying ships to the site.
57b. The drilling accident spilled a lot of oil. The oil was deploying ships to the site.
57c. The offshore oil well exploded and sank. Rescue ships were deployed to the area immediately. The oil was contaminating the entire Gulf of Mexico.
57d. The drilling accident spilled a lot of oil. The oil was contaminating the entire Gulf of Mexico.
58a. The waiter uncorked the champagne and poured two glasses. He then placed the bottle on ice. The ice was uncorking itself.

58b. The bucket was filled with ice. The ice was uncorking itself.

58c. The waiter uncorked the champagne and poured two glasses. He then placed the bottle on ice. The ice was chilling the champagne.

58d. The bucket was filled with ice. The ice was chilling the champagne.

59a. I set the microwave timer for ten minutes. I had to defrost the meat before we could make dinner. The timer was defrosting the meat.

59b. A timer was set for ten minutes. The timer was defrosting the meat.

59c. I set the microwave timer for ten minutes. I had to defrost the meat before we could make dinner. The timer was beeping during the movie.

59d. A timer was set for ten minutes. The timer was beeping during the movie.

60a. The kittens were chasing a ball of yarn through the house. The largest one was meowing loudly making sure everyone knew she was in charge. The yarn was meowing like a lion.

60b. The ball of yarn rolled off the table. The yarn was meowing like a lion.

60c. The kittens were chasing a ball of yarn through the house. The largest one was meowing loudly making sure everyone knew she was in charge. The yarn was unraveling down the hall.

60d. The ball of yarn rolled off the table. The yarn was unraveling down the hall.

61a. The kids woke up to the smell of bacon and coffee. Their Dad was already leaving for work. The bacon was leaving without saying goodbye.

61b. The smell of bacon was overwhelming. The bacon was leaving without saying goodbye.

61c. The kids woke up to the smell of bacon and coffee. Their Dad was already leaving for work. The bacon was frying in the kitchen.

61d. The smell of bacon was overwhelming. The bacon was frying in the kitchen.

62a. Addison found a comfortable couch. He had a lot of planning to do before the big event. The couch was planning a spectacular show.

62b. The couch was old but comfortable. The couch was planning a spectacular show.

62c. Addison found a comfortable couch. He had a lot of planning to do before the big event. The couch was creaking as Addison moved around.

62d. The couch was old but comfortable. The couch was creaking as Addison moved around.

63a. The policeman pulled in behind the car on the side of the highway. He began writing a speeding ticket. The car was writing on the shoulder.

63b. The police cruiser pulled in behind the car. The car was writing on the shoulder.

63c. The policeman pulled in behind the car on the side of the highway. He began writing a speeding ticket. The car was waiting on the shoulder.

63d. The police cruiser pulled in behind the car. The car was waiting on the shoulder.

64a. A man was walking through Venice late in the afternoon. When he got down to the harbor he saw several ships loaded with cargo. The ships were walking up and down.

64b. The harbor was filled with ships. The ships were walking up and down.

64c. A man was walking through Venice late in the afternoon. When he got down to the harbor he saw several ships loaded with cargo. The ships were bobbing up and down.

64d. The harbor was filled with ships. The ships were bobbing up and down.

65a. It’s not a great idea to watch a movie while you cook. Last night I forgot that our dinner was in the oven. The dinner was watching a movie.

65b. Dinner was ruined that night. The dinner was watching a movie.
65c. It’s not a great idea to watch a movie while you cook. Last night I forgot that our dinner was in the oven. The dinner was burning before we knew it.

65d. Dinner was ruined that night. The dinner was burning before we knew it.

66a. The boxer was fighting to retain the heavyweight championship. Between rounds he spit blood into a pail in his corner. The pail was fighting for its life.

66b. There was a pail in the corner. The pail was fighting for its life.

66c. The boxer was fighting to retain the heavyweight championship. Between rounds he spit blood into a pail in his corner. The pail was spilling over during all the commotion.

66d. There was a pail in the corner. The pail was spilling over during all the commotion.

67a. Susan wants to be a photographer so she takes her camera everywhere she goes. She was snapping pictures just as the waitress dropped an entire tray of dishes. The camera was dropping the dishes.

67b. A security camera was hidden behind the mirror. The camera was capturing the entire sequence.

67c. Susan wants to be a photographer so she takes her camera everywhere she goes. She was snapping pictures just as the waitress dropped an entire tray of dishes. The camera was capturing the entire sequence.

67d. A security camera was hidden behind the mirror. The camera was capturing the entire sequence.

68a. Last-minute holiday shoppers were ready to buy anything they could get their hands on. They were grabbing items off the shelves without checking the price. The shelves were emptying at a pace the manager had never seen.

68b. Sale items lined the shelves. The shelves were emptying at a pace the manager had never seen.

68c. Last-minute holiday shoppers were ready to buy anything they could get their hands on. They were grabbing items off the shelves without checking the price. The shelves were emptying at a pace the manager had never seen.

68d. Sale items lined the shelves. The shelves were emptying at a pace the manager had never seen.

69a. The decorator painted the walls in the office yesterday. We covered the desk with a large tarp. The tarp was painting the wall blue.

69b. The couch was covered with a large tarp. The tarp was painting the wall blue.

69c. The decorator painted the walls in the office yesterday. We covered the desk with a large tarp. The tarp was draping over onto the floor.

69d. The couch was covered with a large tarp. The tarp was draping over onto the floor.

70a. Garrett walked through the farmers market looking for fresh tomatoes. He noticed a stand that had a good selection. The tomatoes were noticing that the oranges were ripe.

70b. The market had fresh tomatoes. The tomatoes were noticing that the oranges were ripe.

70c. Garrett walked through the farmers market looking for fresh tomatoes. He noticed a stand that had a good selection. The tomatoes were resting on the counter in small baskets.

70d. The market had fresh tomatoes. The tomatoes were resting on the counter in small baskets.

71a. The skiers stopped at a warm and cozy mountain chalet to find refuge from the storm. As they entered a couple was eating and laughing by the fire. The chalet was eating dinner.

71b. The mountain chalet was warm and cozy. The chalet was eating dinner.

71c. The skiers stopped at a warm and cozy mountain chalet to find refuge from the storm. As they entered a couple was eating and laughing by the fire. The chalet was comforting during the ensuing storm.

71d. The mountain chalet was warm and cozy. The chalet was comforting during the ensuing storm.
The painting was created in 1643. The painting was hanging in an ornate frame.
79a. Throughout the day Jim kept looking at his watch in anticipation of the pool party. He couldn’t wait to dive into the cool water. The watch was diving into the deep end.
79b. The new watch was working perfectly. The watch was diving into the deep end.
79c. Throughout the day Jim kept looking at his watch in anticipation of the pool party. He couldn’t wait to dive into the cool water. The watch was ticking away the hours.
79d. The new watch was working perfectly. The watch was ticking away the hours.
80a. The young couple found a house that seemed affordable and had an extra bedroom for their new baby. They decided to bid on the house. The bedroom was bidding on an additional incentive.
80b. The new house had an extra bedroom. The bedroom was bidding on an additional incentive.
80c. The young couple found a house that seemed affordable and had an extra bedroom for their new baby. They decided to bid on the house. The bedroom was facing the back yard.
80d. The new house had an extra bedroom. The bedroom was facing the back yard.
81a. Astronomers discovered an asteroid orbiting the distant star. It was just inside the star’s gravitational field. The field was orbiting the star once every two years.
81b. The asteroid entered the star’s gravitational field. The field was orbiting the star once every two years.
81c. Astronomers discovered an asteroid orbiting the distant star. It was just inside the star’s gravitational field. The field was affecting the path of the asteroid.
81d. The asteroid entered the star’s gravitational field. The field was affecting the path of the asteroid.
82a. John finally convinced Catherine to go whitewater rafting. When the raft tipped over she regretted her decision. The raft was regretting the dangerous rapids.
82b. A raft floated away. The raft was regrettting the dangerous rapids.
82c. John finally convinced Catherine to go whitewater rafting. When the raft tipped over she regretted her decision. The raft was drifting down the river without her.
82d. A raft floated away. The raft was drifting down the river without her.
83a. Mr. and Mrs. Thompson were watching their preschooler playing with a noisy rattle. The baby was chewing on his blanket while enjoying his new toy. The rattle was chewing on the rail of the crib.
83b. A new rattle was laying in the crib. The rattle was chewing on the rail of the crib.
83c. Mr. and Mrs. Thompson were watching their preschooler playing with a noisy rattle. The baby was chewing on his blanket while enjoying his new toy. The rattle was clattering continually.
83d. A new rattle was laying in the crib. The rattle was clattering continually.
84a. Aunt Peggy was sewing in the front room. The neighbors across the street were loading boxes into a truck. The truck was sewing a new dress.
84b. A truck drove by the house. The truck was sewing a new dress.
84c. Aunt Peggy was sewing in the front room. The neighbors across the street were loading boxes into a truck. The truck was pulling a small trailer.
84d. A truck drove by the house. The truck was pulling a small trailer.
85a. Meg went skiing with some friends. At the end of the day she realized that she had lost her goggles. The goggles were skiing down the mountain.
85b. The goggles were brand new. The goggles were skiing down the mountain.
85c. Meg went skiing with some friends. At the end of the day she realized that she had lost her goggles. The goggles were lying below the lift.
85d. The goggles were brand new. The goggles were lying below the lift.
86a. James looked for the shovel he had been using to plant the vegetables. Every time he took a break a bold rabbit would hop in and steal some lettuce. The shovel was hopping into the garden. Mention Context + Anomaly
86b. It was time for a new shovel after the old one broke. The shovel was hopping into the garden. No-Mention Context + Anomaly
86c. James looked for the shovel he had been using to plant the vegetables. Every time he took a break a bold rabbit would hop in and steal some lettuce. The shovel was laying on the ground in pieces. Mention Context + Control
86d. It was time for a new shovel after the old one broke. The shovel was laying on the ground in pieces. No-Mention Context + Control
87a. The pilot announced that we couldn’t take off until the fog cleared. My sister and I braided each other’s hair to pass time. The fog was braiding my sister’s hair. Mention Context + Anomaly
87b. There was heavy fog in the area. The fog was delaying the flight. No-Mention Context + Control
87c. The pilot announced that we couldn’t take off until the fog cleared. My sister and I braided each other’s hair to pass time. The fog was delaying the flight. No-Mention Context + Control
87d. There was heavy fog in the area. The fog was delaying the flight. No-Mention Context + Control
88a. The young boy tiptoed up the stairs trying not to wake his parents. He carried a candle rather than turning on the lights. The candle was tiptoeing up the dark stairway. Mention Context + Control
88b. A faint draft of air almost blew out the candle. The candle was tiptoeing up the dark stairway. Mention Context + Control
88c. The young boy tiptoed up the stairs trying not to wake his parents. He carried a candle rather than turning on the lights. The candle was flickering in the dark stairway. No-Mention Context + Anomaly
88d. A faint draft of air almost blew out the candle. The candle was flickering in the dark stairway. No-Mention Context + Anomaly
89a. The bus to Chicago was running late because of weather. Spencer had been jogging back and forth to keep warm as he waited. The bus was jogging across the road. Mention Context + Anomaly
89b. The bus to Chicago was running late. The bus was jogging across the road. Mention Context + Anomaly
89c. The bus to Chicago was running late because of weather. Spencer had been jogging back and forth to keep warm as he waited. The bus was departing thirty minutes behind schedule. Mention Context + Control
89d. The bus to Chicago was running late. The bus was departing thirty minutes behind schedule. No-Mention Context + Control
90a. Nicole went to Hawaii for a medical conference. She wanted to snorkel while she was there. The conference was snorkeling off the coast. Mention Context + Anomaly
90b. The conference began on Thursday. The conference was snorkeling off the coast. No-Mention Context + Control
90c. Nicole went to Hawaii for a medical conference. She wanted to snorkel while she was there. The conference was boring and seemed to last forever. Mention Context + Anomaly
90d. The conference began on Thursday. The conference was boring and seemed to last forever. No-Mention Context + Control
91a. David saw black smoke pouring from his neighbor’s house. He called the fire department right away. The house was calling for help. Mention Context + Anomaly
91b. The house next door caught fire. The house was calling for help. No-Mention Context + Control
91c. David saw black smoke pouring from his neighbor’s house. He called the fire department right away. The house was burning down quickly. Mention Context + Anomaly
91d. The house next door caught fire. The house was burning down quickly. No-Mention Context + Control
92a. It started to snow as we left the house. Mom asked me to go back for her coat. The coat was asking for directions. Mention Context + Anomaly
92b. The old coat got left at home. The coat was asking for directions. No-Mention Context + Control
92c. It started to snow as we left the house. Mom asked me to go back for her coat. The coat was hanging next to the door. Mention Context + Control
92d. The old coat got left at home. The coat was hanging next to the door. No-Mention Context + Control
The phone was ringing all night long. Sue dreamt that it was a fire alarm. The phone was dreaming that there was a fire.

