An investigation of individual differences in sentence processing strategies due to dispositional affect using event-related potentials

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Abstract

In cognition, two parallel processing strategies can be observed where one is quick and efficient while the other is slower and rule governed. In language, this is analogous to heuristic and algorithmic processing. The literature in cognitive psychology, and now in language research, demonstrates a relationship between affect and these processing strategies where more positive individuals prefer the fast and frugal, heuristic approach whereas the more negative individuals prefer the more detail oriented, algorithmic approach. In this work, the relationship between affect and sentence processing strategies are investigated separately using an ERP paradigm. In Experiment 1, we are interested in the N400 component elicited for semantic violations as a measure of heuristic processing and the modulation of this component by a preceding anomalous determiner as a measure of algorithmic processing. Here, we observed the expected N400 component in response to anomaly and this was larger for more positive individuals. Unexpectedly, a negative going wave was observed at the anomalous determiner and a larger P200 effect is observed in response to semantic anomaly following the demonstrative determiner. However, as expected, this P200 effect is larger for more negative individuals. Further investigation will be required to understand the nature of the ERPs for this determiner anomaly. In Experiment 2, we are interested in the P600 component elicited by garden path sentences due to syntactic anomaly as a measure of algorithmic processing. The expected P600 effects were observed, with the P600 elicited for subcategorization violations being larger for more negative individuals as predicted. Correlations for the phrase structure constraint violation are less clear. No effects in Experiment 2 are significant due to small sample size and a larger sample will be required to clarify these results.

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In cognition, we often see parallel routes of processing where one is fast and frugal while the other is slower and rule governed. Investigation of language reveals that analogous processing strategies can be observed. Language is a complex phenomenon governed by rules such as meaning/world knowledge (i.e. semantics/pragmatics) and word order/grammar (i.e. syntax). The study of language at the semantic and pragmatic level allows us to identify that the sentence "John buttered his bread with *socks*" as anomalous. On the other hand, the rules of syntax allow us to identify the sentence "The child *throw* the toy" as an anomaly as it exhibits subject-verb disagreement. Violations of these rules are linguistically distinct, and some research was able to dissociate these domains via neuropsychological investigation of disorders of language (Caplan & Hildebrandt, 1988; Caramazza & Zurif, 1976). However, it wasn't until electrophysiological techniques were employed in the investigation of linguistic phenomena that the neural correlates underlying these violations were distinguished (Kutas & Hillyard, 1980; Osterhout & Holcomb, 1992).

Distinguishing these different domains of language allows for deeper investigation of different sentence processing strategies used online. These strategies are analogous to information processing strategies described in various domains of cognition such as top-down vs bottom-up (Sarter, Givens & Bruno, 2001), global vs local (Navon, 1977), scene vs object (Rafique, Solomon-Harris & Steeves, 2015), etc. (Kahneman, 2011). In language, researchers have demonstrated two strategies of sentence processing where the first is quick and efficient, "good enough", heuristic processing and the second is deeper and rule-governed algorithmic computation (Dwivedi, 2013; Ferreira & Patson, 2007).

Understanding how these different levels interact with other cognitive systems such as working memory capacity (King & Just, 1991), familial handedness (Townsend, Carrithers & Bever, 2001) and more recently, affect (Chwilla, Virgillito, & Vissers, 2011; Vissers, Chwilla, Egger, & Chwilla, 2013) is also of interest. In the present work, we investigate how dispositional affect modulates differences in sentence processing.

Dispositional affect and cognition

In many aspects of cognition, two processing strategies can be observed where one is fast and global while the other is more detailed and local. Due to the ability to more easily manipulate visual stimuli, the investigation of visual processing has been a reliable method of delineating these processing strategies. Navon (1977) investigated this using the eponymous Navon letter task, where a large letter (global level) is either composed of smaller copies (local level) of the same letter (i.e. a letter H composed of small letter H's) or of a different letter (i.e. a letter H composed of small letter S's). It was demonstrated that when information from the global and local level conflicted, an inhibitory influence was observed in identifying features at the local level but not at the global level suggesting that global level takes precedence over the local level.

This was further investigated by Kimchi & Palmer (1982) using a novel hierarchical shape task. Here, rather than letters, smaller geometrical shapes (local level) were arranged in the form of a larger shape (global level) and participants were asked to select which of two comparison figures more closely resemble it. When the geometrical shapes at the local level and the global level differ (i.e. small squares arranged in the shape of a triangle or small triangles arranged in the shape of a square), Kimchi and Palmer demonstrated that manipulation of certain features can lead to preference for the local or the global level. For example, increasing the

number of items or decreasing the size of items at the local level lead to preference for the global level. As seen in language, these results support the idea that one system may take preference over the other but information from each system can influence the other.

Neural correlates of this separation between local and global processing in vision have been investigated in comparing processing of scenes and objects. Rafique and colleagues (2015) used repetitive transcranial magnetic stimulation (TMS) and functional magnetic resonance-adaptation to examine the effects of TMS on object processing regions (lateral occipital region; LO) and scene processing regions (transverse occipital sulcus; TOS). They found that stimulation of LO lead to activity in TOS, but stimulation of TOS did not influence LO activity. This is in accordance with previous behavioural work which demonstrated that TMS of LO lead to disruption in object processing but enhancement of scene processing (Mullin & Steeves, 2011) whereas TMS of TOS lead to disruption of scene processing with no influence on object processing (Ganaden, Mullin & Steeves, 2013). These findings provide further evidence that there are separate cognitive processes that can interact with each other and allow for global vs. local processing.

As discussed by Fredrickson (2001), affect can influence the processing strategies used by individuals. The proposed broaden-and-build theory suggests that negative affect leads to a reliance on local cues whereas positive affect leads to a greater reliance on global cues. The effect of affect on these processing streams has been investigated using the tasks outlined above. Gasper and Clore (2002) demonstrated using the hierarchical shape task that individuals in a negative mood induction condition were more likely to use local cues over global cues and that these individuals reported a greater reliance on local cues after the task. In contrast, Fredrickson and Branigan (2005), demonstrated that participants in the positive mood condition had a greater

reliance on global cues over local cues, supporting the claim of the broaden-and-build theory. In addition to the research using mood induction above, research using individual difference measures such as self report measures of dispositional affect have established a relationship between affect and cognition (MacLean, Arnell & Busseri, 2010).

Dispositional affect and language

As stated above, the two processing strategies observed in language are referred to as heuristic and algorithmic processing. The fast and frugal heuristic strategy can be considered analogous to using top-down or global information whereas the algorithmic strategy can be considered to use bottom-up or local information. While these are more difficult to delineate than the processing strategies observed in visual perception, carefully designed paradigms can investigate this question. Dwivedi (2013) investigated this question using sentences with quantifier scope ambiguity (QSA; ex: “Every kid climbed a tree.”). First, the preference for the singular (“The tree was in the park.”) vs the plural (“The trees were in the park.”) disambiguating continuation sentence was determined for 160 items in an offline norming study where it was determined that some items have a strong lexico-pragmatic bias for plural (60-90%; ex: “Every kid climbed a tree. The trees were in the park.”) whereas other items have no lexico-pragmatic bias (40-60%; ex: “Every jeweller appraised a diamond. The diamond was clear and flawless.”). The items that were biased for plural were then investigated in an SPR study in a 2x2 design: context (control: “Every kid climbed that/those tree(s).” vs ambiguous: “Every kid climbed a tree”) by number (singular: “The tree was in the park” vs plural: “The trees were in the park”). Faster reading times were observed at the final word of the disambiguating sentence indicating a preference for the plural condition and this demonstrates a preference for the heuristic interpretation since it is consistent with the plural bias. However, in response to comprehension

questions asked following these sentences, all conditions had high accuracy except for the ambiguous singular condition which was at chance. In the QSA literature (Dwivedi, 2013; Kurtzman & MacDonald, 1993), it has been established that the preferred algorithmic interpretation is the surface scope interpretation (see 1a below) which results in the plural interpretation and so the strong dispreference for the ambiguous singular condition is indicative of algorithmic processing strategies being employed offline.

(1) a. (∀x) (x is a kid (∃y) (y is a tree & x climbed y))
[read as: "For every kid x, there is a tree y, such that x climbed y"]
b. (∃y) (y is a tree & (∀x) (x is a kid x climbed y))
[read as: "There is a tree y, such that for every kid, x, x climbed y"]

Chwilla and colleagues (2011) investigated the role of induced mood on N400 amplitude, to investigate the role of mood on heuristic processing of language. Chwilla and colleagues induced mood by presenting the clips from the film "*Happy Feet*" to participants randomly assigned to the happy mood condition and clips from the film "*Sophie's Choice*" to participants assigned to the sad mood condition with the explicit instructions to enter the specific mood state. They used a rapid serial visual presentation (RSVP) paradigm in Dutch measuring event related potentials (ERPs) where critical sentences had an anomalous noun at the mid-sentence position

Original: De kussens zijn opgevuld met *veren*/**boeken* waardoor ze hard aanvoelen
Word-by-word: The pillows are stuffed with *feathers/*books* which make them feel hard.
Paraphrased: The pillows are stuffed with *feathers/*books* which make them feel hard.

Of interest in this paradigm is the N400 component that is elicited by semantic anomalies and as such is reflective of heuristic processing (see further discussion below). A robust N400

component was elicited at the anomalous word (i.e. *books*) with a broad bilateral distribution across midline sites in the happy mood condition. The sad mood condition demonstrated less clear N400 results where supplementary analyses revealed an effect in the right hemisphere. The results were further broken down by correlating mood scores following mood induction for participants in the happy condition and N400 amplitude (difference between control and anomalous conditions) at each electrode for each participant. The traditional centroparietal electrode sites associated with the N400 component revealed a significant positive correlation between mood ratings and N400 amplitude where individuals with a greater positive mood demonstrated a greater N400 effect. These results support the hypothesis that positive mood is related to a greater reliance on heuristic processing.

Vissers and colleagues (2013) investigated the P600 component using a similar paradigm. They employed a Dutch semantic reversal RSVP paradigm where the verb inflection did not match the number of the expected subject to elicit a P600 effect at the verb.

Original: De docent die aan de studenten *lesgaf* kwam het lokaal in
*De studenten die aan de docent *lesgaven* kwamen het lokaal in

Word-by-word: The teacher who on the students *gave [singular]* lesson entered the room
*The students who on the teacher *gave [plural]* lesson entered the room

Paraphrased: The teacher who *taught [singular]* the students entered the room
*The students who *taught [plural]* the teacher entered the room

As noted by the researchers, the observed P600 component elicited by the syntactic cue of verb inflection is actually reflective of the conflict with the heuristic interpretation. A positive correlation was found between P600 amplitude and mood scores following positive mood

induction, further providing evidence to support a positive correlation between heuristic processing and positive affect.

