

Event-Related Potential Indicators of Text Integration Across Sentence Boundaries

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An event-related potentials (ERPs) study examined word-to-text integration processes across sentence boundaries. In a two-sentence passage, the accessibility of a referent for the first content word of the second sentence (the target word) was varied by the wording of the first sentence in one of the following ways: lexically (explicitly using a form of the target word); conceptually (using a paraphrase of the target word), and situationally (encouraging an inference concerning the referent of the target word). A baseline condition had no coreference between the two sentences. ERP results on the target word indicated multiple effects related to word identification and word-to-referent mapping processes. Both the explicit and paraphrase conditions, but not the inference condition, showed a reduced N400 relative to the baseline condition, consistent with immediate integration by lexico-semantic processes. A 300-ms effect (P300) was found in the paraphrase condition. The results were consistent with an immediate integration hypothesis and furthermore differentiated a lexical (N200), a conceptual (P300), and a situational (N400) component for this integration. The conceptual basis appears not to extend to predictive inferences.

Keywords: text integration, predictive inference, paraphrase, ERPs, PCA, comprehension

If comprehension is partly a word-by-word process, then every word as it is read affords an opportunity for integration into the reader's mental representation of the text. On the other hand, some comprehension work can be spread over subsequent words. Certainly a few words held in memory do not exceed processing capacity, and the high level of verbatim memory within clause and sentence boundaries (Goldman, Hogaboam, Bell, & Perfetti, 1980; Jarvella & Herman, 1972; Perfetti & Goldman, 1976) suggests that readers can hold onto enough word-to-word information to allow sentence integration processes to occur later. Indeed, some integration work has been explicitly assumed to occur at the end of a sentence in the form of "sentence wrap-up" (Just & Carpenter, 1992).

A particularly interesting case for integration is the first words of a sentence. If sentence integration occurs at the end of a

sentence, then as a new sentence begins, there are ample resources to carry out a minimal analysis of the sentence, yielding a syntactic-shallow semantic representation and postponing integration into the larger representation of the text. That is the question we address here: When do readers connect the first words of a sentence with what they have read in a previous sentence?

Evidence in both spoken and written language generally indicates that sentence comprehension is highly incremental, with words processed immediately before the next word is encountered (Bever, 1970; Just & Carpenter, 1980; Tyler & Marslen-Wilson, 1977; see Pickering, 1999, for a review). Indeed, although different theories of parsing give different accounts of which kinds of information are used immediately (Frazier & Clifton, 1996; MacDonald, Perlmutter, & Seidenberg, 1994), they tend to agree on the conclusion that each word is immediately attached to a syntactic phrase.

In general, across a variety of methods, the evidence is consistent with a highly incremental view of semantic processing (Boland, Tanenhaus, Garnsey, & Carlson, 1995; Clifton, 1993; Holmes, Stowe, & Cupples, 1989; Tyler & Marslen-Wilson, 1977). However, delayed processing has been proposed to occur in language processing under certain circumstances in clausal integration (Millis & Just, 1994), syntactic parsing (Rayner, Garrod, & Perfetti, 1992), and lexical processing (Frazier & Rayner, 1987). Some delay in processing is at least a possibility across sentence boundaries, where sentence wrap-up effects at the end of the preceding sentence may combine with low contextual support at the beginning of the sentence to discourage incrementality.

The question we address is whether (or when) each word is incrementally mapped into a semantically interpreted mental representation for comprehension. Given the evidence on incremental processing, we assume that the default comprehension process is linking each word, when possible, to an antecedent representation.

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Accordingly, we propose the immediate integration hypothesis to express the generalization that a reader attempts to integrate each word incrementally, even the very first words of a sentence, into an updated representation. Event-related potentials (ERPs) can provide evidence on whether the first content word of a sentence across a boundary follows the default procedure of incremental, immediate processing (Pickering, 1999) or presents a special case of delayed processing.

Of particular relevance for word-to-text integration is the information structure in sentences. Phrases and sentences contain both given (what the reader knows already) and new information (what the reader does not yet know). For instance, a definite noun phrase (e.g., *the teacher*) at the beginning of a sentence signals that its referent has already been introduced by the preceding sentence and thus elicits integration processes that map the current referent with an already existing referent in the situation model (cf. Kintsch, 1998). Cognitive processing is thus facilitated, and shorter reading times are observed (Haviland & Clark, 1974, Experiment 1). In contrast, an indefinite noun phrase (e.g., *a teacher*) does not signal such retroactive integration but instead is used to introduce a new referent into the situation model. In addition to the given/new information structure, integration processes are modulated by lexicosemantic information of the word being read and its relation to words in the preceding sentence.

Thus, integration processes may involve multiple levels, as shown in the sample passages of Table 1, where we illustrate different contexts for the integration of the word *explosion* at the beginning of the second sentence. Indeed, studies of text integra-

tion have indicated that a surface form that consists of the wording and syntactic structures may be distinguished from an intrinsic meaning representation in terms of the propositions in the text (Kintsch, 1974) and the situation or referential model that may very well be encoded in terms of perceptual symbols (Glenberg, 1997; Kintsch, 1998; Zwaan, Madden, Yaxley, & Aveyard, 2004). To the extent that the lexical form of the antecedent of the first sentence (*exploded*) is fully specified in the situation model and closely matches the surface form of the referring expression of the second sentence (*explosion*), integration will be facilitated and be readily achieved (Forster, 1981). In contrast, when the antecedent is partially represented or situationally implied but does not lexically match the referring expression (*explosion*), as shown in both the referentially paraphrased and inference conditions, the integration may be less readily achieved. Successful integration in these cases will depend on the degrees to which the representation of the preceding context contains a match with the conceptual/referential understanding of the referring expression. In this case, the integration difficulty will be a function of the gap between the representation of multilevel contextual information and the representation of the referring expression.

The inference case in Table 1 is one that has been the object of studies of elaborative or predictive inferences (Graesser, Singer, & Trabasso, 1994; McKoon & Ratcliff, 1986). An elaborative inference during the first sentence could establish a representation that contains a partial or complete match with the opening phrase of the next sentence. This would facilitate integration of the first referring expression of the second sentence into the referential model of the

Table 1
Sample Passages in Each Experimental Condition

Integration type	Sample passage
Sample 1	
Referentially explicit	After being dropped from the plane, the bomb hit the ground and <u>exploded</u> . The explosion was quickly reported to the commander.
Referentially paraphrased	After being dropped from the plane, the bomb hit the ground and <u>blew up</u> . The explosion was quickly reported to the commander.
Inference	After being dropped from the plane, the bomb hit the ground. The explosion was quickly reported to the commander.
Baseline	Once the bomb was stored safely on the ground, the plane dropped off its passengers and left. The explosion was quickly reported to the commander.
Sample 2	
Referentially explicit	The flight attendant had just served a completely full glass of red wine to the passenger when suddenly the plane hit turbulence which spilled the wine. The <u>spilled</u> wine stained the passenger's pants.
Referentially paraphrased	The flight attendant had just served a completely full glass of red wine to the passenger when suddenly the plane hit turbulence that emptied the glass. The <u>spilled</u> wine stained the passenger's pants.
Inference	The flight attendant had just served a completely full glass of red wine to the passenger when suddenly the plane hit turbulence. The <u>spilled</u> wine stained the passenger's pants.
Baseline	After turbulence was completely over, the flight attendant served each passenger a glass of red wine. The <u>spilled</u> food was still lying on the floor.

Note. The word in underlined bold at the beginning of the second sentence within each passage indicates the critical word whose reference has been established to different degrees of availability between sentences. These are the target words where the event-related potentials were extracted.

situation (Zwaan & Radvansky, 1998). For example, consider the following two sentences from Singer and Halldorson (1996): “Mark poured the bucket of water on the bonfire. The bonfire went out.” The second sentence is easily understood if the reader generates the mediating idea that water extinguishes fire during the reading of the first sentence (McDaniel, Schmalhofer, & Keefe, 2001). Important here is the basic idea that a reader constructs a model of the situation (Kintsch & van Dijk, 1978) that is referentially specified and not limited to the words of the sentences. Thus integration can occur at two of the three levels commonly postulated in comprehension models (Fletcher & Chrysler, 1990; Kintsch, 1998; Perfetti, 1999; Schmalhofer & Glavanov, 1986). In the propositional text base, concepts can be linked to their antecedents through argument overlap (Kintsch, 1995). In the situation model, referential expressions are linked to referents in the situation model.

These possibilities for integration can apply to the immediate integration hypothesis that readers attempt to integrate each word, even the first word of a sentence, immediately into their representation of the preceding text. The reader can add a word’s meaning immediately to the reader’s referentially specified model by connecting it to an existing referent if one exists. This should be an especially simple process for referring expressions whose surface forms readily match the lexicosemantic features of an existing referent, for example, “. . . exploded. The explosion . . .” (Haviland & Clark, 1974).

However, when the referring expression’s surface form does not match that of an antecedent, it can be integrated only after its intended referent is inferred. Specifically, the difficulty of this referent-inference process varies with the support provided by (a) the word’s semantics and (b) the availability of a mediating link provided by an earlier predictive inference. Among the contexts shown in Table 1, the referentially paraphrased condition has the advantage of a link through semantics (Keenan & Jennings, 1995). In contrast, the inference condition can be effective for integration only if an elaborative inference is predictively made during the first sentence (Garrod, O’Brien, Morris, & Rayner, 1990; Lucas, Tanenhaus, & Carlson, 1990; McKoon & Ratcliff, 1992). For the inference condition, a minimally constructed inference is necessary to bring in the concept of *explosion* from a representation of *the bomb hit the ground* (McKoon & Ratcliff, 1986). For the referentially paraphrased condition, the range of meaning of a paraphrase can include an existing referent or a predication that includes the referent. Consequently, the concept of *explosion* is readily achieved by the meaning representation of *blew up* of the first sentence (O’Brien, Rizzella, Albrecht, & Halleran, 1998).

In the experiment we report below, we examine the temporal immediacy of text integration as general descriptions for the comprehension processes for sentence beginnings. More specifically, the experiment tests factors that affect the ease of integration at a sentence beginning. Because the initial content word of the continuing sentence is the same across all the conditions, this word provides an examination of the two alternative integration processes, which differ on whether the preceding content should affect the integration of this word. The immediate integration hypothesis predicts that readers will attempt to integrate each word and, accordingly, that differential integration success will be observed as a function of conditions designed to affect the ease of integration. A condition in which an immediate integration is not possi-

ble, a baseline condition that contains no obvious antecedent for *explosion*, will give straightforward evidence of integration difficulty at the target word. All other conditions can be compared with this baseline. In contrast, no distinguishable processing differences among conditions should be observed at the target word if readers simply encode the word into memory as part of syntactic phrase and wait for more information before integrating its meaning into the current representation of the first sentence.

Our method is the recordings of event-related potentials (ERPs), which provide detailed millisecond temporal information during word reading. In addition, ERPs can be recorded without explicit responses that necessarily carry additional components beyond those of interest. Especially useful for the study of semantic processing is the N400 effect, a negative voltage shift between 300 and 500 ms after the onset of a word. The less a word fits into the semantically established context, the larger its amplitude (Federmeier & Kutas, 2001; Kutas & Hillyard, 1980; Van Petten & Kutas, 1990). Thus, the N400 indexes integration effects in word processing. Especially important for our study, the N400 has been found to be sensitive to integration in text processing (van Berkum, Brown, Zwitserlood, Kooijman, & Hagoort, 2005; van Berkum, Hagoort, & Brown, 1999; van Berkum, Zwitserlood, Brown, & Hagoort, 2003), including inferences (St. George, Mannes, & Hoffman, 1997). Consequently, we take the N400 to be an indicator of immediate word-by-word integration.

Experiment

We adopted coherent two-sentence passages, as shown in Table 1. We varied the ease of integration for the first content word of the second sentence by manipulating the accessibility of referents within the representation of the first sentence. ERPs recorded on the first content word of the second sentence (e.g., *explosion*) provided our measure of the temporal immediacy and the ease of integration. The four variant conditions of each passage included two conditions whose integration would be related to a lexico-semantic process (the referentially explicit and referentially paraphrased conditions) and one condition in which the mapping processing of the target word into the representation would be established by a process of situationally based integration (the inference condition). The situational processing of integration was introduced by requiring inference processes (predictive and bridging inferences) to establish a sensible integration (Schmalhofer, McDaniel, & Keefe, 2002; Singer & Halldorson, 1996). In addition, a baseline condition represents a typical sentence in which the first word of the second sentence cannot be easily integrated with the representation of preceding context, because the context information does not support the immediate availability of its intended referent in a referentially specified model. It is important to note that there is no anomaly in this baseline condition in its overall meaning and that it can be integrated eventually with the preceding context—but maybe just some hundred milliseconds later. Thus, the baseline condition is expected to produce an N400 because the immediate integration of the target word with the preceding context is difficult. In contrast, when a referent for *explosion* has been stated directly or by a paraphrase in the preceding sentence, an N400 effect should be reduced. If an antecedent of *explosion* is situationally implied in the first sentence, we would expect a reduced N400 to the extent that readers drew the inference before

reading the second sentence (St. George et al., 1997). On the other hand, if delayed processing would be a general processing strategy right at the sentence boundary during text integration, then no reliable processing differences among conditions in the ERPs would be observed. Specifically, the lack of finding distinguishable ERPs of the baseline condition from other conditions would be a strong indicator of delayed processing in meaning.

Method and Materials

Participants

Sixteen undergraduate students of the University of Pittsburgh (11 women, 5 men) between the ages of 18 and 19 ($M = 18.5$, $SD = 0.5$) participated in the study. We recruited subjects from a pool who had previously been identified as skilled readers using the Nelson–Denny comprehension test (Nelson & Denny, 1973; mean N-D percent score = 0.89, $SD = 0.07$). Participants were right-handed native English speakers with normal or corrected-to-normal vision. Five participants received course credit for an introduction to psychology course; the remainder received a monetary compensation of \$20.

Stimuli

A total of 120 two-sentence experimental passages (mean number of words = 28), illustrated in Table 1, were constructed for the experiment (see Appendix A). The first sentence of each passage established differing degrees of referent information. The target word was always the initial content word of the second sentence, and the first word of the second sentence was typically a determiner, such as *The* (78 out of 120). The target word was not always the head noun of the initial noun phrase but rather was always the initial content word of the second sentence. Target words were often presented as a bare noun phrase (44%; e.g., “The *explosion* . . .,” “The *cut* . . .,” “The *fall* . . .”), and a few were modifiers within the noun phrase (18%; e.g., “The *frightened* expression . . .,” “The *spilled* wine . . .”).¹ Other variations used mainly verb derivation (*-ing* or *-ed*) embedded in the initial noun phrase (4%; e.g., “*Correcting* the error . . .,” “*Showering* after . . .”) or the initial adverbial phrase (32%; e.g., “After *hammering* the nail . . .,” “Having *washed* his hand . . .”).

Variation in syntactic form could produce ERP differences at the subcategorization level (e.g., noun vs. verb; Federmeier, Segal, Lombrozo, & Kutas, 2000; Neville, Nicol, Barss, Forster, & Garrett, 1991). However, our target words were not new words of a different form class but morpho-syntactic variations on a word introduced in the first sentence. It is important to note that because the target word was the same over all experimental conditions, form variation was the same over all experimental conditions. The antecedent referent for the target word was invariably toward the end of the first sentence with 1–5 words (average = 3) intervening between the antecedent referent and the target word. Longer intervals between repeated occurrences may affect the N400 amplitude (Nagy & Rugg, 1989), although the interval may not be as important as at least some linguistic factors that affect referring expressions (Swaab, Cambly, & Gordon, 2004). In any case, we chose this slight variation in this spacing to avoid predictable intervals between antecedent and target words. Again, as with form variation, variations in distance were uniform across experimental conditions.

We constructed four versions of each experimental passage from varying the condition of the integration type (referentially explicit, referentially paraphrased, inference, and baseline). The four versions of the 120 experimental passages were balanced by a Latin-square design that assigned each version of a passage to one of four sets of materials. Each participant received 30 passages from each of the four conditions without repetition of any passage. In this way, each participant read one condition of the experimental passage only once, and across the participants, each version of all 120 passages was presented equally.

Design and Procedure

The electroencephalogram (EEG) was recorded as the participants read each two-sentence passage for comprehension. Each sentence was presented one word at a time on the center of the computer screen for a duration of 300 ms with a stimulus-onset asynchrony (SOA) of 600 ms. The sentence was preceded by a fixation mark to orient participants' attention to the center of the computer screen before the trial started. Participants initiated a trial by pressing the space bar. Each word was presented in the center of a 2-cm (height) × 4-cm (width) column with white text in front of a black background. A true–false comprehension task appeared after one quarter of the trials on a random basis. Participants were asked to make a true–false response on the basis of the meaning of the passage they just read and were given immediate feedback about the accuracy of their responses (“Wrong” in red ink for incorrect and “Good Job” in blue ink for correct). Half of the comprehension questions were true, and half were false. Correctly answering the questions required understanding of the meaning of the passage. The following indicates the comprehension question for sample passage 1 in Table 1.

True or False: The bomb exploded when it hit the ground.

The correct answer for this example question is true for the referentially explicit, referentially paraphrased, and inference conditions, and false for the baseline condition. Half of the comprehension questions had this specific distribution of correct answers across different experimental conditions, whereas the other half had the complementary distribution: false for the referentially explicit, referentially paraphrased, and inference conditions, and true for the baseline condition.

To reduce artifacts of eye movements and eye blinking, participants were instructed to remain as still as possible with their eyes on the center of the computer screen throughout the text, until the last word of each passage. They were requested to refrain from blinking as much as possible when stimuli were presented but were told that they could rest before initiating the next trial. Participants were tested in a series of two experimental blocks of 60–90 min. They were tested individually in a quiet and comfortable environment while the experimenter monitored the ERP recordings and experiment events in an adjacent room. Participants were seated in an adjustable chair, adjusted so that their eyes were about 55 cm from the center of the 15-in. (38.1-cm) CRT monitor screen at the level of the center of the computer screen. The chair could then be adjusted for further comfort to reduce movements.

