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The independence of combinatory semantic processing: Evidence from event-related potentials

Albert Kim*, Lee Osterhout

Department of Psychology, University of Washington, USA

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Abstract

We recorded event-related brain potentials (ERPs) while participants read sentences, some of which contained an anomalous word. In the critical sentences (e.g., *The meal was devouring...*), the syntactic cues unambiguously signaled an Agent interpretation of the subject noun, whereas the semantic cues supported a Theme interpretation. An Agent interpretation would render the main verb semantically anomalous (as meals do not devour things). Conversely, the Theme interpretation would render the main verb syntactically anomalous (as the -ED form, not the -ING form, is syntactically appropriate for this interpretation). We report that the main verbs in such sentences elicit the P600 effect associated with syntactic anomalies, rather than the N400 effect associated with semantic anomalies. We conclude that, at least under certain conditions, semantic information is "in control" of how words are combined during sentence processing.
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Language comprehension involves combining words into larger representational units, such as phrases and clauses. Psycholinguistic investigation of such combinatory processing has focused heavily on the construction of syntactic representations, which provide a structural basis for semantic and pragmatic representations (e.g., Altmann & Steedman, 1988; Clifton et al., 2003; Osterhout, Holcomb, & Swinney, 1994; Rayner, Carlson, & Frazier, 1983; Trueswell, Tanenhaus, & Garnsey, 1994; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995). Within this syntacto-centric view, accurate syntactic analysis of the linguistic input is essential to successful interpretation. Contrary to such models, we report here that under certain syntactically unambiguous conditions the semantic relationships between words in a sentence are determined independently of, and even guide, the syntactic analysis of that sentence.

Syntacto-centric models have been deeply influenced by the issue of syntactic ambiguity and how it is resolved. It is well established that syntactic ambiguity challenges language comprehenders, leading to systematic errors of comprehension known as garden path effects (cf. Altmann, 1998). For instance, readers of temporarily ambiguous sentences like *The defendant examined by the lawyer was lying* often interpret *examined* as the sentence's main verb when it is actually embedded in a relative clause. Processing errors are indicated by difficulty reading *by the lawyer...*, which disambiguates the sentence (Clifton et al., 2003; Ferreira & Clifton, 1986; Rayner et al., 1983; Trueswell et al., 1994).

* Corresponding author. Fax: +1 206 685 3157.
E-mail address: alkim@u.washington.edu (A. Kim).

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Two influential families of models have developed around the study of garden path effects. Syntax-first models argue that a modular syntactic processing system precedes and guides semantic interpretation (e.g., Ferreira & Clifton, 1986, 1996). The syntactic system's initial response to syntactic ambiguity is to choose a single syntactic analysis based on preferences about grammatical structures. This initial analysis is then semantically evaluated and sometimes revised. When grammatical preferences support the wrong analysis, garden-path effects are predicted. Constraint-based models propose that syntactic ambiguities trigger the parallel activation of all analyses consistent with the grammar (e.g., MacDonald, Pearlmutter, & Seidenberg, 1994; Trueswell & Tanenhaus, 1994). A single analysis is selected through the coordination of multiple types of knowledge, including semantic knowledge and statistical knowledge about the structural biases of words. When evidence accumulates in favor of the wrong analysis, garden-path errors are predicted.

Despite fundamental differences, these models share a characterization of combinatory language processing as a series of choices about syntactic analysis. Furthermore, both models assume that syntactic cues, when *unambiguous*, will control the initial combinatory analysis of linguistic input. This assumption is fundamental to the logic of garden path experiments, in which syntactically unambiguous cues in baseline sentences are expected to cause immediate commitment to a single combinatory analysis.[1] Within this view, semantic factors may influence combinatory decisions when syntactic cues are ambiguous, but do not exert a controlling influence when syntactic cues are unambiguous.

Some recent findings seem outside the explanatory scope of the standard syntacto-centric paradigm. For example, head-mounted eye-tracking studies show that participants hearing a transitive verb in a simple sentence can begin eye-movements to plausible post-verbal objects before hearing the referring noun (Altmann & Kamide, 1999; Kamide, Altmann, & Haywood, 2003). One interpretation of such effects is that world knowledge about events and their participants can drive interpretation independently of the syntactic dependencies within the linguistic input (i.e., between the verb and its direct object). Other findings (Ferreira, 2003) suggest that semantic information can determine interpretation even when it directly conflicts with unambiguous syntactic cues. When plausible sentences (e.g., *The mouse ate the cheese)* were reversed to form implausible sentences (e.g., *The cheese ate the mouse*), participants tended to name the wrong entity as "do-er" or "acted-on," as if coercing the reversed sentences to be plausible (see also Caplan, Hildebrandt, & Waters, 1994; Herriot, 1969; Saffran, Schwartz, & Linebarger, 1998; Slobin, 1966). However, these demonstrations of semantic influences on sentence processing are not without complications. "Anticipatory" semantic interpretation, evidenced by eye-movements, might not be truly independent of syntactic control; rather predictive interpretation may be controlled by predictive syntactic structure. Participants hearing a verb might activate verb-specific syntactic knowledge that predicts a post-verbal argument and interpret the visual display accordingly (Kamide et al., 2003). The processing implications of Ferreira's (2003) and related results are uncertain, due to the use of post-sentence ruminative responses, which do not indicate whether semantic influences reflect the listeners' initial responses to the input or some later aspect of processing.

Here we used scalp-recorded event-related potentials (ERPs) to contrast the syntacto-centric view with a view that attributes greater independence to combinatory semantic processing. ERPs provide continuous measurement of the brain's electrical activity with high temporal resolution. Importantly, ERPs also respond differently to syntactic and semantic aspects of sentence processing (cf. Osterhout, McLaughlin, Kim, Greenwald, & Inoue, 2004). Semantically anomalous words elicit a negative wave that peaks approximately 400 ms after word onset (the *N400 effect*; Kutas & Hillyard, 1980, 1984; Osterhout & Nicol, 1999). By contrast, syntactically anomalous words elicit a large positive wave that onsets approximately 500 ms after the word appears and persists for at least half a second (the *P600 effect*) (Hagoort, Brown, & Groothusen, 1993; Osterhout, 1997; Osterhout & Holcomb, 1992, 1993; Osterhout, McKinnon, Bersick, & Corey, 1995; Osterhout et al., 1996; Osterhout & Nicol, 1999).[2] These language-related ERP effects are highly reproducible and generalize across various sub-classes of violation (P600 effects are elicited by violations involving phrase structure, agreement, verb subcategorization, and constituent-movement), types of languages (including word-order languages such as English, Dutch, and French, and case-marked languages such as Italian and Japanese; Inoue & Osterhout, 2004), and various methodological factors (including modality of the input,

[1] This assumption also applies to the "disambiguating" region of temporarily ambiguous sentences. Comprehenders encounter syntactically unambiguous cues in this region, and it is assumed that such cues will force them to compute the syntactically licensed interpretation.

[2] In some studies, syntactic violations have also elicited a negative wave over anterior regions of the scalp, with onsets ranging from 150 to 300 ms (Friederici, 1995; Neville, Nicol, Barss, Forster, & Garrett, 1991; Osterhout & Holcomb, 1992; Osterhout & Mobley, 1995). In the study we describe here and related studies by Kolk, Chwilla, van Herten, and Oor (2003) and Kuperberg, Sitnikova, Caplan, and Holcomb (2003), no such effects were observed.

rate of word presentation, stimuli comprised of isolated sentences or natural prose, and participants' task; McKinnon & Osterhout, 1996; Osterhout & Holcomb, 1993; Osterhout, McLaughlin, Allen, & Inoue, 2002).[3]

Two recent studies have appeared to contradict the generalization that N400 and P600 effects correlate with semantic and syntactic violation, respectively (Kolk et al., 2003; Kuperberg et al., 2003). Kolk et al. (2003) presented Dutch sentences containing relative clauses such as *De vos die op de stropers joeg*... (*The fox that hunted the poachers*...). At the clause-final verb *joeg* (*hunted*), the syntactic cues unambiguously indicated that the fox is the Agent and the poachers are the Theme. Although this analysis is semantically implausible, the verb elicited a P600 effect rather than an N400 effect. Similarly, Kuperberg et al. (2003) report that the apparently semantically anomalous verbs in sentences such as *For breakfast, the eggs would only eat*... elicited a P600 effect. One possible explanation for these unexpected results is that, as proposed by Ferreira (2003), the processing system can (at least in some circumstances) pursue a semantically attractive interpretation even when it contradicts unambiguous syntactic cues. In both of these experiments, the stimulus sentences contained a verb and nouns that could be combined in a semantically plausible manner (e.g., the poachers hunt the fox; someone eats the eggs). Critically, however, this plausible interpretation is inconsistent with the syntactic structure of the sentence. In such situations, the semantic attraction of a particular interpretation might make an unambiguous, syntactically well-formed sentence appear to be syntactically anomalous. Such an account would be incompatible with standard syntacto-centric models.

We examined this possibility by recording brain responses to simple, syntactically unambiguous strings like *The hearty meal was devouring*.... The verb *devouring* is clearly anomalous. Less clear is what type of anomaly is manifested: *devouring* could be perceived as either syntactically or semantically anomalous. The nature of the anomaly depends on how the comprehender coordinates syntactic and semantic knowledge while interpreting the string. The syntactic cues unambiguously signal that the subject noun *meal* is the Agent of the verb *devouring*. Such an interpretation is semantically anomalous, as inanimate objects do not typically devour things. Therefore, models of syntactic ambiguity resolution predict that the verb *devouring* will be perceived to be semantically anomalous, and elicit an N400 effect.

By contrast, the semantic cues in the sentence suggest a different interpretation. While *meal* is an anomalous Agent for *devouring*, it is a highly plausible Theme. The "semantic attraction" to the Theme interpretation might be so compelling that it is pursued even though it contradicts the syntactic structure of the sentence. However, such an interpretation requires a passive -ED inflection at the verb (as in *The hearty meal was devoured*...), rather than -ING. Thus, at the verb, the syntactic cues become ill-formed to support this semantically attractive Theme interpretation. If the language processing system is driven by the semantic attractiveness of the Theme assignment, the verb *devouring* will be perceived to be syntactically anomalous, and hence elicit a P600 effect. That is, powerful semantic cues may cause a syntactically well-formed string to appear to be syntactically ill-formed.