While research using mood induction for positive mood has shown modulation for heuristic processing, results for negative mood induction were less clear. In the research discussed above, negative mood induction resulted in a larger effect on mood than the induction of positive mood. This might mean that an alternative explanation for the results observed in the research discussed above is that positive mood induction, while significantly increasing mood ratings, may not increase mood ratings sufficiently to change the processing strategies of participants from baseline. Note that those in the positive mood condition are being compared to those in the negative mood condition as opposed to both mood conditions being compared to a neutral condition. Therefore, the correlations observed with mood scores may be a result of pre-existing individual differences in dispositional affect. Conversely, individuals in the negative mood condition do not exhibit amplitude differences in any ERP components of interest (N400 or P600) and this may be due to the large effect of negative mood induction.

An approach to further investigate the role of affect on language processing strategies and to corroborate the results from mood induction paradigms while addressing some of the concerns raised above is to observe individual differences due to dispositional affect. Dispositional affect has been used to predict individual differences in other areas of cognition (Arnell, Chung, Dale & MacLean, in prep) as well as in preliminary work from our lab discussed below.

A self-paced reading (SPR) study using the same paradigm as Dwivedi (2013) was conducted where dispositional affect was measured using the Positive and Negative Affect Schedule (PANAS; Watson, Clark & Tellegen, 1988). A positive correlation between online reading time differences and positive affect as well as a negative correlation between

comprehension question accuracy and negative affect was observed (Tarkowski, 2017; Dwivedi, Tarkowski & Selvanayagam, 2017). As discussed above, the online reading time difference between the plural and singular sentences, in sentences that have a plural lexico-pragmatic bias, is reflective of heuristic processing where a greater preference for plural indicates a greater reliance on heuristic processing. Conversely, the dispreference for the ambiguous singular condition (i.e. lower accuracy) indicates a greater reliance on algorithmic processing. These results support the hypothesis that positive dispositional affect is related to a greater reliance on heuristic processing whereas negative dispositional affect is related to a greater reliance on algorithmic processing.

In addition, in preliminary work replicating Dwivedi and Gibson (2017), filler items designed to elicit an N400 component demonstrated a marginally significant correlation with positive dispositional affect (Witte, 2017; Selvanayagam, Witte, Schmidt & Dwivedi, 2018). This work formed the starting point for the present investigation.

Electroencephalography and event related potentials in language

In the present work, electroencephalography (EEG) recordings were obtained with microvolt and millisecond precision following the onset of an event (i.e. Event Related Potentials; ERPs). ERPs recorded immediately following the onset of a word embedded in a sentence allows for an online measure of language processing. The traditional ERP paradigm for investigating language processing is rapid serial visual presentation (RSVP) where sentences are presented one word at a time in the center of a screen at a fixed rate to avoid contamination from ocular artifacts. While this may not be reflective of natural language processing, the validity of this measure has been corroborated by traditional masked self-paced reading tasks (SPR) as well

as ERP investigations using oral presentation at fixed and natural rates (ex: Niznikiewicz et al., 1997).

Since ERPs can vary on multiple measures such as latency, amplitude, polarity and topography, they are an excellent online measure that can provide contrast between different mechanisms of language processing. For example, semantic anomalies and syntactic complexity can both be reflected via increased reading times (Fischler & Bloom, 1980; Wright & Garrett, 1984). In contrast, an ERP paradigm will qualitatively distinguish between these phenomena. For example, a negative deflection peaking at 400ms at centroparietal sites will be observed for semantic anomalies (Kutas & Hillyard, 1980) and a positive deflection peaking at 600ms at various sites for syntactic complexity (Osterhout & Holcomb, 1992). These differences in topography, polarity and latency can distinguish distinct neural processes, which in our case could be indicative of different mechanisms in language processing. The two most investigated ERPs in language are the N400 and P600 components mentioned above and are the ERP components of interest in this study. These components allow us to investigate different levels of processing i.e. semantics and syntax respectively. With an appropriate design, semantic violations can be used to investigate heuristic processes, and syntactic violations for algorithmic processes.

In this investigation, the study of semantic and syntactic violations will be conducted in 2 separate experiments. Gibson and colleagues (2013) demonstrated that filler sentences with semantic and syntactic anomalies can be perceived as noise which can influence sentence processing strategies like revision of errors of insertion and deletion.

To avoid engaging different processing styles and revision by participants, especially considering that the P600 component has been related to syntactic reanalysis and revision

(Osterhout & Holcomb, 1992; Kaan & Swaab, 2003), only the critical items in each experiment are anomalous and only one type of anomaly is investigated at a time.

In Experiment 1 of this work, we will investigate the relationship between dispositional affect and heuristic processing of language by use of the N400 component elicited by semantic anomalies. In Experiment 2, we will investigate the relationship between dispositional affect and algorithmic processing by use of the P600 component elicited by syntactic anomalies in garden path sentences replicating the original paradigm of Osterhout and Holcomb (1992) with some modification.

Investigating heuristic processing with semantics and the N400 component

The N400 component is elicited by many types of meaningful stimuli such as pictures, faces, sounds and of interest here, language. Its role in top-down semantic processing makes the N400 component an excellent tool to measure heuristic processing at the sentence level. Kutas and Hillyard (1980) first discovered this component in an RSVP paradigm with semantically incongruous sentence final words. The discovery of this component by Kutas and Hillyard inspired decades of research addressing a wide array of questions (see Kutas & Federmeier, 2011 for a review).

While physical features do not elicit the N400 component, factors like cloze probability, word frequency and sentence position have been demonstrated to modulate the N400 component. Cloze probability is the probability of a specific word completing a particular sentence meaning and is an operational definition of word expectancy. Kutas & Hillyard (1984) demonstrated that N400 amplitude is inversely correlated with cloze probability demonstrating that the response to semantically unexpected words is continuous as a function of word expectancy. Additionally, low frequency words were shown to elicit an N400 effect as compared to high frequency words

even when matched for word length further supporting the idea that the N400 is sensitive to word expectancy (Van Petten & Kutas, 1990). Van Petten and Kutas (1990) also demonstrated that sentential constraint as a function of semantic context, operationally defined as the position of the word in the sentence, modulated the N400 where greater N400 amplitude is observed at the beginning of sentences as opposed to the end of sentences. The fact that N400 amplitude decreases throughout a sentence suggests that as semantic context is built, processing of contextually congruent words becomes easier providing additional evidence to support the idea that the N400 is reflective of word expectancy due to semantic context.

In sum, the N400 is a component elicited primarily by open-class words that do not match a preceding semantic context. This component is not elicited by physical features such as font size but is modulated by factors like cloze probability, word frequency and sentence position indicating that the N400 is sensitive to conflict with an expected word. For our purposes, the N400 component is indicative of heuristic processing.

In Experiment 1 of this work, the N400 component will be elicited by a semantic violation at the direct object position (compare bolded words in sentences 3 and 4 to sentences 1 and 2 in Table 1). Of particular interest is manipulation of the determiner preceding the direct object that is either the definite determiner *the* or the referential demonstrative determiner *that*. Since the referential *that* has no antecedent in this context, it is expected to be perceived as anomalous. Given this contextual anomaly, the N400 effect observed at the subsequent word should be affected. Previous research has shown that the presence of a syntactic anomaly preceding a semantic anomaly results in an enhanced N400 effect (i.e. syntactic boost; Hagoort, 2003). Therefore, the unexpected demonstrative determiner preceding the anomalous direct

object should result an increase in the N400 amplitude with respect to the N400 elicited at the anomalous direct object preceded by the definite determiner.

Table 1. Critical conditions from Experiment 1 with example stimuli.

Anomaly	Determiner	Example Sentence
Control	**Definite**	The connoisseur tasted *the* **wine** on the tour. (1)
	Demonstrative	The connoisseur tasted *that* **wine** on the tour. (2)
Anomalous	**Definite**	The connoisseur tasted *the* **roof** on the tour. (3)
	Demonstrative	The connoisseur tasted *that* **roof** on the tour. (4)

Investigating algorithmic processing with syntax and the P600 component

In Experiment 2, we investigate the relationship between dispositional affect and algorithmic processing which can be investigated by measuring responses to syntactic violations. While semantic anomalies elicit an N400 component, this component is not elicited by syntactic violations. An N400 component may be observed at the sentence final position of a syntactically anomalous sentence but this is considered to be indicative of an inability to meaningfully parse the sentence (Osterhout & Holcomb, 1992; Hagoort, Brown & Groothusen, 1993). Instead, syntactic anomalies elicit a component called the P600, first observed by Osterhout and Holcomb (1992) in an RSVP paradigm. Osterhout and Holcomb presented garden path sentences (see Bever, 1970) that do not contain an explicit grammatical error but require syntactic reanalysis. These sentences lead the comprehender to an incorrect interpretation until information is presented that requires reanalysis (see Table 2 for examples). In (8), the initial interpretation would lead the reader to believe that "the broker persuaded *someone*" but upon seeing the infinitive *to,* the sentence must be reinterpreted as "the broker *who was* persuaded to …". At the point where the sentence must be reanalyzed i.e. the infinitive *to* in sentences 6 and 8 from Table

2 (subcategorization constraint violation) and the auxiliary *was* from sentence 7 (phrase structure constraint violation), Osterhout and Holcomb (1992) found a positive going waveform peaking at 600 ms and named this component the P600. An N400 component was also observed at the sentence final positions of anomalous sentences (sentences 6 and 7 from Table 2).

Table 2. Critical conditions from Experiment 2 with example stimuli.

Length	Verb Type	Example Sentence
Short	**Transitive**	The broker planned to conceal the transaction. (5)
	Intransitive	The broker persuaded to conceal the transaction. (6)
Long	**Transitive**	The broker planned to conceal the transaction was sent to jail. (7)
	Intransitive	The broker persuaded to conceal the transaction was sent to jail. (8)

Around the same time, Hagoort and colleagues (1993) used a similar paradigm in Dutch and obtained P600 components though they referred to it as the Syntactic Positive Shift. Hagoort and colleagues investigated a subject-verb number disagreement:

Original: Het verwende kind *gooit/*gooien* het speelgoed op de grond.
Paraphrased: The spoilt child *throws/*throw* the toys on the floor.