Apparatus

The EEG was recorded with a 128-channel Electrical Geodesics, Inc. (EGI; Eugene, OR) system (Tucker, 1993) consisting of Geodesic Sensor Net electrodes, Net Amps, and Net Station software running on an Apple Macintosh, 1000 MHz PowerPC G4 class computer with Mac OS 9.2.2. (Apple Computer, Cupertino, CA). The data were recomputed offline against the average reference, the vertex (Lehmann & Skrandies, 1980). Impedances were maintained below 50 k Ω , an acceptable level for the electrodes and amplifier used (Ferree, Luu, Russell, & Tucker, 2001; Tucker, 1993). The EEG was amplified and analog filtered with 0.1–100-Hz bandpass filters (referenced to the vertex) and 60-Hz notch filters, and then digitized at 250 Hz. Six eye channels were used to monitor the trials with eye movement and blinks. The EEG signals

¹ Although their form class was variable, all target words were part of the initial noun phrase of the second sentence. In another EEG study of text integration in our lab, we systematically compared the differences between a bare NP (“The *cut* . . .”) and a modified NP (“The *spilled* wine . . .”) with the same integration type factor as in the current study. A reliable integration effect replicated the ERP results in the current study regardless of whether the target word is the head noun of a bare NP (*cut*) or a modifier in a modified NP (*spilled*).

were recorded continuously at 500 Hz by the Net Station with a 12-bit A/D converter. The EGI Net Station also recorded all event onset times and accuracy for later analysis. Instruction and visual stimuli were presented on a 15-in. (38.1-cm) CRT monitor working at a 60 Hz refresh rate. The experimental trials were controlled by commercial software, Eprime (Psychology Software Distribution, Pittsburgh, Pennsylvania), to present the trials and to record relevant trial information. Eprime also sent event information to an EEG recording system (Net Station).

ERP Recordings

Raw EEG data were recorded continuously, referenced to the vertex, at 500 samples per second. The EEG data were segmented offline into 900-ms epochs spanning 200 ms prestimulus to 700 ms poststimulus for the critical word to examine the ERP patterns as a function of text integration. There was a total of 30 possible trials per participant per condition. Data were digitally screened for artifact (eyeblinks or movements, subject movement, or transient electronic artifact) and contaminated trials were removed. Overall, 9.53% of trials were rejected, between 0 and 10 per subject, leaving no subject with fewer than 20 good trials in any condition. Remaining data were sorted by condition and averaged to create the ERPs. Averaged ERP data were digitally filtered at 30 Hz lowpass to remove residual high-frequency noise, baseline corrected over the 200-ms prestimulus period, and referenced to an average reference frame to remove topographic bias that can result from the selection of a reference site (Dien, 1998). The subject-averaged ERPs were averaged together to produce

the mean waveform across subjects, the grand average waveform for each condition, which was used in subsequent topographic plots and statistical analyses of brain waveforms. Figure 1 shows both the 128 recording sensors of the EGI Geodesic Sensor Net and the 11 clusters of electrodes selected for analysis based on the corresponding 11 recording sensors of the 10/20 system. The grand average reference ERP waveform by electrode sites for the experimental conditions was mapped on the basis of the 10/20 system locations. We created topographic maps of the voltage field across the surface of the scalp by interpolating from the recorded values using spherical splines (Perrin, Pernier, Bertrand, & Echallier, 1989).

ERP Data Analysis Strategies

Our strategy was to acquire a converging view of the ERP results through the use of multiple complementary analyses. These include topographic voltage maps for the experimental conditions and of difference waves, tests of mean amplitude differences, and a temporal principal component analysis (PCA).

Topographic Maps

The topographic maps, which are shown in Figure 2, are especially important for showing the spatiotemporal dynamics of brainwave activities as the process of text integration unfolded over time. These topographic maps can help to identify the ERP components for further brainwave analysis on the

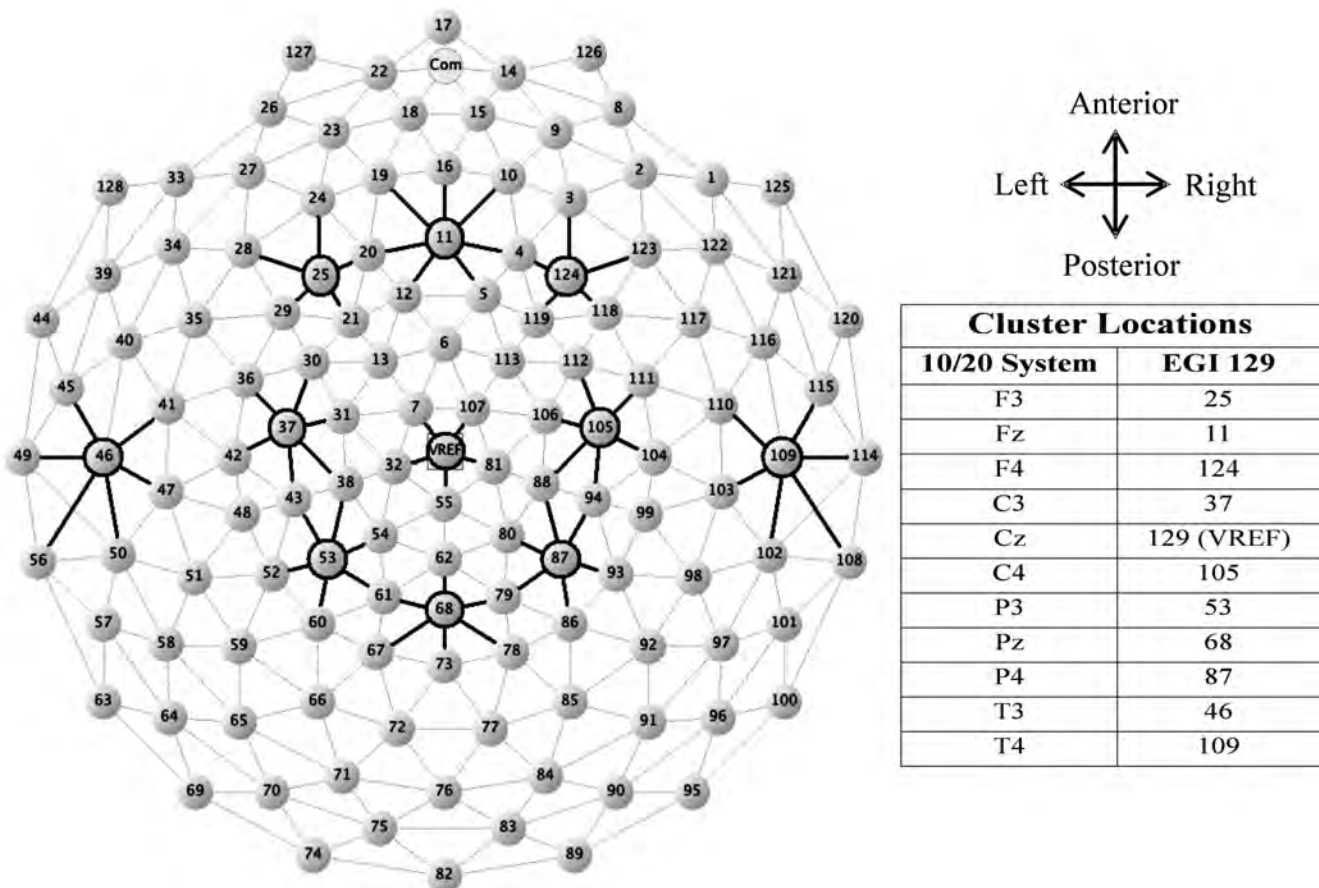


Figure 1. The clustered channels that correspond to the mostly commonly used electrode sites in the international 10/20 system (F3-Fz-F4, C3-Cz-C4, P3-Pz-P4, T3-T4) for the analysis of variance of the event-related potential analysis. EGI = Electrical Geodesics, Inc.; VREF = vertex reference.

basis of mean amplitudes measured from a subset of the electrodes. Following these steps, we then carried out mean amplitude analyses of brain waves and a temporal PCA, which identifies time-related factors associated with systematic voltage shifts, to confirm the patterns we saw in the first two steps.

PCA

A temporal PCA provides a data-driven view of the time-locked correlational structure of the ERP amplitudes, free of the theoretical preconceptions that are implied by standard ERP component labeling (e.g., N200, P300, and N400). As part of an overall strategy that includes standard ANOVAs on a subset of electrodes and temporal-spatial topographic maps, a temporal PCA can provide converging evidence on the temporal data patterns. We carried out the PCA subject averages on the basis of 325 samples of 2 ms each (0–650 ms post-stimulus onset) to extract independent components and allow theory-free, data-driven ERP patterns to emerge on the basis of the covariance matrix of all sample points. The PCA data set consisted of the ERP averages at each electrode site in all the experimental conditions for each subject. Together, the data matrix input of this temporal PCA consisted of 325 timepoints by 8,256 observations (129 Electrode Sites \times 16 Subjects \times 4 Experimental Conditions). The PCA used the covariance matrix with Promax rotation (Chapman & McCrary, 1995; Dien & Frishkoff, 2005; van Boxtel, 1998).

Statistical Analysis

The statistical analysis used two repeated-measures analyses of variance (ANOVAs). One tested the ERPs for the 3 medial electrode sites (Fz, Cz, and Pz), and the other tested 8 lateral electrode sites (F3-F4, C3-C4, P3-P4, and T3-T4). These 11 electrode regions were selected because they provide sufficient coverage to examine the related ERP shifts to the effects of text integration during language comprehension. For the analysis of mean amplitude differences, ANOVAs were conducted on the mean voltage amplitudes extracted from the related timing windows of each prominent ERP component identified from the topographic maps. For the PCA, the ANOVAs were conducted on the component score of each component derived from PCA. The ANOVAs all used two within-subject factors: integration type (referentially explicit, referentially paraphrased, inference, and baseline) and electrodes (3 for medial sites ANOVA and 4 pairs for lateral sites ANOVA), and the ANOVA of lateral sites included an additional within-subject factor of hemisphere (left vs. right). All probability values reported for effects with more than two degrees of freedom were adjusted with the conservative Geisser–Greenhouse correction for deviations from sphericity in the data.

Results

ERP Results

Sixteen participants contributed valid data for analysis. Figure 2 shows topographic maps of the voltage field distributions of difference waves, for which the baseline condition is subtracted from each experimental condition (see Figure 2a). Because the baseline condition produced the expected negativity (N400) at the target word, the experimental conditions show growth of positivities, reflecting their relative ease of integration. Differences in three time frames are visible in Figure 2a. An early time frame from 150 ms to 250 ms showed a posterior positivity for both the referentially explicit and referentially paraphrased conditions. The inference condition showed no apparent processing difference at the posterior regions. It is interesting that at 150 ms, the referentially explicit and referentially paraphrased conditions showed the positivity primarily at the right posterior regions. A middle time frame at 300 ms indicates a medial central

positivity for the referentially paraphrased condition only. Neither the referentially explicit nor the inference condition indicated apparent processing differences at this specific time frame. This suggests that a distinct integration process occurred for the referentially paraphrased condition at \sim 300 ms. Furthermore, a later time frame began at \sim 300 ms and extended to 750 ms, indicating distinguished processing differences for each experimental condition. For the referentially paraphrased condition, a difference from baseline persisted from 300 ms, whereas for both the referentially explicit and inference conditions, a difference from baseline emerged at 400 ms with stronger difference strength for the referentially explicit than for the inference condition.

Mean Amplitude Analysis

To test the temporal and spatial patterns in the data, we carried out analyses of the brainwave forms, examining the latency, amplitude and distribution of the ERPs corresponding to the three time frames (early, middle and later) as identified above. To effectively increase the accuracy of the average-reference derivation (Dien, 1998; Tucker, Liotti, Potts, Russell, & Posner, 1994), we assessed the spatial topography by dividing the electrodes into 11 spatial regions—3 lateral (left, midline, and right) and 4 lobes (frontal, central, posterior, and temporal)—and averaging the mean voltage amplitude of all channels within each region. Figure 1 shows the channels clustered in regions that correspond to commonly used electrode sites in the international 10/20 system (F3-Fz-F4, C3-Cz-C4, P3-Pz-P4, T3-T4). Using clusters that average multiple measurements has the advantage of reducing spurious interactions with single electrode locations, because it provides a more reliable sample of the activity within any region than a single separate measurement taken within the same region (Dien & Santuzzi, 2005).

Early (120–250 ms), middle (260–360 ms), and late (300–550 ms) time windows were tested in two separate repeated-measures ANOVAs each. We defined the time windows by converging analytic sources: the spatiotemporal dynamics of topographic voltage distribution of difference waves (see Figure 2) and the grand average reference ERP (see Figure 3). Selected time windows maintained the greatest amplitude divergence among experimental conditions and were also consistent with the temporal peaks of PCA component waveform.² The two ANOVAs, one for lateral sites and one for medial sites, were conducted on mean voltage amplitudes extracted from each time window. Table 2 outlines the results of ANOVAs for the waveform analyses of each time window.

² To be specific, time windows of each tested ERP were identified primarily by examining the relative differences between experimental conditions from Figure 3 (grand average reference ERP) and Figure 2 (topographic maps of difference waves). The PCA provides a confirmation of these time windows, deriving theory-free and data-driven ERP temporal patterns.

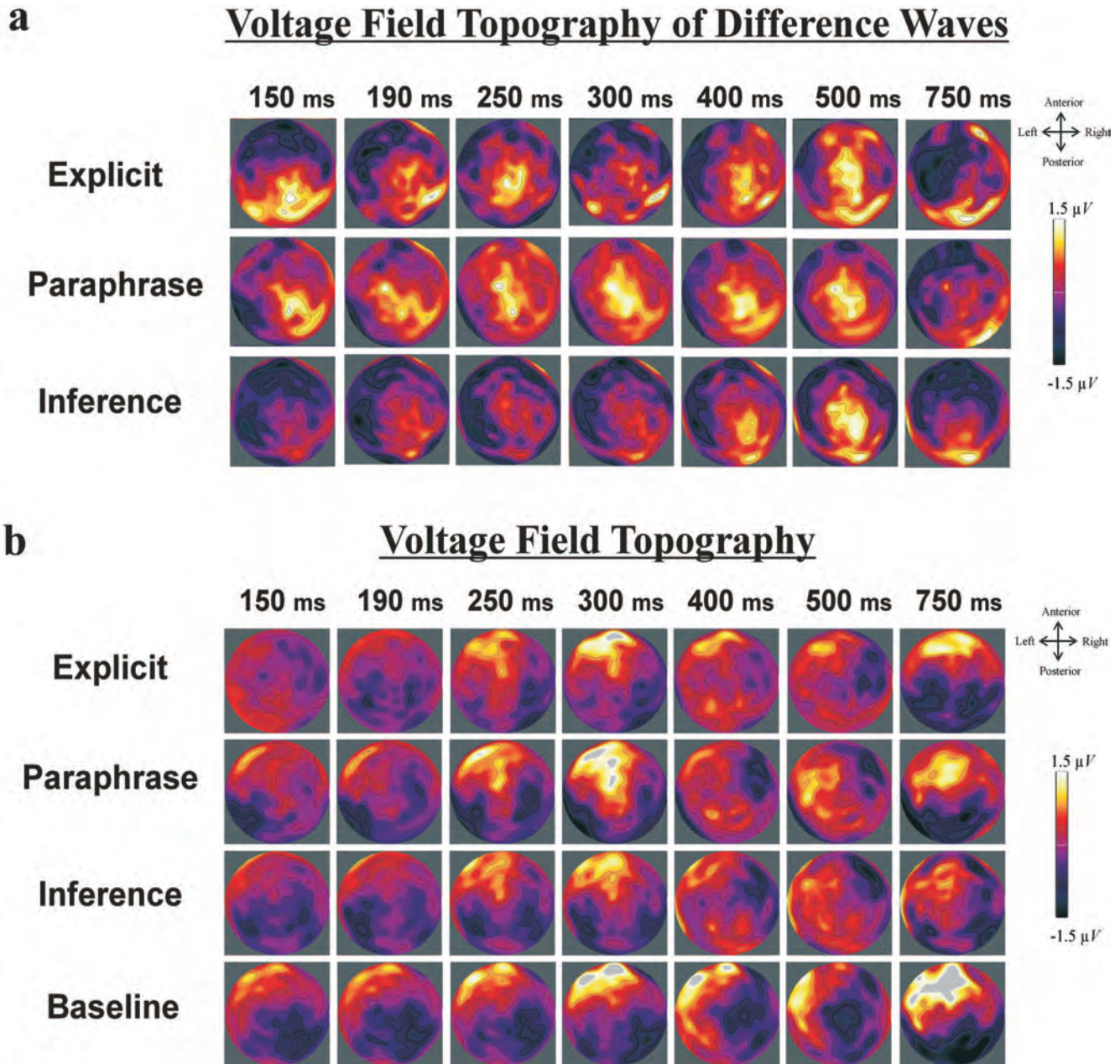


Figure 2. a: Top view of topographic maps of the voltage field distributions of difference waves for which the baseline condition is subtracted from each experimental condition, respectively. The horizontal axis indicates the temporal sequences of topographic voltage maps of the difference waves from 150 to 750 ms showing the spatiotemporal dynamics of developing positivities (relative to the baseline condition) as a function of the relative ease of text integration. b: Top view of topographic maps of the voltage field for each experimental condition.

Early time frame (N200, from 120 to 250 ms). We refer to the early component as an N200 to reflect its peak latency and shape.³ As can be seen in Table 2, this early component showed systematic variance only in the lateral sites analysis. There was no main effect of integration type ($F < 1$). However, there was a trend ($p = .09$) toward greater negativity in posterior electrodes for the baseline condition, compared with the referentially explicit and referentially paraphrased conditions as an interaction of Integration Type \times Electrodes. Al-

though it did not attain standard statistical reliability, this interaction pattern is visible in the topographic maps.