Experiment 1

Method

Participants

Twenty-four undergraduate students (11 females) from the University of Washington participated in the experiment for course credit or cash. Participants ranged in age from 18 to 30 (mean = 19.7) years. All participants in this experiment and in Experiment 2 were right-handed native English speakers with normal or corrected-to-normal vision.

Stimuli

Ninety-six stimulus items were created, each in three forms, as exemplified by 1a–c. The full stimulus set is listed in the Appendix A. Each stimulus exemplar consisted of the following sequence: a noun phrase, an auxiliary verb sequence (e.g., *was*), a critical verb (e.g., *devouring*), and post-verbal material (e.g., *the detective*). In Violation stimuli (1a) the syntactic cues unambiguously signal an Agent interpretation of the initial noun phrase. The initial noun phrase was inanimate and was an anomalous Agent but highly plausible Theme for the critical verb, as determined by experimenter intuition. Two kinds of control stimuli were created, which

[3] Our claim that syntactic anomalies elicit a P600 effect is a simple restatement of empirical evidence and is not a theoretical claim about the cognitive process made manifest by the P600 effect. Because the correlation between the presentation of a syntactic anomaly and elicitation of the P600 is so strong (and likewise for the presentation of a semantic anomaly and the elicitation of the N400 effect), one can reasonably infer that if a sentence-embedded linguistic anomaly elicits a P600 effect, it was perceived to be syntactic in nature; whereas if it elicits an N400 effect, it was perceived to be semantic/pragmatic in nature. This logic accommodates reports that things other than violations of syntactic rules elicit P600-like effects, including the perceived syntactic anomaly resulting from a syntactic garden path effect (Osterhout et al., 1994) and the introduction of syntactic complexity (Kaan, Harris, Gibson, & Holcomb, 2000). The logic furthermore holds even if P600 and N400 effects are not direct manifestations of syntactic and semantic processing, respectively.

were derived from Violation stimuli by altering either the syntactic or the semantic cues in order to provide a well-formed and plausible analog of the Violation stimuli. Passive Control stimuli (1b) were identical to Violation stimuli, up to and including the critical verb, except that the critical verb was inflected with -ED rather than -ING. This resulted in highly plausible passive sentences, with the initial noun phrase assigned to the Theme role of the critical verb. Active Control stimuli (1c) contained the same -ING inflected critical verb as Violation stimuli but began with an animate noun phrase, which was a plausible Agent and anomalous Theme for the critical verb, as determined by experimenter intuition. This resulted in highly plausible active-voice sentences, with the initial noun phrase assigned the Agent role of the critical verb.

1a. The hearty meal was *devouring* the kids. — *Violation*
1b. The hearty meal was *devoured* by the kids. — *Passive Control*
1c. The hungry boy was *devouring* the cookies. — *Active Control*

Within each stimulus triplet, the auxiliary verb sequence was held constant (41% of the items used *was* or a morphological variant thereof, and the rest used *has been* or some variant thereof). The material following the critical verb was not necessarily constant within an item, as discussed below.

Violation stimulus exemplars were constructed with three different types of post-critical-verb continuations: by-phrase (e.g., *...by the kids*); noun phrase (e.g., *...the kids*); verb phrase modifier (e.g., *...rapidly*), in 33, 31, and 32 of the 96 items, respectively. This manipulation affected material after the critical word, and therefore did not directly affect the processing response on a given trial. Its purpose was twofold. First, it was intended to reduce the recognizability of our Violation condition. Second, since the type of continuation may suggest a particular interpretation of the string (by-phrase may suggest a syntactic violation, and noun phrase continuations may suggest a semantic violation), we wanted to eliminate regularities that might allow participants to learn to parse the strings in one particular way, either implicitly or explicitly.

Three stimulus lists were created using these materials. Each participant saw one of these lists. Each list contained 32 stimuli from each stimulus type. Each stimulus item occurred only once in each list. Stimulus items were rotated through condition assignments, such that each item occurred in a different stimulus type in each list. Each list also contained 107 filler stimuli. Of these, 27, 27, and 53 were semantically anomalous (e.g., "He quit smoking when his cloud asked him to."), syntactically anomalous (e.g., "Isaac swim in the municipal swimming pool every day."), and well-formed and plausible (e.g., "The group of tourists hiked up the scenic trail."), respectively. Thus, each list contained 203 sentences in total. Fifty-eight percent were well-formed and 42% were anomalous. Stimuli were pseudo-randomly ordered, subject to the following constraints: (1) target stimuli were separated by at least one filler; (2) each half of the list contained 16 targets of each type.

Procedure

Participants were tested in a single session lasting about 1 h (including about 30 min of experimental preparation). Each participant was randomly assigned to one stimulus list and was seated in front of a CRT monitor. Each participant was instructed to read as normally as possible and to try to understand the sentences. Each trial consisted of the following events: A fixation cross appeared in the center of the screen for 700 ms, after which a stimulus sentence was presented in a word-by-word manner. Each word appeared in the center of the screen for 650 ms, followed by a blank screen interval of 50 ms. Sentence-ending words appeared with a full stop. A 1450 ms blank-screen interval followed each sentence, after which a prompt appeared asking participants to decide if the preceding sentence was a normal sentence of English. Participants were instructed to answer "Yes" if the sentence was semantically coherent and grammatically well-formed and otherwise "No." Participants responded by pressing one of two buttons, which were counter-balanced (left and right) across participants.

Data acquisition and analysis

Continuous EEG was recorded using tin electrodes attached to an elastic cap (Electro-cap International) in accordance with the extended 10–20 system (Newer et al., 1998), as illustrated in Fig. 1. Recordings were

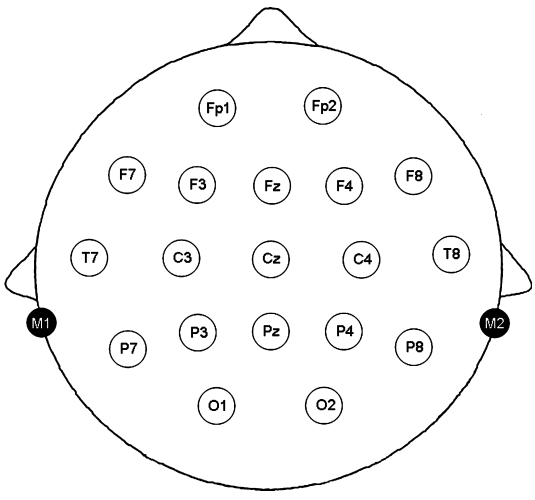

Fig. 1. Nineteen-channel montage used in Experiments 1 and 2.

obtained from left and right pre-frontal (Fp1, Fp2), frontal (F3, F4), inferior frontal (F7, F8), temporal (T7, T8), central (C3, C4), parietal (P3, P4), posterior parietal (P7, P8), and occipital (O1, O2) locations, and from three midline locations (Fz, Cz, and Pz). Vertical eye movements and blinks were monitored by means of two electrodes, one placed beneath the left eye and one placed to the right of the right eye. The above 19 channels were referenced to an electrode placed over the left mastoid bone and were amplified with a bandpass of 0.01–100 Hz (3 db cutoff) by an SAI bioamplifier system. Activity over the right mastoid was actively recorded on a 20th channel to determine if there were any effects of the experimental variables on the mastoid recordings. No such effects were observed.

Continuous analog-to-digital conversion of the EEG and stimulus trigger codes was performed at a sampling frequency of 200 Hz. ERPs, time-locked to the onset of the target stimulus, were averaged off-line within each sentence type (Violation, Passive Control, and Active Control) for each subject at each electrode site. Grand averages were formed by averaging over participants. Trials characterized by eye blinks, excessive muscle artifact, or amplifier blocking were not included in the average; 8, 9, and 8% of the trials were removed due to artifact for the Violation, Passive Control, and Active Control stimuli, respectively.

ERP components of interest were quantified by computer as mean voltage within a window of activity. After visual inspection of the data, the following windows were employed: 50–150 ms (N1), 150–300 ms (P2), 400–600 ms (N400), and 600–900 ms (P600), relative to a 100-ms prestimulus window. Repeated measures analyses of variance (ANOVAs) were performed on the above dependent measures. The Greenhouse and Geisser (1959) correction for inhomogeneity of variance was applied to all repeated measures with greater than one degree of freedom in the numerator. In such cases, the corrected p value is reported. Data acquired at midline, medial–lateral, and lateral–lateral sites were treated separately to allow for quantitative analysis of hemispheric differences. On the data from midline sites, two-way ANOVAs were performed, with repeated measures on three levels of stimulus type (Violation, Passive Control, and Active Control) and three levels of electrode position (frontal, central, and parietal). On the data from medial–lateral electrode sites, three-way ANOVAs were performed on three levels of sentence type, two levels of hemisphere (left, right), and five levels of electrode position (pre-frontal, frontal, central, parietal, and occipital). A three-way ANOVA model was also used for analysis of lateral–lateral sites, with repeated measures on three levels of sentence type, two levels of hemisphere, and three levels of electrode position (inferior frontal, temporal, and posterior parietal). Significant main effects were followed by simple effects analysis.

Results

Acceptability judgments

Participants judged the stimuli to be acceptable at the following rates: Violation, 2%; syntactically or semantically anomalous fillers, 8%; and plausible, well-formed stimuli (controls or fillers), 91%. For all of the stimuli together, participants agreed with the intended acceptability judgments at a mean rate of 92%, with individual participants ranging from 82 to 98%.

ERPs

Grand-average ERPs to the critical verbs in each sentence type are shown in Fig. 2. Fig. 2A compares the Violation condition to the Passive Control condition, and Fig. 2B compares the Violation condition to the Active Control condition. In these and all subsequent figures, the general shapes of the waveforms are consistent with previously reported data (e.g., Osterhout & Nicol, 1999). A clear negative-positive complex was visible in the first 300 ms following word onset (the "N1–P2" complex). These potentials were followed by a negative-going component with a peak around 400 ms (N400).

Inspection of Fig. 2 shows that the ERP response to the Violation verbs was dominated by a positive deflection, relative to the control conditions, beginning at about 550 ms after word onset and persisting beyond the end of the epoch. This positive deflection is highly similar to previously reported P600 responses to syntactic anomalies (cf. Osterhout, McLaughlin, & Bersick, 1997).