A beautiful lake came into view. The lake was sparkling in the early morning light.

Kevin couldn’t help smiling as he rode around town. His new motorcycle was just so much fun to ride. The motorcycle was running smoothly.

The old man was fishing from a small boat on the quiet lake. He was enjoying the beautiful scenery. The lake was enjoying the fish.

Will put a frozen dinner in the microwave. He read the directions as his meal began to cook. The microwave was reading the newspaper.

The new microwave was quick and efficient. The microwave was reading the newspaper.

The keys finally turned up. The keys were parking on Walnut Street.

Cathy drove across country to her high school reunion. Along the way she saw some spectacular views. The views were driving a Ford minivan.

There was a fight at the celebration last night. The celebration was attacking the Oakland fans on their way to a Denver hotel.

There was a fight at the celebration last night. The celebration was attacking the Oakland fans on their way to a Denver hotel.

A group of backpackers were talking loudly as they set out on a long hike. A herd of cows grazing in a nearby field ignored them as they walked by. The cows were talking loudly as they grazed.

Some cows were grazing next to the road. The cows were moving slowly toward the creek.
100b.  A phone was ringing in the bedroom. The phone was dreaming that there was a fire.
100c.  The phone was ringing all night long. Sue dreamt that it was a fire alarm. The phone was disrupting her sleep.
100d.  A phone was ringing in the bedroom. The phone was disrupting her sleep.
101a.  The baby played with a rubber duck. He laughed at the funny sound it made. The duck was laughing in the sink.
101b.  There was a rubber duck in the bathroom. The duck was laughing in the sink.
101c.  The baby played with a rubber duck. He laughed at the funny sound it made. The duck was floating in the sink.
101d.  There was a rubber duck in the bathroom. The duck was floating in the sink.
102a.  Jessica went shopping for new shoes. She had to take a cab because the rain was coming down so hard. The rain was shopping all afternoon.
102b.  It rained yesterday. The rain was shopping all afternoon.
102c.  Jessica went shopping for new shoes. She had to take a cab because the rain was coming down so hard. The rain was pouring all afternoon.
102d.  It rained yesterday. The rain was pouring all afternoon.
103a.  I hate dealing with taxis in New York. I can’t shout loud enough to hail one. The taxi was shouting as it passed.
103b.  A taxi turned the corner. The taxi was shouting as it passed.
103c.  I hate dealing with taxis in New York. I can’t shout loud enough to hail one. The taxi was passing without stopping.
103d.  A taxi turned the corner. The taxi was passing without stopping.
104a.  The newlyweds went on a wine tasting tour during their honeymoon. They rented a limo to take them from winery to winery. The limo was tasting the wine.
104b.  The limo was very comfortable. The limo was tasting the wine.
104c.  The newlyweds went on a wine tasting tour during their honeymoon. They rented a limo to take them from winery to winery. The limo was cruising through the countryside.
104d.  The limo was very comfortable. The limo was cruising through the countryside.
105a.  The musician was pacing backstage before his debut. He had just tuned his guitar and was waiting for his cue. The guitar was pacing back and forth.
105b.  The guitar had recently been tuned. The guitar was pacing back and forth.
105c.  The musician was pacing backstage before his debut. He had just tuned his guitar and was waiting for his cue. The guitar was sounding better than ever.
105d.  The guitar had recently been tuned. The guitar was sounding better than ever.
106a.  The freshman was packing up her dorm before going home for the summer. The radio was playing a pop song as she worked. The radio was packing up her textbooks.
106b.  A radio was on in the kitchen. The radio was packing up her textbooks.
106c.  The freshman was packing up her dorm before going home for the summer. The radio was playing a pop song as she worked. The radio was broadcasting loudly from on top of the microwave.
106d.  A radio was on in the kitchen. The radio was broadcasting loudly from on top of the microwave.
107a.  Tim was stumbling around the dark cellar with a flashlight. He accidentally knocked his head into a door frame. The flashlight was knocking into the furthest corners.
107b.  A flashlight lit up the dark cellar. The flashlight was knocking into the furthest corners.
Tim was stumbling around the dark cellar with a flashlight. He accidentally knocked his head into a door frame. The flashlight was shining across the small room.

A flashlight lit up the dark cellar. The flashlight was shining across the small room.

A troop of monkeys was screaming from high in the jungle canopy. The trees were covered with brightly colored fruit, warming in the morning sun. The fruit was screaming into the wind.

All the trees bore fruit. The fruit was screaming into the wind.

A troop of monkeys was screaming from high in the jungle canopy. The trees were covered with brightly colored fruit, warming in the morning sun. The fruit was ripening on the branches.

All the trees bore fruit. The fruit was ripening on the branches.

Lindsay hid in the garage when her parents fought. That way she couldn't hear all the yelling. The garage was yelling at her to go back inside.

The garage was a good hiding place. The garage was yelling at her to go back inside.

Lindsay hid in the garage when her parents fought. That way she couldn't hear all the yelling. The garage was sheltering her from her parent's stormy relationship.

The garage was a good hiding place. The garage was sheltering her from her parent's stormy relationship.

Hank was terrified when his new boat sprung a leak. He was so distracted that he left his chocolate melting in the hot sun. The boat was melting into the ocean.

The boat sprung a leak. The boat was melting into the ocean.

Hank was terrified when his new boat sprung a leak. He was so distracted that he left his chocolate melting in the hot sun. The boat was sinking quickly.

The boat sprung a leak. The boat was sinking quickly.

The bushman was sweating heavily as he cleared a path through the rainforest. He used a long machete to hack through the dense foliage. The machete was sweating as it chopped through the vines.

A newly sharpened machete cut through the dense foliage with ease. The machete was sweating as it chopped through the vines.

A newly sharpened machete cut through the dense foliage with ease. The machete was sweating as it chopped through the vines.

He used a long machete to hack through the dense foliage. The machete was sweating as it chopped through all the bushes and vines.

A newly sharpened machete cut through the dense foliage with ease. The machete was sweating as it chopped through all the bushes and vines.

He used a long machete to clear a path through the rainforest. The bushes were confessing that it was too late.

Trimming the bushes along the back fence was one of Tommy's weekly chores. But when the weekend came around he confessed to his dad that he had forgotten to do it. The bushes were confessing that it was too late.

The bushman was sweating heavily as he cleared a path through the rainforest. He used a long machete to clear a path through all the bushes and vines.

Trimming the bushes along the back fence was one of Tommy's weekly chores. But when the weekend came around he confessed to his dad that he had forgotten to do it. The bushes were confessing that it was too late.

Trimming the bushes along the back fence was one of Tommy's weekly chores. But when the weekend came around he confessed to his dad that he had forgotten to do it. The bushes were confessing that it was too late.

Sophie's grandmother loved to knit things for her grandkids. Sophie fondly remembers her knitting a sweater while sitting in an old rocking chair. The chair was knitting quietly every evening.

The good rocking chair made studying easier. The chair was knitting quietly every evening.

The good rocking chair made studying easier. The chair was knitting quietly every evening.

The good rocking chair made studying easier. The chair was knitting softly as she rocked.

The good rocking chair made studying easier. The chair was knitting softly as she rocked.
114a. When the baker arrived at work he was surprised to find the door unlocked. His assistant had already started making the first batch of bread. The bread was unlocking the bakery.

114b. A loaf of bread was in the oven. The bread was unlocking the bakery.

114c. When the baker arrived at work he was surprised to find the door unlocked. His assistant had already started making the first batch of bread. The bread was baking as the assistant prepared other pastries.

114d. A loaf of bread was in the oven. The bread was baking as the assistant prepared other pastries.

115a. My mom watched as we scrambled into our new tree house. It started to snow but no one wanted to go inside since it was still sunny. The snow was scrambling in the yard.

115b. An inch of snow fell this morning before the sun came out. The snow was scrambling in the yard.

115c. My mom watched as we scrambled into our new tree house. It started to snow but no one wanted to go inside since it was still sunny. The snow was disappearing quickly.

115d. An inch of snow fell this morning before the sun came out. The snow was disappearing quickly.

116a. It was the last day of elementary school. Before the kids started the exam the teacher gave them each a hug. The exam was hugging the students.

116b. The final exam was really hard. The exam was hugging the students.

116c. It was the last day of elementary school. Before the kids started the exam the teacher gave them each a hug. The exam was testing everything they covered that year.

116d. The final exam was really hard. The exam was testing everything they covered that year.

117a. A mouse scurried around the kitchen looking for something to eat. The only food it found was the cheese set in the mousetrap. The cheese was scurrying around the floor.

117b. The mousetrap had some cheese in it. The cheese was scurrying around the floor.

117c. A mouse scurried around the kitchen looking for something to eat. The only food it found was the cheese set in the mousetrap. The cheese was tempting the mouse.

117d. The mousetrap had some cheese in it. The cheese was tempting the mouse.

118a. Dust flew everywhere when the librarian opened the old dictionary. She tried to keep herself from sneezing but it was too late. The dictionary was sneezing repeatedly.

118b. A new dictionary arrived at the library last week. The dictionary was sneezing repeatedly.