³ We refer to this early component as an N200 only to reflect its polarity and latency. Similarly, we refer to a later positive shift with a peak latency of 300 ms as a P300. In the Discussion section, we consider these two ERP shifts in relation to the interpretations of the N2 and P3 components in the ERP literature.

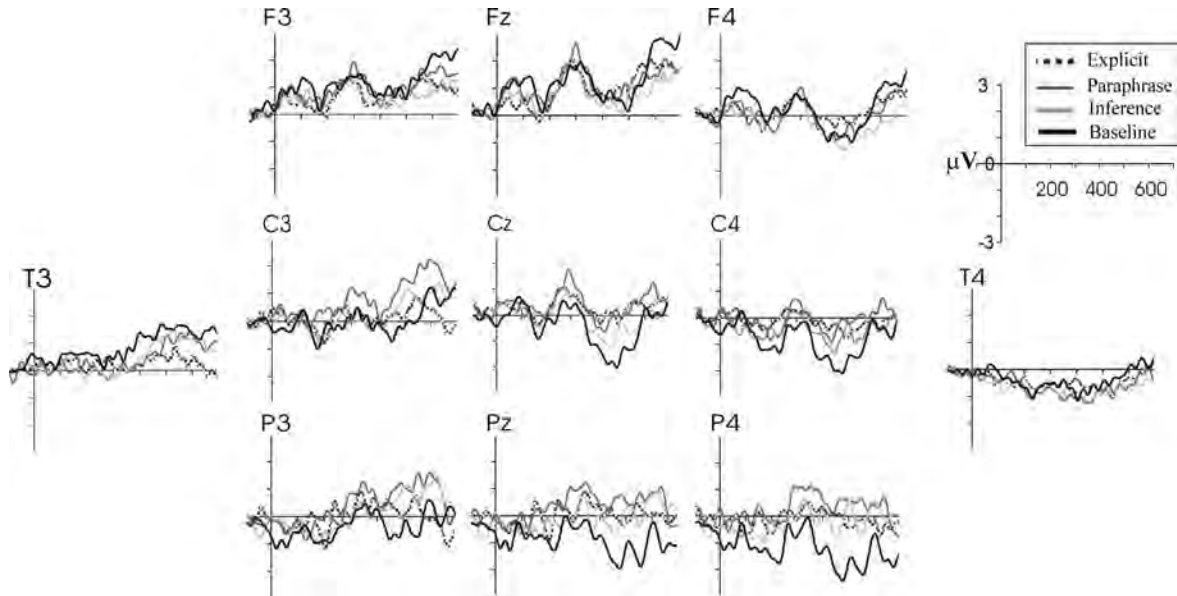


Figure 3. Grand average reference event-related potential (ERP) as a function of text integration during the processing of the critical target word. ERPs were extracted from the onset of the target word (the initial phrase of the second sentence) and were segmented offline into 900-ms epochs spanning 200 ms prestimulus to 700 ms poststimulus. For the purpose of demonstration, only the representative 11 recording sensors that correspond to the international 10/20 system are shown. Note that the Cz site clearly indicates a degrading N400 effect as a function of relative ease of integrating the target word with the preceding context. Other posterior sites showed this pattern as well with somewhat different degrees of N400 reduction.

The topographical maps of Figure 2a show a developing positivity (relative to baseline) at the posterior site for the referentially explicit and referentially paraphrased conditions from ~ 150 ms to ~ 250 ms. The developing positivity at the posterior sites was bilateral, (slightly right dominant) for the referentially explicit condition and right lateralized for the referentially paraphrased condition. It is important to note that the posterior site for this developing positivity extended beyond the lateral sites used in the ANOVA (see Figure 1), which may explain the low reliability of the interaction. In fact, comparison of Figures 2a and 4 shows only a partial overlap of the clustered channels used in the ANOVA and the sites of the developing positivity reflected in the topographic maps. Accordingly, we identified a region of interest (ROI) by examining the waveforms of posterior electrodes and selecting those that shared similar voltage shift patterns, latency and polarity. These ROI electrodes are shown in the left panel of Figure 4.

For the ROI analysis, we carried out a two-way repeated measures ANOVA on the bilateral electrodes clusters shown in Figure 4 at a time window of 120–250 ms. Although there were no main effects, there was an interaction of Integration Type \times Hemisphere, $F(3, 45) = 3.31$, $p < .05$, $MSE = 0.90$. Planned contrasts showed that both referentially explicit and referentially paraphrased conditions showed significant differences from the baseline condition at the right hemisphere sites, $t(15) = -2.54$, $p < .05$; $t(15) = -2.60$, $p < 0.05$, respectively. The inference condition showed a smaller difference from the baseline condition that was not quite reliable, $t(15) = -1.97$, $p = .07$. The experimental conditions at left hemisphere sites showed no reliable differences from the baseline condition. Somewhat surprising is that we did not find a specific effect of explicit lexical repetition.

However, our materials might have provided a basis for both conceptual (paraphrase condition) and perceptual (explicit condition) priming, both of which can benefit the process of word identification (Schacter & Buckner, 1998).

Middle time frame (P300, from 260 to 360 ms). Only the midline analysis showed effects of experimental variables in this time frame. Figure 5 shows these results. The referentially paraphrased condition induced a prominent positivity at this time window, but other conditions did not. The midline ANOVA confirmed this difference in a significant effect of integration type, which did not interact with electrodes. Pairwise comparisons showed that the P300 was greater for the referentially paraphrased than the baseline condition, $t(15) = 3.13$, $p < .01$. It was also visibly (but less reliably) larger in the referentially paraphrased condition than in the referentially explicit condition, $t(15) = 2.01$, $p = .06$. Additional contrasts reinforce the conclusion that this component separated the paraphrase condition from all other conditions, including the explicit condition. The referentially paraphrased condition was significantly higher in mean amplitude than the average of the inference and baseline conditions, $t(15) = 2.52$, $p < .05$; however, the referentially explicit condition was not significantly higher than the average of the inference and baseline conditions, $t(15) = 0.33$, $p = .75$. This pattern of results suggests that at ~ 300 ms, the effects of preceding context came primarily from the conceptual level, rather than from a purely lexical level.

Late time frame (N400, from 300 to 550 ms). For the late 300 to 550 ms time window, both the inference and baseline conditions produced significantly more negativity than the referentially explicit and referentially paraphrased conditions in the midline analysis (See

Table 2
Analyses of Variance (ANOVAs) on the Mean Amplitudes of the Early, Middle and Late Event-Related Potentials

Source	df	Medial ANOVA								
		Early time frame ^a (120–250 ms)			Middle time frame (260–360 ms)			Late time frame (300–550 ms)		
		F	MSE	p	F	MSE	p	F	MSE	p
Medial ANOVA										
Integration	3, 45	0.80	4.85	.488	3.37	1.46	.032*	40.97	0.69	.001*
Electrodes	2, 30	2.33	6.63	.115	4.07	5.79	.027*	0.63	1.71	.538
Integration × Electrodes	6, 90	1.75	2.27	.161	0.68	2.74	.613	1.30	1.22	.286
Lateral ANOVA										
Integration	3, 45	0.39	6.92	.740	0.44	1.67	.694	84.31	0.64	.001*
Electrodes	3, 45	2.84	7.00	.049*	5.87	9.50	.007*	0.93	2.92	.407
Integration × Electrodes	9, 135	1.68	1.29	.092	1.46	3.57	.223	0.86	1.83	.447
Hemisphere	1, 15	6.87	5.46	.019*	3.82	8.12	.070	3.28	3.81	.090
Integration × Hemisphere	3, 45	0.92	2.55	.430	0.35	4.37	.735	0.46	1.55	.531
Electrodes × Hemisphere	3, 45	5.82	1.23	.010*	4.26	1.89	.028*	2.75	0.55	.070
Integration × Electrodes × Hemisphere	9, 135	0.95	0.95	.430	0.46	1.54	.733	0.46	0.55	.670
Posterior region of interest ANOVA										
Integration	3, 45	1.63	1.84	.209						
Hemisphere	2, 30	0.16	2.25	.699						
Integration × Hemisphere	3, 45	3.14	0.90	.035*						

Note. The Geisser–Greenhouse correction was applied when the variance sphericity assumption was not met. The corrected p values are reported. The medial ANOVA used three midline electrodes (Fz, Cz, and Pz), and the lateral ANOVA used four pairs of bilateral electrodes (F3-F4, C3-C4, P3-P4, and T3-T4). Integration = integration type

^a An analysis of region of interest at the bilateral posterior region (see Figure 4) was further conducted.

* $p < .05$.

Table 2 for statistics.). Pairwise comparisons indicated significant differences between the referentially paraphrased versus inference conditions, $t(15) = 11.35$, $p < .001$, and between the referentially paraphrased versus baseline conditions, $t(15) = 5.90$, $p < .001$, but not between the referentially explicit versus referentially paraphrased conditions, $t(15) = -1.18$, $p = .26$, nor between the inference versus baseline conditions, $t(15) = -0.78$, $p = .45$.

A similar pattern separating the referentially explicit and referentially paraphrased from the inference and baseline was observed in the lateral sites analysis. The pattern of pairwise comparisons was identical to that found for the midline analysis: significant differences between the referentially paraphrased versus inference conditions, $t(15) = 13.21$, $p < .001$, and between the referentially paraphrased versus baseline conditions, $t(15) = 8.71$, $p < .001$, but not between the referentially explicit versus referentially paraphrased conditions, $t(15) = -1.59$, $p = .13$, nor between the inference versus baseline conditions, $t(15) = -1.37$, $p = .19$. This pattern was consistent over the scalp, with no interaction of integration type with electrodes and with hemisphere (both $F_s < 1$).⁴

PCA Components

The PCA extracted six major temporal factors (eigenvalue > 1) that accounted for 88% of the total variance in the data from the 325 variables corresponding to each 2-ms ERP time frame (see Figure 6). Because the fourth through the sixth components have early peaks and were not modulated by the integration type factor, they are not of major interest to our comprehension questions. They appear to reflect exogenous components (C4, 58 ms, and C6, 90 ms) related to visual processing and equipment artifact (C5). Accordingly, the first three components (82% of total explained variance) were selected for

further statistical analysis (note that *component* in this section refers to PCA component, not to voltage shifts). Table 3 outlines the results of ANOVAs for each prominent PCA component.

Component 1 (63% explained variance) was a slow wave component, rising from ~ 300 ms to a peak at 516 ms. This peak matched the enhanced negative shift in the EEG data on Cz, C4, Pz, and P4 (see Figures 2 and 3), and the late ERP component, the N400 integration component, in the mean amplitude analysis. The average component scores were negative for central and parietal sites and positive for frontal and temporal sites. Statistical tests (see Table 3) indicated that this component was modulated by the integration type factor at both medial and lateral sites. There was a significant main effect of integration type for medial site ANOVA and a significant interaction of Integration Type × Electrodes for lateral sites ANOVA. The negativity induced by the baseline condition was reliably greater than for the other experimental conditions at the medial and bilateral parietal sites (Fz, Cz, P3, Pz, & P4).

⁴ Because we adopted a traditional temporal range to examine the N400 effect, from 300 ms poststimulus onset, our time windows for the P300 (260–360 ms) and N400 (300–550 ms) overlapped. Although the results indicated reduced N400 for both the paraphrase and explicit conditions, it is possible that the reduced negativity of the paraphrase condition may have resulted from its enhanced positivity at the P300. To test this, we carried out an additional mean amplitude analysis using a nonoverlapping temporal range of 360–600 ms for the N400. The results were similar to those of the main analysis. Crucially, the paraphrase condition showed reduced negativity relative to the baseline condition, $t(15) = 2.73$, $p < .05$, that is not distinguishable from the explicit condition, $t(15) = -0.47$, $p = .64$.

Mean amplitude plot

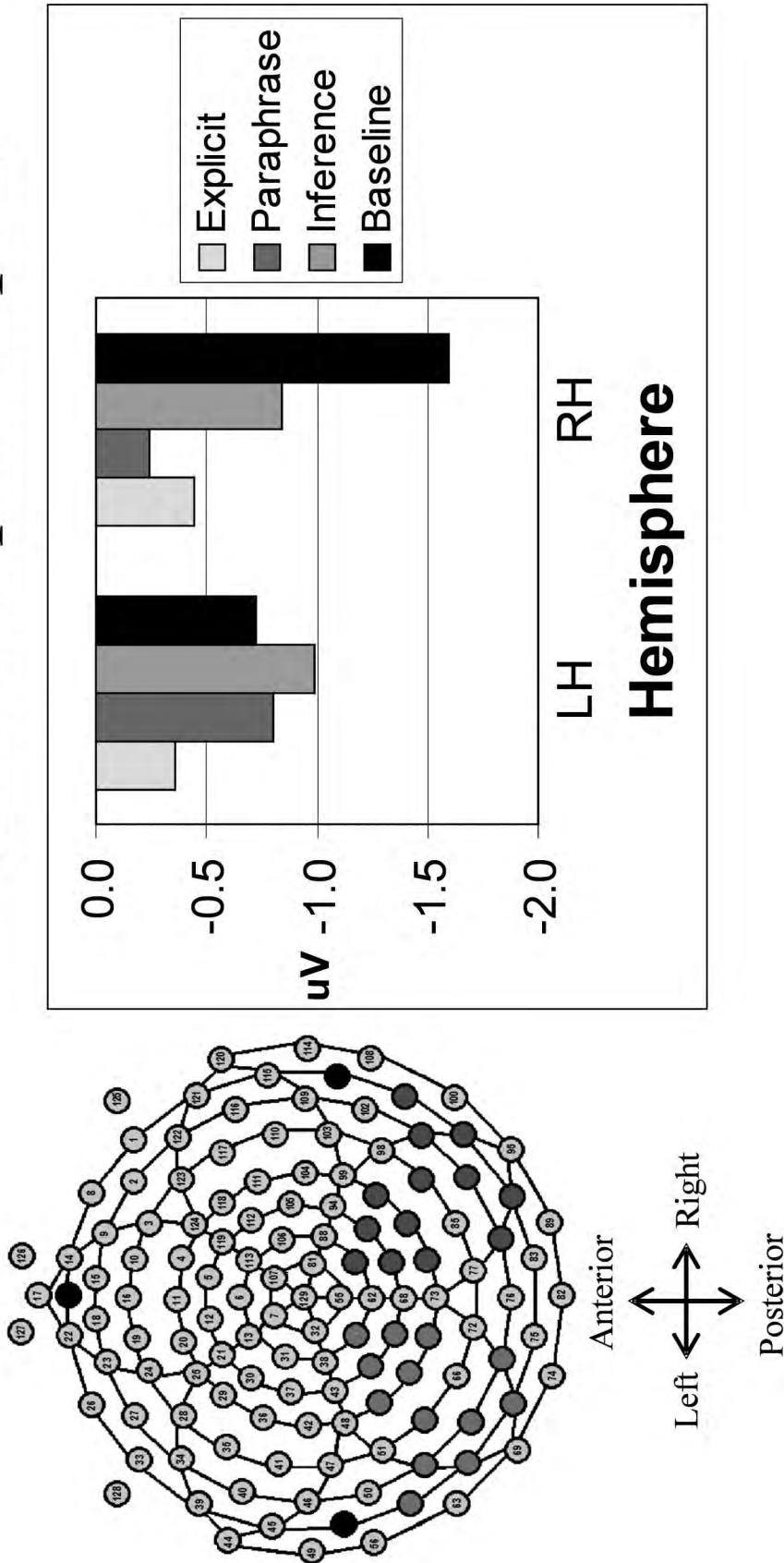


Figure 4. The region of interest (ROI) analysis of the early ERP effects at time windows of 120 to 250 ms. The left panel shows the location of the selected electrodes of the lateralized posterior ROI over the scalp surface of the 128-channel Geodesic Sensor Net. The vertex is at the center of the map (Electrode 129). The global circle represents the cantho-meatal line and the inferior boundary of the recording space. The selected electrodes are marked by shaded circles. The gray shaded circles represent the symmetric pairs of lateralized electrodes. The right panel indicates the interaction between the integration type and hemisphere factors. LH = left hemisphere; RH = right hemisphere.