No statistically reliable differences were observed between 50 and 300 ms. In the 400–600 ms window, ANOVAs revealed a marginal effect of stimulus type [midline: $F(2,46) = 3.45$, $p = .05$; medial–lateral: $F(2,46) = 2.86$, $p < .1$; and lateral–lateral: $F(2,46) = 2.80$, $p < .1$]. Simple effects analyses at midline sites showed that ERPs to the Active Controls were more negative than those to the Passive Controls [$F(1,23) = 4.80$, $p < .05$] but that ERPs to Violation stimuli were not different from those elicited by the Passive Controls, $F = 2.20$, or Active Controls, $F = 2.20$.

In the 600–900 ms window, a main effect of stimulus type was observed [midline: $F(2,46) = 13.16$, $p < .001$; medial–lateral: $F(2,46) = 15.62$; $p < .001$; lateral–lateral: $F(2,46) = 15.03$, $p < .001$]. The effect of stimulus type was largest posteriorly, resulting in an interaction between stimulus type and electrode site [midline, $F(4,92) = 5.80$, $p < .005$; medial–lateral, $F(8,184) = 5.60$, $p < .005$; lateral–lateral, $F(4,92) = 5.58$, $p < .005$]. Simple effects analyses showed that ERPs to Violation verbs were more positive-going than those to either control condition [*Violation* vs. *Passive Control*: midline, $F(1,23) = 18.8$,

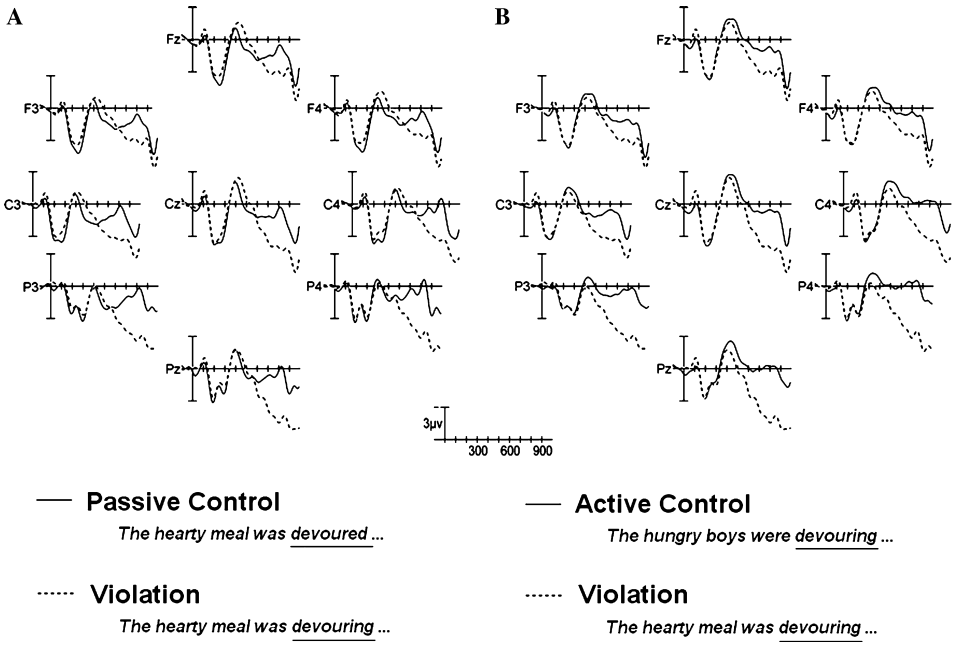

Fig. 2. (A) Grand-average ERPs recorded at three midline sites and six medial–lateral sites to Passive Control verbs (solid line) and Violation verbs (dashed line), Experiment 1. (B) Grand-average ERPs to Active Control verbs (solid line) and Violation verbs (dashed line), Experiment 1. Onset of the critical verbs is indicated by the vertical bar. Each has mark represents 100 ms of activity. Positive voltage is plotted down.

$p < .001$; medial–lateral, $F(1,23) = 22.27$, $p < .001$; and lateral–lateral, $F(1,23) = 25.44$, $p < .001$; *Violation* vs. *Active Control*: midline, $F(1,23) = 23.47$, $p < .001$, medial–lateral, $F(1,23) = 28.13$, $p < .001$; and lateral–lateral, $F(1,23) = 23.66$, $p < .001$]. The control conditions were not different from each other in this time window (midline, medial–lateral, and lateral–lateral, F's < 1).

Discussion

The critical verbs in strings such as *The hearty meal was devouring* elicited a robust P600 effect compared to the control conditions, rather than an increase in N400 amplitude. The P600 effect cannot be attributed to an outright syntactic violation, as these stimuli are syntactically well-formed. The absence of an N400 effect suggests that the syntactically supported interpretation (*meal* as Agent) was not pursued; if it had been, the verb should have been perceived to be semantically anomalous, and should have elicited an N400 effect. The semantic attraction of interpreting *meal* as Theme of *devouring* seems to be so compelling that the reader pursues this analysis even when it contradicts the unambiguous syntactic cues in the sentence. This result is inconsistent with syntacto-centric processing models. The result indicates that, at least under some circumstances, semantic processing operates independently of and perhaps even controls syntactic analysis.

We can think of two objections to our conclusions. First, statistical processing accounts (e.g., Hare, McRae, & Elman, 2004) might argue that the inanimacy of the subject noun (*meal*) predisposed the comprehension system to assume a passive syntactic analysis before the critical verb was encountered. If so, the critical verb (*devouring*) would have been perceived to be in the wrong grammatical form, since a passive structure requires the passive participle form (*devoured*).

Alternatively, a syntax-first processor might assign the anomalous Agent interpretation but detect its implausibility and begin syntactic re-analysis, manifested in the P600 effect. Re-analysis might begin so quickly (Frazier & Clifton, 1996) that the anomalous Agent interpretation is terminated before an N400 effect is elicited.

We contrasted both of these accounts with our "semantic attraction" hypothesis in Experiment 2 by presenting new sentences such as *The dusty tabletops were devouring*... Here, the subject noun and critical verb from two different Violation exemplars were combined (e.g., *tabletops* comes from *The dusty tabletops were wiping*...). The new pairings caused subject nouns to be anomalous in both Agent and Theme roles for the critical verb (*tabletops–devour*). If inanimate subject nouns cause early commitments to the passive structure, then they should do so again in Experiment 2; the set of subject nouns is the same. If syntax-first processing causes

an anomalous Agent interpretation, rapid termination, and syntactic re-analysis, then it should do so again in Experiment 2; the subject nouns were anomalous in the Agent role, as in Experiment 1. Kuperberg et al. (2003) consider a version of the syntax-first account that predicts larger P600 effects in Experiment 2 than Experiment 1. This account attributes P600 to an attempt to syntactically repair the sentence through re-assignment of thematic roles (e.g., assigning Theme instead of Agent to the pre-verbal noun). Syntactic repair is predicted to be most difficult, and P600 amplitude largest, when it creates implausible interpretations, as in our new sentences (*tabletops* is an implausible Theme for *devour*.)

In contrast, a semantic attraction hypothesis predicts a qualitatively new pattern of effects for *The dusty tabletops were devouring*.... Without semantic attraction to the syntactically unsupported Theme assignment (*tabletops* is an implausible Theme for *devour*), no P600 effect is expected. The syntactic cues in the string unambiguously signal the Agent assignment, and this assignment is expected to be pursued. The implausibility of this assignment should cause an increase in N400 amplitude.

Finally, in Experiment 1, a small but significant increase in N400 amplitude was observed for the Active Control condition relative to the Passive Control condition. One possible explanation of this difference is the relative semantic fit between the subject noun and the subsequent main verb; nouns in the Passive Control condition may have been closer semantic associates of the verb (e.g., *meal–devour*) than were nouns in the Active Control condition (e.g., *boys–devour*).

Experiment 2

Method

Participants

Twenty-nine undergraduate students (16 females) from the University of Washington participated. None had participated in the first experiment. Ages ranged from 18 to 27 (mean = 20.4) years.

Stimuli

Ninety-six stimulus items were created, each in three forms: Attraction Violation (2a), Passive Control (2b), and No-Attraction Violation (2d). The full stimulus set is listed in the Appendix A. The Attraction Violation stimuli were identical to the Violation stimuli from Experiment 1. The No-Attraction Violation stimuli were identical in syntactic cues to the Attraction Violations, but the initial noun phrases were now implausible in any thematic role offered by the main verb. The Passive Control sentences were identical to the Passive Control sentences from Experiment 1.

2a. The hearty meal was *devouring*...	*Attraction Violation*
2b. The hearty meal was *devoured* ...	*Passive Control*
2d. The dusty tabletops were *devouring* ...	*No-Attraction Violation*

No-Attraction Violation exemplars were created by pairing Attraction Violation exemplars (e.g., *The hearty meal was devouring by the kids./The dusty tabletops were wiping thoroughly*.) and swapping material preceding the critical verb (e.g., *The hearty meal was wiping by the kids./The dusty tabletops were devouring thoroughly.*). The stimuli were counterbalanced such that a given initial noun phrase or critical verb from any item was seen exactly once by each subject. Furthermore, when parts of a Violation exemplar appeared in two No-Attraction exemplars within the same list, these occurrences were separated by at least 30 trials.

Three stimulus lists were created using these materials. Each participant saw one of these lists. Each list contained 32 stimuli from each condition type. Each stimulus item occurred only once in each list. Stimulus items were rotated through condition assignments, such that each stimulus item occurred in a different condition in each list. Each list also contained 112 filler stimuli. Of these, 20, 20, and 72 were semantically anomalous, syntactically anomalous, and well-formed and plausible, respectively. The proportion of anomalous fillers was lower in Experiment 2 than in Experiment 1. This was done to partially counteract a concomitant increase in the proportion of anomalous target stimuli, which resulted from the removal of well-formed Active Controls and introduction of anomalous No-Attraction Violations to the design. Thus, each list contained 208 sentences. Fifty percent were well-formed and 50% were anomalous. Fillers and Targets were pseudorandomly ordered, as in Experiment 1.

Procedure

All procedures were the same as in Experiment 1.

Data acquisition and analysis

Data acquisition was the same as in Experiment 1. Data analysis was also the same as in Experiment 1, except that the stimulus-type variable now had the following three levels: Attraction Violation, No-Attraction Violation, and Passive Control. Approximately 12, 9, and 9% of the trials were removed due to artifact for the Attraction Violation, No-Attraction Violation, and Passive Control stimuli, respectively.