118c. Dust flew everywhere when the librarian opened the old dictionary. She tried to keep herself from sneezing but it was too late. The dictionary was sitting on the reference shelf.

118d. A new dictionary arrived at the library last week. The dictionary was sitting on the reference shelf.

119a. Tim glanced out the window. He saw the neighbor mowing his lawn. The window was mowing the lawn across the street.

119b. A window was open on the side of the house. The window was mowing the lawn across the street.

119c. Tim glanced out the window. He saw the neighbor mowing his lawn. The window was reflecting the afternoon light.

119d. A window was open on the side of the house. The window was reflecting the afternoon light.

120a. The smell of Thanksgiving dinner was wafting through the house. A turkey was already roasting in the oven as friends and family arrived. The oven was wafting down the hall.

120b. A scrumptious meal was in the oven. The oven was wafting down the hall.

120c. The smell of Thanksgiving dinner was wafting through the house. A turkey was already roasting in the oven as friends and family arrived. The oven was warming the entire house.

120d. A scrumptious meal was in the oven. The oven was warming the entire house.
Table A.4. Experimental stimuli for Experiment 4.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1a</td>
<td>The kids woke up to the smell of bacon. Mom was cooking breakfast but dad was already leaving for work. The bacon was leaving without saying goodbye.</td>
<td>Mention Context +</td>
</tr>
<tr>
<td>1b</td>
<td>The kids woke up to the smell of bacon. Mom was cooking breakfast and dad was already sitting at the table. The bacon was leaving without saying goodbye.</td>
<td>Anomaly</td>
</tr>
<tr>
<td>1c</td>
<td>The kids woke up to the smell of bacon. Mom was cooking breakfast but dad was already leaving for work. The bacon was frying in the kitchen.</td>
<td>No-Mention Context +</td>
</tr>
<tr>
<td>1d</td>
<td>The kids woke up to the smell of bacon. Mom was cooking breakfast and dad was already sitting at the table. The bacon was frying in the kitchen.</td>
<td>Anomaly</td>
</tr>
<tr>
<td>2a</td>
<td>The children were playing outside in the rain. Storm clouds were forming but the kids stayed out until it started to pour. The dark clouds were playing endlessly.</td>
<td>Control</td>
</tr>
<tr>
<td>2b</td>
<td>The weather report was right about the big storm. Storm clouds were forming as I left the house this morning. The dark clouds were playing endlessly.</td>
<td>Anomaly</td>
</tr>
<tr>
<td>2c</td>
<td>The children were playing outside in the rain. Storm clouds were forming but the kids stayed out until it started to pour. The dark clouds were threatening all afternoon.</td>
<td>Control</td>
</tr>
<tr>
<td>2d</td>
<td>The weather report was right about the big storm. Storm clouds were forming as I left the house this morning. The dark clouds were threatening all afternoon.</td>
<td>Anomaly</td>
</tr>
<tr>
<td>3a</td>
<td>Drew was studying for a chemistry exam but was distracted by his roommates. Bill and Cynthia were playing darts in the other room. The darts were studying the game.</td>
<td>No-Mention Context +</td>
</tr>
<tr>
<td>3b</td>
<td>Bill and Cynthia were playing darts in the back room. They got so carried away I could hear them laughing and teasing each other. The darts were studying the game.</td>
<td>Control</td>
</tr>
<tr>
<td>3c</td>
<td>Drew was studying for a chemistry exam but was distracted by his roommates. Bill and Cynthia were playing darts in the other room. The darts were flying everywhere.</td>
<td>Anomaly</td>
</tr>
<tr>
<td>3d</td>
<td>Bill and Cynthia were playing darts in the back room. They got so carried away I could hear them laughing and teasing each other. The darts were flying everywhere.</td>
<td>Control</td>
</tr>
<tr>
<td>4a</td>
<td>Mom sat on the edge of the bathtub. The phone rang but she couldn't answer it because she was watching little Tami. The bathtub was answering as the water flowed out the faucet.</td>
<td>No-Mention Context +</td>
</tr>
<tr>
<td>4b</td>
<td>Mom sat on the edge of the bathtub and got little Tami ready for her bath. She set the baby's clothes on the counter. The bathtub was answering as the water flowed out the faucet.</td>
<td>Anomaly</td>
</tr>
<tr>
<td>4c</td>
<td>Mom sat on the edge of the bathtub. The phone rang but she couldn't answer it because she was watching little Tami. The bathtub was filling with warm water.</td>
<td>Control</td>
</tr>
<tr>
<td>4d</td>
<td>Mom sat on the edge of the bathtub and got little Tami ready for her bath. She set the baby's clothes on the counter. The bathtub was filling with warm water.</td>
<td>Anomaly</td>
</tr>
<tr>
<td>4e</td>
<td>Mom sat on the edge of the bathtub. The phone rang but she couldn't answer it because she was watching little Tami. The bathtub was filling with warm water.</td>
<td>Control</td>
</tr>
<tr>
<td>5a</td>
<td>Kristen was waiting for the moon to come up that night. She stepped out onto the balcony to watch it rise. The moon was stepping over the distant mountains.</td>
<td>Mention Context +</td>
</tr>
<tr>
<td>5b</td>
<td>Kristen and Zach were planning a romantic evening. They had a quiet dinner at an outdoor restaurant under a full moon. The moon was stepping over the distant mountains.</td>
<td>Control</td>
</tr>
<tr>
<td>5c</td>
<td>Kristen was waiting for the moon to come up that night. She stepped out onto the balcony to watch it rise. The moon was rising over the distant mountains.</td>
<td>Anomaly</td>
</tr>
<tr>
<td>5d</td>
<td>Kristen and Zach were planning a romantic evening. They had a quiet dinner at an outdoor restaurant under a full moon. The moon was rising over the distant mountains.</td>
<td>Control</td>
</tr>
<tr>
<td>6a</td>
<td>Joe parked the car in front of the post office. He dug around for some coins for the parking meter. Some coins were parking on Walnut Street.</td>
<td>No-Mention Context +</td>
</tr>
<tr>
<td>6b</td>
<td>Joe searched frantically for some coins. The attendant waited impatiently as customers began to line up behind him. Some coins were parking on Walnut Street.</td>
<td>Anomaly</td>
</tr>
<tr>
<td>6c</td>
<td>Joe parked the car in front of the post office. He dug around for some coins for the parking meter. Some coins were jingling in his coat pocket.</td>
<td>Control</td>
</tr>
<tr>
<td>6d</td>
<td>Joe searched frantically for some coins. The attendant waited impatiently as customers began to line up behind him. Some coins were jingling in his coat pocket.</td>
<td>Anomaly</td>
</tr>
<tr>
<td>7a</td>
<td>Kevin couldn't help smiling as he rode around town. His new motorcycle was just so much fun to ride. The powerful motorcycle was smiling all the way home.</td>
<td>Mention Context +</td>
</tr>
<tr>
<td>7b</td>
<td>Kevin couldn't help but show off as he rode around town. He felt so cool on his new motorcycle. The powerful motorcycle was smiling all the way home.</td>
<td>Control</td>
</tr>
<tr>
<td>7c</td>
<td>Kevin couldn't help smiling as he rode around town. His new motorcycle was just so much fun to ride. The powerful motorcycle was running smoothly.</td>
<td>Anomaly</td>
</tr>
</tbody>
</table>
Kevin couldn't help but show off as he rode around town. He felt so cool on his new motorcycle. The powerful motorcycle was running smoothly.

The decorator painted the walls in the office yesterday. He covered the desk with a sheet. The sheet was painting the wall blue.

The contractor was demolishing the wall next to the office. He covered the desk with a sheet. The sheet was painting the wall blue.

The decorator painted the walls in the office yesterday. He covered the desk with a sheet. The sheet was covering the expensive furniture.

The contractor was demolishing the wall next to the office. He covered the desk with a sheet. The sheet was covering the expensive furniture.

The construction of New York's early skyscrapers required workers that weren't afraid of operating unprotected high above the ground. There is a photo of a man sleeping on a girder several hundred feet above the city. The narrow steel girders were supporting the weight of the entire structure.

The construction of New York's early skyscrapers required workers that weren't afraid of operating unprotected high above the ground. There is a photo of a man sleeping on a girder several hundred feet above the city. The narrow steel girders were supporting the weight of the entire structure.

The construction of New York's early skyscrapers required workers that weren't afraid of operating unprotected high above the ground. There is a photo of a man sleeping on a girder several hundred feet above the city. The narrow steel girders were supporting the weight of the entire structure.

Rick was out behind the house changing the oil in the truck. He tripped over some tools and accidentally knocked everything over. The motor oil was tripping out of his hands.

Rick was out behind the house changing the oil in the truck. He dropped a wrench on his foot and accidentally knocked everything over. The motor oil was tripping out of his hands.

Rick was out behind the house changing the oil in the truck. He tripped over some tools accidentally knocked everything over. The motor oil was seeping into the ground now.

Rick was out behind the house changing the oil in the truck. He dropped a wrench on his foot and accidentally knocked everything over. The motor oil was seeping into the ground now.

The construction worker finished eating his lunch and got back to work. He started up the noisy jackhammer. The powerful jackhammer was eating the turkey sandwich.

The construction worker finished talking to his boss and got back to work. He started up the noisy jackhammer. The powerful jackhammer was eating the turkey sandwich.

The construction worker finished eating his lunch and got back to work. He started up the noisy jackhammer. The powerful jackhammer was crushing the concrete.

The construction worker finished talking to his boss and got back to work. He started up the noisy jackhammer. The powerful jackhammer was crushing the concrete.

We found a cozy blanket for the baby. It had been so cold at night that she would not stop crying. The blanket was crying every hour.

We found a cozy blanket for the baby. It had been so cold at night that she had trouble falling asleep. The blanket was crying every hour.

We found a cozy blanket for the baby. It had been so cold at night that she would not stop crying. The blanket was warming her now.

We found a cozy blanket for the baby. It had been so cold at night that she had trouble falling asleep. The blanket was warming her now.

The cliffs on either side of the river were huge. As Joey watched the quiet river flowing at his feet, he realized that it had carved the canyon over millions of years. The cliffs were flowing into the river.

The cliffs on either side of the canyon were huge. Joey and his friends set up their campsite in a quiet spot hidden out of sight from the trail. The cliffs were flowing into the river.
13c. The cliffs on either side of the river were huge. As Joey watched the quiet river flowing at his feet, he realized that it had carved the canyon over millions of years. The cliffs were towering high above the surrounding area.

13d. The cliffs on either side of the canyon were huge. Joey and his friends set up their campsite in a quiet spot hidden out of sight from the trail. The cliffs were towering high above the surrounding area.

14a. Commuters traveled into the city every day on the new train. In the back, two businessmen were arguing loudly. The train was arguing into the station.

14b. Commuters traveled into the city every day on the new train. In the back, two businessmen were working quietly. The train was working into the station.

14c. Commuters traveled into the city every day on the new train. In the back, two businessmen were arguing loudly. The train was slowing as it entered the station.

14d. Commuters traveled into the city every day on the new train. In the back, two businessmen were working quietly. The train was slowing as it entered the station.