…and a violation of a Dutch phrase structure constraint that requires adverbs to precede the adjective in noun phrases with a noun, adjective and an adverb:

Original: De echtgenoot schrikt van de *nogal emotionele reactie* van zijn vrouw.
*De echtgenoot schrikt van de *emotionele nogal reactie* van zijn vrouw.

Paraphrased: The husband [is startled] by the *rather emotional response* of his wife.
* The husband [is startled] by the *emotional rather response* of his wife.

Note that in the latter case, an adverb following an adjective is less probable but not a violation if followed by a second adjective (ex: … emotional rather unreasonable response…). Therefore, the adverb forces a reanalysis, but does not render the sentence ungrammatical (i.e. determiner-adjective-adverb-adjective-noun as opposed to the preferred determiner-adjective-noun) whereas the noun excludes this interpretation and does render the sentence ungrammatical. Hagoort and colleagues (1993) found a P600 component at the verb in the case of the subject-verb disagreement and at the adverb and noun in the case of the phrase structure constraint violation. These results further support the claim that the P600 component can be observed in cases of explicit syntactic violation but also in cases of syntactic reanalysis where an initial, preferred interpretation must be reparsed into a less probable interpretation. Hagoort and colleagues (1993) also found a N400 component at the sentence final position of unacceptable sentences but also found an N400 component at the penultimate position in sentences that were harder to meaningfully interpret (i.e. violation of phrase structure constraints) supporting the claim that the N400 component isn't elicited by syntactic violations but rather is due to the resulting semantic anomaly.

In addition to cases of explicit syntactic violation and syntactic reanalysis, the P600 component has been observed in cases of semantic anomalies that involve syntactic reanalysis. Kim and Osterhout (2005) first investigated this using semantically anomalous sentences with no syntactic error such as "The hearty meal was *devouring* the kids." While this sentence is syntactically well formed, the fact that inanimate objects like meals do not generally devour things makes the sentence semantically anomalous. Revising the sentence to say "The hearty meal was *devoured by* the kids" resolves this anomaly but would require the syntactically well-formed sentence to be perceived as syntactically anomalous due to the semantic anomaly. The

P600 component observed at the verb (*devouring*) supports this conclusion. Dwivedi and colleagues (2006) also found a P600 component in a discourse where the context sentence contains either a hypothetical or actual noun phrase antecedent and is followed by a continuation that did or did not include a modal auxiliary (ex: *must, should*). When a pronoun that asserts the existence of an antecedent is preceded by a hypothetical antecedent (ex: "John is considering writing a novel. It ends quite abruptly.") as opposed to an actual antecedent (ex: "John is reading a novel. It ends quite abruptly."), the former is perceived as ungrammatical and a P600 effect is observed. Again, the P600 effect is elicited because the conflict that arises from the semantic information can be resolved by syntactic reanalysis. While Kim and Osterhout (2005) call this the semantic P600, the term heuristic P600 coined by Vissers and colleagues (2013) may be more fitting. The P600 component elicited here is due to a conflict between the syntactic cue of verb inflection (-ING as opposed to -ED) and the heuristic interpretation of the scene.

In sum, the P600 component is demonstrated to be a marker of syntactic complexity elicited by either explicit violations or reanalysis due to violations of phrase structure constraints. Unlike the N400, this component can be elicited by open and closed class words. Additionally, the P600 being a syntactic component does not mean that it is always indicative of algorithmic processing as it can be elicited due to conflict with a heuristic interpretation.

Experiment 2 of this work will be a replication of Osterhout and Holcomb (1992) with some modification. Note that the original paradigm had a sentence acceptability task following all critical trials, and participants were trained prior to the experiment regarding what items were acceptable. It is known that there can be task effects on the P600 (Schacht et al., 2014) and tasks such as sentence acceptability judgements may engage undesirable meta-linguistic strategies (Kaan & Swaab, 2003). So instead, in this experiment, the task will be answering comprehension

questions that contrast the initial and the final interpretation of these garden path sentences (ex: “Did the broker persuade someone?” vs “Was the broker persuaded?”). This is to ensure deep processing of these sentences as Swets and colleagues (2008) have demonstrated that in an SPR paradigm, the slower reading times expected in ambiguous sentences are only seen when questions requiring deep processing are asked. It is expected that the findings of Osterhout and Holcomb (1992) summarized above will be replicated as Hagoort and colleagues (1993) found the P600 component without any additional tasks. Of interest in this experiment is the P600 component elicited at points of reanalysis in these garden path sentences. Unlike the heuristic P600 discussed above, the P600 components elicited in this design are elicited by syntactic reanalysis due to violation of phrase structure or subcategorization constraints and are indicative of algorithmic processing.

Predictions

In sum, in Experiment 1, **(1a)** we predict that an N400 component will be elicited at the direct object position in anomalous sentences (sentences 3 and 4 in Table 1) as compared to control sentences (sentences 1 and 2 in Table 1) and that **(1b)** the N400 effect observed in the demonstrative condition (sentence 4 in Table 1) will be greater in amplitude due to the “boost” from the syntactic anomaly. Regarding dispositional affect, it is expected that **(2a)** the N400 effect observed will correlate directly with positive dispositional affect and **(2b)** the modulation of the N400 by the syntactic anomaly will correlate directly with negative dispositional affect.

Furthermore, in Experiment 2, it is expected that the results found by Osterhout and Holcomb (1992) will be replicated. Therefore, a P600 effect is expected to be observed at **(3a)** the infinitive *to* in transitive sentences (sentences 5 and 7 in Table 2) compared to intransitive sentences (sentences 6 and 8 in Table 2) as well as at **(3b)** the auxiliary *was* in long intransitive

sentences (sentence 8 in Table 2) as compared to long transitive sentences (sentence 7 in Table 2). Regarding dispositional affect, **(4)** the P600 effects observed here should correlate positively with negative dispositional affect.

Experiment 1

Methods

Participants

26 Brock University undergraduate students were recruited. These participants were monolingual speakers of English, right-handed, as assessed by the Handedness Inventory (Briggs & Nebes, 1975), had normal or corrected to normal vision and reported no neurological, reading or learning related impairments. 4 participants with comprehension question accuracy below 85% were excluded from analysis leaving 22 eligible participants (18 females; mean age = 19; ranging from 18 to 23). The study was conducted under the approval of the Brock University Bioscience Research Ethics Board (REB 13-282) and written consent was obtained from all participants prior to beginning the experiment. Participants were recruited by poster (Appendix A: Recruitment Poster) and by use of the online SONA system (Appendix B: SONA System Recruitment Post).

Materials

Each participant saw one of four pseudorandomized, counterbalanced lists consisting of 360 items. The experiment was divided into six blocks, each with 60 sentences. An approximately equal number of items from each condition were presented in each block. The pseudorandomized lists were created using the Mix utility (van Casteran & Davis, 2006; see Appendix L: Mix Protocol for Pseudorandomization for a detailed description) such that the first three items and last two items of each block were always filler sentences; no more than two

critical items were presented sequentially and items from the same condition were never presented sequentially.

160 items (adapted from Dwivedi & Gibson, 2017; Appendix H: Experiment 1 Critical Sentences) were presented in four conditions (see Table 1) counterbalanced across four lists such that each participant only saw each item once. The items in this experiment are in a 2x2 design: object type (congruent vs. incongruent object) and determiner type (definite vs demonstrative). All sentences in this experiment were simple active sentences, using SUBJECT VERB OBJECT word order, followed by a prepositional phrase. All subjects were animate (ex: connoisseur, kid) and preceded by the definite determiner *the*. An active, past-tense verb followed the subject (ex: *tasted, climbed*). All direct objects were inanimate (ex: *wine, roof*) and were either semantically congruous in the control conditions (ex: connoisseur – tasted – **wine**, kid – climbed – **tree**) or semantically incongruous in the anomalous conditions (ex: connoisseur – tasted – **roof**, kid – climbed – **jade**). Direct objects were not repeated, were matched for word length and the items in the two conditions did not differ significantly in word frequency (SUBTLEX-US database; see Brysbeart & New, 2009; Appendix K: Word frequency comparisons for Experiment 1). The direct object was preceded by the determiner *the* in the definite conditions and by the determiner *that* in the demonstrative conditions. The three-word prepositional phrases were additions that did not alter the interpretation of the direct object. These modified the event by referring to time (ex: in the morning), manner (ex: with difficulty), instrument (ex: with a pen) or event (ex: during the robbery). There were no comprehension questions following presentation of these items.

In order to reduce predictability, 170 filler sentences (Appendix J: Filler Sentences) were included. 20 are sentences that begin with a prepositional phrase (FPP; ex: After thirty

minutes…). 60 are sentences that begin with a plural quantifier (FQP; ex: Many, Most). 20 are sentences with an irregular plural nouns as direct objects, half of which are plural (FIP; ex: teeth, women) and half are singular (FIS; ex: fireman, mouse). The remaining 70 are "other filler" items without any particular sentence construction (FS). These sentences were 6 to 10 words in length and a subset (125 items; all FPP, FQP, FIP, FIS, and 25 FS items) were followed by a superficial Yes/No or True/False comprehension question.

Electrophysiological Measures

Electroencephalographic recordings were obtained using the 64-channel ActiveTwo BioSemi system (BioSemi, Amsterdam). The sampling rate of the data was 512 Hz and was digitized using a 24-bit analog-to-digital converter. The 64 Ag-AgCl electrodes were arranged in the international 10-20 system (Jasper, 1958). Eye movements and blinks were monitored by use of an electrooculogram (EOG) via 3 electrodes, one located by the outer canthus of each eye and one below the right eye, placed out of the participant's peripheral vision. All recordings were obtained against a common mode sense (CMS) electrode located adjacent to Pz and amplified by the ActiveTwo system.

All recordings were filtered and analyzed using EMSE data editor v5.5.1 (Cortech Solutions, 2013). To remove artifactual trends such as linear drift or non-linear interference from power sources, polynomial detrend was applied to the data at order 3 across the entire time series. The electrodes (excluding EOG electrodes) were re-referenced offline to the linked mastoids. Two infinite impulse response filters were applied at 12 db/octave to all electrodes. The first was a bandpass of 0.1-100 Hz to remove low and high frequency noise, and the second was a bandstop of 59-61 Hz to remove 60 Hz noise. Eye movement and blink artifacts were corrected via a spatial ocular artifact correction algorithm (Pflieger, 2001) from the EMSE v5.5.1

software (Cortech Solutions, 2013). Due to equipment malfunction, data from electrode Fp1 was lost in some participants. A spatial interpolation filter (Cortech Solutions, 2013) was applied for this electrode, for all participants. Average ERPs were computed for each participant time-locked from stimulus onset to 1200ms with a pre-stimulus baseline of 200ms. ERPs were averaged for each participant at the determiner and the direct object for all critical conditions (italicized and bolded words from Table 1 respectively).