Results

Acceptability judgments

Participants judged the stimuli to be acceptable at the following rates: Attraction Violation, 3%; No-Attrac-

tion Violation, 6%; syntactically or semantically anomalous fillers, 9%; and well-formed, plausible stimuli (Passive Control or fillers), 92%. For all of the stimuli together, participants agreed with the intended acceptability judgments at a mean rate of 94%, with individual participants ranging from 82 to 99%.

ERPs

Grand-average ERPs to the critical verbs are shown in Fig. 3. Fig. 3A compares the Attraction Violation condition to the Passive Control condition. Fig. 3B compares the No-Attraction Violation condition to the Passive Control condition. In both figures, a clear negative–positive complex was visible in the first 300 ms following word onset. These potentials were followed by a negative-going component with a peak around 400 ms (N400).

Inspection of Fig. 3A shows that, as in Experiment 1, Attraction Violation verbs elicited a positive deflection of ERPs, relative to the Passive Control, beginning around 600 ms after word onset and lasting beyond the end of the epoch. Fig. 3B shows that No-Attraction Violation verbs elicited no positive deflection, but did elicit a negative deflection, beginning at around 400 ms after word onset and persisting for approximately 200–400 ms, depending on the electrode site.

As in Experiment 1, no statistically reliable differences were observed between 50 and 300 ms. In the 400–600 ms window, ANOVA revealed a main effect of stimulus type [midline, $F(2,56) = 3.55$, $p < .05$; medial–lateral, $F(2,56) = 3.49$, $p < .05$; and lateral–lateral, $F(2,56) = 2.41$, $p = .11$]. Simple effects analyses showed that ERPs to No-Attraction Violation verbs were more negative than those to both Passive Control and Attraction Violation verbs [*No-Attraction Violation* vs. *Passive Control*: midline, $F(1,28) = 6.06$, $p < .05$; medial–lateral, $F(1,28) = 3.36$, $p < .1$; *No-Attraction Violation* vs. *Violation*: midline $F(1,28) = 4.52$, $p < .05$; medial–lateral, $F(1,28) = 5.73$, $p < .05$].[4] ERPs to the Attraction Violation verbs were no different from those to Passive Controls [midline, medial–lateral, and lateral–lateral: $F(1,28) < 1.5$].[5]

At non-midline sites, the effect in this window was concentrated in the left hemisphere, as indicated by an interaction between stimulus type and hemisphere [medial–lateral: $F(2,56) = 7.60$, $p < .001$, lateral–lateral: $F(2,56) = 6.08$, $p < .01$]. Simple effects showed that the effect of stimulus type was significant in the left hemisphere but not the right [*Left*: medial–lateral, $F(2,56) = 5.52$, $p < .01$, lateral–lateral, $F(2,56) = 6.02$, $p < .005$; *Right*: medial–lateral, $F(2,56) = 1.92$; lateral–lateral, $F(2,56) = 1.53$].

In the 600–900 ms window, ANOVA revealed a main effect of stimulus type [midline, $F(2,56) = 7.23$, $p < .005$, medial–lateral: $F(2,56,) = 8.91$, $p < .001$; and lateral–lateral, $F(2,56) = 9.22$, $p < .001$]. The effect of stimulus type was largest posteriorly, although not so robustly as in Experiment 1 [*stimulus type* × *electrode site*: midline, $F(4,112) = 2.73$, $p = .05$; medial–lateral, $F(8,224) = 1.90$, $p = .1$; lateral–lateral, $F(4,112) = 3.15$, $p < .05$]. Simple effects analyses revealed that ERPs to Attraction Violation verbs were more positive-going than those to either Passive Control or No-Attraction Violation verbs [*Attraction Violation* vs. *Passive Control*: midline, $F(1,28) = 12.74$, $p < .01$, medial–lateral, $F(1,28) = 11.72$, $p < .01$; lateral–lateral, $F(1,28) = 13.60$, $p < .001$; *Attraction Violation* vs. *No-Attraction Violation*: midline, $F(1,28) = 8.23$, $p < .01$; medial–lateral, $F(1,28) = 11.61$, $p < .01$; and lateral–lateral, $F(1,28) = 7.53$, $p < .05$]. ERPs to No-Attraction Violation verbs were not reliably different from those to Passive Control verbs (midline, medial–lateral, F's < 1, lateral–lateral, $p > .1$).

Discussion

Attraction Violation verbs (e.g., *the hearty meal was devouring*...) elicited a P600 effect but not an N400 effect, replicating the result of Experiment 1. In contrast, No-Attraction Violation verbs (e.g., *the dusty tabletops were devouring*...) elicited an N400 effect but not a P600 effect, relative to the same Passive Control stimuli.

Our results were qualitatively modulated by the semantic attractiveness of particular predicate–argument combinations. In the Attraction Violation condi-

[4] A reviewer questioned whether this N400 effect might best be identified as a LAN effect, which is sometimes seen in the response to syntactic anomalies. Descriptively, the N400 label is clearly appropriate as the effect is a modulation of a well-defined negative component that peaks at about 400 ms. With respect to the LAN-N400 distinction, the effect we report here has a central distribution typical of the N400 effect, rather than the anterior distribution that is strongly characteristic of the LAN effect. Furthermore, recent experiments using procedures highly similar to those used here have found no evidence of a LAN effect to anomalies involving inflectional morphology (Allen, Badecker, & Osterhout, 2003; Osterhout et al., 2002; Osterhout & Nicol, 1999); nor was a LAN effect observed in Experiment 1. Finally, in sentence-processing studies that do report a LAN effect, the LAN effect is almost always followed by a P600 effect. All of these considerations support our identification of this effect as a modulation of the N400 component.

[5] In Experiments 1 and 2, critical verbs elicited a slightly larger N400 in the Violation Attraction condition than in the Passive Control condition. Although this effect was not statistically robust within the 400–600 ms window, we performed one-way ANOVAs on 50 ms windows surrounding the regions of largest differences, for midline sites. These differences were not statistically robust [Experiment 1: 400–450 ms, $F(1,23) = 1.35$, $p > .2$, 450–500 ms, $F(1,23) = 3.70$, $p = .07$; Experiment 2: 380–430 ms, $F(1,28) = .52$, $p > .4$].

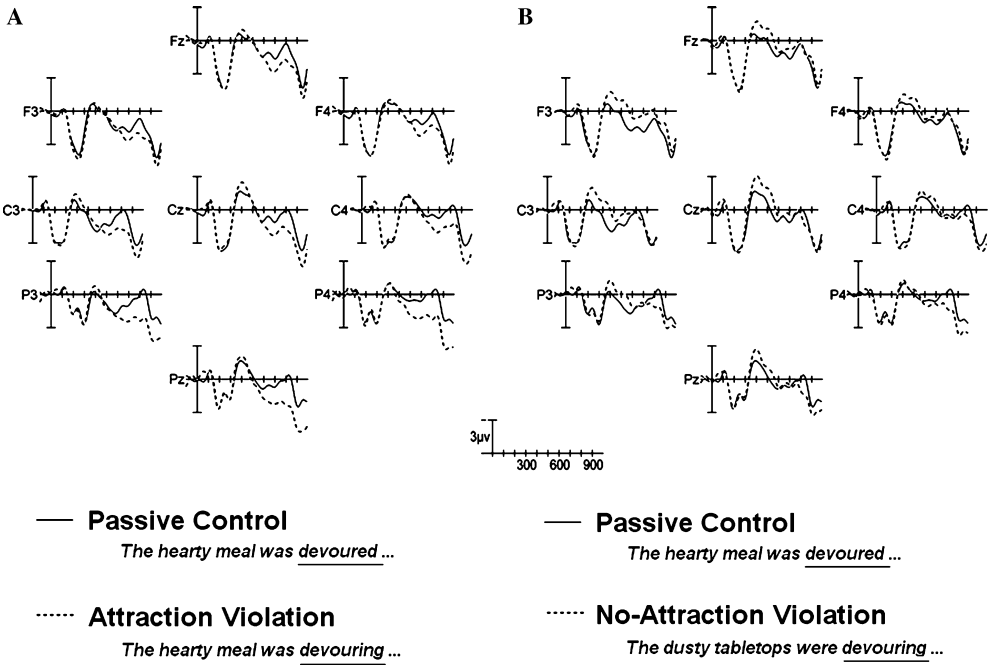

Fig. 3. (A) Grand-average ERPs recorded at three midline sites and six medial–lateral sites to Passive Control verbs (solid line) and Attraction Violation verbs (dashed line), Experiment 2. (B) Grand Average ERPs recorded at three midline sites and six medial–lateral sites to Passive Control verbs (solid line) and No-Attraction Violation verbs (dashed line), Experiment 2.

tion, there is a strong semantic attraction to a syntactically unsupported Theme assignment. Commitment to this assignment and the resulting syntactic processing difficulty explains the P600 effect. In the No-Attraction Violation condition, there is no semantic attraction to either of the critical verb's thematic roles (both assignments are implausible). Commitment to the semantically anomalous Agent assignment, guided by syntactic cues, explains the N400 effect.

The P600 effect to Attraction Violations here and in Experiment 1 cannot be explained in terms of early commitments to a passive structural analysis caused by the inanimacy of the initial noun phrase, the auxiliary verb, or some combination of the two. The No-Attraction Violations began with the same noun phrases and auxiliary verbs. The only difference was in the critical verb and other material that followed. Thus, the striking difference between ERPs to Attraction Violations and No-Attraction Violations cannot be explained without some account of the combinatory processing involving the critical verb and the initial noun. For similar reasons, syntax-first models cannot account for the difference in brain responses to Attraction Violations and No-Attraction Violations. Syntax-first accounts might attribute the P600 effect in Attraction Violations to rapid syntactic re-analysis. However, such an account would then inaccurately predict the same effect or a larger one (Kuperberg et al., 2003) in No-Attraction Violations.

General discussion

It seems to be nearly universally assumed that syntactic cues determine combinatory analysis, when those cues are unambiguous. We report here, however, that the semantic attractiveness of certain predicate–argument combinations is so compelling that it dominates combinatory analysis, overwhelming unambiguous syntactic cues. This conclusion is supported by the results of two experiments in which we recorded brain activity elicited by strings such as *The hearty meal was devouring*... The syntactic cues in this string unambiguously signal that *devour* should assign an Agent role to *meal*. Such an interpretation would render the verb semantically anomalous. However, *meal* is a semantically compelling Theme for *devour*. The semantically attractive interpretation can be accommodated by assuming that the verb required the passive -ED suffix rather than the active -ING suffix—that is, by assuming that the verb was in the wrong grammatical form. We observed that verbs such as *devouring* in these sentences elicit a P600 effect (indicating a perceived syntactic anomaly) rather than an N400 effect. Apparently, the semantic attraction between a predicate and an argument can be so compelling that readers perceive a syntactically well-formed string to be syntactically ill-formed. Experiment 2 demonstrated that this finding was not due to the inanimacy of the subject noun and in fact requires a semantic attraction.