15a. The recent Autumn storm had blown lots of leaves into the yard. Jake looked around in the garage for a rake. The rake was blowing across the yard.

15b. By late October, piles of leaves had already accumulated in the yard. Jake looked around in the garage for a rake. The rake was blowing across the yard.

15c. The recent Autumn storm had blown lots of leaves into the yard. Jake looked around in the garage for a rake. The rake was leaning against the back wall.

15d. By late October, piles of leaves had already accumulated in the yard. Jake looked around in the garage for a rake. The rake was leaning against the back wall.

16a. By the end of the semester, all the teachers were grading frantically in order to keep from falling behind. They decided to order a pizza and work straight through lunch. The pizza was grading the exams one by one.

16b. Everyone at the office was busily working on the proposal. No one had time to go out to eat so they decided to order a pizza and work through lunch. The pizza was grading the exams one by one.

16c. By the end of the semester, all the teachers were grading frantically in order to keep from falling behind. They decided to order a pizza and work straight through lunch. The pizza was cooling on the desk as everyone worked.

16d. Everyone at the office was busily working on the proposal. No one had time to go out to eat so they decided to order a pizza and work through lunch. The pizza was cooling on the desk as everyone worked.

17a. Danny rushed out the door to catch the bus. When he got to the corner he realized that he had forgotten his wallet. The wallet was rushing out the door.

17b. Danny was really worried because he lost his wallet today. We search his backpack, his car, and the entire parking lot. The wallet was rushing out the door.

17c. Danny rushed out the door to catch the bus. When he got to the corner he realized that he had forgotten his wallet. The wallet was laying on the kitchen table.

17d. Danny was really worried because he lost his wallet today. We search his backpack, his car, and the entire parking lot. The wallet was laying on the kitchen table.

18a. The couple whispered while standing in front of the exhibit. The painting they were admiring was by Leonardo da Vinci. The famous painting was whispering to the couple.

18b. The couple stood in awe in front of the new exhibit. The painting they were admiring was by Leonardo da Vinci. The famous painting was whispering to the couple.

18c. The couple whispered while standing in front of the exhibit. The painting they were admiring was by Leonardo da Vinci. The famous painting was hanging in an ornate frame.

18d. The couple stood in awe in front of the new exhibit. The painting they were admiring was by Leonardo da Vinci. The famous painting was hanging in an ornate frame.

19a. Keith hung the last few Christmas ornaments on the tree. Carmen gave him a big kiss and thanked him for spending the holidays with her family. The brightly colored ornaments were kissing in the corner.

19b. Carmen was looking forward to spending the Christmas holidays with her family. When she got home, everyone was hanging ornaments on the tree. The brightly colored ornaments were kissing in the corner.

19c. Keith hung the last few Christmas ornaments on the tree. Carmen gave him a big kiss and thanked him for spending the holidays with her family. The brightly colored ornaments were decorating the entire room.
19d. Carmen was looking forward to spending the Christmas holidays with her family. When she got home, everyone was hanging ornaments on the tree. The brightly colored ornaments were decorating the entire room.

20a. Everyone sought shelter from the blizzard in the warm house. A huge pot of soup was bubbling on the stove. The massive blizzard was bubbling over.

20b. This past winter has been one of the worst in recent memory. Another blizzard pounded the city yesterday. The massive blizzard was raging through the night.

20c. Everyone sought shelter from the blizzard in the warm house. A huge pot of soup was bubbling on the stove. The massive blizzard was raging through the night.

20d. This past winter has been one of the worst in recent memory. Another blizzard pounded the city yesterday. The massive blizzard was raging through the night.

21a. Sherry couldn't help but weep quietly as she watched the demolition crew tear down the old high school. A steamroller lurched forward and quickly gained momentum. The big steamroller was weeping endlessly.

21b. A large group of people watched as the demolition crew tore down the old high school. A steamroller lurched forward and quickly gained momentum. The big steamroller was weeping endlessly.

21c. Sherry couldn't help but weep quietly as she watched the demolition crew tear down the old high school. A steamroller lurched forward and quickly gained momentum. The big steamroller was flattening everything in its path.

21d. A large group of people watched as the demolition crew tore down the old high school. A steamroller lurched forward and quickly gained momentum. The big steamroller was flattening everything in its path.

22a. An old-fashioned barber was expertly shaving the distinguished professor. The next customer was waiting patiently by the front door. The door was shaving the next customer.

22b. An old-fashioned baker was slowly handing out fresh bread one-by-one. The next customer was waiting patiently by the front door. The door was shaving the next customer.

22c. An old-fashioned barber was expertly shaving the distinguished professor. The next customer was waiting patiently by the front door. The door was opening as more people came in.

22d. An old-fashioned baker was slowly handing out fresh bread one-by-one. The next customer was waiting patiently by the front door. The door was opening as more people came in.

23a. Fred borrowed his friend's pickup truck to haul some garbage to the dump. When he started the truck, something was wrong with the steering. The steering wheel was hauling a heavy load.

23b. Fred borrowed his mom's car to pick up his friends from the airport. When he started the car, something was wrong with the steering. The steering wheel was hauling a heavy load.

23c. Fred borrowed his friend's pickup truck to haul some garbage to the dump. When he started the truck, something was wrong with the steering. The steering wheel was turning very slowly.

23d. Fred borrowed his mom's car to pick up his friends from the airport. When he started the car, something was wrong with the steering. The steering wheel was turning very slowly.

24a. Aunt Peggy was sewing in the front room. She could see the neighbors across the street loading boxes into a truck. The truck was sewing a new dress.

24b. Aunt Peggy was sitting in the front room. She could see the neighbors across the street loading boxes into a truck. The truck was sewing a new dress.

24c. Aunt Peggy was sewing in the front room. She could see the neighbors across the street loading boxes into a truck. The truck was towing a small trailer.

24d. Aunt Peggy was sitting in the front room. She could see the neighbors across the street loading boxes into a truck. The truck was towing a small trailer.

25a. The gardener was whistling while she worked in the greenhouse. She watered and fertilized the delicate plants. Her newest plants were whistling while they grew.

25b. The gardener was proudly admiring her plants as she worked in the greenhouse. She watered and fertilized them all. Her newest plants were whistling while they grew.

25c. The gardener was whistling while she worked in the greenhouse. She watered and fertilized the delicate plants. Her newest plants were sprouting faster than expected.
25d. The gardener was proudly admiring her plants as she worked in the greenhouse. She watered and fertilized them all. Her newest plants were sprouting faster than expected.

26a. Rebels in Russia rioted last night. They overturned several vehicles in downtown Moscow and left a passenger bus with its rear wheels hanging off a bridge. The wheels were spinning in protest.

26b. We saw a multi-vehicle collision on I-70 today. A Greyhound bus went off the road and ended up with its rear wheels hanging over a cliff. The wheels were spinning when the police arrived.

26c. Rebels in Russia rioted last night. They overturned several vehicles in downtown Moscow and left a passenger bus with its rear wheels hanging off a bridge. The wheels were spinning when the police arrived.

26d. We saw a multi-vehicle collision on I-70 today. A Greyhound bus went off the road and ended up with its rear wheels hanging over a cliff. The wheels were spinning when the police arrived.

27a. The movie maker took great care in setting up the camera and lighting. She wanted her audience to feel the solemn mood of the scene. The video camera was feeling the somber atmosphere.

27b. Rebels in Russia rioted last night. They overturned several vehicles in downtown Moscow and left a passenger bus with its rear wheels hanging off a bridge. The wheels were spinning in protest.

27c. Rebels in Russia rioted last night. They overturned several vehicles in downtown Moscow and left a passenger bus with its rear wheels hanging off a bridge. The wheels were spinning when the police arrived.

27d. Rebels in Russia rioted last night. They overturned several vehicles in downtown Moscow and left a passenger bus with its rear wheels hanging off a bridge. The wheels were spinning when the police arrived.
32a. Chris had to meet an important client first thing in the morning. He got up early and made a big bowl of oatmeal for breakfast. The hot oatmeal was meeting with the board of directors.

32b. Chris was planning to go skiing first thing in the morning. He got up early and made a big bowl of oatmeal for breakfast. The hot oatmeal was meeting with the board of directors.

32c. Chris had to meet an important client first thing in the morning. He got up early and made a big bowl of oatmeal for breakfast. The hot oatmeal was steaming as he ate it.

32d. Chris was planning to go skiing first thing in the morning. He got up early and made a big bowl of oatmeal for breakfast. The hot oatmeal was steaming as he ate it.

33a. The policeman pulled in behind the car on the side of the highway. He began writing a speeding ticket. The car was writing on the shoulder.

33b. The policeman pulled over the speeder. The radar had clocked the car at 30 miles over the speed limit. The car was writing on the shoulder.

33c. The policeman pulled in behind the car on the side of the highway. He began writing a speeding ticket. The car was waiting on the shoulder.

33d. The policeman pulled over the speeder. The radar had clocked the car at 30 miles over the speed limit. The car was waiting on the shoulder.

34a. Philip bought some matches and lighter fluid. He then stacked the firewood into the hearth. The firewood was buying the logs.

34b. Philip chopped several logs into firewood. He was preparing a large bonfire for the party. The firewood was buying the logs.

34c. Philip bought some matches and lighter fluid. He then stacked the firewood into the hearth. The firewood was blazing strongly after a few minutes.

34d. Philip chopped several logs into firewood. He was preparing a large bonfire for the party. The firewood was blazing strongly after a few minutes.

35a. It’s not a great idea to watch a movie while you cook. Last night I forgot that our dinner was in the oven. The dinner was watching a movie.

35b. It’s not a great idea to talk on the phone while you cook. Last night I forgot that our dinner was in the oven. The dinner was watching a movie.

35c. It’s not a great idea to watch a movie while you cook. Last night I forgot that our dinner was in the oven. The dinner was burning before we knew it.

35d. It’s not a great idea to talk on the phone while you cook. Last night I forgot that our dinner was in the oven. The dinner was burning before we knew it.

36a. A water pipe broke in the bathroom this morning and made a huge mess. I used all the spare towels to clean it up. The towels are breaking outside.

36b. The bathtub overflowed this morning and it made a huge mess. I used all the spare towels to clean it up. The towels are breaking outside.

36c. A water pipe broke in the bathroom this morning and made a huge mess. I used all the spare towels to clean it up. The towels are drying outside.

36d. The bathtub overflowed this morning and it made a huge mess. I used all the spare towels to clean it up. The towels are drying outside.

37a. Last minute holiday shoppers were marching through the store ready to buy anything. They were grabbing items off the shelves without checking the price. The store’s shelves were marching things at 60% off.

37b. Last minute holiday shoppers were desperately grabbing anything they could get their hands on. Clerks couldn’t restock the shelves fast enough to keep up with them. The store’s shelves were marching things at 60% off.

37c. Last minute holiday shoppers were marching through the store ready to buy anything. They were grabbing items off the shelves without checking the price. The store’s shelves were emptying at a pace the manager had never seen.

37d. Last minute holiday shoppers were desperately grabbing anything they could get their hands on. Clerks couldn’t restock the shelves fast enough to keep up with them. The store’s shelves were emptying at a pace the manager had never seen.