Procedure

Each participant was individually tested in a session lasting approximately three hours. Participants began by completing a consent form (Appendix C: Consent Form) preliminary questionnaire regarding reading habits (Appendix E: Preliminary Questionnaire), followed by a handedness inventory (Briggs and Nebes, 1975; Appendix F: Handedness Questionnaire) and the PANAS scales (Watson et al., 1988; Appendix G: Positive and Negative Affect Schedule). Participants were then seated in front of a computer screen in a sound proof booth. After electrodes were applied, participants were instructed to perform a series of jaw and eye movements in order to demonstrate what should be avoided during the task and what corresponding artifacts are produced. The experiment began with a series of on screen instructions followed by a set of eight practice trials to familiarize participants with the procedure. Six experimental blocks were then presented, lasting approximately 15 minutes each, with breaks in between. Sentences were presented in the centre of the computer monitor in light grey, 18-point Courier New font on a black background. See Figure 1 for a breakdown of each trial.

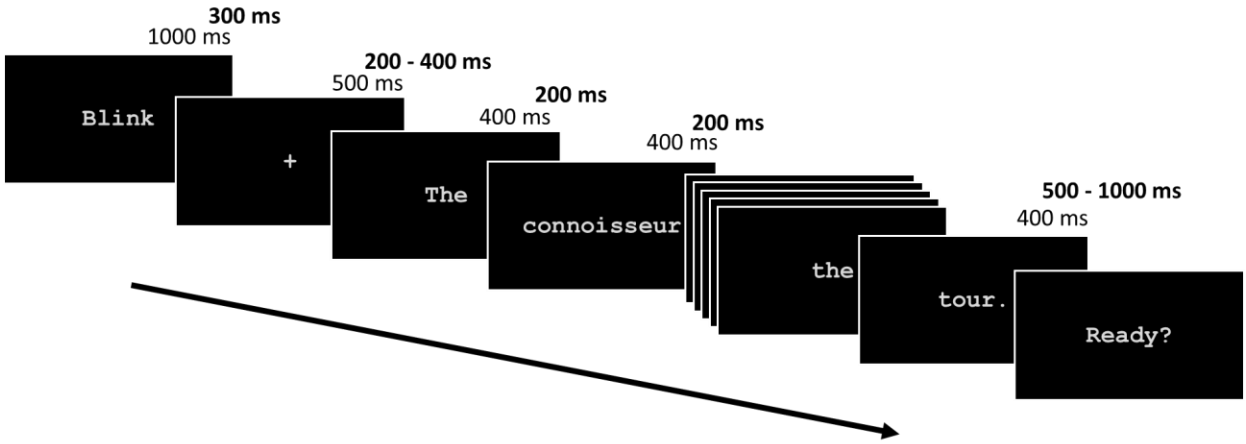

Figure 1. Condensed sample trial for the current paradigm. Presentation time for each slide is at the top right of each slide and the ISI is in bold. The "Ready?" slide requires user input to proceed and is intermittently preceded by a comprehension question.

Each trial sentence began with the participant being prompted to press a button on the response pad, then the word "Blink" was presented for 1000ms, followed by a fixation cross (+) for 500ms. After a variable inter-trial interval lasting between 200-400ms, the sentence was presented one word at a time with a stimulus onset asynchrony (SOA) of 600ms and an inter-stimulus interval (ISI) of 200ms. 125 filler items (38% of all trials) were followed by comprehension questions after the last word of the sentence, to which participants were asked to press a "1" or "2" key corresponding to answers on the screen using the response pad. Response time and accuracy was recorded for each response. The next trial began following another inter-trial interval lasting between 500-1000ms.

Results

Behavioural Analyses

Filler comprehension question accuracy. Mean accuracy was near ceiling in all conditions (M = 94.7%, SE = 0.54%). By condition, mean accuracy rates are listed by condition in Table 3.

Table 3. Mean filler comprehension question accuracy by condition for Experiment 1.

Condition	Mean Accuracy (SE) %
Filler Preposition Phrase (FPP)	93.2 (0.62)
Filler Quantifier Plural (FQP)	93.6 (0.84)
Filler Irregular Plural (FIP)	99.1 (0.63)
Filler Irregular Singular (FIS)	95.5 (1.43)
Filler Singular (FS)	96.7 (0.68)

Electrophysiological Analyses

All analyses below were conducted on averaged ERPs for 22 participants. Averaged ERPs were computed at midline electrode sites: Fz, FCz, Cz, CPz and Pz for each condition at the critical word (see Figure 3) and the preceding determiner (see Figure 4). See Appendix N: Topographic maps for all ERP effects in Experiment 1 and 2 for topographic maps. Repeated measures analyses of variance (ANOVA) were conducted using SPSS (IBM Corp, 2013) for all comparisons and the Greenhouse-Geisser correction (Greenhouse & Geisser, 1959) was applied where the assumption of sphericity was not met ($p < .05$ for Mauchly's Test of Sphericity; Mauchly, 1940). Where the assumption of sphericity is violated, the unadjusted degrees freedom, the adjusted mean square error and the adjusted p-value are reported. Partial eta squared is reported as a measure of effect size and all pairwise comparisons are reported using Fisher's Least Significant Difference test.

N400 at the Critical Word. A repeated measures ANOVA was conducted at the critical word on mean voltage in the traditional N400 time window (300-500ms) for the independent variables of object type (congruent vs incongruent), determiner type (definite vs demonstrative) and electrode site (Fz, FCz, Cz, CPz, Pz). A significant main effect of object type was observed (see Figure 3a), $F(1, 21) = 26.973$, $MSE = 11.691$, $p < .001$, $\eta_p^2 = .562$, where incongruent conditions were 1.693 μV more negative than congruent conditions ($p < .001$). A significant main effect of electrode was observed ($p = .021$). A significant interaction of object type and determiner type was observed (see Figure 3b), $F(1, 21) = 5.203$, $MSE = 15.853$, $p = .033$, $\eta_p^2 = .199$, where the incongruent condition was significantly more negative than its control in the definite condition (*the wine/#roof*; $\Delta = -2.559$ μV, $p < .001$) but not the demonstrative condition (*that wine/#roof*; $\Delta = -.827$ μV, $p = .154$). No other significant effects were observed (p's $< .05$).

P200 at the Critical Word. Upon visual inspection, a repeated measures ANOVA was conducted at the critical word on mean voltage in the traditional P200 time window (100-300ms) for the independent variables of object type (congruent vs incongruent), determiner type (definite vs demonstrative) and electrode site (Fz, FCz, Cz, CPz, Pz). A significant main effect of determiner type was observed, $F(1, 21) = 8.560$, $MSE = 12.856$, $p = .008$, $\eta_p^2 = .290$, where the demonstrative conditions (*that wine/#roof*) were 1.000 μV more positive than the definite conditions (*the wine/#roof*; $p = .008$). A marginally significant interaction of object type and determiner type was observed, $F(1, 21) = 3.771$, $MSE = 11.168$, $p = .066$, $\eta_p^2 = .152$, where the incongruent condition is significantly more positive than its control in the demonstrative condition (*that wine/#roof* ; $\Delta = .905$ μV, $p = .043$) but not in the definite condition (*the wine/#roof* ; $\Delta = -.333$ μV, $p = .381$). No other significant effects were observed (p's $< .05$).

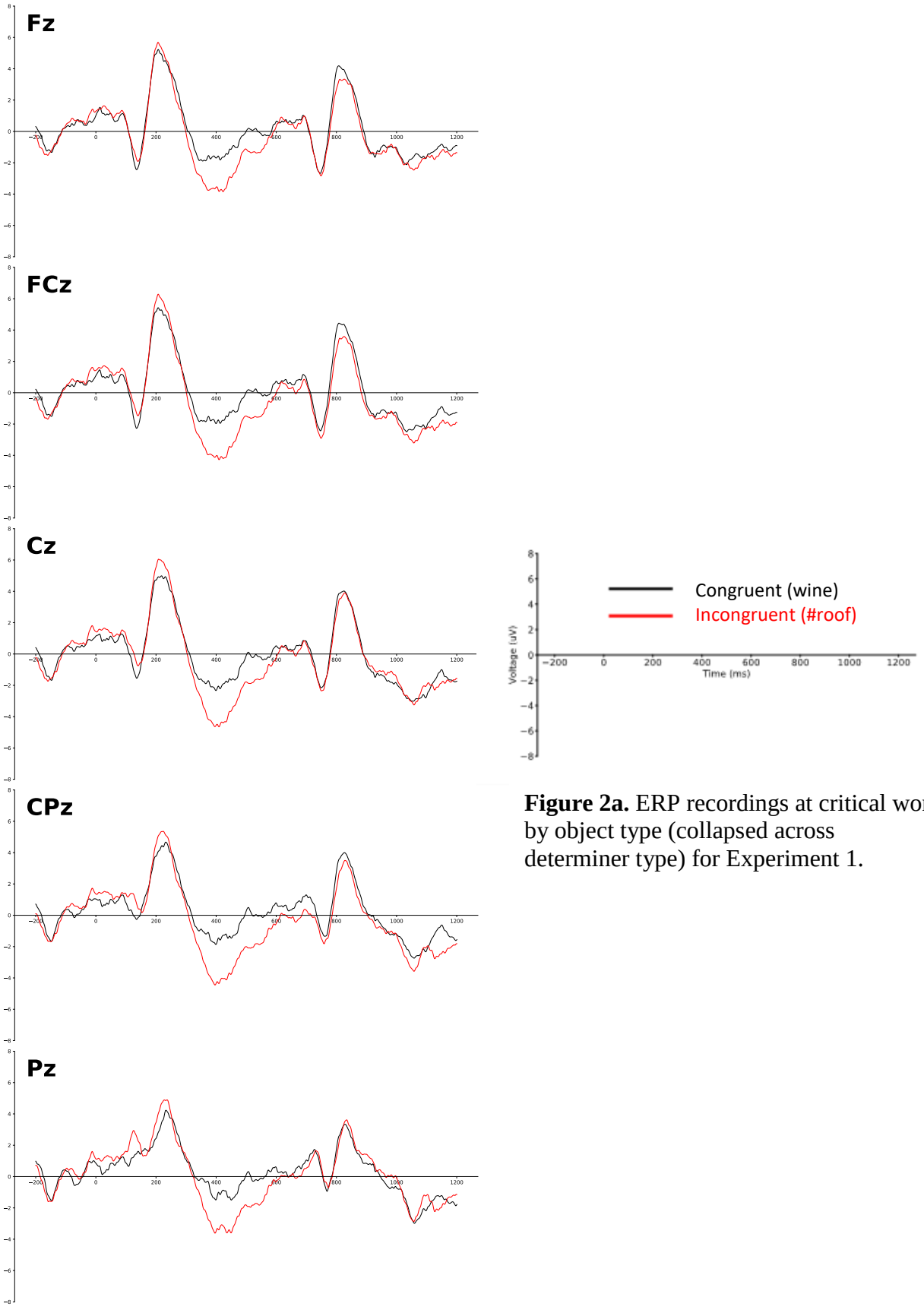

Figure 2a. ERP recordings at critical word by object type (collapsed across determiner type) for Experiment 1.