Related ERP findings

Kolk et al. (2003) and Kuperberg et al. (2003) both reported P600 effects to verbs that were seemingly semantically anomalous (e.g., *The eggs would eat*...) (see also Hoeks, Stowe, & Doedens, 2004). As in our Attraction Violation stimuli, the semantic cues in these sentences support a Theme assignment at the critical verb, whereas the syntactic cues support an implausible Agent assignment. The P600 effects might therefore be attributed to syntactic breakdown when syntactic cues fail to support the attractive Theme assignment. These findings are suggestive but complicated. The stimuli used by Kuperberg et al. (2003) were a mixture of some resembling our Attraction Violations and others resembling our No-Attraction Violations (e.g., *the rings finally kissed*). This variation may explain the fact that their P600 effect was small in amplitude and accompanied by a small N400 effect. The Kolk et al. (2003) study included a condition resembling our No-Attraction Violations (called "selectional restriction" violations). This condition elicited an N400 effect. Confusingly, however, the condition also elicited a robust P600 effect in the first of their two studies and none in the second. The Kolk et al. (2003) results are further complicated by the placement of the critical verbs inside complex linguistic structures. It is possible that the antecedents of positivities in such situations are different from that in simpler situations, perhaps due to the processing demands of maintaining complex syntactic structures in memory (cf. Kaan et al., 2000). Our study manipulated the presence or absence of semantic attraction to ungrammatical interpretations, using syntactically simple stimuli, and found a qualitative modulation of brain responses to the anomalous verbs (from P600 to N400). This finding suggests a unification of the prior findings with our own by an account based on semantic attraction to an ungrammatical interpretation.

Models of sentence processing

Our data appear to be consistent with a system of parallel, independent syntactic and semantic processing mechanisms. Semantic processing commits to highly attractive predicate–argument combinations, even when they contradict unambiguous syntactic cues. This is not simply a matter of ignoring syntactic cues, however, as the resulting P600 effect indicates that the participants were syntactically analyzing the sentence and finding it to be syntactically ill-formed.

Historically, a number of models of syntactic ambiguity resolution have included elements of parallelism in syntactic and semantic processing (Altmann & Steedman, 1988; Boland, 1997; Frazier, 1987; Rayner et al., 1983; Trueswell et al., 1994). However, most of these models explicitly restrict the independence of semantic processing, so that it is either slower than syntactic analysis and therefore unable to determine initial combinatory commitments (Frazier, 1987; Rayner et al., 1983) or only capable of pursuing grammatically legal analyses (Altmann & Steedman, 1988; Boland, 1997). Our results strongly conflict with such restrictions on semantic processing. Some of these models are, in principle, free of such restrictions (e.g., Trueswell et al., 1994). However, even in such cases, explicit predictions have focused exclusively on garden path situations. Combinatory language processing is characterized as a series of choices about syntactic analyses. Semantic constraints influence syntactic choices when syntactic cues are ambiguous. However, when syntactic cues are *unambiguous*, they control combinatory language processing. This syntacto-centric assumption limits the independence of combinatory semantic processing and conflicts with our results.

Recent proposals by Ferreira, Bailey, and Ferraro (2002) and Kamide et al. (2003) allow greater independence for semantic processing. Ferreira et al. (2002) propose that combinatory interpretation is served by "good-enough" heuristics. One heuristic combines the words of a sentence in the manner most consistent with world knowledge. A second treats all Noun–Verb–Noun (NVN) sequences as Agent–Predicate–Theme sequences (Bever, 1970; Carlson & Tanenhaus, 1988). These heuristics sometimes determine interpretation instead of syntactic analysis.[6] Consistent with this proposal, numerous studies have shown that plausibility and NVN strategies influence post-sentence measures of language comprehension in syntactically unambiguous sentences (Caplan et al., 1994; Ferreira, 2003; Herriot, 1969; Saffran et al., 1998; Slobin, 1966). Other studies have reported that asyntactic aphasics depend on plausibility and NVN heuristics for comprehension abilities preserved in brain damage (Caramazza & Zurif, 1976; Grodzinsky, 2000; Saffran et al., 1998). Our findings provide on-line evidence of a process that might be understood as a kind of semantic "heuristic."

Kamide et al. (2003; see also Altmann, 1999; Altmann and Kamide, 1999; Boland et al., 1995) propose that world knowledge allows combinatory semantic processing to *predict* upcoming linguistic input, using semantic constraints imposed by the input already encountered. This proposal appears consistent with head-mounted eye-tracking studies showing "anticipatory" interpretation (Kamide et al., 2003) as well as lexical

[6] Townsend and Bever (2001) propose a model that is similar in many respects. However, their proposal attributes algorithmic syntactic analysis to a late stage of analysis, which follows the operation of other more heuristic processes. Although our data might be accommodated within such 'syntax-last' account, they do not require that syntactic processing is last; rather they require that it is not first.

priming studies in which briefly presented verbs speeded the recognition of typical Agents, Patients, and Instruments (Ferretti, McRae, & Hatherell, 2001). Our results appear consistent with such a proposal.

Our data suggest refinements to these proposals. Ferreira (2003) argues that the NVN heuristic is more influential than the plausibility heuristic, when the two compete for influence. Contrary to this argument, we found that semantic cues favoring a Theme-first analysis determined thematic role assignments even when an NVN heuristic and syntactic cues both signaled an Agent-first analysis, as in our Attraction Violation stimuli.

Kamide et al.'s (2003) proposal does not preclude the possibility that the influence of world knowledge on sentence processing must respect syntactic constraints, for instance verb-specific syntactic knowledge that predicts post-verbal arguments. However, our data show clearly that combinatory semantic processing can operate independently of syntactic constraints; semantic commitments can *contradict* clear syntactic cues.

Syntactic and semantic streams of processing: Attraction, independence, and interaction

We suggest here that the proposal of Trueswell et al. (1994; see also Trueswell and Tanenhaus, 1994), while excessively focused on syntactic ambiguity, introduces ideas that are valuable in understanding our findings. The proposal focuses on similarities between the language processing system and the visual processing system, which is widely understood to contain multiple parallel streams of processing (e.g., dorsal and ventral streams that process object and spatial vision, respectively; Ungerleider & Haxby, 1994). These processing streams are thought to be independent in some respects (each processes a distinct aspect of the visual world) and interactive in others (crosstalk occurs between the multiple streams). Analogously, combinatory language processing might be divided into two independent but constantly interacting streams of analysis. Each stream processes a different dimension of the linguistic input (e.g., syntactic cues and semantic/thematic cues). Each dimension of linguistic input is characterized by pervasive local indeterminacies that can often be resolved by appeal to correlated information from the others.

To accommodate our data, this proposal must expand beyond the exclusive focus on syntactic ambiguity to allow an account of how semantic processing can pursue ungrammatical interpretations. But an expanded parallel model, with truly independent syntactic and semantic subsystems, must reconcile the functional independence of subsystems with interactions between them. That is, how can subsystems be independent of each other even as they influence each other? Here we suggest that the functional independence of syntactic and semantic systems is rooted in the existence of system-specific forms of attraction (e.g., Tabor & Tanenhaus, 1999). Each system recognizes attractive analyses. Strongly attractive analyses engender such certainty that they are pursued in the face of countervailing inputs from the other stream. When a system lacks a strongly attractive analysis, it becomes susceptible to the influences of other knowledge sources, which impinge upon it constantly. For the semantic system, strong attraction occurs when one thematic role assignment is far more plausible than any other logically possible assignment. Weak attraction is exemplified in the classic descriptions of the function of syntax (e.g., *John attacked Bob* vs. *John was attacked by Bob*). For the syntactic system, strong attraction occurs when unambiguous cues (e.g., morphological inflection) or strong statistical cues make one analysis far more likely than any other. Weak attraction is exemplified in the situations widely studied by models of semantic ambiguity resolution. Viewed this way, there is no inconsistency in the simultaneous proposal of functional independence and constant interaction.

Conclusions and future work

Our findings demonstrate that, at least under certain conditions, semantic attraction to particular predicate–argument combinations determines combinatory processing, even when these combinations contradict unambiguous syntactic cues in the sentence. This provides strong support for a model in which semantic processing can operate independently of syntactic control, and also points to the basis of semantic independence, semantic attraction. But the result raises the question of why semantic attraction "wins" the conflict of cues manifested in our stimuli, in which syntactic cues were also strong, not weak or ambiguous. Our model does not explain this. Perhaps strong semantic attraction is strictly more influential than the strongest syntactic cues in determining interpretations. But this leads to questions about what constitutes "strong" semantic attraction. In the current study, we treated semantic attraction as a binary variable, with a P600 effect elicited in situations of strong attraction to ungrammatical interpretations and an N400 effect when no such attraction existed. In reality, however, semantic attraction almost certainly varies continuously. This implies that there should be a "tipping point" at which the semantic attraction is sufficiently strong to control combinatory processing. We are investigating this issue by manipulating the strength of the semantic association in a pseudo-continuous fashion, and determining the amount of attraction required to "flip" the brain response from one state (manifested by an N400 effect) to another (manifested by a P600 effect).

Perhaps the phenomenon here is best understood in terms of the different natures of syntactic and semantic processing, rather than their relative strengths. Semantic attraction may reflect the activation of highly stable representations in world knowledge (e.g., Ferretti et al., 2001; Kamide et al., 2003; McRae, Ferretti, & Amyote, 1997). Confronted by opposition from stable semantic representations, syntactic processing may find some structures easy to "repair." For example, the semantic attraction in *The hearty meal was devouring* can be accommodated by simply changing the inflectional morpheme on *devour* from -ING to -ED. The data of Kolk et al. (2003) and Kuperberg et al. (2003) suggest difficulty with this account, because their stimuli could not be repaired through inflectional change. Perhaps syntactic processing creates "fragile" representations (Ferreira et al., 2002), which collapse without support from semantic interpretations. This syntactic fragility is presumably difficult to observe, because syntactic and semantic processing tend to agree on a single interpretation (indeed, syntactic representations appear stable even when interpretations are quite difficult, as in our No-Attraction Violations and other N400 situations). We are currently investigating these issues with syntactic priming manipulations designed to bolster fragile syntactic representations and systematic manipulations of the ease of syntactic repair (e.g., Difficult: *The hearty meal will devour*... vs. Easy: *The hearty meal was devouring*...). Thus, further study of the phenomenon here may reveal not only the independence of semantic processing but also fundamental but poorly understood differences between syntactic and semantic processing.