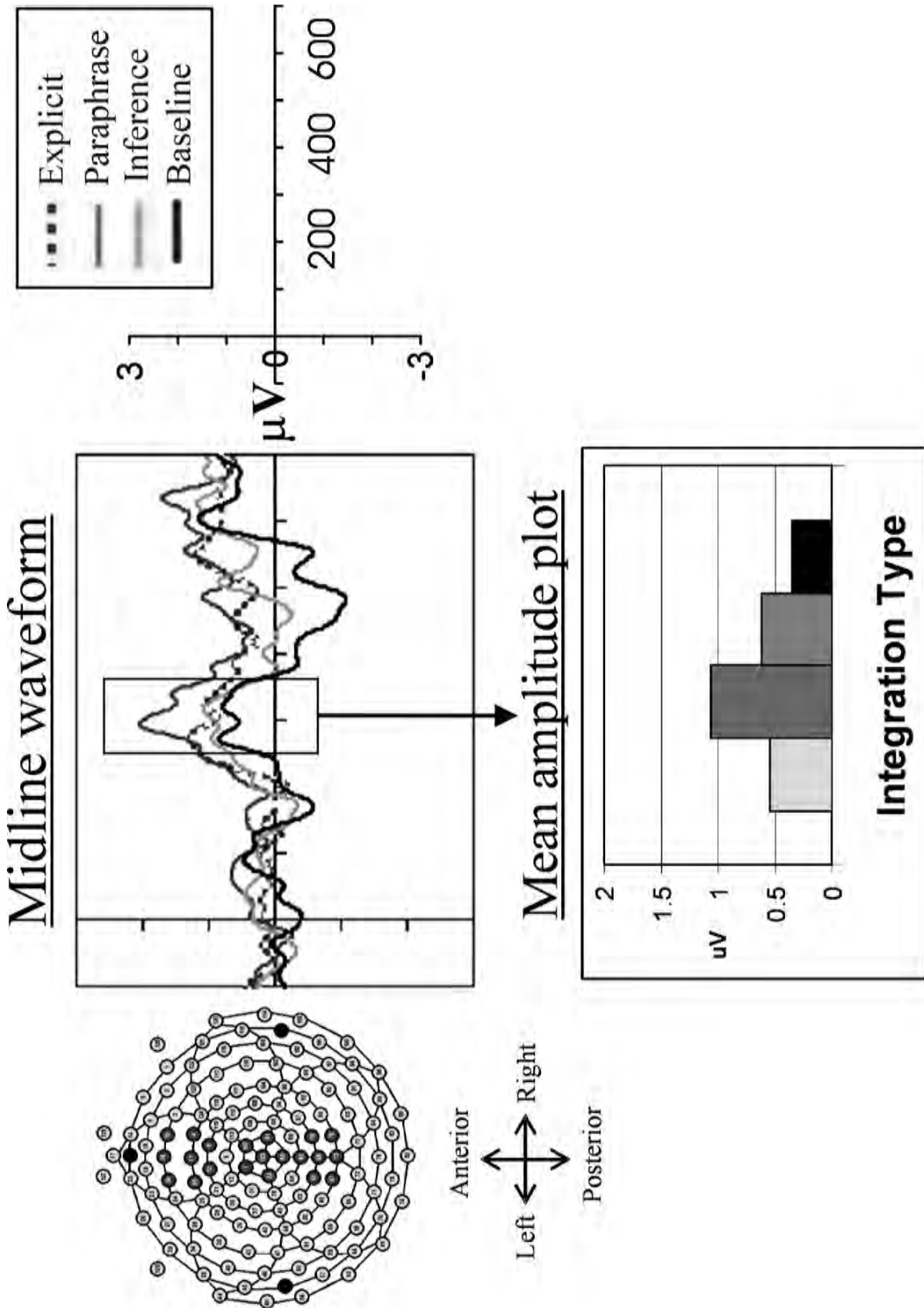


Figure 5. The midline waveform as a function of the processing of different types of text integration. This was plotted by averaging the grand average references event-related potentials (ERPs) over the clustered midline electrodes (Fz, Cz, and Pz) as shown by the gray shaded dots within the leftmost scalp figure. The bottom figure shows the mean amplitude differences of time windows of 260 to 360 ms as a function of experimental manipulations. As can be seen, the processing of the referentially paraphrased words induced an enhanced positivity with a sharp peak at 300 ms. This is consistent with the topographic maps of difference waves of Figure 2a that indicate a central-midline positivity peak for the referentially paraphrased condition at the 300-ms time frame.

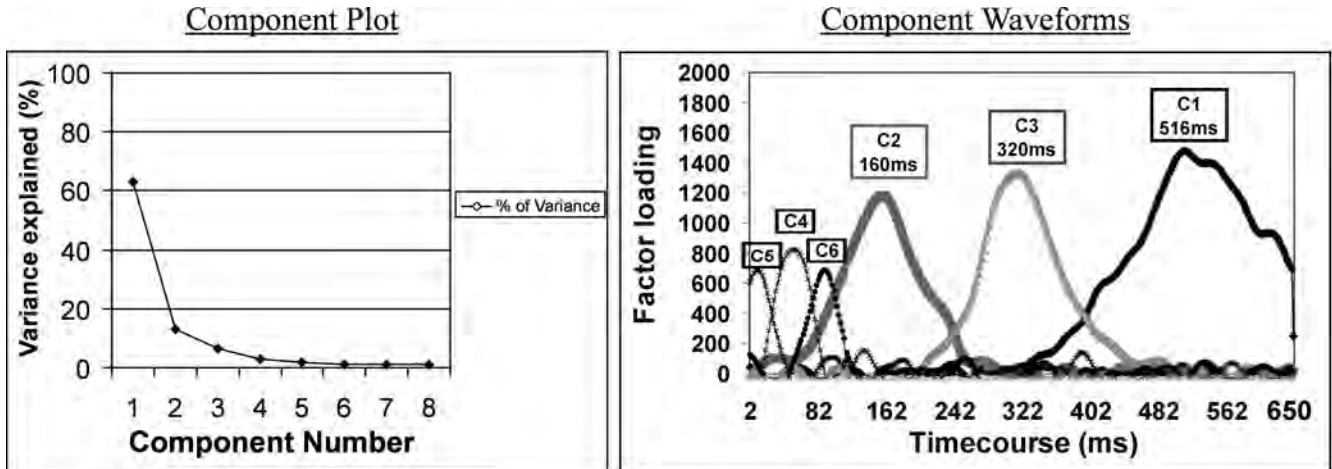


Figure 6. Scree plot and component waveforms of the extracted principal component analysis (PCA) components. For the scree plot, note that the number of extracted components after promax rotation was 18 (eigenvalues are greater than 1), but only the first 8 components were plotted for display purposes. For the component waveforms, the text boxes within the plot area indicate the corresponding components (C1 = Component 1, C2 = Component 2, etc.). The time points of peak loadings for the first three components are shown in the text boxes. Note that *component* here refers to PCA component, not to voltage shifts.

Component 2 (13% explained variance) rose from ~110 ms with a peak loading at 162 ms. The average component scores were positive at the frontal sites and negative at the central, parietal, and temporal sites. The peak and timecourse matched the negative shift in the EEG data at around 160 ms and the early ERP component, N200, in the mean amplitude analysis. ANOVAs (see Table 3) indicated a trend toward an interaction of Integration Type × Electrodes ($p = .07$) for the lateral site ANOVA. This effect is visible in the topographic maps of difference waves (see Figure 3), which show a salient posterior positivity for experimen-

tal conditions relative to the baseline from around ~150 ms to 250 ms, and is statistically reliable in the ROI analysis reported above in the mean amplitude analysis.

Component 3 (6% explained variance) rose from ~260 ms, with a peak at 314 ms. The average component scores were positive for frontal, and central sites, and negative at parietal and temporal sites. The peak and time course closely matched the ERP waveform of Figure 2 that indicates positive shifts at this time window, P300, over most electrodes sites except the temporal sites (T3 and T4). Furthermore, the peak and time course matched the middle

Table 3

Analyses of Variance (ANOVAs) on the Component Score of Each Temporal Factor Extracted From Principal Components Analysis

Source	df	Component 1 (516 ms, 63%)			Component 2 (160 ms, 13%)			Component 3 (320 ms, 6%)		
		F	MSE	p	F	MSE	p	F	MSE	p
Medial ANOVA										
Integration	3, 45	5.14	0.63	.004*	1.23	0.56	.310	4.03	0.43	.015*
Electrodes	2, 30	4.77	0.95	.020*	0.92	3.13	.361	6.72	1.36	.006*
Integration × Electrodes	6, 90	0.96	0.66	.457	1.32	0.65	.274	0.24	0.69	.901
Lateral ANOVA										
Integration	3, 45	0.52	0.63	.649	0.46	0.45	.679	0.41	0.54	.744
Electrodes	3, 45	1.63	1.57	.216	1.67	3.79	.211	7.73	1.15	.001*
Integration × Electrodes	9, 135	2.03	1.70	.040*	1.81	0.80	.072	0.94	1.21	.491
Hemisphere	1, 15	8.70	3.32	.010*	3.67	1.40	.075	1.85	1.75	.194
Integration × Hemisphere	3, 45	0.52	0.79	.662	0.71	0.62	.535	0.77	0.91	.501
Electrodes × Hemisphere	3, 45	1.55	0.62	.227	3.84	0.53	.035*	2.16	0.78	.135
Integration × Electrodes × Hemisphere	9, 135	0.39	0.53	.825	1.28	0.39	.286	0.64	0.38	.643

Note. The Geisser–Greenhouse correction was applied when the variance sphericity assumption was not met. The corrected p values are reported. Integration = integration type. The medial ANOVA used three midline electrodes (Fz, Cz, and Pz), and the lateral ANOVA used four pairs of bilateral electrodes (F3-F4, C3-C4, P3-P4, and T3-T4).

* $p < .05$.

ERP component in the mean amplitude analysis. ANOVAs (see Table 3) showed that this component is modulated by the integration type factor at the medial site and that the referentially paraphrased condition induced reliably greater positivity than the referentially explicit and baseline conditions, but not than the inference condition.

Thus, the PCA identified temporal components that are consistent with the topographic and mean amplitude analyses. Importantly, the PCA provides the quantitative basis to identify components that relate to the endogenous effect of lexico-semantic processing (component 2) and integration processing, separable from those components that relate to the exogenous effect of visual processing.

Behavioral Results

The mean accuracy for each participant ranged from 96% to 73% ($M = 88\%$, $SD = 7.8\%$): referentially explicit (91%), referentially paraphrased (96%), inference (89%), and baseline (77%). Because the immediate processing of the target word in the baseline condition was designed to be unrelated to a sensible integration process, it was excluded in further statistical analysis. A repeated measures ANOVA indicated that the main effect of integration type was significant, $F(2, 30) = 3.79$, $p < .05$, $MSE = 51$. Pairwise comparisons showed that the referentially paraphrased condition produced reliably better accuracy than the inference condition, $t(15) = 2.34$, $p < .05$. No other comparisons were found to be significant.

The mean reaction time of each condition, from the fastest to the slowest, was 2,920 ms for the referentially paraphrased; 3,232 ms for the inference; 3,242 ms for the baseline; and 3,515 ms for the referentially explicit. We conducted a repeated measures ANOVA to test the generality of this pattern. The results showed that the main effect of integration type was significant, $F(2, 30) = 4.91$, $p < .05$, $MSE = 288,393$. Pairwise comparisons showed the main locus of this integration type effect to be the referentially paraphrased condition. It is interesting that the behavioral results suggested that the referentially paraphrased condition actually promoted text integration better than other experimental conditions, as shown in the fastest reaction times to the comprehension questions and the highest accuracy.

Coherence Check

To examine the coherence of our two-sentence contexts, we carried out a study to collect coherence ratings from a new set of 36 participants. Its purpose was to test the extent to which our texts were viewed as equally coherent across experimental conditions. It was possible, for example, that in our referentially explicit condition, repeating a word from the next sentence was not as natural a continuation as use of a pronoun would have been. For another example, by hypothesis the inference condition was not as coherent as the referentially explicit condition because of a lack of argument overlap. We wanted to see whether the four conditions were viewed as reasonably coherent when readers could view the sentences in their entirety rather than one at a time.

The test used the four sets of 120 experimental passages plus 30 items that replaced the target word with appropriate pronominal expressions (see Appendix B). These pro-form texts were adapted

from the passages of the referentially explicit condition. Sixty new incoherent filler passages were added, constructed by randomly pairing two sentences together (45 total) and by creating lexical ambiguity (15 total). Participants pressed the space bar to read through each passage one sentence at a time and then rated "How well do the two sentences go together?" on a 4-point scale (1 = *very poorly*, 4 = *well*). Each participant received one set of stimulus materials and across participants the different versions of all of experimental passages were presented equally.

The pooled mean percentage of the top two ratings (*somewhat good* or *well*; 3 and 4) was 94% for the referentially explicit condition, 93% for the referentially paraphrase condition, 88% for the inference condition, 82% for the pro-form condition, 43% for the baseline condition, 7% for the scrambled fillers, and 58% for the referentially ambiguous fillers. An ANOVA (excluding the baseline) indicated a main effect of integration type factor (explicit, paraphrase, inference, and pro-form), $F_1(3, 105) = 25.41$, $p < .001$, $MSE = 0.004$; $F_2(3, 357) = 21.17$, $p < .001$, $MSE = 0.02$. Post hoc contrasts further indicated that the referentially explicit and referentially paraphrased passages elicited equivalent perceived coherence, $t_1(35) = 0.64$, $p = .53$; $t_2(119) = 0.74$, $p = .46$, that was greater than the inference and pro-form passages: referentially explicit versus inference, $t_1(35) = 3.35$, $p < .01$, and $t_2(119) = 3.49$, $p < .01$; referentially explicit versus pro-form, $t_1(35) = 7.43$, $p < .001$, and $t_2(119) = 5.94$, $p < .01$; referentially paraphrased versus inference, $t_1(35) = 3.35$, $p < .01$, and $t_2(119) = 2.86$, $p < .01$; referentially paraphrased versus pro-form, $t_1(35) = 6.58$, $p < .01$, and $t_2(119) = 5.95$, $p < .01$. The inference passages were perceived to have greater coherence than the pro-form passages, $t_1(35) = 3.87$, $p < .01$, and $t_2(119) = 3.41$, $p < .01$. This same pattern of significant results over all comparisons was obtained when we applied the most stringent criterion of the percentage of sentences given the top rating (4).

Thus, the ratings confirm that the experimental conditions included texts that were perceived as coherent and that differences among conditions aligned with the assumptions that both explicit and paraphrase conditions would be viewed as coherent and that inference passages, because they lack explicit argument overlap, are viewed as less coherent. An important conclusion is that, although repeating a word is not the preferred way to establish coherence, our explicit condition appears to have reflected conditions that favor repetition, because the explicit condition was viewed as coherent. The finding that the pro-form condition did not promote the highest level of coherence reflects the fact that in many cases a pronoun created an unclear reference compared with an explicit repetition, especially when the referent from the first sentence was not a noun. More generally, the facilitative effect of pro-forms depends on the accessibility of the referent, which varies with its status of discourse focus and syntactic prominence (Gordon, Grosz, & Gilliom, 1993; Gordon & Hendrick, 1998; Lappin & Leass, 1994; Reinhart, 1981). Our texts placed the antecedent in a less-focused and syntactically nonprominent status, a condition which favors its repetition (Garrod, 1994; Garrod, Freudenthal, & Boyle, 1994; Gordon et al., 1993; Gordon & Chan, 1995).

Discussion

With the use of multiple analyses of ERP recordings on a single word, we have obtained a convergent picture of the word-to-text

integration processes that occur on the first words of a sentence. This picture shows an attempt at immediate integration of a word into the reader's representation of the text to that point, despite the fact that the integration must take place across a sentence boundary. The immediate integration hypothesis predicts that differential ERP effects will reflect differences in the ease of integration, because such differences arise only if integration attempts are being made. The ease of integration highly depends on two major factors: the availability of the intended referent in the representation and the lexicosemantic match between the target word and its intended referent in the representation. Integration difficulty occurs when the context information does not support access to a referent for the word. Specifically, integration difficulty should be a function of the cognitive effort needed to access the intended referent of the word in relation to the preceding context.

Our test of this assumption rested on the first sentence, which varied the accessibility of a referent needed for the initial content word of the second sentence. The integration of the referent across the sentence boundary could be lexically based (referentially explicit), semantically associated and conceptual based (referentially paraphrased), and situation based (inference). The integration of the baseline condition was the most difficult, because the initial phrase had no immediate match to the situation model established from the initial sentence. Below we discuss first how the ERP data support this general picture and then the implications of the results for general accounts of text comprehension.

The ERP results suggest effects that arise by 200 ms and are continued through two later shifts which are identifiable as a P300 and an N400. The major predicted effect was the N400, which indicated that during the reading of the first content word across a sentence boundary, readers tend to attempt to integrate the word to a potential referent in their representation of the context. This effect was found by the major ERP analysis of N400, which found that both the referentially explicit and referentially paraphrased conditions produced reduced N400s relative to both inference and baseline conditions. The N400 had a later peak (at ~500 ms; see Figure 2) than is generally observed. Late latencies generally indicate increasing task demands (Donchin & Coles, 1988b), which might be higher when integration is required across sentence boundaries. The main point is that these N400 effects support the assumption that readers attempted to integrate the target word with the context and that these attempts varied in difficulty according to the conditions. On the other hand, these results suggest that delayed processing did not occur. Incremental integration of each incoming linguistic constituent tends to be a general processing strategy in language comprehension.

The earliest effects (from 150 ms) were visible in the topographic wave forms and could be confirmed in an ROI analysis on posterior electrodes (although not in the original ANOVA that included fewer posterior electrodes). Figure 3 shows a very early developing positivity at the 150-ms time frame for both the referentially explicit and referentially paraphrased conditions at the posterior sites. Because both the referentially explicit and referentially paraphrased conditions induced an early developing positivity at the posterior sites (from 120 ms to around 250 ms), we interpret this as a lexicosemantic effect.

In the 300-ms window, the referentially paraphrased condition diverged from the other conditions at the midline site, with the referentially paraphrased condition inducing the greatest ERP en-

hancement from the baseline condition. This effect is also quite visible in the topographic maps of Figure 3. We interpret this P300 effect as a conceptual effect that reflects integration based on word meaning rather than word form.

The cognitive functions of the N200 and P300 effects do not necessarily match those traditionally attributed to the N200 and P300 in the ERP literature. Both components have been related to stimulus novelty and task relevance. The N200 has been identified as a mismatch negativity that reflects an automatic feature discrimination process related to a stimulus that deviates from the prevailing context (Gehring, Gratton, Coles, & Donchin, 1992; Squires, Squires, & Hillyard, 1975). The P300 often has been related to memory updating in task events that involve novel stimuli (Donchin & Coles, 1988a, 1988b).

To interpret these components in the present study, we must consider the cognitive task of word-by-word reading. The readers integrate the target word with a memory representation of the preceding context. This integration unfolds rapidly as readers identify the word's form and its meaning and select a meaning relevant to the context. The ERP shifts track these processes, showing a posterior negativity at 200 ms (N200) and 300 ms (P300) moving to anterior regions that relate to meaning integration. This pattern is consistent with what has been found in Marinkovic et al. (2003), who, using an anatomically constrained magnetoencephalography paradigm, found that repeated written words induced increased brain activity of the ventral visual stream that included the occipitotemporal and posterolateral temporal regions at ~200 ms and that the brain activation moves along the posterior–anterior axis in the time course that the activity spreads to the anterior regions after ~200 ms word onset (Marinkovic et al., 2003, p. 488). A memory updating interpretation of the P300 may be a highly general one in which a model of the environment is modified and updated as a function of incoming information (Donchin & Coles, 1988a). In the case of word-to-text integration, we can suggest that this updating process is enhanced for a word (a paraphrase) that has a conceptual association with the preceding text representation (Keenan & Jennings, 1995).