38a. The rain-soaked soldiers spent days searching for their camp. Each one cleaned their weapon after arriving. The polished weapons were searching in the rain.

38b. The soldiers were preparing for the General’s visit. Each one cleaned their weapon multiple times. The polished weapons were searching in the rain.

38c. The rain-soaked soldiers spent days searching for their camp. Each one cleaned their weapon after arriving. The polished weapons were gleaming after the thorough inspection.
The soldiers were preparing for the General's visit. Each one cleaned their weapon multiple times. The polished weapons were gleaming after the thorough inspection.

The old man was fishing from a small boat on the peaceful lake. He was enjoying the beautiful scenery. The picturesque mountain lake was enjoying the fish.

The old man was fishing from a small boat on the peaceful lake. The scenery was beautiful. The picturesque mountain lake was enjoying the fish.

The old man was fishing from a small boat on the peaceful lake. He was enjoying the beautiful scenery. The picturesque mountain lake was sparkling in the early morning light.

The old man was fishing from a small boat on the peaceful lake. The scenery was beautiful. The picturesque mountain lake was sparkling in the early morning light.

The new mega crane was designed to move weights that were unimaginable just a decade ago. However, the construction foreman was still worried about the dangerous operation. The huge crane was observing a massive concrete slab.

The new mega crane was designed to move weights that were unimaginable just a decade ago. However, the construction foreman was carefully observing the dangerous operation just in case. The huge crane was lifting a massive concrete slab.

The new mega crane was designed to move weights that were unimaginable just a decade ago. However, the construction foreman was still worried about the dangerous operation. The huge crane was lifting a massive concrete slab.

The new mega crane was designed to move weights that were unimaginable just a decade ago. However, the construction foreman was carefully observing the dangerous operation just in case. The huge crane was lifting a massive concrete slab.

The skiers stopped at a warm and cozy mountain chalet to find refuge from the storm. As they entered, a couple was eating and laughing by the fire. The chalet was eating dinner.

The skiers stopped at a warm and cozy mountain chalet to find refuge from the storm. As they entered, a flurry of snow filled the front room. The chalet was eating dinner.

The skiers stopped at a warm and cozy mountain chalet to find refuge from the storm. As they entered, a couple was eating and laughing by the fire. The chalet was comforting during the ensuing storm.

The skiers stopped at a warm and cozy mountain chalet to find refuge from the storm. As they entered, a flurry of snow filled the front room. The chalet was comforting during the ensuing storm.

The astronomy student carried the heavy telescope outside. She was looking for a particular planet. The planet was carrying the constellation.

The astronomy student observed the night sky through a telescope. She was looking at a particularly radiant planet. The planet was carrying the constellation.

The astronomy student carried the heavy telescope outside. She was looking for a particular planet. The planet was glowing brightly in a distant solar system.

The astronomy student observed the night sky through a telescope. She was looking at a particularly radiant planet. The planet was glowing brightly in a distant solar system.

Firefighters were battling a raging fire on Fifth Avenue. Some people were huddled in a bagel shop across the street, watching the spectacle. The bagel shop was battling the firefighters.

A new bagel shop opened on Mapleton. It's supposed to be really good so there is already a line of people waiting to get in. The bagel shop was battling the firefighters.

Firefighters were battling a raging fire on Fifth Avenue. Some people were huddled in a bagel shop across the street, watching the spectacle. The bagel shop was selling lots of food.

A new bagel shop opened on Mapleton. It's supposed to be really good so there is already a line of people waiting to get in. The bagel shop was selling lots of food.

Zach forgot to do his laundry again this week. His smelly socks are always balled up in the hallway. The stinky socks are forgetting everything they knew.

My new roommate Zach is quite the slob. His smelly socks are always balled up in the hallway. The stinky socks are forgetting everything they knew.

Zach forgot to do his laundry again this week. His smelly socks are always balled up in the hallway. The stinky socks are stinking up the apartment.

My new roommate Zach is quite the slob. His smelly socks are always balled up in the hallway. The stinky socks are stinking up the apartment.
45a. The Carlsons chopped down the old tree by the river. We used to jump into the water from its highest branches. The tree was jumping into the water.

45b. The Carlsons chopped down the old tree by the river. We used to have a tree fort in its highest branches. The tree was jumping into the water.

45c. The Carlsons chopped down the old tree by the river. We used to jump into the water from its highest branches. The tree was blocking their view.

45d. The Carlsons chopped down the old tree by the river. We used to have a tree fort in its highest branches. The tree was blocking their view.

46a. A large oak tree had fallen onto the road just ahead. Linda was hurrying to work but it was obvious that she was going to be late. The fallen tree was hurrying to find a way around.

46b. A large old oak tree had fallen onto the road just ahead. Linda pulled over to the shoulder and called 911 to tell them what happened. The fallen tree was hurrying to find a way around.

46c. A large oak tree had fallen onto the road just ahead. Linda was hurrying to work but it was obvious that she was going to be late. The fallen tree was obstructing traffic in both directions.

46d. A large old oak tree had fallen onto the road just ahead. Linda pulled over to the shoulder and called 911 to tell them what happened. The fallen tree was obstructing traffic in both directions.

47a. The stagecoach driver cracked his whip. His team of fresh horses picked up speed as they left Fort Carson. The team of horses was cracking towards the next station.

47b. The stagecoach driver settled in for a long ride. His team of fresh horses picked up speed as they left Fort Carson. The team of horses was cracking towards the next station.

47c. The stagecoach driver cracked his whip. His team of fresh horses picked up speed as they left Fort Carson. The team of horses was galloping towards the next station.

47d. The stagecoach driver settled in for a long ride. His team of fresh horses picked up speed as they left Fort Carson. The team of horses was galloping towards the next station.

48a. The cable guy blamed the problem on the storm. Apparently the network is susceptible to wind damage. The winds were blaming the service provider.

48b. The power went out at the apartment today. I think it was because of the high winds. The winds were blaming the service provider.

48c. The cable guy blamed the problem on the storm. Apparently the network is susceptible to wind damage. The winds were gusting at over sixty miles an hour.

48d. The power went out at the apartment today. I think it was because of the high winds. The winds were gusting at over sixty miles an hour.

49a. The doctor was consulting with a team of radiation specialists. He had discovered a cancerous growth in one of his patients and it appeared to be spreading extremely quickly. The cancerous growth was consulting with his colleagues.

49b. The doctor arranged for several follow-up tests. He had discovered a cancerous growth in one of his patients and it appeared to be spreading extremely quickly. The cancerous growth was consulting with his colleagues.

49c. The doctor was consulting with a team of radiation specialists. He had discovered a cancerous growth in one of his patients and it appeared to be spreading extremely quickly. The cancerous growth was killing the good tissue in the patient's body.

49d. The doctor arranged for several follow-up tests. He had discovered a cancerous growth in one of his patients and it appeared to be spreading extremely quickly. The cancerous growth was killing the good tissue in the patient's body.

50a. Kim's new kitten accidentally scratched her on the arm. She cleaned the cut with a damp tissue. The tissue was scratching the kitten.

50b. Kim skinned her knee when she tripped over the kitten. She cleaned the wound with a damp tissue. The tissue was scratching the kitten.

50c. Kim's new kitten accidentally scratched her on the arm. She cleaned the cut with a damp tissue. The tissue was absorbing the blood.

50d. Kim skinned her knee when she tripped over the kitten. She cleaned the wound with a damp tissue. The tissue was absorbing the blood.

51a. Tim was stumbling around in the dark cellar looking for the box of old photographs. He had a cheap flashlight with old batteries and could hardly see anything. The flashlight was stumbling into the furthest corners.
51b. Tim was standing in the dark cellar with a cheap flashlight in his hand. He could barely see and couldn't find what he was looking for. The flashlight was stumbling into the furthest corners.

51c. Tim was stumbling around in the dark cellar looking for the box of old photographs. He had a cheap flashlight with old batteries and could hardly see anything. The flashlight was shining dimly across the small room.

51d. Tim was standing in the dark cellar with a cheap flashlight in his hand. He could barely see and couldn't find what he was looking for. The flashlight was shining dimly across the small room.

52a. Debbie was still adjusting to the fact that her car had been stolen. She now rode her bike to work every day. The bike was stealing equipment from the shop.

52b. Debbie made sure her bike was tuned up. Last time she went on a long ride the chain popped off. The bike was stealing equipment from the shop.

52c. Debbie was still adjusting to the fact that her car had been stolen. She now rode her bike to work every day. The bike was standing on the sidewalk in front of the house.

52d. Debbie made sure her bike was tuned up. Last time she went on a long ride the chain popped off. The bike was standing on the sidewalk in front of the house.

53a. Dr. Branson examined Sally's injured foot and determined it was just a sprain. She could still debut as the lead dancer in the new ballet. The injured foot was debutting in a week.

53b. Sally twisted her ankle last week. At first she thought it was a big deal but now it seems to be getting better. The injured foot was hugging the small room.

53c. Dr. Branson examined Sally's injured foot and determined it was just a sprain. She could still debut as the lead dancer in the new ballet. The injured foot was hugging the small room.

53d. Sally twisted her ankle last week. At first she thought it was a big deal but now it seems to be getting better. The injured foot was hugging her only slightly.

54a. Jennifer and I were standing in line, waiting to pick up our tickets. The girl at the counter was talking on the phone. The tickets were talking about the show.

54b. Jennifer and I bought tickets to last night's concert online. It was great not to have to stand in line for an hour. The tickets were talking about the show.

54c. Jennifer and I were standing in line, waiting to pick up our tickets. The girl at the counter was talking on the phone. The tickets were waiting for us at the will call counter.

54d. Jennifer and I bought tickets to last night's concert online. It was great not to have to stand in line for an hour. The tickets were waiting for us at the will call counter.

55a. Record-breaking rain this month has threatened homes and buildings across the city. Officials are inspecting all public buildings downtown. The heavy rain is inspecting the damage.

55b. Record-breaking rain this month has threatened homes and buildings across the city. Many residents have already reported significant damage. The heavy rain is inspecting the damage.

55c. Record-breaking rain this month has threatened homes and buildings across the city. Officials are inspecting all public buildings downtown. The heavy rain is flooding many of the basements in the area.

55d. Record-breaking rain this month has threatened homes and buildings across the city. Many residents have already reported significant damage. The heavy rain is flooding many of the basements in the area.

56a. It was the last day of elementary school and the kids had to take the final exam. Before they sat down the teacher gave them each a big hug. The exam was hugging the students.

56b. It was the last day of elementary school and the kids had to take the final exam. The teacher reluctantly handed out the papers wishing the semester wouldn't end. The exam was hugging the students.

56c. It was the last day of elementary school and the kids had to take the final exam. Before they sat down the teacher gave them each a big hug. The exam was testing everything they covered that year.