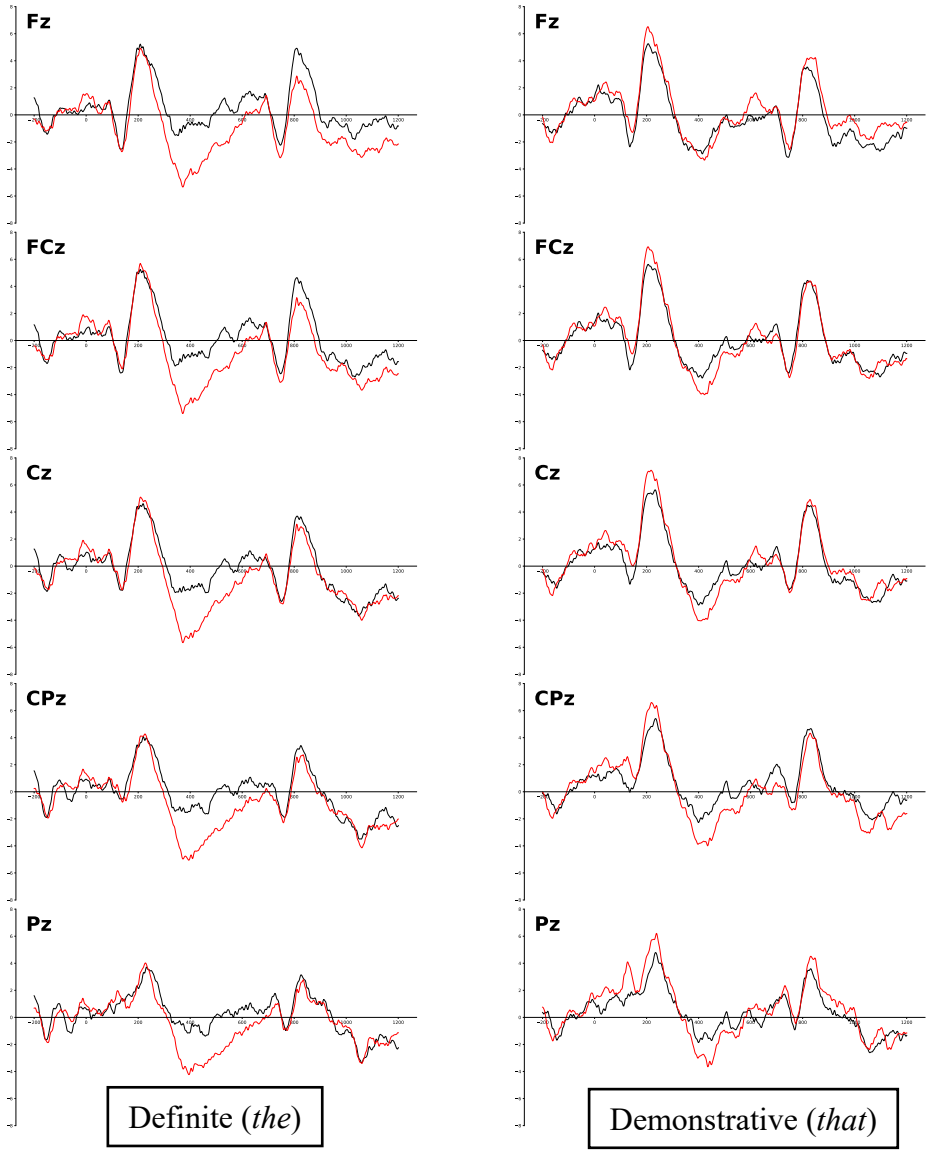

Figure 3b. ERP recordings at critical word by anomaly and determiner type for Experiment 1.

ERPs at the Determiner. A repeated measures ANOVA was conducted at the determiner on mean voltage for the independent variables of object type (congruent vs incongruent), determiner (definite vs demonstrative), electrode site (Fz, FCz, Cz, CPz, Pz) and time window (100-300ms, 300-500ms, 500-700ms, 700-900ms, 900-1100ms). A significant main effect of time and a significant interaction of time and electrode were observed (p's < .05). A significant interaction of Determiner and time window was observed, $F(4, 84) = 4.244$, $MSE = 11.656$, $p = .009$, $\eta_p^2 = .168$, where the demonstrative conditions were 1.079 µV more negative than the definite conditions at 300-500ms ($p = .025$), with no significant differences at any other time windows (all p's > .05). A significant interaction of anomaly and time window was observed, $F(4, 84) = 12.588$, $MSE = 8.947$, $p < .001$, $\eta_p^2 = .375$, where the anomalous conditions are 1.662 µV more negative than control conditions at 900-1100ms ($p = .006$), with no significant differences at any other time windows (all p's > .05). No other significant effects were observed (p's < .05).

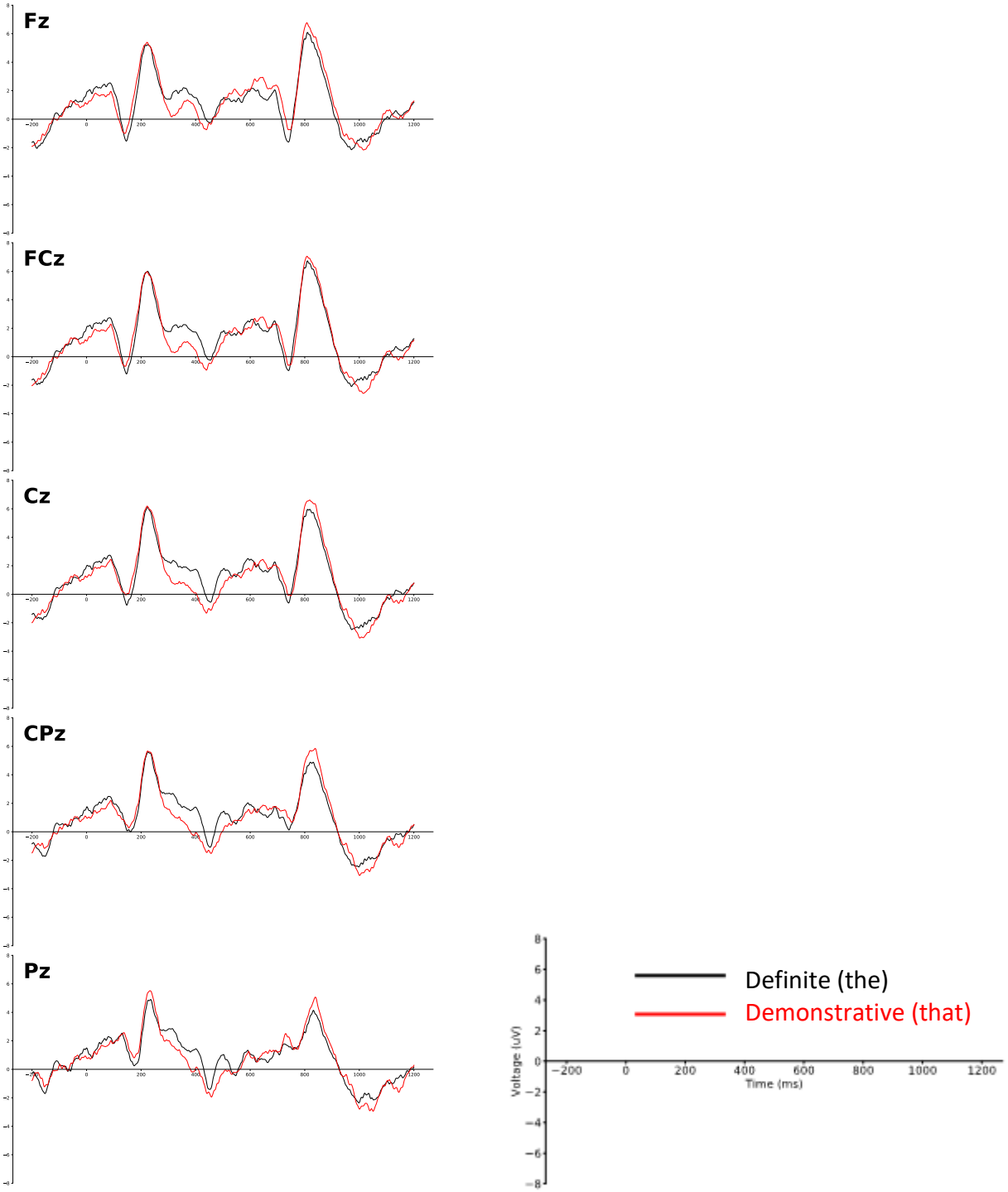

Figure 4. ERP recordings at the determiner by determiner type for Experiment 1.

Correlational Analyses

Ratings for 10 positive and 10 negative items were summed to obtain positive affect (PA) and negative affect (NA) scores for each participant. PA scores (M = 26.1, SE = 1.51) ranged from 14 to 37 and NA scores (M = 16.3, SE = 1.11) ranged from 10 to 28.

N400 at the Critical Word and dispositional affect. The amplitude of the N400 components were computed for each participant as the mean voltage at the control condition subtracted from the mean voltage at anomalous condition at 300-500ms post stimulus. The amplitudes differences collapsed across determiner type were first computed at the five midline electrode sites (Fz, FCz, Cz, CPz and Pz) and were correlated with PA and NA scores. Pearson correlations are reported in Table 4.

Table 4. Correlations between N400 amplitudes at critical word and dispositional affect.