Two additional observations about the interpretation of the ERP data are relevant to the general question of how ERPs reflect word integration processes. The first concerns the apparent lack of evidence for predictive inferences, which have been the object of much research and controversy (Graesser, Singer, & Trabasso, 1994) with both positive (Murray, Klin, & Myers, 1993; Zwaan & van Oosterndorp, 1993) and negative results (Corbett & Doshier, 1978; McKoon & Ratcliffe, 1989, 1992; Singer & Ferreira, 1983). Our ERP results suggest that readers did not generally draw predictive inference during the first sentence. Accordingly, they were not prepared to integrate the target word of the second sentence and instead had to draw a bridging inference in comprehending the target word. There are some suggestions in the topographic maps that this occurred. One can see in Figure 2a that the inference condition induced a transient N400 reduction at around 500 ms at the central-parietal site, which could suggest a relatively easy bridging inference that enabled some integration (St. George et al., 1997). Additional converging evidence comes from comprehension accuracy and perceived coherence that indicate a clear separation of inference condition from baseline condition. These offline measures are coherence guided in establishing a meaningful representation of the text.

Numerous inference studies have indicated that coherence requirements guide the reader to compute bridging inference during the course of text comprehension (Keenan, Baillet, & Brown, 1984; McKoon & Ratcliff, 1986; Myers, Shinjo, & Duffy, 1987; Singer, 1980). By and large, the results are consistent with the view that readers routinely make only more passive coherence-driven inferences rather than fully constructed inferences (McKoon & Ratcliff, 1992). They are less consistent with the constructionist hypothesis (Graesser et al., 1994) that readers are active in drawing a variety of inferences while constructing mental representation in reading text. However, we note the possibility that unreliable differences between the inference and baseline conditions may reflect individual differences in the tendencies for readers to make such inferences or in the likelihood that specific texts trigger them. Such differences would be consistent with the assumption that such inferences are not routinely triggered but are variably influenced by a variety of factors (Calvo, Castillo, & Schmalhofer, 2006; Fincher-Kiefer, 1993; McKoon & Ratcliff, 1989; Singer & Leon, in press; Trabasso & Suh, 1993).

The second point concerns the absence of a clear, specific effect of word repetition—the referentially explicit condition compared with the referentially paraphrased condition. Certainly, one expects an effect when a word is repeated (Van Petten, Kutas, Kluender, Mitchiner, & McIsaac, 1991). In fact, the middle time window did show a repetition effect, but it was not statistically reliable. It is possible that a more reliable repetition effect would be observed for complete form repetition. Recall that the first-sentence antecedent and the second-sentence target word often varied in their forms (e.g., “. . . exploded. The explosion . . .” and “. . . cause a flood. The flooding . . .”). Furthermore, the words intervening between the antecedent and target word range from 1 to 5 words, with an average of 3 words. The N400 amplitude has been found to vary with the lag between the first and second occurrence of a word (Nagy & Rugg, 1989; Van Petten et al., 1991). Thus, although both the variation of the form class and of the lag between the first and second occurrence of a word in our passage stimuli have been shown to have no systematic variation with the experimental factors, they could affect the reliability of a specific repetition effect. In fact, in a recent EEG study of text integration in our lab, a reliable repetition effect was found from ~250 ms at the medial central-frontal site when the antecedent and the target word matched exactly in their form class (“. . . a bridesmaid. . . The bridesmaid . . .”). A third possibility is that form effects are reduced in a situation that emphasizes meaning integration. If so, repetition and paraphrase would contribute equally to the text integration.

Another result concerns the comprehension questions. The major ERP analysis suggested that both surface match (referentially explicit) and conceptual association (referentially paraphrased) with the referent in the context facilitated the immediate integration of the text material. The behavioral data look somewhat different in that the referentially paraphrased condition facilitated comprehension relative to the other experimental conditions. Furthermore, the referentially explicit condition did not facilitate text comprehension more than the inference condition. This pattern shows a dissociation between immediate integration and final comprehension. The explicit match of the surface form promoted the immediate mapping and integration of the referent into the

representation, but it did not actually promote text comprehension better than the inference condition, a pattern consistent with McNamara, Kintsch, Songer, and Kintsch's (1996) findings. McNamara et al. (1996), using longer texts in a learning task, reported that a text with consistent and explicit argument overlap may make for a coherent text representation, but it may make it harder for readers to acquire the situation model.

Finally, and most provocative we think, is the question of what is advantageous about a paraphrase. One possibility is that a paraphrase leads to fuller processing than an explicitly repeated word. This fuller processing leads to a more integrated representation that serves the comprehension question. On the other hand, the explicit condition may receive its integration only through a passive memory resonance process, adequate for integration and immediate comprehension but not providing any special boost to final comprehension. We can link the comprehension advantage of the paraphrase condition to the paraphrase P300 effect as follows: The paraphrase P300 effect may result from a memory match process that responds to a word that is similar in meaning. For example, when the word *explosion* is encountered, this recalls *blown up* from the first sentence and a referent that would have been established through predication, namely, “the bomb . . . blew up.”

This process distinguishes a paraphrase not only from explicit word repetition but also from inference. The difference in our results between the paraphrase and inference conditions can be seen in these terms: A word meaning-based mechanism is sufficient for paraphrase-based integration but not for forward inference-based integration. As indicated above, paraphrase relations can be computed through lexical connections, which may be context sensitive, given that our paraphrase relations were not simply highly associated words. Thus, paraphrase relations, but not inferences, can take advantage of memory processes that resonate for words with related meanings (O'Brien et al., 1998). A resonance process that is initiated by encoding the meaning of a word would be a rapid and efficient process that could lead to immediate word-to-text integration. Schmalhofer and Perfetti (in press) present behavioral and fMRI data that converge with the present ERP data in supporting the broad features of this account.

Conclusion

Not only do the present results expose the processes of word-to-text integration in text comprehension, they also specifically show that integration processes operate immediately on the first content word of a sentence. Both the explicit and paraphrase conditions facilitated the immediate integration of the target word. Further, the earliness of the paraphrase effect suggests that the word conceptual level is available very quickly to comprehension and is sensitive to its contextual appropriateness. The comprehension results allow an additional suggestion that an integration process that requires a conceptual level process (as in the paraphrase case) may lead to higher comprehension than integration that can be achieved more superficially on the basis of argument overlap (word repetition). However, when integration requires a predictive inference to have been made in the previous sentence, it is less successful.

In this ERP experiment, we deliberately designed the materials of the (a) referentially explicit, (b) referentially paraphrased, (c) inference and (d) baseline conditions so that they would optimally align to the materials from behavioral studies on inferencing (e.g. Keenan et al., 1984; McDaniel et al., 2001) and studies that separate the wording, the conceptual, and the situational levels of representations from each other (Schmalhofer & Glavanov, 1986). We can thus compare the ERP results with the results of behavioral studies: The PCA analysis clearly identified three separate components in the ERP signals, which we were able to describe as N400, P300 and N200. The N400 component clearly differentiated the integration processes of the baseline and the inference conditions, on the one hand, and the referentially explicit and referentially paraphrased conditions, on the other hand. Because predictive inferences were hardly ever drawn, the processes yielding the N400 may be associated with a situational bonding of the critical word to the previous context. The P300 component furthermore differentiated the integration process of the referentially paraphrased condition from the three other conditions. The P300 may thus be implicated for conceptual or propositional processes. Finally, the N200 effect has always been assumed to reflect lexical processes. Our results are therefore also quite consistent with previous behavioral studies and with the multilevel representation assumption.

Our study has focused on the text reading of skilled readers. It is quite possible that less skilled readers show a word-to-text integration pattern that is different from what we observed here. Indeed, in a recent study in our lab (Yang, Perfetti, & Schmalhofer, 2006), less skilled college readers showed little evidence of integration for explicit and paraphrase words (relative to baseline words) within the first ~300 ms of word processing. This contrasts with the evidence of the current study that high-skill readers integrate words through lexico-semantic processing within ~300 ms. Such a difference in lexical level integration is consistent with the hypothesis that comprehension skill varies at least in part with the lexical processing skills that are required during comprehension (Perfetti & Hart, 2001).

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Appendix A
Experimental Stimuli

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
A01-1	cut	While swimming in the shallow water near the rocks, Sharon stepped on a piece of glass and cut her foot. The cut was one inch long.	While swimming in the shallow water near the rocks, Sharon stepped on a piece of glass and injured her foot. The cut was one inch long.	While swimming in the shallow water near the rocks, Sharon stepped on a piece of glass. The cut was one inch long.	While resting her foot in the shallow water near the rocks, Sharon found a piece of glass. The cut of the crystal was quite amazing.
A02-2	pieces	No longer able to control his fury, the boyfriend hurled the delicate, porcelain vase against the wall and broke it into pieces. The pieces took a long time to clean up.	No longer able to control his fury, the boyfriend hurled the delicate, porcelain vase against the wall and shattered it into bits. The pieces took a long time to clean up.	No longer able to control his fury, the boyfriend hurled the delicate, porcelain vase against the wall. The pieces took a long time to clean up.	In one final attempt to win the delicate, porcelain vase, the furious boyfriend hurled the ball against the wall. The pieces of pie he ate later tasted good.
A03-9	fall	The trapeze artist was very good and attracted large crowds, but as tonight's audience watched, he suddenly lost his grip and fell. The fall resulted in a broken leg.	The trapeze artist was very good and attracted large crowds, but as tonight's audience watched, he suddenly lost his grip and plummeted to the ground. The fall resulted in a broken leg.	The trapeze artist was very good and attracted large crowds, but as tonight's audience watched, he suddenly lost his grip. The fall resulted in a broken leg.	The artist tightened his grip on the brush as he realized he was almost done with his depiction of the graceful trapeze act. The fall weather always made him perform better.
A04-23	birth	Mary was having hard labor pains, so she went to the hospital to give birth. The birth of her child was a joyous occasion for all.	Mary was having hard labor pains, so she went to the hospital to have her baby. The birth of her child was a joyous occasion for all.	Mary was having hard labor pains, so she went to the hospital. The birth of her child was a joyous occasion for all.	Mary, like others who work at hard labor, suffers more aches and pains and spends more time in the hospital than office workers. The birth of her child was a breeze compared to her job at the mill.
A05-32	explosion	After being dropped from the plane, the bomb hit the ground and exploded. The explosion was quickly reported to the commander.	After being dropped from the plane, the bomb hit the ground and blew up. The explosion was quickly reported to the commander.	After being dropped from the plane, the bomb hit the ground. The explosion was quickly reported to the commander.	Once the bomb was stored safely on the ground, the plane dropped off its passengers and left. The explosion that occurred last week was already forgotten.
A06-42	accident	The driver looked up and saw the bus headed straight for her, but it was too late to stop the accident. The accident was later reported on the news.	The driver looked up and saw the bus headed straight for her, but it was too late to stop the collision. The accident was later reported on the news.	The driver looked up and saw the bus headed straight for her, but it was too late. The accident was later reported on the news.	The bus driver was late so she headed straight to the next station. The accident that had occurred had made her lose time.
A07-78	hospital	Allen's baby became violently ill, so Allen got the baby in the car and rushed off to the hospital. The hospital had a long waiting line.	Allen's baby became violently ill, so Allen got the baby in the car and rushed off to the emergency room. The hospital had a long waiting line.	Allen's baby became violently ill, so Allen got the baby in the car and rushed off. The hospital had a long waiting line.	Allen rushed off to work, when his wife was no longer feeling very ill. The hospital that she finally went to was very crowded.
A08-87	flu	Patty had a headache and a fever and finally realized she had the flu. The flu kept her in bed for days.	Patty had a headache and a fever and finally realized she had this year's virus. The flu kept her in bed for days.	Patty had a headache and a fever. The flu kept her in bed for days.	Patty never got headaches or fevers because of her healthy lifestyle. The flu completely bypassed her.

(Appendix continues)

Appendix A (*continued*)

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
A09-94	crash	The drunk driver was speeding at 70 mph towards a tree when he lost control of his car and crashed. The crash killed all four passengers.	The drunk driver was speeding at 70 mph towards a tree when he lost control of his car and wrecked. The crash killed all four passengers.	The drunk driver was speeding at 70 mph towards a tree when he lost control of his car. The crash killed all four passengers.	The cab driver drove the drunk passenger 70 miles at a moderate speed and parked by a tree. The crash of an airplane that was reported on the news did not bother him.
A10-98	rain	After Cathy had been riding her bike for two hours along the beach, the sun disappeared, the clouds became very dark and it rained. The rain ruined her beautiful sweater.	After Cathy had been riding her bike for two hours along the beach, the sun disappeared, the clouds became very dark and it started to pour. The rain ruined her beautiful sweater.	After Cathy had been riding her bike for two hours along the beach, the sun disappeared and the clouds became very dark. The rain ruined her beautiful sweater.	There had been very dark clouds when Cathy started to ride her bike, but then the sun came out for two hours. The rain that had been predicted for this afternoon never happened.
A11-110	visit	Doris had already postponed seeing her mother several times when she grabbed some clothes and packed her suitcase to visit her. The visit was a great pleasure.	Doris had already postponed seeing her mother several times when she grabbed some clothes and packed her suitcase to stay with her. The visit was a great pleasure.	Doris had already postponed seeing her mother several times when she grabbed some clothes and packed her suitcase. The visit was a great pleasure.	Her mother took the clothes out, unpacked Doris' suitcase and told her to postpone her date. The visit to her friend was not permitted by her mother.
A12-4	drilling	Ann opened her mouth as the dentist drilled her tooth. The drilling was loud but not painful.	Ann opened her mouth as the dentist bore into her tooth. The drilling was loud but not painful.	Ann opened her mouth as the dentist worked on her cavity. The drilling was loud but not painful.	Ann opened her mouth for the dentist, but there were no cavities. The drilling sound from the other room made her glad she brushed three times a day.
A13-21	crying	After being announced the winner, the contestant was overwhelmed with emotion and started to cry. Her crying annoyed the other contestants who thought she was being melodramatic.	After being announced the winner, the contestant was overwhelmed with emotion and she started to sob. Her crying annoyed the other contestants who thought she was being melodramatic.	After being announced the winner, the contestant was overwhelmed with emotion. Her crying annoyed the other contestants who thought she was being melodramatic.	After overwhelming opposition, the contestant showed no emotion as she was announced the winner. Her crying in the past had resulted in some embarrassing pictures in the news.
A14-44	showering	After the workout, Katie grabbed her shampoo and towel, headed to the bathroom, turned on the faucet, and stepped in the shower. Showering after an early morning workout always woke her up and prepared her for the day.	After the workout, Katie grabbed her shampoo and towel, headed to the bathroom, turned on the faucet, and let the water drip on her body. Showering after an early morning workout always woke her up and prepared her for the day.	After her workout, Katie grabbed her shampoo and towel, headed to the bathroom and turned on the faucet. Showering after an early morning workout always woke her up and prepared her for the day.	Katie turned on the bathroom faucet, splashed water on her face, dried it with the towel near the shampoo, and went to work out. Showering after an early morning workout always woke her up and prepared her for the day.
A15-61	watering	The plant was drooping, so Eddie filled up a pitcher in the kitchen and watered it. Watering the plant made it perk up.	The plant was drooping, so Eddie filled up a pitcher in the kitchen and poured it in the plant's pot. Watering the plant made it perk up.	The plant was drooping, so Eddie filled up a pitcher in the kitchen. Watering the plant made it perk up.	After Eddie cleaned the kitchen, he filled up a pitcher with lemonade and rested next to the drooping plant. Watering the plant was still a chore he had to do.

Appendix A (continued)

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
A16-75	correcting	Suzie was lucky enough to notice her mistake before she turned in her test, so she ran back to her desk and corrected it. Correcting the error helped her get an A.	Suzie was lucky enough to notice her mistake before she turned in her test, so she ran back to her desk and fixed it. Correcting the error helped her get an A.	Suzie was lucky enough to notice her mistake before she turned in her test, so she ran back to her desk. Correcting the error helped her get an A.	Suzie was lucky enough to never make mistakes on her tests, so she would turn them in early and run back to her desk to read. Correcting the test was easy for her teacher.
A17-5	stolen	The dishonest man stuck a hanger in the vehicle's window, opened the door, and in no time at all stole the car. The stolen car was found by the police the next day.	The dishonest man stuck a hanger in the vehicle's window, opened the door, and in no time at all drove off with the car. The stolen car was found by the police the next day.	The dishonest man stuck a hanger in the vehicle's window, opened the door, and in no time at all was able to start the engine. The stolen car was found by the police the next day.	The man started the engine and opened the vehicle's door while his dishonest girlfriend moved the hanger off the seat and rolled down the window. The stolen cigarettes were in her purse.
A18-51	killed	After spotting the cockroach in the bathtub, John reached over to grab an old shoe and killed it. Killing bugs never bothered John.	After spotting the cockroach in the bathtub, John reached over to grab an old shoe and smashed it. Killing bugs never bothered John.	After spotting the cockroach in the bathtub, John reached over to grab an old shoe. Killing bugs never bothered John.	After taking off his old shoes, John got in the bathtub and spotted a cockroach. Killing bugs never bothered John.
A19-83	frightened	When Rose noticed a stranger in her apartment, she sat still in the corner of her laundry room and was frightened. The frightened expression of her face could be seen in the mirror.	When Rose noticed a stranger in her apartment, she sat still in the corner of her laundry room and tensed up. The frightened expression of her face could be seen in the mirror.	When Rose noticed a stranger in her apartment, she sat still in the corner of her laundry room. The frightened expression of her face could be seen in the mirror.	When Rose showed her apartment to the stranger, he stood still in the corner of her laundry room. The frightened stranger ran away.
A20-55	hammering	Jane wanted to hang the antique painting she bought at an auction, so she looked for a nail and hammered it into the wall. After hammering the nail she hung the picture on the wall.	Jane wanted to hang the antique painting she bought at an auction, so she looked for a nail and pounded it into the wall. After hammering the nail she hung the picture on the wall.	Jane wanted to hang the antique painting she bought at an auction, so she looked for a nail. After hammering the nail she hung the picture on the wall.	Jane bought an antique painting to hang in her office, and then went to get her nails done. After hammering her thumb accidentally, she thought she deserved a manicure.
A21-66	losing	Alison had hurt her knee, and when the start gun fired, she quickly fell behind the other runners and eventually lost the race. After losing this race, she could not get into the finals anymore.	Alison had hurt her knee, and when the start gun fired, she quickly fell behind the other runners and eventually came in last. After losing this race, she could not get into the finals anymore.	Alison had hurt her knee, and when the start gun fired, she quickly fell behind the other runners. After losing this race, she could not get into the finals anymore.	Alison was watching the runners when suddenly a gun fired and she fell to the ground with a hurt knee. After losing her ability to walk, she decided to stay on the ground.
A22-10	washed	When the mechanic was done for the day, he went over to the sink and washed his hands. Having washed his hands meant he was finished with work.	When the mechanic was done for the day, he went over to the sink and scrubbed his hands. Having washed his hands meant he was finished with work.	When the mechanic was done for the day, he went over to the sink. Having washed his hands meant he was finished with work.	The mechanic had worked all day to repair what had been a working sink. Having washed his car, he decided to take it out for a spin.