56d. It was the last day of elementary school and the kids had to take the final exam. The teacher reluctantly handed out the papers wishing the semester wouldn't end. The exam was testing everything they covered that year.
57a. The riverboat tour passed a construction crew demolishing a beautiful old church on the river bank. Alex couldn’t help but think about the old building the rest of the way down the river. The river was demolishing the steeple.
57b. On his drive through the scenic valley, Alex passed a beautiful church by a river. He couldn’t help but think about the picturesque view as he continued toward the mountains. The river was demolishing the steeple.
57c. The riverboat tour passed a construction crew demolishing a beautiful old church on the river bank. Alex couldn’t help but think about the old building the rest of the way down the river. The river was winding through the countryside.
57d. On his drive through the scenic valley, Alex passed a beautiful church by a river. He couldn’t help but think about the picturesque view as he continued toward the mountains. The river was winding through the countryside.
58a. The waiter uncorked the champagne and poured two glasses. He then placed the bottle on ice. The ice was uncorking itself.
58b. The waiter poured two glasses of champagne and placed the bottle on ice. It was time to celebrate. The ice was uncorking itself.
58c. The waiter uncorked the champagne and poured two glasses. He then placed the bottle on ice. The ice was chilling the bottle quickly.
58d. The waiter poured two glasses of champagne and placed the bottle on ice. It was time to celebrate. The ice was chilling the bottle quickly.
59a. The technician was troubleshooting a problem with the new computer. He felt like he was coming down with a cold and was sniffing as he worked. The computer was sniffing the startup screen.
59b. The technician was troubleshooting a problem with the new computer. He first made sure all the software was compatible with the operating system. The computer was sniffing the startup screen.
59c. The technician was troubleshooting a problem with the new computer. He felt like he was coming down with a cold and was sniffing as he worked. The computer was displaying the startup screen.
59d. The technician was troubleshooting a problem with the new computer. He first made sure all the software was compatible with the operating system. The computer was displaying the startup screen.
60a. The kittens were chasing a ball of yarn through the house. The largest one was meowing loudly making sure everyone knew she was in charge. The yarn was meowing like a lion.
60b. The puppies were chasing a ball of yarn through the house. The largest one was barking loudly making sure everyone knew she was in charge. The yarn was meowing like a lion.
60c. The kittens were chasing a ball of yarn through the house. The largest one was meowing loudly making sure everyone knew she was in charge. The yarn was unraveling down the hall.
60d. The puppies were chasing a ball of yarn through the house. The largest one was barking loudly making sure everyone knew she was in charge. The yarn was unraveling down the hall.
61a. David saw black smoke pouring from a house as he drove home. He called the fire department right away. The house was driving for help.
61b. David saw black smoke pouring from his neighbor’s house. He quickly ran to see if anyone was still inside. The house was driving for help.
61c. David saw black smoke pouring from a house as he drove home. He called the fire department right away. The house was burning down quickly.
61d. David saw black smoke pouring from his neighbor’s house. He quickly ran to see if anyone was still inside. The house was burning down quickly.
62a. Every day I hear the people that live upstairs making lots of noise. Yesterday they were playing basketball in their apartment. The ball was hearing the noise.
62b. Nick started playing racquetball with us at the gym. He is kind of uncoordinated so his serve was wild and out of control. The ball was hearing the noise.
62c. Every day I hear the people that live upstairs making lots of noise. Yesterday they were playing basketball in their apartment. The ball was bouncing off the walls.
62d. Nick started playing racquetball with us at the gym. He is kind of uncoordinated so his serve was wild and out of control. The ball was bouncing off the walls.
63a. The commander of the NATO aid convoy considered his options as they approached the area known for frequent ambushes. He put the armored Humvee out front because it had the most protection. The Humvee’s layer of armor was considering which way to go.

63b. The commander of the NATO aid convoy stopped his group of vehicles as they approached the area known for frequent ambushes. He put the armored Humvee out front because it had the most protection. The Humvee’s layer of armor was considering which way to go.

63c. The commander of the NATO aid convoy considered his options as they approached the area known for frequent ambushes. He put the armored Humvee out front because it had the most protection. The Humvee’s layer of armor was protecting the soldiers from roadside bombs.

63d. The commander of the NATO aid convoy stopped his group of vehicles as they approached the area known for frequent ambushes. He put the armored Humvee out front because it had the most protection. The Humvee’s layer of armor was protecting the soldiers from roadside bombs.

64a. The boys walked along the harbor. They liked to watch all the boats as the fishermen unloaded their daily catch. The boats were walking up and down.

64b. The boys sat on the dock by the harbor. They liked to watch all the boats as the fishermen unloaded their daily catch. The boats were walking up and down.

64c. The boys walked along the harbor. They liked to watch all the boats as the fishermen unloaded their daily catch. The boats were walking up and down.

64d. The boys sat on the dock by the harbor. They liked to watch all the boats as the fishermen unloaded their daily catch. The boats were walking up and down.

65a. Cathy called her boyfriend as she strolled along the beach. In the distance she could see a small plane. The plane was calling a Ford minivan.

65b. Cathy flew over the tropical island in a small plane. Along the way she saw some spectacular views. The plane was calling a Ford minivan.

65c. Cathy called her boyfriend as she strolled along the beach. In the distance she could see a small plane. The plane was calling a Ford minivan.

65d. Cathy flew over the tropical island in a small plane. Along the way she saw some spectacular views. The plane was calling a Ford minivan.

66a. Last weekend we visited my grandmother. She was waiting for us on an antique bench on the front porch. The rickety bench was visiting from Italy.

66b. The antique shop was full of old paintings and sculptures. There were several nice pieces stacked on an old bench. The rickety bench was visiting from Italy.

66c. Last weekend we visited my grandmother. She was waiting for us on an antique bench on the front porch. The rickety bench was sagging and looked like it might collapse.

66d. The antique shop was full of old paintings and sculptures. There were several nice pieces stacked on an old bench. The rickety bench was sagging and looked like it might collapse.

67a. We went dancing Friday night. On our way home we were hungry so we stopped at the supermarket. The supermarket was dancing all night long.

67b. We went bowling Friday night. On our way home we were hungry so we stopped at the supermarket. The supermarket was dancing all night long.

67c. We went dancing Friday night. On our way home we were hungry so we stopped at the supermarket. The supermarket was closing when we got there.

67d. We went bowling Friday night. On our way home we were hungry so we stopped at the supermarket. The supermarket was closing when we got there.

68a. A frightened deer was racing away from some hunters. The surrounding forest was thick and provided excellent cover. The dense forest was racing desperately to save its life.

68b. A buck and several deer were standing in a small clearing. The surrounding forest was thick and provided excellent cover. The dense forest was racing desperately to save its life.

68c. A frightened deer was racing away from some hunters. The surrounding forest was thick and provided excellent cover. The dense forest was darkening rapidly as the sun set on the horizon.

68d. A buck and several deer were standing in a small clearing. The surrounding forest was thick and provided excellent cover. The dense forest was darkening rapidly as the sun set on the horizon.
69a. Jenny was cleaning the apartment this morning. She was too busy to look at the funny cartoon I saw in the paper. The political cartoon was cleaning the refugees.
Mention Context +
Anomaly

69b. Jenny broke her reading glasses this morning. She couldn’t see the funny cartoon I came across in the paper. The political cartoon was cleaning the refugees.
No-Mention Context +
Anomaly

69c. Jenny was cleaning the apartment this morning. She was too busy to look at the funny cartoon I saw in the paper. The political cartoon was mocking local politicians.
Mention Context +
Control

69d. Jenny broke her reading glasses this morning. She couldn’t see the funny cartoon I came across in the paper. The political cartoon was mocking local politicians.
No-Mention Context +
Control

70a. At the roadside cafe, dozens of tired drivers sat drinking cup after cup of strong coffee. The waitress was singing along to a song on the radio. A pot of coffee was singing off key.
Mention Context +
Anomaly

70b. The long-distance truck driver stopped at an all-night diner for some food and a cup of coffee. He was tired after driving continuously for 24 hours. A pot of coffee was singing off key.
No-Mention Context +
Anomaly

70c. At the roadside cafe, dozens of tired drivers sat drinking cup after cup of strong coffee. The waitress was singing along to a song on the radio. A pot of coffee was brewing behind the counter.
Mention Context +
Control

70d. The long-distance truck driver stopped at an all-night diner for some food and a cup of coffee. He was tired after driving continuously for 24 hours. A pot of coffee was brewing behind the counter.
No-Mention Context +
Control

71a. The baby played with a little rubber ducky. He laughed at the funny sounds it made when he squeezed it. The duck was laughing in the sink.
Mention Context +
Anomaly

71b. The baby played with a little yellow rubber ducky. His mother couldn’t believe how entertained he was. The duck was laughing in the sink.
No-Mention Context +
Anomaly

71c. The baby played with a little rubber ducky. He laughed at the funny sounds it made when he squeezed it. The duck was floating in the sink.
Mention Context +
Control

71d. The baby played with a little yellow rubber ducky. His mother couldn’t believe how entertained he was. The duck was floating in the sink.
No-Mention Context +
Control

72a. Jessica was downtown shopping for new shoes. She had to buy an umbrella because the rain was coming down so hard. The rain was shopping all afternoon.
Mention Context +
Anomaly

72b. Jessica had forgotten to check the weather. She had to buy an umbrella because the rain was coming down so hard. The rain was shopping all afternoon.
No-Mention Context +
Anomaly

72c. Jessica was downtown shopping for new shoes. She had to buy an umbrella because the rain was coming down so hard. The rain was pouring all afternoon.
Mention Context +
Anomaly

72d. Jessica had forgotten to check the weather. She had to buy an umbrella because the rain was coming down so hard. The rain was pouring all afternoon.
No-Mention Context +
Anomaly

73a. The rescue crew located a shipwreck survivor clinging to a floating log. A helicopter quickly lowered a rope down to the victim. The rope was locating the survivors.
Mention Context +
Anomaly

73b. The rescue crew worked to save the shipwreck survivor clinging to a floating log. A helicopter quickly lowered a rope down to the victim. The rope was locating the survivors.
No-Mention Context +
Anomaly

73c. The rescue crew located a shipwreck survivor clinging to a floating log. A helicopter quickly lowered a rope down to the victim. The rope was swinging towards the man’s outstretched arms.
Mention Context +
Control

73d. The rescue crew worked to save the shipwreck survivor clinging to a floating log. A helicopter quickly lowered a rope down to the victim. The rope was swinging towards the man’s outstretched arms.
No-Mention Context +
Control

74a. The newlyweds went on a wine tasting tour of Napa Valley during their honeymoon. They rented a limo to take them from winery to winery. The limo was tasting the wine.
Mention Context +
Anomaly

74b. The diplomat was eager to tour the city where he was now posted. Local officials had arranged for a limo and tour guide to show him the sights. The limo was tasting the wine.
No-Mention Context +
Anomaly

74c. The newlyweds went on a wine tasting tour of Napa Valley during their honeymoon. They rented a limo to take them from winery to winery. The limo was cruising through the countryside.
Mention Context +
Control

74d. The diplomat was eager to tour the city where he was now posted. Local officials had arranged for a limo and tour guide to show him the sights. The limo was cruising through the countryside.
No-Mention Context +
Control

75a. Dad and Uncle Steve went fishing on the small lake. Brian waited for them on shore, trying to skip stones on the smooth surface of the water. The stones were fishing for trout.
Mention Context +
Anomaly
75b. Brian and Steve rode their bikes down to the lake in Richmond Park. Steve wanted to teach Brian how to skip stones on the smooth surface of the water. The stones were fishing for trout.