Given the novelty of these results, there are inevitably limitations and potential objections that apply to them. One possible objection is that we presented the sentences at a relatively slow rate of one word every 700 ms. We did this in order to maximally isolate the brain responses of interest. It is conceivable that this rate, which is far from the typical rate at which sentences are read, might somehow have altered the normal course of comprehension. This seems unlikely, however, as our sentences were unexceptional up until the critical anomalous word, and it is difficult to see how or why the rate of presentation would induce a change in the brain response to the anomalous words. Nonetheless, we are currently replicating these experiments using faster visual presentation of the stimuli and by presenting sentences as continuous natural speech. Regardless of the outcome of these replications, our findings provide a compelling demonstration that, at least under certain conditions, semantics (and not syntax) is "in control" of how words are combined during on-line sentence processing.

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Appendix. Experimental stimuli for Experiments 1 and 2

Stimulus sentences labeled "E1" occurred in Experiment 1. Those labeled "E2" occurred in Experiment 2. The "Violation" stimuli from Experiment 1 are identical to the "Attraction Violation" stimuli from Experiment 2; here we use the latter label.

1.	The murder had been witnessing by the three bystanders	Attraction Violation	E1	E2
	The murder had been witnessed in the dark.	Passive Control	E1	E2
	The bystanders had been witnessing the crime.	Active Control	E1	
	The unpleasant cough syrup was witnessing in the dark.	No-Attraction Violation		E2
2.	Patty's overgrown lawn was mowing the boy next door.	Attraction Violation	E1	E2
	Patty's overgrown lawn was mowed only last week.	Passive Control	E1	E2
	Patty's teenage son was mowing the lawn.	Active Control	E1	
	All of her money had been mowing the grass.	No-Attraction Violation		E2
3.	Three more martinis were ordering by Laurie's sister.	Attraction Violation	E1	E2
	Three more martinis were ordered repeatedly.	Passive Control	E1	E2
	The regular customers were ordering quiche, as usual.	Active Control	E1	
	The rough part of the wood was ordering late.	No-Attraction Violation		E2
4.	The quality of Karla's work was evaluating frequently.	Attraction Violation	E1	E2
	The quality of Karla's work was evaluated frequently.	Passive Control	E1	E2
	The engineers were evaluating the success of the new device.	Active Control	E1	
	The old lady's purse had been evaluating Nelson's idea.	No-Attraction Violation		E2
5.	The legal contract had been signing falsely.	Attraction Violation	E1	E2
	The legal contract had been signed by the family.	Passive Control	E1	E2

Appendix (*continued*)

	The state's governor had been signing new legislation.	Active Control	E1	
	An appointment was signing falsely.	No-Attraction Violation		E2
6.	The vocabulary list was memorizing well.	Attraction Violation	E1	E2
	The vocabulary list was memorized well.	Passive Control	E1	E2
	The medical students were memorizing sample exam questions all night.	Active Control	E1	
	The simple coffin was memorizing the lines of the poem.	No-Attraction Violation		E2
7.	The firewood had been chopping poorly.	Attraction Violation	E1	E2
	The firewood had been chopped by Jen's grandfather.	Passive Control	E1	E2
	Jen's grandfather had been chopping the firewood.	Active Control	E1	
	Mark's wrinkly shirts were chopping vegetables.	No-Attraction Violation		E2
8.	Lisa's phone had been disconnecting last month.	Attraction Violation	E1	E2
	Lisa's phone had been disconnected last month.	Passive Control	E1	E2
	The electrician had been disconnecting the machine's power source.	Active Control	E1	
	Mother Theresa's death was disconnecting the two cables.	No-Attraction Violation		E2
9.	Wendy's muddy car was washing the boys.	Attraction Violation	E1	E2
	Wendy's muddy car was washed wearily.	Passive Control	E1	E2
	Wendy and Harriet were washing the muddy car.	Active Control	E1	
	Frank's loan application had been washing the used pencil.	No-Attraction Violation		E2
10.	The library books had been borrowing the graduate student.	Attraction Violation	E1	E2
	The library books had been borrowed by the graduate student.	Passive Control	E1	E2
	Katie and Lara had been borrowing dozens of books about botany from the library.	Active Control	E1	
	The tragic mistake was borrowing in a hurry.	No-Attraction Violation		E2
11.	The dark, underwater cave was exploring by the divers.	Attraction Violation	E1	E2
	The dark, underwater cave was explored by the divers.	Passive Control	E1	E2
	The cautious scuba divers were exploring the underwater cave.	Active Control	E1	
	The phone bill had been exploring at the zoo.	No-Attraction Violation		E2
12.	The unpleasant cough syrup was swallowing the boy.	Attraction Violation	E1	E2
	The unpleasant cough syrup was swallowed by the boy.	Passive Control	E1	E2
	The huge adult alligator had been swallowing fish by the bucket.	Active Control	E1	
	The murder had been swallowing with disgust.	No-Attraction Violation		E2
13.	The pizza had been delivering once more.	Attraction Violation	E1	E2
	The pizza had been delivered by Antonio himself.	Passive Control	E1	E2
	The exhausted messenger had been delivering packages all over town.	Active Control	E1	
	A genetic mutation was delivering once more.	No-Attraction Violation		E2
14.	Frank's loan application had been approving by the bank.	Attraction Violation	E1	E2
	Frank's loan application had been approved anyways.	Passive Control	E1	E2
	The board of directors had been approving too many expensive projects.	Active Control	E1	
	Wendy's muddy car was approving the boy's request.	No-Attraction Violation		E2
15.	The cheap products had been manufacturing a Belgian firm.	Attraction Violation	E1	E2
	The cheap products had been manufactured by a Belgian firm.	Passive Control	E1	E2
	The auto company had been manufacturing parts in China.	Active Control	E1	
	A drawing of the house had been manufacturing at a factory.	No-Attraction Violation		E2
16.	Their secret conversation had been overhearing by a surprised neighbor.	Attraction Violation	E1	E2
	Their secret conversation had been overheard by a surprised neighbor.	Passive Control	E1	E2
	The annoyed resident had been overhearing his neighbor's phone conversations through the wall.	Active Control	E1	
	A wet snowball had been overhearing despite the precautions.	No-Attraction Violation		E2
17.	The rough part of the wood was sanding to perfection.	Attraction Violation	E1	E2
	The rough part of the wood was sanded by the carpenter.	Passive Control	E1	E2
	The skillful carpenter was sanding the rough edge of the wood.	Active Control	E1	
	Three more martinis were sanding the chair.	No-Attraction Violation		E2
18.	A package had been receiving by the secretary in the office.	Attraction Violation	E1	E2
	A package had been received by the secretary in the office.	Passive Control	E1	E2
	The secretary had been receiving flowers all day.	Active Control	E1	
	The noises in the attic had been receiving assistance from the government.	No-Attraction Violation		E2

(*continued on next page*)

Appendix (*continued*)

19. The club's rules had been violating Richard.	Attraction Violation	E1	E2
The club's rules had been violated only twice.	Passive Control	E1	E2
The rebel had been violating the rules.	Active Control	E1	
Thirty pounds of potatoes had been violating only twice.	No-Attraction Violation		E2
20. A new medication had been prescribing the physician.	Attraction Violation	E1	E2
A new medication had been prescribed by the physician.	Passive Control	E1	E2
The new doctor had been prescribing powerful painkillers for Jelena's sore knee.	Active Control	E1	
The portrait of Napoleon had been prescribing with caution.	No-Attraction Violation		E2
21. The wheat crops had been harvesting by the local farmers.	Attraction Violation	E1	E2
The wheat crops had been harvested after the rain.	Passive Control	E1	E2
The local farmers had been harvesting the corn all week.	Active Control	E1	
The elevator button had been harvesting after the rain.	No-Attraction Violation		E2
22. The musical piece was composing by Beethoven in 1799.	Attraction Violation	E1	E2
The musical piece was composed in a dream.	Passive Control	E1	E2
Ludwig von Beethoven was composing symphonies as a teenager.	Active Control	E1	
The bank had been composing in a dream.	No-Attraction Violation		E2
23. The old lady's purse had been snatching a kid.	Attraction Violation	E1	E2
The old lady's purse had been snatched with speed.	Passive Control	E1	E2
The clever dog had been snatching cookies from the table.	Active Control	E1	
The quality of Karla's work was snatching victory from the jaws of defeat.	No-Attraction Violation		E2
24. Olson's bulging suitcase had been packing his assistant.	Attraction Violation	E1	E2
Olson's bulging suitcase had been packed for the trip.	Passive Control	E1	E2
The excited vacationers had been packing their suitcases when the hurricane hit.	Active Control	E1	
Stormy weather had been packing for the trip.	No-Attraction Violation		E2
25. Several spelling errors were noticing the careful editor.	Attraction Violation	E1	E2
Several spelling errors were noticed by the careful editor.	Passive Control	E1	E2
Brittany's close friends were noticing changes in her personality.	Active Control	E1	
The final destination had been noticing too late.	No-Attraction Violation		E2
26. An illegal weapon had been smuggling only once.	Attraction Violation	E1	E2
An illegal weapon had been smuggled only once.	Passive Control	E1	E2
The drug dealer had been smuggling heroin into Canada.	Active Control	E1	
Cleopatra's beauty was smuggling only once.	No-Attraction Violation		E2
27. The leftover food was discarding wastefully.	Attraction Violation	E1	E2
The leftover food was discarded wastefully.	Passive Control	E1	E2
The campers were discarding the leftover food.	Active Control	E1	
The sleek new building was discarding wastefully.	No-Attraction Violation		E2
28. Thirty pounds of potatoes had been peeling by the cooks.	Attraction Violation	E1	E2
Thirty pounds of potatoes had been peeled carefully.	Passive Control	E1	E2
The bored looking cooks had been peeling potatoes for hours.	Active Control	E1	
The club's rules had been peeling the sticker off the box.	No-Attraction Violation		E2
29. The grimy pots and pans had been scrubbing the dishwashers.	Attraction Violation	E1	E2
The grimy pots and pans had been scrubbed by the dishwashers.	Passive Control	E1	E2
The guys in the kitchen had been scrubbing the pots and pans.	Active Control	E1	
The stolen artwork had been scrubbing with vigor.	No-Attraction Violation		E2
30. The roast lamb had been carving by a servant.	Attraction Violation	E1	E2
The roast lamb had been carved by a servant.	Passive Control	E1	E2
The butcher had been carving the meat.	Active Control	E1	
Janet's houseplants were carving before dinner.	No-Attraction Violation		E2
31. Cleopatra's beauty was admiring many people.	Attraction Violation	E1	E2
Cleopatra's beauty was admired always.	Passive Control	E1	E2
The men were admiring the beautiful woman from a distance.	Active Control	E1	
An illegal weapon had been admiring always.	No-Attraction Violation		E2
32. A wet snowball had been tossing by the girls through the window.	Attraction Violation	E1	E2
A wet snowball had been tossed in anger.	Passive Control	E1	E2
The baseball players had been tossing the ball around the infield.	Active Control	E1	
Their secret conversation had been tossing a steak on the grill.	No-Attraction Violation		E2