	Fz	FCz	Cz	CPz	Pz
PA	.051 (p=.822)	.132(p=.559)	.032 (p=.887)	-.224 (p=.317)	.016 (p=.945)
NA	-.146 (p=.516)	-.156 (p=.488)	-.309 (p=.161)	-.200 (p=.373)	-.177 (p=.431)

In Table 5**,** the amplitudes were computed separately for the definite and demonstrative conditions at the five midline electrode sites (Fz, FCz, Cz, CPz and Pz) and were correlated with PA and NA scores.

Table 5. Correlations between N400 amplitudes by determiner type at critical word and dispositional affect.

	Definite					**Demonstrative**				
	Fz	FCz	Cz	CPz	Pz	Fz	FCz	Cz	CPz	Pz
PA	-.077	.060	-.044	-.230	-.075	.141	.096	.072	-.106	.073
NA	-.252	-.365†	-.406†	-.386†	-.209	.097	.159	-.024	.058	-.096

† = $p < .1$; * = $p < .05$

Note that NA correlates marginally with N400 amplitude at central sites (FCz, Cz, CPz) where low NA individuals have a large N400 amplitude (see Figure 5).

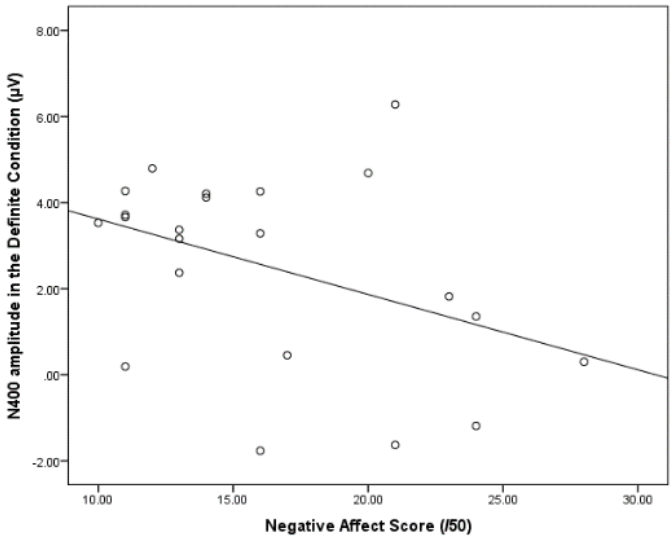

Figure 5. Correlation between NA and N400 amplitude in the definite condition at Cz.

P200 at the Critical Word and dispositional affect. The amplitude of the P200 components were computed for each participant as the mean voltage at the anomalous condition subtracted from the mean voltage at the control condition at 100-300ms post stimulus. The amplitudes were computed separately for the definite and demonstrative conditions at the five midline electrode sites (Fz, FCz, Cz, CPz and Pz) and were correlated with PA and NA scores. Pearson correlation results are reported in Table 6.

Table 6. Correlations between P200 amplitudes at critical word and dispositional affect.

	Definite					**Demonstrative**				
	Fz	FCz	Cz	CPz	Pz	Fz	FCz	Cz	CPz	Pz
PA	.056	-.172	.033	.308	.170	-.524*	-.466*	-.331	-.201	-.180
NA	.053	.235	.176	.173	.054	-.173	-.262	-.049	-.075	.151

† = $p < .1$; * = $p < .05$

Note that PA correlates negatively with P200 amplitude differences at frontal sites (Fz, FCz; see Figure 6).

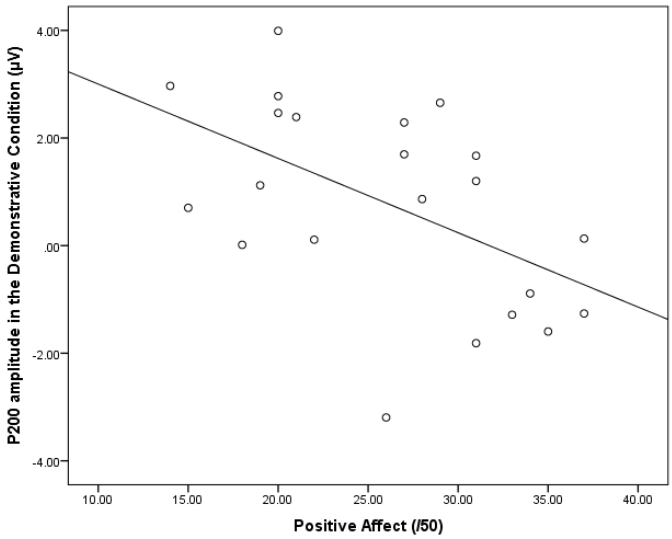

Figure 6. Correlation between PA and P200 amplitude in the demonstrative condition at Fz.

Discussion

At the critical word, an N400 effect was observed for the anomalous object (*roof*) as compared to the control (*wine*). Specifically, the effect was observed in the definite (*the wine/#roof*) but was attenuated in the demonstrative (*that wine/#roof*) determiner condition. Additionally, the attenuated N400 component in the demonstrative condition was preceded by a larger P200 effect. A marginally significant negative correlation between the amplitude of the observed N400 effect in the definite condition and negative affect was observed, where less negative (happy) individuals had a larger N400 component. Conversely, the observed P200 effect in the demonstrative condition was observed to correlate negatively with positive affect, where less positive (sad) individuals had a larger P200 component. Finally, manipulation of the determiner preceding the critical word resulted in a negative going waveform in the 300-500ms time window.

The aim of this work was to investigate the relationship between dispositional affect and heuristic processing by investigating the N400 component elicited by semantic anomalies. In this work; the anomaly is expected to elicit an N400 component (prediction 1a), the elicited N400 component is expected to be modulated by the preceding determiner (demonstrative or definite; prediction 1b), the N400 component and modulation of the N400 component are expected to correlate with dispositional affect (predictions 2a,b).

At the critical word, as predicted (1), an N400 effect was elicited in the anomalous compared to the control conditions. Furthermore, there was modulation of the N400 component depending on the preceding determiner. However, contrary to prediction (2), the N400 component in the demonstrative anomalous condition was attenuated. In addition, a P200 amplitude was found. In the demonstrative conditions (*that wine/#roof*), it was larger in the incongruent condition than its control. A potential explanation of these results is discussed below. As there were no a priori hypotheses regarding this component, interpretation of these results will need to be confirmed with follow up investigation.

Work by Federmeier and colleagues has demonstrated that the P200 is involved in sentential constraint and word expectancy (Federmeier & Kutas, 2002; Federmeier, Mai & Kutas, 2005; Wlotko & Federmeier, 2007). This is similar to the N400 component, though evidence from left vs right visual field presentation suggests that the P200 is a left and the N400 is a right hemisphere response to sentential constraint and word expectancy. In the present work, the increase in P200 amplitude is observed in response to anomalous words only when following the demonstrative determiner (*that*). The demonstrative determiner could therefore act as a constraining cue, priming the reader for anomaly and allowing an early response to the subsequent anomalous word as compared to its control.

This P200 amplitude difference may explain the observed attenuation of the N400 component in the demonstrative condition (*that wine/#roof*) via component overlap. An alternative explanation however is that the N400 is attenuated in this condition because the demonstrative determiner engenders readers more accepting of subsequent anomaly. An offline norming study will be conducted using the stimuli from this experiment to see if the plausibility ratings differ between definite and demonstrative conditions.

Regarding dispositional affect, we confirmed prediction (2a), where less negative individuals tend to have larger N400 amplitude differences in response to anomaly. This is in accordance with the idea that more positive (less negative) individuals are more likely to rely on heuristic processing and are more sensitive to semantic anomalies. As the N400 effect was attenuated in the demonstrative condition, no correlation between dispositional affect and N400 amplitude was observed in this condition (prediction 2b). However, the larger P200 amplitude in response to anomaly in the demonstrative condition does correlate with dispositional affect where less positive individuals have a larger amplitude difference. As the P200 amplitude difference is being interpreted as a word expectancy response cued by a preceding syntactic anomaly, it can be inferred that the more negative individuals (less positive) are more sensitive to this syntactic cue. This is in line with preliminary work in our lab which has found that low positive affect is correlated with a greater reliance on informational cues within the sentence and results in attenuation of P300 amplitude in underspecified conditions (Selvanayagam et al., 2018).

The manipulation of the determiner elicited a distributed negative going waveform from 300 to 500ms for the demonstrative compared to the definite determiner. While it was expected that the demonstrative determiner would be perceived as anomalous, no specific a priori

hypotheses were made regarding the ERPs elicited at this point in the sentence. The negative going waveform is elicited in the same time window as the N400 and the left anterior negativity (LAN; a left anterior effect observed at unexpected closed class words). However, this effect is widely distributed and does not reflect the standard distributions of the N400 (slightly right lateralized and posterior sites) or the LAN (left anterior sites). This could be a weak N400 effect elicited by the difference in frequency between the two determiners as the demonstrative is nearly half as frequent as the definite (Brysbeart & New, 2009). Alternatively, this could be a LAN effect signifying taxed working memory resources resulting from search for the antecedent of the demonstrative determiner (King & Kutas, 1995; Kluender & Kutas, 1993a, b). It would be of interest to, in future investigations, include several different determiners to see if the observed effect is due to the frequency of the determiner or its referential nature. Future investigations could also include context sentences which provide an antecedent for the demonstrative determiner before critical sentences.

Experiment 2

Methods

Participants

11 Brock University undergraduate students were recruited satisfying the same criteria as in Experiment 1. 2 participants with comprehension question accuracy below 85% were excluded from analysis leaving 9 eligible participants (9 females; mean age = 18.9; ranging from 18 to 20). The study was conducted under the approval of the Brock University Bioscience Research Ethics Board (REB 13-282) and written consent was obtained from all participants prior to beginning the experiment. Participants were recruited by poster (Appendix A:

Recruitment Poster) and by use of the online SONA system (Appendix B: SONA System Recruitment Post).

Materials

Table 2. Critical conditions from Experiment 2 (repeated for ease of exposition)

Length	Verb Type	Example Sentence
Short	**Transitive**	The broker planned **to** conceal the transaction. (5)
	Intransitive	The broker persuaded ***to** conceal the transaction. (6)
Long	**Transitive**	The broker planned **to** conceal the transaction ***was** sent to jail. (7)
	Intransitive	The broker persuaded ***to** conceal the transaction **was** sent to jail. (8)

Each participant saw one of four pseudorandomized, counterbalanced lists consisting of 330 items. The experiment was divided into six blocks, each with 55 sentences. An approximately equal number of items from each condition were presented in each block. Pseudorandomization was completed in the same manner as in Experiment 1, with the same constraints.