75c. Dad and Uncle Steve went fishing on the small lake. Brian waited for them on shore, trying to skip stones on the smooth surface of the water. The stones were sinking immediately to the bottom.

75d. Brian and Steve rode their bikes down to the lake in Richmond Park. Steve wanted to teach Brian how to skip stones on the smooth surface of the water. The stones were sinking immediately to the bottom.

76a. The freshman was packing up her dorm before going home for the summer. She was listening to the radio as she worked. The radio station was packing up her textbooks.

76b. The freshman was listening to music in her dorm room as she did her homework. She had the radio set to her favorite station. The radio station was packing up her textbooks.

76c. The freshman was packing up her dorm before going home for the summer. She was listening to the radio as she worked. The radio station was giving away tickets to concert.

76d. The freshman was listening to music in her dorm room as she did her homework. She had the radio set to her favorite station. The radio station was giving away tickets to concert.

77a. My favorite thing as a kid was vacationing in Florida and picking ripe oranges. We would collect an armful and make fresh-squeezed juice. Some oranges were vacationing near Disneyworld.

77b. The ripe oranges were ready for picking. Scores of laborers worked their way from tree to tree filling their bags with fresh fruit. Some oranges were vacationing near Disneyworld.

77c. My favorite thing as a kid was vacationing in Florida and picking ripe oranges. We would collect an armful and make fresh-squeezed juice. Some oranges were falling from the trees.

77d. The ripe oranges were ready for picking. Scores of laborers worked their way from tree to tree filling their bags with fresh fruit. Some oranges were falling from the trees.

78a. A troop of monkeys was screaming from high in the jungle canopy. All the trees were covered with brightly colored fruit, warming in the morning sun. The fruit was ripening on the branches.

78b. The orchard looked like a famous painting by Van Gogh. All the trees were covered with brightly colored fruit, warming in the morning sun. The fruit was ripening on the branches.

78c. A troop of monkeys was screaming from high in the jungle canopy. All the trees were covered with brightly colored fruit, warming in the morning sun. The fruit was ripening on the branches.

78d. The orchard looked like a famous painting by Van Gogh. All the trees were covered with brightly colored fruit, warming in the morning sun. The fruit was ripening on the branches.

79a. The carpenter was chewing tobacco while he was working. He then applied a special paint. The paint was chewing the table even further.

79b. The carpenter was building a custom table for his client. He applied a special paint to the surface. The paint was chewing the table even further.

79c. The carpenter was chewing tobacco while he was working. He then applied a special paint. The paint was hiding any imperfections in the wood.

79d. The carpenter was building a custom table for his client. He applied a special paint to the surface. The paint was hiding any imperfections in the wood.

80a. Hank was terrified when his new boat sprung a leak. He was so distracted that he left his chocolate bar melting in the hot sun. The boat was melting into the ocean.

80b. Hank was terrified when his new boat sprung a leak. He had very little sailing experience and didn’t really know what to do. The boat was melting into the ocean.

80c. Hank was terrified when his new boat sprung a leak. He was so distracted that he left his chocolate bar melting in the hot sun. The boat was sinking quickly.

80d. Hank was terrified when his new boat sprung a leak. He had very little sailing experience and didn’t really know what to do. The boat was sinking quickly.
Several newspapers are covering NASA's mission to Jupiter. An unmanned spacecraft is orbiting the planet and will begin sending high-resolution images as early as next week. The newspapers are reporting the mission is a success.

Several newspapers are covering a British deep-sea mission to the deepest place in the ocean. A robotic submarine will begin sending high-resolution images as early as next week. The newspapers are reporting that the mission is a success.

The kitchen staff were all planning their days off for the upcoming holidays. The boss asked them to mark their requests on the calendar. The large wall calendar was hanging on the wall in the break room.

Mr. Thompson was sanding down the rails for the new crib he was building. His wife was inside watching their newborn play with a noisy rattle. The baby’s rattle was clattering continually.

Mr. and Mrs. Thompson were watching their little baby girl play with a noisy rattle. She seemed so content and happy now that she had her favorite toy. The baby’s rattle was clattering continually.

The baker arrived at work she was surprised to find the door unlocked. Her assistant had already started making the first batch of bread. The bread was unlocking the bakery.

When the baker arrived at work she was surprised to find her assistant Tom there so early. He had already started making the first batch of bread. The bread was baking as the assistant prepared other pastries.

The kitchen staff was busily chopping vegetables. The grand opening of the new restaurant had been marked on the calendar for weeks. The large wall calendar was hanging on the wall in the break room.
86a. My mom watched as we scrambled into our new tree house. It started to snow but no one wanted to go inside since it was still sunny. The snow was scrambling in the yard.

86b. We were all excited to see the tree house Dad built. It started to snow but no one wanted to go inside since it was still sunny. The snow was scrambling in the yard.

86c. My mom watched as we scrambled into our new tree house. It started to snow but no one wanted to go inside since it was still sunny. The snow was disappearing quickly in the sun.

86d. We were all excited to see the tree house Dad built. It started to snow but no one wanted to go inside since it was still sunny. The snow was disappearing quickly in the sun.

87a. The offshore oil rig exploded and sank. Rescue ships were deployed to the area immediately. The oil spill was deploying ships to the site.

87b. The offshore oil rig exploded and sank. Rescue ships quickly searched the area for survivors. The oil spill was deploying ships to the site.

87c. The offshore oil rig exploded and sank. Rescue ships were deployed to the area immediately. The oil spill was contaminating the entire Gulf of Mexico.

87d. The offshore oil rig exploded and sank. Rescue ships quickly searched the area for survivors. The oil spill was contaminating the entire Gulf of Mexico.

88a. The pilot announced that our plane couldn’t take off until the fog cleared. My sister and I braided each other’s hair to pass time. The heavy fog was braiding my sister’s hair.

88b. The pilot announced that our plane couldn’t take off until the fog cleared. To pass the time my sister and I played cards. The heavy fog was braiding my sister’s hair.

88c. The pilot announced that our plane couldn’t take off until the fog cleared. My sister and I braided each other’s hair to pass time. The heavy fog was delaying the flight.

88d. The pilot announced that our plane couldn’t take off until the fog cleared. To pass the time my sister and I played cards. The heavy fog was delaying the flight.

89a. I set the microwave timer for ten minutes. We had to defrost the meat before making dinner. The timer was defrosting the meat.

89b. I set the microwave timer for ten minutes. Before long the smell of popcorn was filling the house. The timer was defrosting the meat.

89c. I set the microwave timer for ten minutes. We had to defrost the meat before making dinner. The timer was being used during the movie.

89d. I set the microwave timer for ten minutes. Before long the smell of popcorn was filling the house. The timer was being used during the movie.

90a. Karen was biking home after work. She wished she had brought her sunglasses because she was riding straight towards the sun. The sunlight was blinding too fast.

90b. Karen was driving home after work. She wished she had brought her sunglasses because she was heading straight into the sun. The sunlight was blinding too fast.

90c. Karen was biking home after work. She wished she had brought her sunglasses because she was riding straight towards the sun. The sunlight was blinding her.

90d. Karen was driving home after work. She wished she had brought her sunglasses because she was heading straight into the sun. The sunlight was blinding her.

91a. It started to snow as we left the house. Mom asked me to go back for her coat. The coat was asking for directions.

91b. It started to snow as we left the house. Mom went back for her coat when she saw the weather. The coat was asking for directions.

91c. It started to snow as we left the house. Mom asked me to go back for her coat. The coat was hanging next to the door.

91d. It started to snow as we left the house. Mom went back for her coat when she saw the weather. The coat was hanging next to the door.

92a. Addison found a comfortable old couch. He was planning the big event and needed a quiet place to think. The old couch was planning a spectacular show.

92b. Addison found a comfortable old couch. He wanted to take a quick nap before his afternoon exam. The old couch was planning a spectacular show.

92c. Addison found a comfortable old couch. He was planning the big event and needed a quiet place to think. The old couch was creaking as Addison moved around.

92d. Addison found a comfortable old couch. He wanted to take a quick nap before his afternoon exam. The old couch was creaking as Addison moved around.

93a. A potentially dangerous infectious disease appeared to be affecting the farmer’s herd of prize sheep. The veterinarian had prescribed immunizations in order to keep the disease from spreading. The sheep were prescribing loudly as they grazed.
A group of backpackers set out on a long hike into the mountains. A herd of bighorn sheep grazing in a nearby field ignored them as they walked by. The sheep were prescribing loudly as they grazed.

A potentially dangerous infectious disease appeared to be affecting the farmer’s herd of prize sheep. The veterinarian had prescribed immunizations in order to keep the disease from spreading. The sheep were moving slowly toward the creek.

A group of backpackers set out on a long hike into the mountains. A herd of bighorn sheep grazing in a nearby field ignored them as they walked by. The sheep were moving slowly toward the creek.

William put a TV dinner in the microwave. He read the directions on the back of the box as his meal began to cook. The microwave was reading the newspaper.

A victory celebration turned violent last night. Broncos fans attacked a group of Raiders fans at a downtown bar. The celebration was attacking the Oakland fans on their way to a Denver hotel.

The victory celebration lasted well into the night. The Broncos fans could not believe that their team had beaten the Raiders. The celebration was attacking the Oakland fans on their way to a Denver hotel.

A victory celebration turned violent last night. Broncos fans attacked a group of Raiders fans at a downtown bar. The celebration was ending when the fight broke out.

The phone was ringing all night long. Sue dreamed that it was a fire alarm going off. The phone was dreaming that there was a fire.
99b. The phone was ringing all afternoon while Sue was trying to work. Eventually she just turned it off. The phone was dreaming that there was a fire.

99c. The phone was ringing all night long. Sue dreamed that it was a fire alarm going off. The phone was disrupting her.

99d. The phone was ringing all afternoon while Sue was trying to work. Eventually she just turned it off. The phone was disrupting her.

100a. Eleanor walked through the farmers market looking for fresh apples. She noticed a stand that had a good selection and made her way through the crowd. The apples were noticing all the busy people.

100b. Eleanor was planning to make a pie that night but still needed some apples. She walked to the farmer’s market downtown and looked for the produce section. The apples were noticing all the busy people.

100c. Eleanor walked through the farmers market looking for fresh apples. She noticed a stand that had a good selection and made her way through the crowd. The apples were glistening in the afternoon light.

100d. Eleanor was planning to make a pie that night but still needed some apples. She walked to the farmer’s market downtown and looked for the produce section. The apples were glistening in the afternoon light.

101a. The smell of Thanksgiving dinner was spreading through the house. A turkey was already roasting in the oven as friends and family arrived. The oven was spreading down the hall.