Appendix (*continued*)

33. The sealed envelope was opening the judge.	Attraction Violation	E1	E2
The sealed envelope was opened without permission.	Passive Control	E1	E2
Tuxedoed waiters were opening bottles of champagne for the toast.	Active Control	E1	
The men's faces had been opening without permission.	No-Attraction Violation		E2
34. The man's beard had been shaving twice a day.	Attraction Violation	E1	E2
The man's beard had been shaved twice a day.	Passive Control	E1	E2
His uncle Ralph had been shaving his beard off.	Active Control	E1	
The popular amusement park is shaving twice a day.	No-Attraction Violation		E2
35. The elevator button had been pressing slowly.	Attraction Violation	E1	E2
The elevator button had been pressed by the attendant.	Passive Control	E1	E2
The attendant had been pressing the buttons.	Active Control	E1	
The wheat crops had been pressing slowly.	No-Attraction Violation		E2
36. The winning lottery numbers had been announcing the TV news.	Attraction Violation	E1	E2
The winning lottery numbers had been announced by the TV news.	Passive Control	E1	E2
The flight attendant had been announcing the reason for the delay.	Active Control	E1	
The tarnished silverware was announcing on the television.	No-Attraction Violation		E2
37. The victim's body had been identifying at the morgue.	Attraction Violation	E1	E2
The victim's body had been identified by the family members.	Passive Control	E1	E2
The laboratory technicians had been identifying the chemical.	Active Control	E1	
The movie was identifying rare fish for the divers.	No-Attraction Violation		E2
38. The hearty meal was devouring by the kids.	Attraction Violation	E1	E2
The hearty meal was devoured with gusto.	Passive Control	E1	E2
The hungry boys were devouring the plate of cookies when Jack arrived.	Active Control	E1	
The dusty tabletops were devouring with gusto.	No-Attraction Violation		E2
39. The overgrown shrubs were trimming regularly.	Attraction Violation	E1	E2
The overgrown shrubs were trimmed by a gardener.	Passive Control	E1	E2
A gardener was trimming the overgrown shrubbery.	Active Control	E1	
The alarm clock had been trimming regularly.	No-Attraction Violation		E2
40. Wilson's unreasonable proposal was rejecting by the boss.	Attraction Violation	E1	E2
Wilson's unreasonable proposal was rejected at the hospital.	Passive Control	E1	E2
The admissions committee was rejecting nearly every application.	Active Control	E1	
The rare bird's behavior was rejecting all offers.	No-Attraction Violation		E2
41. Hathaway's gigantic fortune had been inheriting by his daughters.	Attraction Violation	E1	E2
Hathaway's gigantic fortune had been inherited by his daughters.	Passive Control	E1	E2
Generations of aristocratic Englishmen have been inheriting their fortunes.	Active Control	E1	
The strange mystery had been inheriting the estate from her grandmother.	No-Attraction Violation		E2
42. All of her money had been spending before the wedding.	Attraction Violation	E1	E2
All of her money had been spent before the wedding.	Passive Control	E1	E2
The shopping fanatic had been spending all her money in Bloomingdales.	Active Control	E1	
Patty's overgrown lawn was spending its time on the beach.	No-Attraction Violation		E2
43. An appointment was scheduling by the secretary.	Attraction Violation	E1	E2
An appointment was scheduled by the secretary.	Passive Control	E1	E2
The secretary was scheduling new appointments for the afternoon.	Active Control	E1	
The legal contract had been scheduling for next week.	No-Attraction Violation		E2
44. The men's faces had been photographing by a security camera.	Attraction Violation	E1	E2
The men's faces had been photographed by a security camera.	Passive Control	E1	E2
The intrusive reporter had been photographing the celebrities at the party.	Active Control	E1	
The sealed envelope was photographing at the party.	No-Attraction Violation		E2
45. The broken television had been repairing the technician.	Attraction Violation	E1	E2
The broken television had been repaired by the technician.	Passive Control	E1	E2
The competent technician had been repairing the television.	Active Control	E1	
Larry's note had been repairing the computer's hard drive.	No-Attraction Violation		E2
46. The alarm clock had been unplugging accidentally.	Attraction Violation	E1	E2
The alarm clock had been unplugged late.	Passive Control	E1	E2

(*continued on next page*)

Appendix (*continued*)

	The frantic woman had been unplugging every electrical device in the house.	Active Control	E1	
	The overgrown shrubs were unplugging accidentally.	No-Attraction Violation		E2
47.	The car door had been unlocking late at night.	Attraction Violation	E1	E2
	The car door had been unlocked by the child.	Passive Control	E1	E2
	The babysitter had been unlocking the back door.	Active Control	E1	
	The Queen's 80th birthday was unlocking late at night.	No-Attraction Violation		E2
48.	The portrait of Napoleon had been painting by a Dutch artist.	Attraction Violation	E1	E2
	The portrait of Napoleon had been painted by a Dutch artist.	Passive Control	E1	E2
	The French Impressionist artists had been painting with a focus on light and color.	Active Control	E1	
	A new medication had been painting on Tuesday.	No-Attraction Violation		E2
49.	The embarrassing allegations had been denying by the mayor.	Attraction Violation	E1	E2
	The embarrassing allegations had been denied by the mayor.	Passive Control	E1	E2
	The embarassed mayor had been denying allegations of corruption.	Active Control	E1	
	Tamara's birthday gift had been denying the rumor.	No-Attraction Violation		E2
50.	The noises in the attic had been hearing nightly.	Attraction Violation	E1	E2
	The noises in the attic had been heard by the boys.	Passive Control	E1	E2
	The frightened campers had been hearing noises in the woods.	Active Control	E1	
	A package had been hearing nightly.	No-Attraction Violation		E2
51.	The appetizers had been serving before the meal.	Attraction Violation	E1	E2
	The appetizers had been served before the meal.	Passive Control	E1	E2
	The waiters had been serving the meal.	Active Control	E1	
	The final exams had been serving before the meal.	No-Attraction Violation		E2
52.	Billy's unruly hair was combing his mother to one side.	Attraction Violation	E1	E2
	Billy's unruly hair was combed by his mother to one side.	Passive Control	E1	E2
	The patient barber was combing the boy's hair to one side.	Active Control	E1	
	The girl's disease was combing the area for escaped prisoners.	No-Attraction Violation		E2
53.	A drawing of the house had been sketching again.	Attraction Violation	E1	E2
	A drawing of the house had been sketched again.	Passive Control	E1	E2
	An artist in the studio had been sketching the house.	Active Control	E1	
	The cheap products had been sketching again.	No-Attraction Violation		E2
54.	The simple coffin was burying the villagers.	Attraction Violation	E1	E2
	The simple coffin was buried at the church.	Passive Control	E1	E2
	The tribal people were burying their dead.	Active Control	E1	
	The vocabulary list was burying at the church.	No-Attraction Violation		E2
55.	The homicide case had been investigating diligently.	Attraction Violation	E1	E2
	The homicide case had been investigated by the FBI.	Passive Control	E1	E2
	The FBI agents had been investigating the homicide case for weeks.	Active Control	E1	
	Martin's tonsils had been investigating the problem.	No-Attraction Violation		E2
56.	Mark's wrinkly shirts were ironing by his mother.	Attraction Violation	E1	E2
	Mark's wrinkly shirts were ironed by his mother.	Passive Control	E1	E2
	Mark's doting mother was ironing his shirts while he slept.	Active Control	E1	
	The firewood had been ironing her dress.	No-Attraction Violation		E2
57.	An important lesson had been learning in space.	Attraction Violation	E1	E2
	An important lesson had been learned in space.	Passive Control	E1	E2
	The children had been learning Spanish.	Active Control	E1	
	The bathroom floor had been learning in space.	No-Attraction Violation		E2
58.	The height of the bookcase was measuring by a carpenter.	Attraction Violation	E1	E2
	The height of the bookcase was measured incorrectly.	Passive Control	E1	E2
	The carpenter was measuring the height of the bookcase.	Active Control	E1	
	An urgent message had been measuring her heart rate.	No-Attraction Violation		E2
59.	Several important topics were discussing despite the weather.	Attraction Violation	E1	E2
	Several important topics were discussed by the board of trustees.	Passive Control	E1	E2
	The board members were discussing several important topics.	Active Control	E1	
	The fresh, warm bread was discussing despite the weather.	No-Attraction Violation		E2
60.	The dusty tabletops were wiping thoroughly.	Attraction Violation	E1	E2
	The dusty tabletops were wiped thoroughly.	Passive Control	E1	E2
	The tired busboy was wiping for hours.	Active Control	E1	
	The hearty meal was wiping thoroughly.	No-Attraction Violation		E2

Appendix (*continued*)