120 items were adapted from Experiment 2 of Osterhout and Holcomb (1992) and were also presented in four conditions (see Table 2) counterbalanced across four lists such that each participant only saw each item once. In this 2x2 experiment, sentence length (short vs long) and verb type (intransitive and transitive) were the relevant factors. The sentences were in the SUBJECT VERB form, followed by a clausal complement (see sentences 5 and 6 in Table 2). The sentences were extended by addition of a reduced relative clause continuation in the long conditions (see sentences 7 and 8 in Table 2). All subjects were animate (ex: *broker, man*), preceded by the definite determiner *the*. The subject was followed by a verb that was either intransitive (ex: *planned, agreed*) or transitive (ex: *persuaded, implored*). 15 verbs in each

condition were repeated an approximately equal number of times across the critical items. These verbs were controlled for word length and word frequency (Kucera & Francis, 1967, as cited in Osterhout & Holcomb, 1992). The verb was followed by a clausal complement starting with the infinitival marker *to* (ex: …*to sell the stock*, …*to help the store*). In the long sentences, a reduced relative was added that began with an auxiliary *was* or *had* (ex: …*was sent to jail*, …*had left the hospital*). These items were followed by Yes/No comprehension questions, counterbalancing Yes and No responses across conditions (see Appendix I: Experiment 2 Critical Sentences for a complete list of sentences and questions).

There are also 210 filler sentences (Appendix J: Filler Sentences) to reduce predictability for the experimental items. In addition to the 170 filler items used in Experiment 1, 40 additional "other filler" items without comprehension questions were included as there were fewer critical items in Experiment 2 (120 as compared to 160).

Electrophysiological Measures

Electrophysiological data collection and filtering procedures were the same as in Experiment 1. ERPs were averaged for each participant at the infinitive (*to*) and auxiliary (*was*) for all critical conditions (bolded words from Table 2).

Procedure

The setup procedure, instructions and the timing of events was the same as in Experiment 1. In this experiment, the critical items (36% of all trials) and 125 filler items (38% of all trials) were followed by comprehension questions after the last word of the sentence, to which participants were asked to press a "1" or "2" key corresponding to answers on the screen using the response pad. Response time and accuracy was recorded for each response.

Results

Behavioural Analyses

Filler comprehension question accuracy. Mean accuracy was at or near ceiling in all conditions (M = 93.9%, SE = 1.17%). Mean accuracy rates are listed by condition in Table 7.

Table 7. Mean filler comprehension question accuracy by condition for Experiment 2.

Condition	Mean Accuracy (SE) %
Filler Preposition Phrase (FPP)	92.8 (0.88)
Filler Quantifier Plural (FQP)	95.0 (1.36)
Filler Irregular Plural (FIP)	100 (0)
Filler Irregular Singular (FIS)	100 (0)
Filler Singular (FS)	92.4 (1.62)

Critical comprehension question accuracy. Mean accuracy for each of the critical conditions were high in all conditions. By condition, mean accuracy rates were: M = 85.2%, SE = 4.16% for long intransitive, M = 85.2%, SE = 3.15% for long transitive, 97.8%, SE = 1.24% for short intransitive and M = 85.9%, SE = 4.90% for short transitive.

Electrophysiological Analyses

All analyses below were conducted on averaged ERPs for 9 participants. Averaged ERPs were computed at midline electrode sites: Fz, FCz, Cz, CPz and Pz for each condition at the infinitive (*to*; see Figure 7), the auxiliary (*was*; see Figure 8) and the sentence final positions (see Appendix P). See Appendix N: Topographic maps for all ERP effects in Experiment 1 and 2 for topographic maps. Repeated measures analyses of variance (ANOVA) were conducted using SPSS (IBM Corp, 2013) for all comparisons and the Greenhouse-Geisser correction (Greenhouse & Geisser, 1959) was applied where the assumption of sphericity was not met ($p < .05$ for Mauchly's Test of Sphericity; Mauchly, 1940). Where the assumption of sphericity is violated,

the unadjusted degrees freedom, the adjusted mean square error and the adjusted *p*-value are reported. Partial eta squared is reported as a measure of effect size and all pairwise comparisons are reported using Fisher's Least Significant Difference test.

P600 at the infinitive. A repeated measures ANOVA was conducted at the infinitive on mean voltage at the traditional P600 time window (500-700ms) for the independent variables of verb type (transitive vs intransitive) and electrode site (Fz, FCz, Cz, CPz, Pz). A marginally significant main effect of verb type was observed, $F(1,8) = 2.713$, $MSE = 19.224$, $p = .138$, $\eta_p^2 = .253$, where the transitive conditions were 1.523 μV more positive than the intransitive conditions. A marginally significant main effect of electrode was observed, $F(4, 32) = 2.474$, $MSE = 6.018$, $p = .111$, $\eta_p^2 = .236$. The interaction of verb type and electrode was not significant, $F(4, 32) = 1.615$, $MSE = 2.395$, $p = .227$, $\eta_p^2 = .168$.

Figure 7. ERP recordings at the infinitive for Experiment 2.

P600 at the auxiliary. For the long conditions only, a repeated measures ANOVA was conducted at the auxiliary on mean voltage at the traditional P600 time window (500-700ms) for the independent variables of verb type (transitive vs intransitive) and electrode site (Fz, FCz, Cz, CPz, Pz). A marginally significant main effect of verb type was observed, $F(1,8) = 4.326$, $MSE = 28.386$, $p = .071$, $\eta_p^2 = .351$, where the intransitive conditions were 2.336 μV more positive than the transitive conditions. A marginally significant main effect of electrode was observed, $F(4, 32) = 2.018$, $MSE = 5.183$, $p = .153$, $\eta_p^2 = .201$. A marginally significant interaction of verb type and electrode was observed, $F(4, 32) = 2.225$, $MSE = 3.165$, $p = .147$, $\eta_p^2 = .218$, where the effect of verb type was strongest for frontal electrodes such as Fz ($\Delta = 3.451$, $p = .021$) and FCz ($\Delta = 2.890$, $p = .048$).

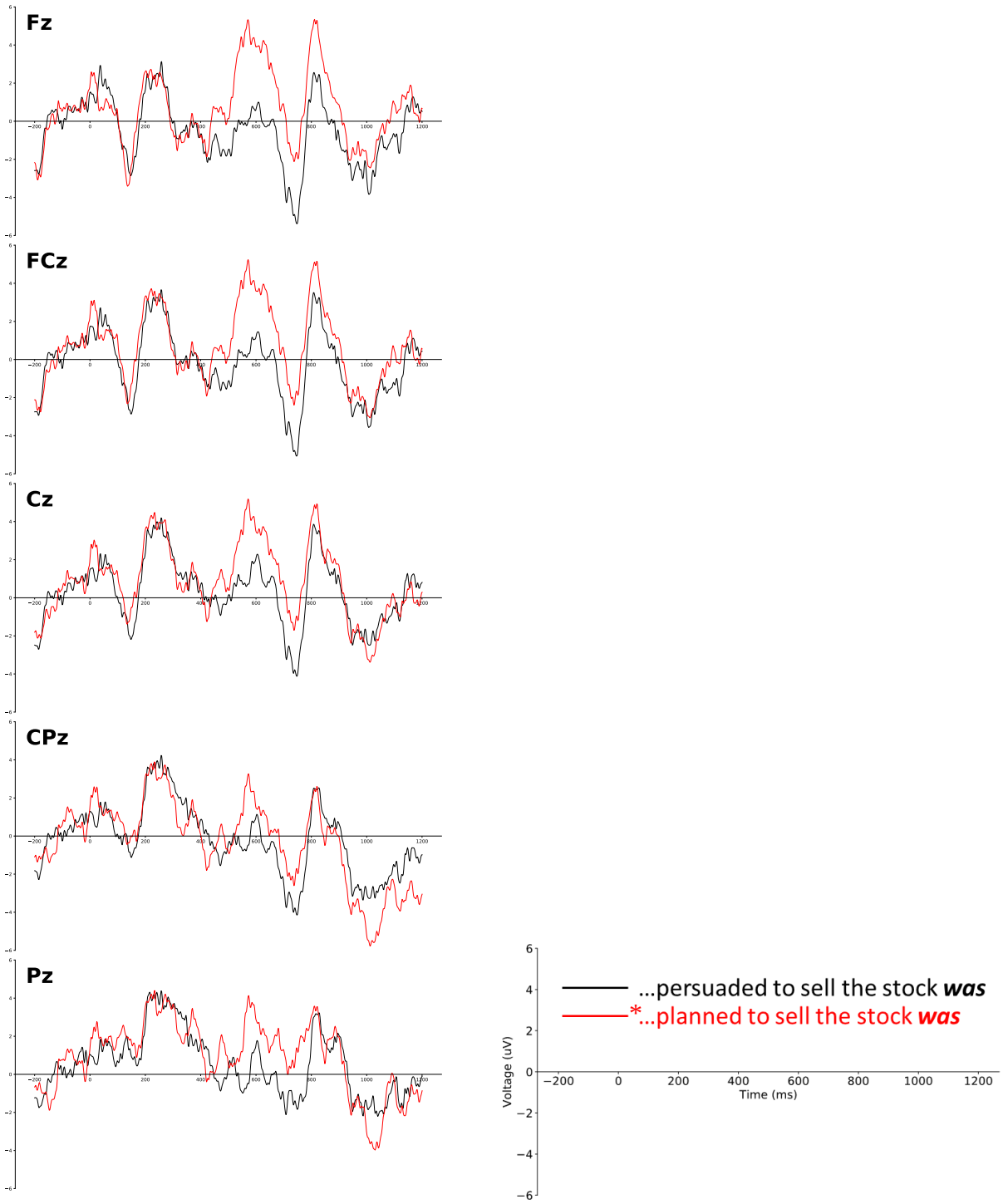

Figure 8. ERP recordings at the auxiliary for Experiment 2.

Correlational Analyses

Ratings for 10 positive and 10 negative items were summed to obtain positive affect (PA) and negative affect (NA) scores for each participant. PA scores (M = 33.1, SE = 1.03) ranged from 30 to 40 and NA scores (M = 20.9, SE = 1.90) ranged from 16 to 32.

P600 effect at the infinitive and NA. The amplitude of the P600 components were computed for each participant as the mean voltage at the infinitive for the transitive conditions subtracted from the intransitive conditions at 500-700ms post stimulus. The amplitudes were computed separately for the five midline electrode sites (Fz, FCz, Cz, CPz and Pz) and were correlated with PA and NA scores. Pearson correlation results are reported in Table 8.