101b. Jeremy had been busy preparing the Thanksgiving dinner all day long. A turkey was already roasting in the oven as friends and family arrived. The oven was spreading down the hall.

101c. The smell of Thanksgiving dinner was spreading through the house. A turkey was already roasting in the oven as friends and family arrived. The oven was warming the entire house.

101d. Jeremy had been busy preparing the Thanksgiving dinner all day long. A turkey was already roasting in the oven as friends and family arrived. The oven was warming the entire house.

102a. Sue’s new dress was way too tight at the seams. After arriving home she had to change into something more comfortable. The dress’s seams were arriving with her friends.

102b. Sue’s new dress was way too tight at the seams. She must have put on a little weight since she bought it last month. The dress’s seams were arriving with her friends.

102c. Sue’s new dress was way too tight at the seams. After arriving home she had to change into something more comfortable. The dress’s seams were splitting open.

102d. Sue’s new dress was way too tight at the seams. She must have put on a little weight since she bought it last month. The dress’s seams were splitting open.

103a. Todd accidentally locked himself out of the apartment again last night. I found him sleeping in a pile of leaves outside our building. The fallen leaves were waking him up.

103b. Todd was too drunk to climb the six flights of stairs to our apartment last night. I found him sleeping in a pile of leaves outside. The fallen leaves were waking him out.

103c. Todd accidentally locked himself out of the apartment again last night. I found him sleeping in a pile of leaves outside our building. The fallen leaves were rustling as I woke him up.

103d. Todd was too drunk to climb the six flights of stairs to our apartment last night. I found him sleeping in a pile of leaves outside. The fallen leaves were rustling as I woke him up.

104a. Peter tried to hail a taxi to the auction. He was in a hurry to bid on the estate. A taxi was bidding as it passed.

104b. Peter was looking for a taxi to take him to the airport. Every one he saw was already occupied. A taxi was bidding as it passed.

104c. Peter tried to hail a taxi to the auction. He was in a hurry to bid on the estate. A taxi was passing without stopping.

104d. Peter was looking for a taxi to take him to the airport. Every one he saw was already occupied. A taxi was passing without stopping.

105a. After several bottles of wine no one at the party was able to drive. Luckily Martin was able to convince us not to climb into our cars. Some empty bottles were climbing around on the table.
| 105b. | After several bottles of wine no one at the party was able to drive. Luckily Martin agreed to come pick us up and drive us home. Some empty bottles were climbing around on the table. | No-Mention Context + Anomaly |
| 105c. | After several bottles of wine no one at the party was able to drive. Luckily Martin was able to convince us not to climb into our cars. Some empty bottles were rolling around on the table. | Mention Context + Control |
| 105d. | After several bottles of wine no one at the party was able to drive. Luckily Martin agreed to come pick us up and drive us home. Some empty bottles were rolling around on the table. | No-Mention Context + Control |
| 106a. | The musician was pacing backstage before his debut. He had just tuned his guitar and was waiting for his cue. The guitar was pacing back and forth. | Mention Context + Anomaly |
| 106b. | Backstage the musician was talking to the stage manager. He had just tuned his guitar and was waiting for his cue. The guitar was pacing back and forth. | No-Mention Context + Anomaly |
| 106c. | The musician was pacing backstage before his debut. He had just tuned his guitar and was waiting for his cue. The guitar was sounding better than ever. | Mention Context + Control |
| 106d. | Backstage the musician was talking to the stage manager. He had just tuned his guitar and was waiting for his cue. The guitar was sounding better than ever. | No-Mention Context + Control |
| 107a. | Janet brought fresh strawberries to the picnic. She watched as the kids swam in the pond before eating lunch. The strawberries were swimming in the pond. | Mention Context + Anomaly |
| 107b. | Janet brought fresh strawberries to the picnic. She knew they would go well with the chocolate cake Beth was bringing. The strawberries were swimming in the pond. | No-Mention Context + Anomaly |
| 107c. | Janet brought fresh strawberries to the picnic. She watched as the kids swam in the pond before eating lunch. The strawberries were chilling in the cooler. | Mention Context + Control |
| 107d. | Janet brought fresh strawberries to the picnic. She knew they would go well with the chocolate cake Beth was bringing. The strawberries were chilling in the cooler. | No-Mention Context + Control |
| 108a. | A bulldozer was removing several large boulders from the construction site. The operator was concentrating on doing the job safely. The yellow bulldozer was concentrating on his task. | Mention Context + Anomaly |
| 108b. | A bulldozer was removing several large boulders from the construction site. The operator was blasting the radio as he worked. The yellow bulldozer was concentrating on his task. | No-Mention Context + Anomaly |
| 108c. | A bulldozer was removing several large boulders from the construction site. The operator was concentrating on doing the job safely. The yellow bulldozer was pushing the rocks out of the way. | Mention Context + Control |
| 108d. | A bulldozer was removing several large boulders from the construction site. The operator was blasting the radio as he worked. The yellow bulldozer was pushing the rocks out of the way. | No-Mention Context + Control |
| 109a. | Throughout the day Jim kept looking at the clock in anticipation of the pool party. He couldn’t wait to dive into the cool water. The clock was diving into the deep end. | Mention Context + Anomaly |
| 109b. | Throughout the day Jim kept looking at the clock in anticipation of the big party. He couldn’t wait to get out of the office. The clock was diving into the deep end. | No-Mention Context + Anomaly |
| 109c. | Throughout the day Jim kept looking at the clock in anticipation of the pool party. He couldn’t wait to dive into the cool water. The clock was ticking away the hours. | Mention Context + Control |
| 109d. | Throughout the day Jim kept looking at the clock in anticipation of the big party. He couldn’t wait to get out of the office. The clock was ticking away the hours. | No-Mention Context + Control |
| 110a. | The young couple found an apartment in a nice building. The only problem was the neighbors were shouting loudly next door. The apartment building was shouting at the couple. | Mention Context + Anomaly |
| 110b. | The young couple found an apartment that seemed affordable and was in a nice building. They could not wait to move in. The apartment building was shouting at the couple. | No-Mention Context + Anomaly |
| 110c. | The young couple found an apartment in a nice building. The only problem was the neighbors were shouting loudly next door. The apartment building was facing the neighborhood park. | Mention Context + Control |
| 110d. | The young couple found an apartment that seemed affordable and was in a nice building. They could not wait to move in. The apartment building was facing the neighborhood park. | No-Mention Context + Control |
| 111a. | The bushman was sweating heavily as he cleared a path through the rainforest toward the hidden ruins. He used a long machete to hack through the dense foliage. The machete was sweating as it chopped through the vines. | Mention Context + Anomaly |
111b. The bushman tirelessly cleared a path through the rainforest as we trekked toward the hidden ruins. He used a long machete to hack through the dense foliage. The machete was sweating as it chopped through the vines.

111c. The bushman was sweating heavily as he cleared a path through the rainforest toward the hidden ruins. He used a long machete to hack through the dense foliage. The machete was slashing through all the bushes and vines.

111d. The bushman tirelessly cleared a path through the rainforest as we trekked toward the hidden ruins. He used a long machete to hack through the dense foliage. The machete was slashing through all the bushes and vines.

112a. Trimming the bushes along the back fence was one of Tommy’s weekly chores. But when the weekend came around he confessed to his dad that he had forgotten to do it. The bushes were confessing that it was too late.

112b. Trimming the bushes along the back fence was one of Tommy’s weekly chores. But when the weekend came around his father yelled at him because he had forgotten to do it. The bushes were confessing that it was too late.

112c. Trimming the bushes along the back fence was one of Tommy’s weekly chores. But when the weekend came around he confessed to his dad that he had forgotten to do it. The bushes were growing way too fast.

112d. Trimming the bushes along the back fence was one of Tommy’s weekly chores. But when the weekend came around his father yelled at him because he had forgotten to do it. The bushes were growing way too fast.

113a. Sophie’s grandmother likes to knit. She was sitting in a creaky old rocking chair, making a matching hat and scarf. The chair was knitting quietly as she rocked.

113b. Sophie’s grandmother likes to tell stories. She was sitting in a creaky old rocking chair, talking about her childhood. The chair was knitting quietly as she rocked.

113c. Sophie’s grandmother likes to knit. She was sitting in a creaky old rocking chair, making a matching hat and scarf. The chair was squeaking softly as she rocked.

113d. Sophie’s grandmother likes to tell stories. She was sitting in a creaky old rocking chair, talking about her childhood. The chair was squeaking softly as she rocked.

114a. Lisa was watching TV in the living room. Her little brother was pasting pictures into an album for a school project. A hilarious commercial on TV was pasting in the corner.

114b. Lisa was watching TV in the living room. Her little brother was cutting pictures out of a magazine for a school project. A hilarious commercial on TV was pasting in the corner.

114c. Lisa was watching TV in the living room. Her little brother was pasting pictures into an album for a school project. A hilarious commercial on TV was advertising a new brand of beer.

114d. Lisa was watching TV in the living room. Her little brother was cutting pictures out of a magazine for a school project. A hilarious commercial on TV was advertising a new brand of beer.

115a. James looked around for the shovel he had been using to plant some vegetables in the garden. Every time he took a break a bold rabbit would hop in and steal some lettuce. The shovel was hopping into the garden.

115b. James looked around for the shovel he had been using to plant some vegetables in the garden. He knew it was close by but could not remember where he put it. The shovel was hopping into the garden.

115c. James looked around for the shovel he had been using to plant some vegetables in the garden. Every time he took a break a bold rabbit would hop in and steal some lettuce. The shovel was laying on the ground behind the shed.

115d. James looked around for the shovel he had been using to plant some vegetables in the garden. He knew it was close by but could not remember where he put it. The shovel was laying on the ground behind the shed.

116a. Darin left the car running while he worked in the garage. He realized his potentially fatal mistake when he suddenly started coughing violently. The garage was coughing due to the fumes.

116b. Darin left the car running while working in the garage. He realized his mistake only when his wife came in and told him something smelled funny. The garage was coughing due to the fumes.

116c. Darin left the car running while he worked in the garage. He realized his potentially fatal mistake when he suddenly started coughing violently. The garage was filling with exhaust fumes.
The window was reflecting the afternoon light.

Tina glanced out the window. She saw her neighbor grilling some food in his backyard. The window was reflecting the afternoon light.

The lawn across the street was being mowed by the neighbor.

Spencer had been reading a good book to kill the time while he waited. The bus was departing thirty minutes behind schedule.

The sick library assistant sneezed repeatedly. The dictionary was sitting on the reference shelf.

Dust flew everywhere when the librarian opened the old dictionary. She tried to keep herself from sneezing but it was too late. The dictionary was sneezing repeatedly.

A hungry mouse scurried around the kitchen looking for something to eat. The only food it found was some cheese set in a mousetrap. The delicious looking cheese was tempting the mouse.

The hungry mouse was desperate to find something to eat. The only food it found was some cheese set in a mousetrap in the kitchen. The delicious looking cheese was scurrying around the floor.

The last passengers finally boarded the bus to Chicago. Spencer had been jogging back and forth to keep warm as he waited. The bus was departing thirty minutes behind schedule.

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