(Appendix continues)

Appendix A (continued)

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
A23–48	sewed	Since Sonya had ripped her pants and had some free time, she found some matching thread and sewed them up. Having sewed the pants she wore them for another summer.	Since Sonya had ripped her pants and had some free time, she found some matching thread and stitched them up. Having sewed the pants she wore them for another summer.	Since Sonya had ripped her pants and had some free time, she found some matching thread. Having sewed the pants she wore them for another summer.	Sonya ripped off a bit of thread from her shirt so that she could find some matching pants in her free time. Having sewed the shirt last week, she wore it for another summer.
A24–88	joining	Jake knew about the Peace Corps and he wanted to help the third world people, so he joined the group. Joining the Peace Corps gave him the confidence of doing something meaningful with his life.	Jake knew about the Peace Corps and he wanted to help the third world people, so he became a member. Joining the Peace Corps gave him the confidence of doing something meaningful with his life.	Jake knew about the Peace Corps and he wanted to help the third world people. Joining the Peace Corps gave him the confidence of doing something meaningful with his life.	Jake hated the Peace Corps because he didn't care about people in third world countries. Joining the Peace Corps was the last thing he wanted to do.
A25–26	slept	Shortly after the patient was wheeled into the operating room, the doctor arrived and immediately placed the anaesthesia mask over the patient to put her to sleep. She slept soundly as the doctor injected collagen into her lips.	Shortly after the patient was wheeled into the operating room, the doctor arrived and immediately placed the anaesthesia mask over the patient to put her under. She slept soundly as the doctor injected collagen into her lips.	Shortly after the patient was wheeled into the operating room, the doctor arrived and immediately placed the anaesthesia mask over the patient. She slept soundly as the doctor injected collagen into her lips.	The day before the girl's surgery, the doctor showed the excited patient around the operating room and let her play with the mask she would wear to get the anaesthesia. She slept soundly that night with pleasant dreams of her new lips.
A27–99	fired	The salesperson had lost one customer after the other when his supervisor called him to his office and fired him. Being fired from a lousy job did not hurt him all that much.	The salesperson had lost one customer after the other when his supervisor called him to his office and terminated his contract. Being fired from a lousy job did not hurt him all that much.	The salesperson had lost one customer after the other when his supervisor called him to his office. Being fired from a lousy job did not hurt him all that much.	The salesperson called the customer who had lost his money to his office and introduced him to his supervisor. Being fired from a lousy job, the salesperson had to pass this case to his supervisor.
A28–107	spilled	The flight attendant had just served a completely full glass of red wine to the passenger when suddenly the plane hit turbulence, which spilled the wine. The spilled wine stained the passenger's pants.	The flight attendant had just served a completely full glass of red wine to the passenger when suddenly the plane hit turbulence, which emptied the glass. The spilled wine stained the passenger's pants.	The flight attendant had just served a completely full glass of red wine to the passenger when suddenly the plane hit turbulence. The spilled wine stained the passenger's pants.	After turbulence was completely over, the flight attendant served each passenger a glass of red wine. The spilled food was still lying on the floor.
A29–121	donation	The banker felt sorry for the homeless, reached for his checkbook and made a large donation. This donation was the largest he had ever given.	The banker felt sorry for the homeless, reached for his checkbook and made a large financial contribution. This donation was the largest he had ever given.	The banker felt sorry for the homeless and reached for his checkbook. This donation was the largest he had ever given.	The now homeless banker looked for his checkbook and felt sorry for himself. The donation that he had received was not yet deposited in his account.

Appendix A (continued)

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
A30-84	bruises	After playing baseball, his older brother punched Joey again and bruised him. The bruises were all over Joey's body.	After playing baseball, his older brother punched Joey again and injured him. The bruises were all over Joey's body.	After playing baseball, his older brother punched Joey again and again. The bruises were all over Joey's body.	Joey watched while his older brother punched the ball again and again. The bruises on his leg were fading away.
B01-7	drink	After a day in the hot sun, the dog ran to a puddle with his tongue hanging out and drank from it. The drink of water quenched his thirst.	After a day in the hot sun, the dog ran to a puddle with his tongue hanging out and began to lap it up. The drink of water quenched his thirst.	After a day in the hot sun, the dog ran to a puddle with his tongue hanging out. The drink of water quenched his thirst.	With his tongue hanging out, the dog ran over to a puddle and splashed about. The drink of water that the owner offered the dog was much cleaner than the puddle.
B02-3	stings	The hostile swarm of bees hurried out of the hive and landed on Joan's hand and stung her. The stings hurt a lot.	The hostile swarm of bees hurried out of the hive and began attacking Joan's hand. The stings hurt a lot.	The hostile swarm of bees hurried out of the hive and began attacking Joan's hand. The stings hurt a lot.	Growing hostile, Joan complained to her employee that the bees had not been moved to their new hive. The stings hurt a lot.
B03-15	fire	When Mildred, a Las Vegas salesgirl, carelessly dropped her cigarette near the woods, the result was a tragic fire. The fire engulfed many trees before being extinguished.	When Mildred, a Las Vegas salesgirl, carelessly dropped her cigarette near the woods, the result was tragic flames. The fire engulfed many trees before being extinguished.	When Mildred, a Las Vegas salesgirl, carelessly dropped her cigarette near the woods, the result was tragic. The fire engulfed many trees before being extinguished.	Mildred, a Las Vegas cigarette salesgirl, carelessly and tragically crashed her car into the woods. The fire from her car engulfed the million dollars she had just stolen from the bank.
B04-119	divorce	Heidi found out that her spouse was not faithful to her and went to a lawyer to file for a divorce. The divorce required only six weeks to be completely finished.	Heidi found out that her spouse was not faithful to her and went to a lawyer to end their marriage. The divorce required only six weeks to be completely finished.	Heidi found out that her spouse was not faithful to her and went to a lawyer. The divorce required only six weeks to be completely finished.	Heidi was a lawyer and had been married to a faithful husband. The divorce that she had to prepare for her client required a difficult settlement.
B05-37	water	Steve saw that the grass was dry and went outside to turn on the hose and water the lawn. The water was quickly soaked up by the thirsty grass.	Steve saw that the grass was dry and went outside and turned on the hose and sprinkler. The water was quickly soaked up by the thirsty grass.	Steve saw that the grass was dry and went outside to turn on the hose. The water was quickly soaked up by the thirsty grass.	With the turn of the seasons, Steve went outside, across the dry grass and brought in the hose. The water was still running in the kitchen.
B06-58	smell	After his three day fishing trip, Charles accidentally forgot the fish he caught in his trunk for one week, leaving a horrible smell. The smell was excruciating for Charles.	After his three day fishing trip, Charles accidentally forgot the fish he caught in his trunk for one week, leaving a horrible stench. The smell was excruciating for Charles.	After his three day fishing trip, Charles accidentally forgot the fish he caught in his trunk for one week. The smell was excruciating for Charles.	After talking for a week about how he was going to catch a fish and bring it home in the trunk, Charles accidentally forgot to get up in time for his three day fishing trip. The smell of fish made Charles happy.
B07-79	bite	The little girl was quietly walking on the sidewalk when a vicious dog chased her and bit her. The bite took two weeks to heal.	The little girl was quietly walking on the sidewalk when a vicious dog chased her and sunk its teeth into her. The bite took two weeks to heal.	The little girl was quietly walking on the sidewalk when a vicious dog chased her. The bite took two weeks to heal.	The vicious dog was walking slowly on the sidewalk while the little girl chased a butterfly. The bite which she got last week was forgotten.

(Appendix continues)

Appendix A (*continued*)

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
B08-89	aspirin	After having been out drinking last night, John had his worst hangover and searched through the medicine cabinet for an aspirin. The aspirin made his headache go away.	After having been out drinking last night, John had his worst hangover and searched through the medicine cabinet for a pain killer. The aspirin made his headache go away.	After having been out drinking last night, John had his worst hangover and searched through the medicine cabinet. The aspirin made his headache go away.	Cleaning out the medicine cabinet was the last of John's chores, before he began searching for a place to go out drinking with his friends. The aspirin pills were nowhere to be found.
B09-95	ace	With his serve the tennis player smashed the ball over the net so that the opponent could not even reach it and scored an ace. This ace was the beginning of an exciting match.	With his serve the tennis player smashed the ball over the net so that the opponent could not even reach it and scored a point. This ace was the beginning of an exciting match.	With his serve the tennis player smashed the ball over the net so that the opponent could not even reach it. This ace was the beginning of an exciting match.	The tennis player smashed the ball into the net on his serve, and it never reached his opponent. This ace was the beginning of an exciting match.
B10-100	dinner	Dick and Nancy had been married for one year, so they decided to leave work early and celebrate with a fancy dinner. The dinner had five courses and was wonderful.	Dick and Nancy had been married for one year, so they decided to leave work early and celebrate with a fancy meal. The dinner had five courses and was wonderful.	Dick and Nancy had been married for one year, so they decided to leave work early and celebrate. The dinner had five courses and was wonderful.	After their early marriage, Dick and Nancy decided to work hard to save up some money. The dinner was often eaten late in the evening.
B11-112	launch	At Cape Canaveral, the rocket was sitting on the ground waiting for a signal to be given for it to be launched. The launch caused a huge roar.	At Cape Canaveral, the rocket was sitting on the ground waiting for a signal to be given for it to be blasted off. The launch caused a huge roar.	At Cape Canaveral, the rocket was sitting on the ground waiting for a signal to be given. The launch caused a huge roar	There was a fourth of July celebration at Cape Canaveral, where the kids got to fire bottle rockets and other firecrackers. The launch had occurred two days ago.
B12-8	writing	The debutante owed a letter to her mother, so she picked up some paper, went to her desk and wrote it. Her writing was sloppy.	The debutante owed a letter to her mother, so she picked up some paper, went to her desk, and composed it. Her writing was sloppy.	The debutante owed a letter to her mother, so she picked up some paper and went to her desk. Her writing was sloppy.	The debutante's mother appreciated the letter of the law and knew that she owed the paperboy a desk. Her writing fetched in the desk was vulgar.
B13-22	shooting	The policeman took out his gun and aimed it at the fleeing suspect, and then shot him. The shooting was reported on the news.	The policeman took out his gun and aimed it at the fleeing suspect, and then pulled the trigger. The shooting was reported on the news.	The policeman took out his gun and aimed it at the fleeing suspect. The shooting was reported on the news.	The policeman explained that the suspect's only aim was to reassure people that there was no gun involved and he would never hurt anyone. The shooting was unrelated to his crime.
B14-46	playing	Ron picked up his guitar, opened the sheet music to his favorite song, and started to play. His playing was beautiful enough to woo any woman.	Ron picked up his guitar, opened the sheet music to his favorite song, and started to strum. His playing was beautiful enough to woo any woman.	Ron picked up his guitar and opened the sheet music to his favorite song. His playing was beautiful enough to woo any woman.	Ron picked up his girlfriend from guitar lessons, and turned up his favorite song on the radio as they headed towards a movie. His playing had been beautiful.
B15-69	vomiting	Julie ate some rancid mayonnaise, ran to the bathroom and vomited. Her vomiting made her feel much better.	Julie ate some rancid mayonnaise, ran to the bathroom and threw up. Her vomiting made her feel much better.	Julie ate some rancid mayonnaise and ran to the bathroom. Her vomiting made her feel much better.	Julie cleaned out the bathroom and kitchen and found some rancid mayonnaise. Her vomiting, which occurred last year after eating rancid mayonnaise, came to her mind.

Appendix A (continued)

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
B16-76	typing	Mike needed to work on his novel and he knew exactly what should happen next, so he sat down at the computer and began to type. His typing became fast and furious as his story poured out.	Mike needed to work on his novel and he knew exactly what should happen next, so he sat down at the computer and began plunking out the story. His typing became fast and furious as his story poured out.	Mike needed to work on his novel and he knew exactly what should happen next, so he sat down at the computer. His typing became fast and furious as his story poured out.	Mike stopped working on the computer and sat down to read the novel, but he already knew exactly what would happen next. His typing on the computer was to be continued later in the evening.
B17-13	spilled	The clumsy workman on the ladder accidentally kicked the paint bucket over and spilled the paint. The spilled paint could cost him his job.	The clumsy workman on the ladder accidentally kicked the paint bucket, dumping paint everywhere. The spilled paint could cost him his job.	The clumsy workman on the ladder accidentally kicked the paint bucket over. The spilled paint could cost him his job.	The clumsy workman kicked the ladder and then remembered that he had accidentally forgotten the paint bucket. The spilled paint had stained the carpet.
B18-52	drowned	Melanie was a good, athletic swimmer, but as the spectators watched, she sank to the bottom of the pool and drowned. The drowning devastated her parents.	Melanie was a good, athletic swimmer, but as the spectators watched, she sank to the bottom of the pool and suffocated. The drowning devastated her parents.	Melanie was a good, athletic swimmer, but as the spectators watched, she sank to the bottom of the pool. The drowning devastated her parents.	The coin sank to the bottom of the pool, but Melanie, who was a good, athletic swimmer, dove after it as the spectators watched. The drowning devastated the swim team.
B19-103	extinguished	It was past midnight when Susie took a bucket of water, poured it on the bonfire and extinguished it. The extinguished fire steamed for a few minutes.	It was past midnight when Susie took a bucket of water, poured it on the bonfire and put it out. The extinguished fire steamed for a few minutes.	It was past midnight when Susie took a bucket of water and poured it on the bonfire. The extinguished fire steamed for a few minutes.	After midnight, Susie had again emptied the water, filled the bucket with wood and brought it to the bonfire. The extinguished fire was still steaming.
B20-12	sinking	The wooden sailing ship cruised through the ice-cold sea, struck the iceberg with a tremendous crunch, and began to sink. After sinking the ship, the captain lost his job.	The wooden sailing ship cruised through the ice-cold sea, struck the iceberg with a tremendous crunch, and went under the water. After sinking the ship, the captain lost his job.	The wooden sailing ship cruised through the ice-cold sea, and struck the iceberg with a tremendous crunch. After sinking the ship, the captain lost his job.	From the wooden sailing ship, they could see across the ice-cold sea to where two icebergs struck each other with a tremendous crunch. The sinking sun behind the icebergs was beautiful.
B21-67	lighting	Brad fumbled through the dark until he located the box of matches and lit one. After lighting the match, it was easier to see.	Brad fumbled through the dark until he located the box of matches and struck one. After lighting the match, it was easier to see.	Brad fumbled through the dark until he located the matches. After lighting the match, it was easier to see.	Brad fumbled through the dark box of matchbox cars to locate one to play with. After lighting his hand on fire, matchbox cars were his only joy.
B22-29	flunked	On the midterm, Jerry found out that he had gotten the lowest grade in the class, and had flunked. Having flunked this class meant he had to repeat the seventh grade again.	On the midterm, Jerry found out that he had gotten the lowest grade in the class and had failed. Having flunked this class meant he had to repeat the seventh grade again.	On the midterm, Jerry found out that he had gotten the lowest grade in the class. Having flunked this class meant he had to repeat the seventh grade again.	Since he had good grades, Jerry was allowed to go on vacation during the midterm break. Having flunked last year, he was now ahead in the class that he had to repeat.
B23-50	opened	It was Nicole's birthday, and she eagerly picked up the biggest present and opened it. Having opened the present, she saw a beautiful vase.	It was Nicole's birthday, and she eagerly picked up the biggest present and unwrapped it. Having opened the present, she saw a beautiful vase.	It was Nicole's birthday, and she eagerly picked up the biggest present. Having opened the present, she saw a beautiful vase.	Nicole was eager to buy her best friend the biggest present for her birthday. Having opened the present, she saw a beautiful vase.