61. A tiny spy camera was concealing by the agent inside a flowerpot.	Attraction Violation	E1	E2
A tiny spy camera was concealed by the agent inside a flowerpot.	Passive Control	E1	E2
The sneaky lawyer was concealing the truth.	Active Control	E1	
A faint light was concealing their identity.	No-Attraction Violation		E2
62. The fresh, warm bread was slicing by the baker into halves.	Attraction Violation	E1	E2
The fresh, warm bread was sliced with love.	Passive Control	E1	E2
The chef's assistants were slicing the mushrooms for a pie.	Active Control	E1	
Several important topics were slicing with love.	No-Attraction Violation		E2
63. The tarnished silverware was polishing by the butler.	Attraction Violation	E1	E2
The tarnished silverware was polished by the butler.	Passive Control	E1	E2
The thorough butler was polishing the doorknobs.	Active Control	E1	
The winning lottery numbers had been polishing his shoes.	No-Attraction Violation		E2
64. Poisonous fumes had been inhaling the firefighters.	Attraction Violation	E1	E2
Poisonous fumes had been inhaled by the firefighters.	Passive Control	E1	E2
The firefighters had been inhaling the smoke.	Active Control	E1	
The man's signature was inhaling during the fire.	No-Attraction Violation		E2
65. A genetic mutation was discovering the scientists.	Attraction Violation	E1	E2
A genetic mutation was discovered suddenly.	Passive Control	E1	E2
The excited explorers were discovering ancient artifacts everywhere they looked.	Active Control	E1	
The pizza had been discovering new methods for making dough.	No-Attraction Violation		E2
66. The Queen's 80th birthday was celebrating expensively.	Attraction Violation	E1	E2
The Queen's 80th birthday was celebrated by thousands of people in the streets.	Passive Control	E1	E2
Thousands of excited fans were celebrating the Superbowl victory in the streets.	Active Control	E1	
The car door had been celebrating her promotion.	No-Attraction Violation		E2
67. The diagram on the chalkboard had been erasing Mrs. Larson.	Attraction Violation	E1	E2
The diagram on the chalkboard had been erased by Mrs. Larson.	Passive Control	E1	E2
Mrs. Larson had been erasing the chalkboard.	Active Control	E1	
Food for the homeless had been erasing over and over.	No-Attraction Violation		E2
68. The movie was directing Steven Spielberg.	Attraction Violation	E1	E2
The movie was directed professionally.	Passive Control	E1	E2
Steven Spielberg was directing another blockbuster.	Active Control	E1	
The victim's body had been directing the police.	No-Attraction Violation		E2
69. Theresa's birthday gift had been wrapping yesterday.	Attraction Violation	E1	E2
Theresa's birthday gift had been wrapped yesterday.	Passive Control	E1	E2
Theresa's loving grandmother had been wrapping the presents.	Active Control	E1	
The embarrassing allegations had been wrapping yesterday.	No-Attraction Violation		E2
70. The popular amusement park is visiting by millions of tourists eh year.	Attraction Violation	E1	E2
The popular amusement park is visited daily.	Passive Control	E1	E2
The tourists had been visiting the amusement park in the morning.	Active Control	E1	
The man's beard had been visiting a friend in the hospital.	No-Attraction Violation		E2
71. Ten new trees had been planting on dry land.	Attraction Violation	E1	E2
Ten new trees had been planted by the Forestry Service.	Passive Control	E1	E2
The forestry workers had been planting cedar saplings on the hillside.	Active Control	E1	
The sin had been planting doubt in her mind.	No-Attraction Violation		E2
72. Food for the homeless had been donating neighborhood residents.	Attraction Violation	E1	E2
Food for the homeless had been donated many times.	Passive Control	E1	E2
The wealthy American philanthropist had been donating money to Romanian orphanages.	Active Control	E1	
The diagram on the chalkboard had been donating blood.	No-Attraction Violation		E2
73. The rare bird's behavior was observing by the biologists.	Attraction Violation	E1	E2
The rare bird's behavior was observed by the biologists.	Passive Control	E1	E2
The excited bird watchers were observing the rare eagle.	Active Control	E1	
Wilson's unreasonable proposal was observing the stars.	No-Attraction Violation		E2
74. Stormy weather had been forecasting by the weatherman.	Attraction Violation	E1	E2
Stormy weather had been forecasted by the weatherman.	Passive Control	E1	E2
The weather service had been forecasting snow for the mountain areas.	Active Control	E1	
Olson's bulging suitcase had been forecasting correctly.	No-Attraction Violation		E2

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Appendix (*continued*)

75. The tragic mistake was regretting by Erika for many years.	Attraction Violation	E1	E2
The tragic mistake was regretted years later.	Passive Control	E1	E2
Erika was regretting the mistake.	Active Control	E1	
The library books had been regretting their behavior.	No-Attraction Violation		E2
76. The stolen artwork had been seizing without warning.	Attraction Violation	E1	E2
The stolen artwork had been seized by the border police.	Passive Control	E1	E2
The police had been seizing shipments of drugs at the border.	Active Control	E1	
The grimy pots and pans had been seizing without warning.	No-Attraction Violation		E2
77. The value of the jewels was estimating the dealer.	Attraction Violation	E1	E2
The value of the jewels was estimated by the dealer.	Passive Control	E1	E2
The jewel expert was estimating the value of the diamond.	Active Control	E1	
The useful new gadget had been estimating professionally.	No-Attraction Violation		E2
78. Larry's note had been scribbling his wife.	Attraction Violation	E1	E2
Larry's note had been scribbled with haste.	Passive Control	E1	E2
Larry's wife had been scribbling a note to him about dinner plans.	Active Control	E1	
The broken television had been scribbling his thoughts on a napkin.	No-Attraction Violation		E2
79. Carrie's morning meeting was canceling as expected.	Attraction Violation	E1	E2
Carrie's morning meeting was canceled by the boss.	Passive Control	E1	E2
Carrie had been canceling all of her meetings.	Active Control	E1	
The bubblegum had been canceling as expected.	No-Attraction Violation		E2
80. The girl's disease was curing a simple treatment.	Attraction Violation	E1	E2
The girl's disease was cured by a simple treatment.	Passive Control	E1	E2
The foreign doctors were curing hundreds of villagers of malaria.	Active Control	E1	
Billy's unruly hair was curing his cold.	No-Attraction Violation		E2
81. Janet's houseplants were watering too much.	Attraction Violation	E1	E2
Janet's houseplants were watered by her neighbor.	Passive Control	E1	E2
The gardener was watering the plants.	Active Control	E1	
The roast lamb had been watering too much.	No-Attraction Violation		E2
82. The useful new gadget had been inventing by a bored waiter.	Attraction Violation	E1	E2
The useful new gadget had been invented by a bored waiter.	Passive Control	E1	E2
The resourceful engineers had been inventing tiny new devices.	Active Control	E1	
The value of the jewels was inventing the digital computer.	No-Attraction Violation		E2
83. The phone bill had been paying his roommate.	Attraction Violation	E1	E2
The phone bill had been paid quickly.	Passive Control	E1	E2
Juan and Perry had been paying too much for their apartment.	Active Control	E1	
The dark, underwater cave was paying attention to the divers.	No-Attraction Violation		E2
84. The man's signature was forging the lawyers.	Attraction Violation	E1	E2
The man's signature was forged by the lawyers.	Passive Control	E1	E2
The con artists were forging the signatures on checks.	Active Control	E1	
Poisonous fumes had been forging very well.	No-Attraction Violation		E2
85. The bank had been robbing two masked men.	Attraction Violation	E1	E2
The bank had been robbed repeatedly.	Passive Control	E1	E2
The clever burglars had been robbing houses in broad daylight.	Active Control	E1	
The musical piece was robbing repeatedly.	No-Attraction Violation		E2
86. An urgent message had been sending by the ambassador to the President.	Attraction Violation	E1	E2
An urgent message had been sent again.	Passive Control	E1	E2
The Prime Minister had been sending urgent messages to her Ambassador.	Active Control	E1	
The height of the bookcase was sending mixed signals to the carpenter.	No-Attraction Violation		E2
87. The sleek new building was designing a team of German architects.	Attraction Violation	E1	E2
The sleek new building was designed by a team of German architects.	Passive Control	E1	E2
A team of architects had been designing the new building.	Active Control	E1	
The leftover food was designing with flair.	No-Attraction Violation		E2
88. The final exams had been grading in school.	Attraction Violation	E1	E2
The final exams had been graded in school.	Passive Control	E1	E2
The professor had been grading the final exams until 4 AM.	Active Control	E1	
The appetizers had been grading Iverson's students.	No-Attraction Violation		E2
89. The final destination had been reaching too late.	Attraction Violation	E1	E2
The final destination had been reached too late.	Passive Control	E1	E2

Appendix (*continued*)

	The curious child had been reaching for the cup on the table.	Active Control	E1	
	Several spelling errors were reaching too late.	No-Attraction Violation		E2
90.	A faint light was perceiving by the rescue workers.	Attraction Violation	E1	E2
	A faint light was perceived underwater.	Passive Control	E1	E2
	The worried pilot was perceiving a rattling sound in the jet's engine.	Active Control	E1	
	A tiny spy camera was perceiving underwater.	No-Attraction Violation		E2
91.	The bubblegum had been chewing by the boy.	Attraction Violation	E1	E2
	The bubblegum had been chewed by the boy.	Passive Control	E1	E2
	The hungry dog had been chewing a bone.	Active Control	E1	
	Carrie's morning meeting was chewing for a long time.	No-Attraction Violation		E2
92.	Martin's tonsils had been removing at the hospital.	Attraction Violation	E1	E2
	Martin's tonsils had been removed at the hospital.	Passive Control	E1	E2
	The surgeon had been removing the cancerous growth.	Active Control	E1	
	The homicide case had been removing at the hospital.	No-Attraction Violation		E2
93.	Mother Theresa's death was mourning millions of people.	Attraction Violation	E1	E2
	Mother Theresa's death was mourned by millions of people.	Passive Control	E1	E2
	The black-clad women were mourning the death of their brother.	Active Control	E1	
	Lisa's phone had been mourning the loss of a loved one.	No-Attraction Violation		E2
94.	The bathroom floor had been mopping by a janitor.	Attraction Violation	E1	E2
	The bathroom floor had been mopped in the past.	Passive Control	E1	E2
	The school janitor had been mopping the bathroom.	Active Control	E1	
	An important lesson had been mopping in the past.	No-Attraction Violation		E2
95.	The sin had been confessing by the repentant Catholic.	Attraction Violation	E1	E2
	The sin had been confessed on Sunday.	Passive Control	E1	E2
	The repentant Catholic had been confessing his sins.	Active Control	E1	
	Ten new trees had been confessing on Sunday.	No-Attraction Violation		E2
96.	The strange mystery had been solving the detectives.	Attraction Violation	E1	E2
	The strange mystery had been solved at the station.	Passive Control	E1	E2
	The brilliant detective had been solving mysterious crimes for two decades.	Active Control	E1	
	Hathaway's gigantic fortune had been solving at the station.	No-Attraction Violation		E2

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