(Appendix continues)

Appendix A (*continued*)

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
B24–92	turned	Richard had been under the hot shower for twenty minutes when he finally grabbed the faucet handle and turned it off. Having turned off the shower, he dried his body with the towel.	Richard had been under the hot shower for twenty minutes when he finally gave the faucet handle a twist. Having turned off the shower, he dried his body with the towel.	Richard had been under the hot shower for twenty minutes when he finally grabbed the faucet handle. Having turned off the shower, he dried his body with the towel.	Richard had taken a hot shower twenty minutes ago and now he was getting drowsy. Having turned off his radio, he could now only hear the water running.
B25–33	flew	The male robin climbed out of the nest, spread his wings, and flew. He flew south where it was warmer this time of year.	The male robin climbed out of the nest, spread his wings, and took off. He flew south where it was warmer this time of year.	The male robin climbed out of the nest and spread his wings. He flew south where it was warmer this time of year.	The male robin jumped as the vet spread antiseptic on his broken wing. He flew around the room frantically trying to get away.
B26–108	fed	At dinner time, Jeffrey, who had promised to take care of the neighbor's dog for the day, went over to her house and fed it. Having fed the dog, he went back home to do his homework.	At dinner time, Jeffrey, who had promised to take care of the neighbor's dog for the day, went over to her house and brought some meat. Having fed the dog, he went back home to do his homework.	At dinner time, Jeffrey, who had promised to take care of the neighbor's dog for the day, went over to her house. Having fed the dog, he went back home to do his homework.	After dinner, Jeffrey went to the neighbor's house and took her dog for a walk, which he had promised to do. Having fed the dog, he went back home to do his homework.
B27–49	drunk	After Erik had six beers and some bourbon, he stumbled out of the door, drunk. Being drunk always made him crave a cigarette.	After Erik had six beers and some bourbon, he stumbled out of the door, smashed. Being drunk always made him crave a cigarette.	After Erik had six beers and some bourbon, he stumbled out of the door. Being drunk always made him crave a cigarette.	Erik bought a six-pack of beer and a bottle of bourbon for tomorrow's party. Being drunk always made him crave a cigarette.
B28–116	melted	During the party, the container with ice cream had been sitting on the table for 30 minutes, when Angela opened it and found it all melted. The melted ice cream looked disgusting.	During the party, the container with ice cream had been sitting on the table for 30 minutes, when Angela opened it and found it all ruined. The melted ice cream looked disgusting.	During the party, the container with ice cream had been sitting on the table for 30 minutes, when Angela opened it. The melted ice cream looked disgusting.	During the party, Angela took a half-gallon of ice cream from the freezer and served a dish to everyone sitting at the table. The melted ice cream that was sitting on the table had to be thrown out.
B29–27	touchdown	In the final seconds of the game, the football floated into the hands of the receiver in the end zone to score a touchdown. The touchdown secured their victory in the Super Bowl.	In the final seconds of the game, the football floated into the hands of the receiver in the end zone and the team scored six points. The touchdown secured their victory in the Super Bowl.	In the final seconds of the game, the football floated into the hands of the receiver in the end zone. The touchdown secured their victory in the Super Bowl.	In the final seconds of the game, the receiver watched the football float out of bounds past the end zone. The touchdown was never scored.
B30–77 (cf. 18)	fainting	The linguistics professor had not eaten anything for several days and stood in front of the large class where she became increasingly dizzy and fainted. Her fainting alarmed the students who took her to the hospital.	The linguistics professor had not eaten anything for several days and stood in front of the large class where she became increasingly dizzy and collapsed. Her fainting alarmed her students who took her to the hospital.	The linguistics professor had not eaten anything for several days and stood in front of the large class where she became increasingly dizzy. Her fainting alarmed her students who took her to the hospital.	After having been dizzy for several days, the Stanford trained linguistics professor had eaten well and stood in front of the large class. Her fainting was a big surprise to the students.

Appendix A (continued)

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
C01-14	throw	As the player headed toward home base, the outfielder raced toward the ball, picked it up, drew back his arm, and threw the ball. The throw saved the game.	As the player headed toward home base, the outfielder raced toward the ball, picked it up, drew back his arm, and hurled the ball. The throw saved the game.	As the player headed toward home base, the outfielder raced toward the ball, picked it up, and drew back his arm. The throw saved the game.	After they had won the game, the outfielder aimed to give the player the final game ball; he raced toward him, grabbed his arm and pulled him out of the crowd. The throw saved the game.
C02-62	photos	Brad positioned the camera, focused it on the tall skyscraper and took a photograph of it. Photographing cityscapes was what he was known for.	Brad positioned the camera, focused it on the tall skyscraper and took a picture of it. Photographing cityscapes was what he was known for.	Brad positioned the camera and focused it on the tall skyscraper. Photographing cityscapes was what he was known for.	Brad positioned himself on the edge of the roof and threw his camera off of the tall skyscraper. Photographing cityscapes was what he was known for.
C03-18 (cf. 77)	collapse	Near the end of his first marathon, the fatigued jogger barely finished the race and then collapsed. His collapse worried no one—it was a marathon after all.	Near the end of his first marathon, the fatigued jogger barely finished the race and then fell to the ground. His collapse worried no one—it was a marathon after all.	Near the end of his first marathon, the fatigued jogger barely finished the race. His collapse worried no one—it was a marathon after all.	Still fatigued from staying out too late, the jogger could barely finish breakfast in time to get downtown to sign up for next week's marathon. His collapse from last year's race was not something he wanted to repeat.
C04-30	ticket	Jan was nervous when she saw the police car turn on its flashing red lights, and the policeman waved her car over to the curb to give her a ticket. This ticket would cause them to revoke her license.	Jan was nervous when she saw the police car turn on its flashing red lights, and the policeman waved her car over to the curb to write her a citation. This ticket would cause them to revoke her license.	Jan was nervous when she saw the police car turn on its flashing red lights, and the policeman waved her car over to the curb. This ticket would cause them to revoke her license.	Jan loved to make her friends nervous by having her dad pick her up from parties in his police car with its flashing red lights turned on. The ticket for not cleaning her room was another example of her dad's sense of humor.
C05-39	death	The director and the cameraman were preparing to shoot close-ups of the actress on the edge of the roof of the 14th story building, when suddenly the actress fell and died. Her death was a tragic accident.	The director and the cameraman were preparing to shoot close-ups of the actress on the edge of the roof of the 14th story building, when suddenly the actress fell and was killed. Her death was a tragic accident.	The director and the cameraman were preparing to shoot close-ups of the actress on the edge of the roof of the 14th story building, when suddenly the actress fell. Her death was a tragic accident.	Suddenly, the director fell over the camera stand, interfering with the cameraman's efforts to shoot close-ups of the actress on the 14th floor. Her death twelve years later deeply upset the director.
C06-63	surgery	Jason needed to have his appendix removed immediately and was rushed to the hospital for the surgery. The surgery went as planned and he had a full recovery.	Jason needed to have his appendix removed immediately and was rushed to the hospital for the operation. The surgery went as planned and he had a full recovery.	Jason needed to have his appendix removed immediately and was rushed to the hospital. The surgery went as planned and he had a full recovery.	The hospital kept a jar with Jason's removed appendix in it to show to the medical students. The surgery on an appendix was being discussed with the new students.
C07-85	loan	Peter did not have the money for the fancy sports car, so he went to the bank to get a loan. The loan had to be paid back within five years.	Peter did not have the money for the fancy sports car, so he went to the bank to borrow some money. The loan had to be paid back within 5 years.	Peter did not have the money for the fancy sports car, so he went to the bank. The loan had to be paid back within 5 years.	Peter went to the bank with his fancy sports car. The loan which he wanted to take out from the bank had not yet been signed by the official.

(Appendix continues)

Appendix A (*continued*)

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
C08-90	itch	When Tom was sound asleep, his cat that had collected fleas sneaked into his bed and Tom became itchy. The itch annoyed Tom.	When Tom was sound asleep, his cat that had collected fleas sneaked into his bed and the fleas irritated his skin. The itch annoyed Tom.	When Tom was sound asleep, his cat that had collected fleas sneaked into his bed. The itch annoyed Tom.	His cat had collected fleas, so Tom put him outside before he sneaked into bed. The itch annoyed Tom.
C09-96	dent	Jimmy was playing a game that involved throwing rocks at targets, when he hit a car door and dented it. The dent in the car could easily be noticed by the owner.	Jimmy was playing a game that involved throwing rocks at targets, when he hit a car door and damaged it. The dent in the car could easily be noticed by the owner.	Jimmy was playing a game that involved throwing rocks at targets, when he hit a car door. The dent in the car could easily be noticed by the owner.	Jimmy got out of the car and closed the door because he wanted to play a game that involved throwing rocks at targets. The dent in his car had been forgotten by now.
C10-104	burger	Mary, who had become a real junk food addict, went to McDonalds and ordered a burger. The burger did not taste as good today, however.	Mary, who had become a real junk food addict, went to McDonalds and ordered a large patty. The burger did not taste as good today, however.	Mary, who had become a real junk food addict, went to McDonalds and ordered. The burger did not taste as good today, however.	Mary McDonald had become a real junk collector and seafood addict. The burger did not taste as good now that she'd started eating fish.
C11-115	stop	Without having found any gas station in the Nevada desert, Frank drove his Buick until it ran out of gas and stopped. The stop in the desert caused additional problems.	Without having found any gas station in the Nevada desert, Frank drove his Buick until it ran out of gas and came to a halt. The stop in the desert caused additional problems.	Without having found any gas station in the Nevada desert, Frank drove his Buick until it ran out of gas. The stop in the desert caused additional problems.	Frank ran out of the gas station he'd found in the Nevada desert and drove away in his Buick. The stop in the desert caused additional problems.
C12-11	studying	With his exam coming up, the student opened his book and studied intently. Studying for the exam would take several hours.	With his exam coming up, the student opened his book and read it intently. Studying for the exam would take several hours.	With his exam coming up, the student opened his book. Studying for the exam would take several hours.	When he finished the test, the student closed his exam book. Studying for the exam had been time consuming.
C13-28	eating	The teenager was at the table; she put the napkin on her lap and then picked up a fork to eat her salad. Eating feta cheese reminded her of her trip to Greece.	The teenager was at the table; she put the napkin on her lap and then picked up a fork, ready to chow down on her salad. Eating feta cheese reminded her of her trip to Greece.	The teenager was at the table; she put the napkin on her lap and then picked up a salad fork. Eating feta cheese reminded her of her trip to Greece.	The teenager was choosing her bridal tableware; she still had to pick a napkin pattern and salad forks. Eating delicious meals was a major part of her life.
C14-53	answering	The telephone had already rung five times before Rob reached over and answered it. Answering the phone turned out to be a bad idea because it was a creditor calling.	The telephone had already rung five times before Rob reached over and picked it up. Answering the phone turned out to be a bad idea because it was a creditor calling.	The telephone had already rung five times before Rob reached it. Answering the phone turned out to be a bad idea because it was a creditor calling.	The telephone had already rung five times before Rob lost his patience and threw it out the window. Answering the phone would have been a bad idea.
C15-71	landing	It had been a long plane ride and Robert was glad to be descending into Pittsburgh and finally landing. The landing was smooth and uneventful.	It had been a long plane ride and Robert was glad to be descending into Pittsburgh and finally touching down. The landing was smooth and uneventful.	It had been a long plane ride and Robert was glad to be descending into Pittsburgh. The landing was smooth and uneventful.	Robert was descending to the first floor of the airport to leave for his long plane ride to Pittsburgh. The landing in Pittsburgh was one hour ahead of time.

Appendix A (continued)

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
C16-81	slamming	Bill got angry at his father, ran towards the exit, energetically grabbed the door and slammed it. The slamming of the door hurt his father's feelings.	Bill got angry at his father, ran towards the exit, energetically grabbed the door and violently shut it. The slamming of the door hurt his father's feelings.	Bill got angry at his father, ran towards the exit and energetically grabbed the door. The slamming of the door hurt his father's feelings.	Bill was full of energy when his angry father stood near the door and blocked it. The slamming of the door could not be anticipated by either one of them.
C17-17	closed	The den was much sunnier than he liked, so the decorator walked over and closed the blinds. Having closed blinds made the room too dark.	The den was much sunnier than he liked, so the decorator walked over and shut the blinds. Having closed blinds made the room too dark.	The den was much sunnier than he liked, so the decorator walked over to the blinds. Having closed blinds made the room too dark.	The decorator reclined amidst the piles of wallpaper, blinds and rugs, sunning himself and contemplating the den. Having closed blinds made the room too dark.
C18-54	sour	The milk had been left out in the hot kitchen for a week before anyone realized it had gone sour. The sour milk was used to make buttermilk pancakes.	The milk had been left out in the hot kitchen for a week before anyone realized it was rancid. The sour milk was used to make buttermilk pancakes.	The milk had been left out in the hot kitchen for a week. The sour milk was used to make buttermilk pancakes.	Working in a hot kitchen for a week will make anyone want a fresh glass of milk. The sour milk can be used later on to make buttermilk pancakes.
C19-109	acquitted	Not finding any evidence that the accused boy had stolen the money, the judge reached his decision and acquitted him. The acquitted boy was then released from prison.	Not finding any evidence that the accused boy had stolen the money, the judge reached his decision and declared him free of guilt. The acquitted boy was then released from prison.	Not finding any evidence that the accused boy had stolen the money, the judge reached his decision. The acquitted boy was then released from prison.	Before making his decision, the judge had found ample evidence that the accused boy had stolen the money. The acquitted friends were proven not to be at the scene of the burglary.
C20-36	running	The star athlete stretched his muscles and assumed a ready position at the line, heard the starter gun fire and started to run. After running for so many years, the athlete had a strong, muscular body.	The star athlete stretched his muscles and assumed a ready position at the line, heard the starter gun fire and took off. After running for so many years, the athlete had a strong, muscular body.	The star athlete stretched his muscles, assumed a ready position at the line and heard the starter gun fire. After running for so many years, the athlete had a strong, muscular body.	The star athlete was stretching his muscles, when he saw a line of soldiers start to fire a gun salute. After running to the car, he noticed that his shoes were unted.
C21-70	finding	Angela had lost her car keys until she checked her nightstand and found them. After finding her keys she was relieved.	Angela had lost her car keys until she checked her nightstand and saw them. After finding her keys she was relieved.	Angela had lost her car keys until she checked her nightstand. After finding her keys she was relieved.	After Angela lost her car in the bet, she got her keys from the nightstand and sadly gave them away. After finding some sympathy from her mother she felt better.
C22-41	burnt	Beth left the turkey in the oven for too long, and smoke started coming out because it was burning. Serving burnt turkey does not make a very good dinner.	Beth left the turkey in the oven for too long, and smoke started coming out because it was scorching. Serving burnt turkey does not make a very good dinner.	Beth left the turkey in the oven for too long, and smoke started coming out. Serving burnt turkey does not make a very good dinner.	Beth put the turkey in the oven and left to take a long smoke. Serving burnt turkey does not make a very good dinner.
C23-64	chopped	The dead tree in Stan's yard was an eyesore, so Stan got out his axe and chopped it down. Having chopped down the tree, he went inside and rested.	The dead tree in Stan's yard was an eyesore, so Stan got out his axe and cut it down. Having chopped down the tree, he went inside and rested.	The dead tree in Stan's yard was an eyesore, so Stan got out his axe. Having chopped down the tree, he went inside and rested.	Stan thought the huge axe was a bigger eyesore than a dead tree, so he sold it. Having chopped down many trees, he called it quit for the day.

(Appendix continues)

Appendix A (continued)

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
C24-111	passed	During the race, Michael accelerated his Ferrari before the turn, and continued gaining on his competitor before finally passing him. Having passed him, Michael was now in first place.	During the race, Michael accelerated his Ferrari before the turn, and continued gaining on his competitor before finally leaving him behind. Having passed him, Michael was now in first place.	During the race, Michael accelerated his Ferrari before the turn, and continued gaining on his competitor. Having passed him, Michael was now in first place.	When Michael bought a Ferrari with the gain from his bet on the race, his life took a more competitive turn. Having passed a glass of champagne to all his friends, he decided to go into car racing.
C25-34	baked	The teacher was preparing the cake for the party, so she put it in the oven to bake it. She baked the cake for the guest of honor.	The teacher was preparing the cake for the party, so she put it in the oven to cook it. She baked the cake for the guest of honor.	The teacher was preparing the cake for the party, so she put it in the oven. She baked the cake for the guest of honor.	The teacher was preparing for the party, so she turned off the oven and put the cake in the truck. She baked the cake for the guest of honor.
C26-6	sitting	After standing through the three-hour debate, the tired speaker walked over to his chair and sat down. While sitting in the chair he got a second wind.	After standing through the three-hour debate, the tired speaker walked over to his chair and plopped down into it. While sitting in the chair he got a second wind.	After standing through the three-hour debate, the tired speaker walked over to his chair. While sitting in the chair he got a second wind.	The tired speaker moved the chair that was in his way and walked to the podium to continue his three-hour debate. While sitting in the chair he got a second wind.
C27-56	soaked	Mark was out walking in the park and was completely unprepared for the sudden downpour which soaked him. Being soaked to the bone, he went back home.	Mark was out walking in the park and was completely unprepared for the sudden downpour which drenched him. Being soaked to the bone, he went back home.	Mark was out walking in the park and was completely unprepared for the sudden downpour. Being soaked to the bone, he went back home.	Since the sudden downpour was over, and dinner was still unprepared, Mark went out walking in the park. Being soaked with perfumes, he attracted much attention from by passers.
C28-117	frozen	The weather was getting very cold and the water of the lake became quieter and smoother until it froze. The frozen surface reflected the sun in beautiful colors.	The weather was getting very cold and the water of the lake became quieter and smoother until it hardened to ice. The frozen surface reflected the sun in beautiful colors.	The weather was getting very cold and the water of the lake became quieter and smoother. The frozen surface reflected the sun in beautiful colors.	The cold water of the lake was nice in this weather, with the surface often quiet and smooth. The frozen water of the winter was cut, stored and provided ice for the summer.
C29-60	overflow	While waiting for the water to fill her bathtub, Jan accidentally fell asleep on her bed for several hours and let the water overflow. The overflow of water damaged the floor.	While waiting for the water to fill her bathtub, Jan accidentally fell asleep on her bed for several hours and water poured over the edge of the tub. The overflow of water damaged the floor.	While waiting for the water to fill her bathtub, Jan accidentally fell asleep on her bed for several hours. The overflow of water damaged the floor.	While waiting for her husband to get out of the bathtub, Jan accidentally fell asleep on her waterbed. The overflow of pressured air released the valve of the waterbed.
C30-57	winning	Anita grinned as she put her chess opponent in checkmate and won the game. Her winning streak was five games in a row.	Anita grinned as she put her chess opponent in checkmate and was once again victorious. Her winning streak was five games in a row.	Anita grinned as she put her chess opponent in checkmate. Her winning streak was five games in a row.	Anita made such a bad chess opponent that she didn't even know what checkmate meant, she just grinned. Her winning a game was out of the question.
D01-16	tear	Don tried to be careful, but as he turned to fix a shingle, his new flannel shirt got caught on a nail and tore. The tear on his shirt made his wife angry.	Don tried to be careful, but as he turned to fix a shingle, his new flannel shirt got caught on a nail and ripped. The tear on his shirt made his wife angry.	Don tried to be careful, but as he turned to fix a shingle, his new flannel shirt got caught on a nail. The tear on his shirt made his wife angry.	Don went to the store in his new flannel shirt to buy shingles to fix his roof, but he got caught up trying to decide what type of nails to buy. The tear in the back of a lady's jeans caught his attention.

Appendix A (continued)

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
D02–80	present	Bart had a crush on the pretty girl, so he went to a nearby store and bought her a present. The present was much appreciated by the girl.	Bart had a crush on the pretty girl, so he went to a nearby store and bought her a gift. The present was much appreciated by the girl.	Bart had a crush on the pretty girl, so he went to a nearby store. The present was much appreciated by the girl.	The pretty girl had met Bart when he was in a nearby store. The present which Bart wanted to buy was no longer available.
D03–19	applause	The pianist was overjoyed by the audience's enthusiastic applause. The applause was not customary in her country.	The pianist was overjoyed by the audience's enthusiastic clapping. The applause was not customary in her country.	The pianist was overjoyed by the audience's enthusiastic reception. The applause was not customary in her country.	The pianist wondered how far back one could sit in the audience at the competition and still get good reception. The applause would be heard the loudest in the middle.
D04–31	kiss	Having just finished reciting their wedding vows, Kristi and Tom were positively glowing as they kissed. The kiss left a bright pink smudge on Tom's face.	Having just finished reciting their wedding vows, Kristi and Tom were positively glowing as they smooched. The kiss left a bright pink spot on Tom's face.	Having just finished reciting their wedding vows, Kristi and Tom were positively glowing as they turned toward each other. The kiss left a bright pink spot on Tom's face.	Kristi and Tom were turned off by the notion of gay couples exchanging wedding vows, even when the relationship is glowing. The kiss is a different matter.
D05–40	flat	While driving around the construction site, Phil's tire rolled over a large spike sticking up out of the road and went flat. The flat put him behind in his work for the rest of the day.	While driving around the construction site, Phil's tire rolled over a large spike sticking up out of the road, releasing all of its air. The flat put him behind in his work for the rest of the day.	While driving around the construction site, Phil's tire rolled over a large spike sticking up out of the road. The flat put him behind in his work for the rest of the day.	While driving a large spike that was sticking up from a board at the construction site, Phil noticed that a tire had rolled onto the road. The flat road was luckily empty, so no cars had to swerve around the tire.
D06–73	pop	Olivia poked the balloon with a pin and it popped. The pop was loud and surprising.	Olivia poked the balloon with a pin and it burst. The pop was loud and surprising.	Olivia poked the balloon with a pin. The pop was loud and surprising.	Olivia poked Charles with a pin and then got him a balloon because she felt bad. The pop was loud when it burst.
D07–86	rent	Lisa decided which apartment to get, and then went to the landlord and rented it. The rent for her current apartment had been too expensive.	Lisa decided which apartment to get, and then went to the landlord and leased it. The rent for her current apartment had been too expensive.	Lisa decided which apartment to get, and then went to the landlord. The rent for her current apartment had been too expensive.	Lisa's landlord died, so she decided to leave her apartment and then went to the funeral. The rent for her apartment was quite expensive.
D08–91	stock	Fred wanted to make money by investing in businesses, so he went to the bank and bought stock. The stock increased in value during the next week.	Fred wanted to make money by investing in businesses, so he went to the bank and bought shares. The stock increased in value during the next week.	Fred wanted to make money by investing in businesses, so he went to the bank. The stock increased in value during the next week.	Fred had to bring money from the investment bank to small businesses. The stock had been predicted to increase in value.
D09–97	restoration	The old Victorian house needed a lot of work, so the Historical Society came in to do a restoration. The restoration took one week.	The old Victorian house needed a lot of work, so the Historical Society came in to do a renovation. The restoration took one week.	The old Victorian house needed a lot of work, so the Historical Society came in. The restoration took one week.	The man came home from working at the Historical Society to his old Victorian house. The restoration he was doing would take two weeks.
D10–106	gold	The winner of the Olympics was stepping onto the podium when the president approached, congratulated and honored her with the gold. This gold was already the third medal that she had won.	The winner of the Olympics was stepping onto the podium when the president approached, congratulated and honored her with the medal. This gold was already the third medal that she had won.	The winner of the Olympics was stepping onto the podium when the president approached, congratulated and honored her. This gold was already the third medal that she had won.	The audience now saw the winner of the Olympics on the podium congratulating and honoring the president. The gold medal which she had won last year had made her a very popular athlete.

(Appendix continues)

Appendix A (continued)

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
D11-118	growth	After a long winter, the sun warmed the plant which now had the heat and the nutrients it needed for growing. The growth of one inch per year was about average.	After a long winter, the sun warmed the plant which now had the heat and the nutrients it needed to increase in size. The growth of one inch per year was about average.	After a long winter, the sun warmed the plant which now had the heat and the nutrients it needed. The growth of one inch per year was about average.	In the winter, the sun no longer warmed the plant and the warmth and nutrients it needed were gone. The growth which had happened in the summer had now stopped.
D12-20	flooding	George had quickly left his riverside cabin when the river began to rise and cause a flood. The flooding damaged many of his wife's belongings.	George had quickly left his riverside cabin when the river began to rise and drench the entire valley. The flooding damaged many of his wife's belongings.	George had quickly left his riverside cabin when the river began to rise. The flooding damaged many of his wife's belongings.	George had left his riverside cabin to visit the valley. The flooding that had just subsided after forty days and nights had ruined his old shelter.
D13-35	paying	At the restaurant, when dinner was finished and the waiter had left the check, Jim got out his wallet and paid for it. Paying the bill was something he felt was a man's job.	At the restaurant, when dinner was finished and the waiter had left the check, Jim got out his wallet and gave the waiter his money. Paying the bill was something he felt was a man's job.	At the restaurant, when dinner was finished and the waiter had left the check, Jim got out his wallet. Paying the bill was something he felt was a man's job.	Jim called the restaurant to ask the waiter if he had left his wallet and the check on the table. Paying the huge bill had left him a little absentminded.
D14-59	stealing	Katie thought she could keep her chocolate cake safe by hiding it in the refrigerator, but while Katie was not looking, Nicole sneaked into the fridge and stole a piece. Stealing food was normal behavior for Nicole.	Katie thought she could keep her chocolate cake safe by hiding it in the refrigerator, but while Katie was not looking, Nicole sneaked into the fridge and took a piece. Stealing food was normal behavior for Nicole.	Katie thought she could keep her chocolate cake safe by hiding it in the refrigerator, but while Katie was not looking, Nicole sneaked into the fridge. Stealing food was normal behavior for Nicole.	Katie and Nicole were hungry and when they looked in their refrigerator they found a piece of chocolate cake. Stealing food would not have been any worse than breaking a diet.
D15-72	choking	After his first bite of the juicy steak, Jason felt that he could not breathe as he began to choke. His choking disgusted his date.	After his first bite of the juicy steak, Jason felt that he could not breathe as the steak became lodged in his throat. His choking disgusted his date.	After his first bite of the juicy steak, Jason felt that he could not breathe. His choking disgusted his date.	As Jason took his first bite of juicy steak, he breathed in its wonderful aroma. His choking was fake and did not impress his date.
D16-105	closing	The food inspectors again found unsanitary conditions in the restaurant, informed its owner and had it closed. The closing of this restaurant caused a big scandal in town. Superman grabbed the prison bars that enclosed him and started to slowly bend the bars. The bent bars allowed Superman to escape.	The food inspectors again found unsanitary conditions in the restaurant, informed its owner and had it shut down. The closing of this restaurant caused a big scandal in town. Superman grabbed the prison bars that enclosed him and started to slowly pull them apart. The bent bars allowed Superman to escape.	The food inspectors again found unsanitary conditions in the restaurant, and informed its owner about it. The closing of this restaurant caused a big scandal in town. Superman grabbed the prison bars that enclosed him and used all his might to make an opening. The bent bars allowed Superman to escape.	The food inspectors testified that the sanitary conditions in the restaurant were very good. The closing of the nearby trash dump had improved the situation.
D17-24	bent	Superman grabbed the prison bars that enclosed him and started to slowly bend the bars. The bent bars allowed Superman to escape.	Superman grabbed the prison bars that enclosed him and started to slowly pull them apart. The bent bars allowed Superman to escape.	Superman grabbed the prison bars that enclosed him and used all his might to make an opening. The bent bars allowed Superman to escape.	Superman grabbed his arch-enemy, Lex Luthor, and enclosed him behind the prison bars. The bent bars established additional security.
D18-74	pricked	While repairing the rip in her blouse, Jessica slipped with the needle and pricked her finger. Her pricked finger throbbled.	While repairing the rip in her blouse, Jessica slipped with the needle and stuck her finger. Her pricked finger throbbled.	While repairing the rip in her blouse, Jessica slipped with the needle. Her pricked finger throbbled.	It was lucky that Jessica kept a needle and thread handy, because while repairing her car she slipped on some oil and ripped her blouse. Her pricked finger throbbled.

Appendix A (continued)

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
D19-114	married	Robert and Sally had been engaged for two years when they agreed to make the decision of their lives and get married. The married couple went on their honeymoon to the Fiji islands.	Robert and Sally had been engaged for two years when they agreed to make the decision of their lives and become wedded. The married couple went on their honeymoon to the Fiji islands.	Robert and Sally had been engaged for two years when they agreed to make the decision of their lives. The married couple went on their honeymoon to the Fiji islands.	Robert and Sally were engaged in a debate about a big decision that would affect their two year business plan. The married couple was quite successful in running a small business.
D20-38	lifting	The mover bent his knees, put his arms around the heavy box, took a deep breath, and began to lift it. After lifting the box, the mover left and went to lunch.	The mover bent his knees, put his arms around the heavy box, took a deep breath and picked it up. After lifting the box, the mover left and went to lunch.	The mover bent his knees, put his arms around the heavy box, and took a deep breath. After lifting the box, the mover left and went to lunch.	The mover sat on the heavy box, rested his knees and arms and caught his breath. After lifting so many things, he was happy to rest.
D21-25	stab	The angry wife could not hold her temper against her spouse, so she picked up a knife and stabbed him. The stab wounds sent him to the hospital screaming.	The angry wife could not hold her temper against her spouse, so she picked up a knife and plunged it into his shoulder. The stab wounds sent him to the hospital screaming.	The angry wife could not hold her temper against her spouse, so she picked up a knife. The stab wounds sent him to the hospital screaming.	The short-tempered wife was surprised that her spouse had used the knife without putting it back in the drawer. The stab wounds were a lesson he would never forget.
D22-47	caught	Jason had almost fallen asleep in the canoe, when he finally felt a pull on the line and realized he had caught a fish. Catching a fish made the whole day worthwhile.	Jason had almost fallen asleep in the canoe, when he finally felt a pull on the line and realized he had snagged a fish. Catching a fish made the whole day worthwhile.	Jason had almost fallen asleep in the canoe, when he finally felt a pull on the line. Catching a fish made the whole day worthwhile.	Jason pulled up his sheets, which had canoes on them and had almost fallen asleep when the phone line rang. Catching the phone before the answering machine turned on was important to him.
D23-68	tripped	Donald was walking very quickly and didn't notice how uneven the sidewalk was until he tripped accidentally. Tripping was embarrassing because there was a cute girl watching.	Donald was walking very quickly and didn't notice how uneven the sidewalk was until he stumbled accidentally. Tripping was embarrassing because there was a cute girl watching.	Donald was walking very quickly and didn't notice how uneven the sidewalk was. Tripping was embarrassing because there was a cute girl watching.	Donald was walking very quickly along the sidewalk and didn't notice how uneven his pants legs were. Tripping was embarrassing because there was a cute girl watching.
D24-120	buried	The cowboy shot the gangster at high noon and then dug a large enough hole in the ground to bury him. Having buried this criminal, he rode back into town.	The cowboy shot the gangster at high noon and then dug a large enough hole to put him in the ground. Having buried this criminal, he rode back into town.	The cowboy shot the gangster at high noon and then dug a large enough hole in the ground. Having buried this criminal, he rode back into town.	The cowboy dug a large hole in the ground to hide and wait for the gangster to come his way. Having buried his father a day before, he wanted revenge.
D25-43	paid	Erica gave the milk to the cashier, took out her wallet and paid for it. She paid with a twenty dollar bill.	Erica gave the milk to the cashier, took out her wallet and purchased it. She paid with a twenty dollar bill.	Erica gave the milk to the cashier and took out her wallet. She paid with a twenty dollar bill.	The cashier put down her wallet so she could drink her milk. She paid for it with a twenty dollar bill.

(Appendix continues)

Appendix A (*continued*)

Passage and item number	Critical word	Referentially explicit	Referentially paraphrased	Inference	Baseline
D26–93	pouring	After not getting a tip, the waitress went to the customer, held a bowl of soup over his head and poured it on him. After pouring the soup, the waitress felt sorry for the customer.	After not getting a tip, the waitress went to the customer held a bowl of soup over his head and dumped it on him. After pouring the soup, the waitress felt sorry for the customer.	After not getting a tip, the waitress went to the customer and held a bowl of soup over his head. After pouring the soup, the waitress felt sorry for the customer.	The waitress was holding a bowl of soup when the customer pointed to her head. After pouring the soup on his pants, he felt like a fool.
D27–102	returning	In Boston, Philip had rented a car for three days and was now driving back towards the airport to return it. After returning the car, he got in the courtesy van to catch his flight.	In Boston, Philip had rented a car for three days and was now driving back towards the airport to check it in. After returning the car, he got in the courtesy van to catch his flight.	In Boston, Philip had rented a car for three days and was now driving back towards the airport. After returning the car, he got in the courtesy van to catch his flight.	In Boston, each day for the last three days, Philip drove his car past the airport. After returning to the hometown of his adolescence he felt quite happy.
D28–65	dissected	In biology lab, Tony grabbed the scalpel and used it on the dead frog to dissect it. The dissected frog smelled awful.	In biology lab, Tony grabbed the scalpel and used it on the dead frog to cut it open. The dissected frog smelled awful.	In biology lab, Tony grabbed the scalpel and used it on the dead frog. The dissected frog smelled awful.	In biology lab, after Tony misplaced his scalpel, he decided to take his frog to the bathroom with him. The dissected frog smelled awful.
D29–113	frying	The oil in the pan was hot and the chicken was breaded when the chef told the apprentice to fry it. Frying the chicken took only a short time.	The oil in the pan was hot and the chicken was breaded when the chef told the apprentice to throw it in the pan. Frying the chicken took only a short time.	The oil in the pan was hot and the chicken was breaded when the chef told the apprentice what to do next. Frying the chicken took only a short time.	The chef knew there was no pan so he told the apprentice to forget the oil. Frying food is part of many recipes.
D30–45	cook	Emily was very hungry, so she got out the chicken and threw some vegetables in a pan and cooked it. Having cooked a dinner, she made a mess in the kitchen.	Emily was very hungry, so she got out the chicken and threw some vegetables in a pan and started making dinner. Having cooked a dinner, she made a mess in the kitchen.	Emily was very hungry, so she got out the chicken and threw some vegetables in a pan. Having cooked a dinner, she made a mess in the kitchen.	The chicken was very hungry, so Emily threw some vegetables into its food pan. Having cooked chickens before, she knew they should be well-fed.

Appendix B

Sample Passages of the Pro-Form Condition in Text Coherence Norm

Table B1
Experimental Stimuli

Passage type	Sentence 1	Sentence 2		Explicit (94%)	Paraphrase (93%)	Inference (88%)	Pro-form (82%)	Baseline (43%)
		Explicit	Pro-form					
Bare NP and initial NP	While swimming in the shallow water near the rocks, Sharon stepped on a piece of glass and cut her foot.	The cut was one inch long.	It was one inch long.	96%	94%	88%	83%	39%
	No longer able to control his fury, the boyfriend hurled the delicate porcelain vase against the wall and broke it into pieces.	The pieces took a long time to clean up.	They took a long time to clean up.					
	After being announced the winner, the contestant was overwhelmed with emotion and started to cry.	Her crying annoyed the other contestants who thought she was being melodramatic.	It annoyed the other contestants who thought she was being melodramatic.					
Modified NP	The clumsy workman on the ladder accidentally kicked the paint bucket over and spilled the paint.	The spilled paint could cost him his job.	It could cost him his job.	93%	94%	89%	72%	44%
Adverbial phrase	Jane wanted to hang the antique painting she bought at an auction, so she looked for a nail and hammered it into the wall.	After hammering the nail she hung the picture on the wall.	After that she hung the picture on the wall.	90%	93%	91%	84%	43%
	Since Sonya had ripped her pants and had some free time, she found some matching thread and sewed them up.	Having sewed the pants she wore them for another summer.	Having done that she wore them for another summer.	92%	90%	89%	84%	47%

Note. Only representative types of passages are shown here with the corresponding pooled mean percentage of the top two ratings (e.g., 3 = *somewhat good*, 4 = *well*) for each condition. Sample filler passages are also shown. NP = noun phrase.

Table B2
Filler Item

Passage type	Sentence 1	Sentence 2	Mean rating
Scrambled (75%)	None of the local firefighters wanted to work over the holiday break.	Ironically, the rest of the book was filled with dark and gruesome imagery.	7%
	The pianist said that the piano sounded better than ever before and the conductor agreed.	The conductor slowed the train before pulling into the station.	
Referential ambiguity (25%)	The strong earthquake cracked the foundation of the house.	Reporters talked about it on the evening news.	58%
	Elliott and Floyd like doing things together outside of work.	He always came home late afterward.	

Note. Only representative types of passages are shown here with the corresponding pooled mean percentage of the top two ratings (e.g., 3 = *somewhat good*, 4 = *well*) for each condition.

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