Table 8. Correlations between P600 amplitudes at the infinitive and dispositional affect.

	Fz	FCz	Cz	CPz	Pz
PA	-.177 (p=.648)	-.202 (p=.603)	.006 (p=.988)	.043 (p=.913)	-.055 (p=.888)
NA	.566 (p=.112)	.549 (p=.126)	.424 (p=.256)	.438 (p=.239)	.242 (p=.530)

Note a marginally significant negative correlation between NA and P600 amplitude at frontal sites (Fz, FCz; see Figure 9).

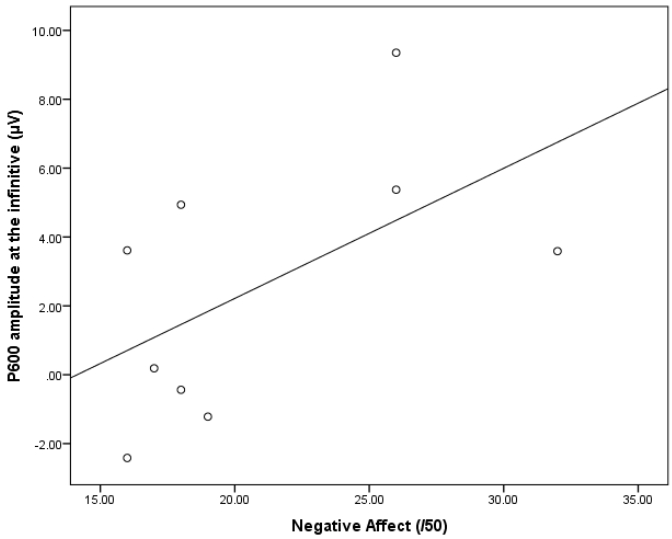

Figure 9. Correlation between NA and P600 amplitude at the infinitive at Fz.

P600 effect at the auxiliary and NA. The amplitude of the P600 components were computed for each participant as the mean voltage at the auxiliary for the long intransitive condition subtracted from the long transitive conditions at 500-700ms post stimulus. The amplitudes were computed separately for the five midline electrode sites (Fz, FCz, Cz, CPz and Pz) and were correlated with PA and NA scores. Pearson correlation results are reported in Table 9.

Table 9. Correlations between P600 amplitudes at the auxiliary and dispositional affect.

	Fz	FCz	Cz	CPz	Pz
PA	-.011 (*p*=.978)	.126 (*p*=.746)	.124 (*p*=.751)	-.300 (*p*=.433)	-.023 (*p*=.953)
NA	-.045 (*p*=.909)	-.141 (*p*=.718)	-.480 (*p*=.191)	-.413 (*p*=.269)	-.644 (*p*=.061)

Note a marginally significant negative correlation between NA and P600 amplitude at the most posterior site, Pz (see Figure 10).

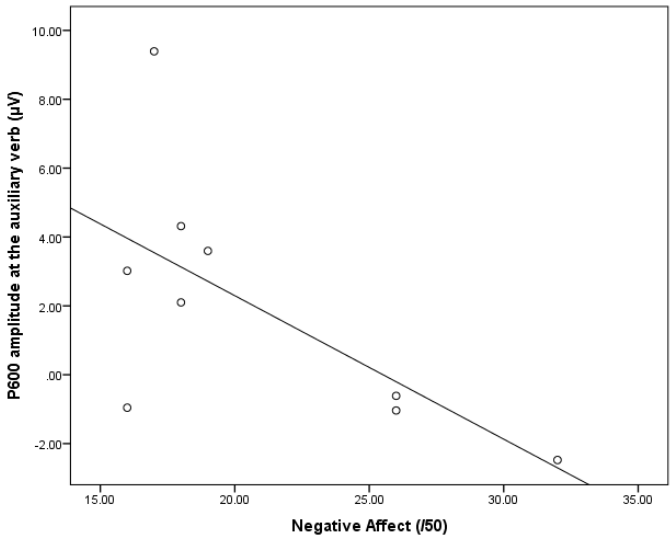

Figure 10. Correlation between NA and P600 amplitude at the auxiliary at Pz.

Discussion

All effects observed in Experiment 2 were marginally significant and observed trends will be discussed. First, the P600 effect at the infinitive (*to*) in response to the subcategorization violation (*The broker planned to…* vs **The broker persuaded to…*) and the P600 effect at the auxiliary (*was*) in response to phrase structure constraint violation (*The broker persuaded to sell the stock was…* vs **The broker planned to sell the stock was…*) were replicated. The trend was observed where the P600 effect at the infinitive was larger for more negative individuals at frontal electrodes and the P600 effect at the auxiliary was larger for less negative individuals at posterior electrodes.

The aim of this experiment was to investigate the relationship between dispositional affect and algorithmic processing by investigating the P600 component elicited by syntactic reanalysis. To elicit this component, the original paradigm of Osterhout and Holcomb (1992) was employed with some modification. First, filler sentences were added in order to reduce predictability. Also, comprehension questions were used as opposed to a sentence acceptability task to mitigate the effects of metalinguistic judgement tasks on ERPs while still replicating the original paradigm and ensuring deep processing of sentences. It was predicted that the two P600 effects would be replicated (predictions 3a,b). It was also predicted that the observed P600 effects would be larger for more negative individuals (prediction 4).

As there were no a priori predictions regarding comprehension question accuracy in the critical conditions and considering the small sample size of this experiment, statistical analyses regarding comprehension question accuracy will not be discussed here (see Appendix O: Analysis of Comprehension Question Accuracy in Experiment 2 for a breakdown of means by

question type). High accuracy in the critical and filler conditions suggests that these participants were attending to the task.

Predictions (3a,b) regarding the replication of the P600 components observed by Osterhout and Holcomb (1992) were confirmed. A marginally significant P600 effect was observed at the infinitive in intransitive sentences compared to the transitive sentences (i.e. the subcategorization violation). A marginally significant P600 effect was also observed at the auxiliary in the long transitive sentences compared to the long intransitive sentences (i.e. the phrase structure constraint violation). In the transitive sentence, the clausal complement is unexpected as the sentence is complete and it cannot be integrated into the sentence due to the phrase-structure constraints of English. In contrast, the clausal complement is expected in the intransitive sentence as it is required to complete the sentence.

Prediction (4), regarding the effect of affect on the P600, was partially confirmed. The first P600 effect, for the subcategorization violation, correlated positively with NA with marginal significance. This is in accordance with the idea that more negative individuals are more reliant on algorithmic sentence processing and as such are more sensitive to syntactic features of a sentence. However, the second P600 effect, for the phrase structure constraint violation, appears to be correlated negatively with NA with marginal significance. As this is only observed at posterior sites, where the P600 effect is the smallest, it may not truly represent modulation of P600 amplitude by dispositional affect. Alternatively, this may suggest that despite both the subcategorization and the phrase structure constraint violation demonstrating the same ERP component, the underlying processes are distinct. Therefore, the response to these two violations have opposite correlations with dispositional affect. However, considering the small sample size

of this experiment, it is too early to conclude whether this correlation truly reflects modulation of the P600 component by dispositional affect.

General Discussion

To summarize the findings in Experiment 1: semantic anomalies elicit an N400 component that is larger for more positive and smaller for more negative individuals; a negative going waveform is observed at a demonstrative determiner without an antecedent as compared to a definite determiner; an attenuated N400 component and a larger P200 component are observed in the demonstrative anomalous condition; the P200 amplitude difference observed in the demonstrative condition is correlated with dispositional affect where it is larger for less positive individuals. The relationship between dispositional affect and the N400 in the definite condition is clear. The response to the demonstrative determiner is unclear and warrants further investigation. As there were no a priori hypotheses regarding the unexpected P200 effect, further investigation is required to confirm this finding. However, the observed trends suggest that more negative individuals are more sensitive to syntactic cues that prime the individual for an early response to subsequent anomaly.

Regarding the findings of Experiment 2: the P600 observed by Osterhout and Holcomb (1992) were replicated; the P600 elicited by subcategorization violation appears to be larger for more negative individuals; the P600 elicited by phrase structure constraint violation appears to be larger for less negative individuals. The correlations with dispositional affect at the subcategorization violation suggest that more negative individuals have a larger P600 response to syntactic anomalies due to a greater reliance on algorithmic processing. The correlation with affect at the phrase structure constraint violation appear to conflict with the hypothesis. However, this correlation is at a posterior electrode site for what is supposedly a frontally

maximal effect. The results discussed here are preliminary and due to the small sample size, none of the effects are significant. However, the trends observed are in line with the hypotheses and are promising.

In sum, these findings support the idea that more positive individuals are more reliant on heuristic processes and more negative individuals are more reliant on algorithmic processes. Areas to be addressed in future investigations are: the response to anomalous determiners, the effect of determiners on processing subsequent anomaly, the influence of task on the end of sentence N400 in syntactically anomalous sentences and the differences in the relationship with dispositional affect for subcategorization and phrase structure constraint violations. Additionally, this work allows an understanding of how baseline differences in dispositional affect leads to differences in sentence processing which can inform future research using mood induction to study sentence processing.

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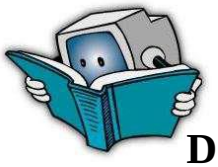
Appendix A: Recruitment Poster

Dept. of Psychology
Brock University
Dr. Veena Dwivedi, PhD



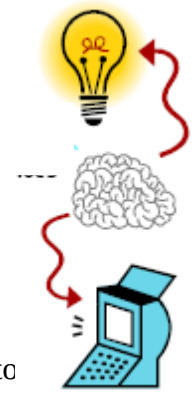
*** PARTICIPANTS WANTED ***

Earn credit for your Psychology classes

Do you want to lend your brainwaves to research?

BRAIN & LANGUAGE EEG STUDY

The Experiment: Participants will read a variety of sentences and perform a number judgment task on a computer while having electrophysiological data recorded.



Duration: approximately 3 hours

Compensation: 1 credit of course participation per hour or $10/hour

Restrictions

- Must be a monolingual speaker of English
- Must be 18-25 years of age
- Must be right handed
- Must have normal to corrected-to-normal vision
- Must **not** have been diagnosed with a neurological disorder or a disorder related to learning, speech-language, or hearing
- Any piercings on the head or hair ornaments must be removable

Please do not hesitate to sign up on SONA or contact the lab to book a time-slot and ask questions:

dwivedilab@gmail.com or 905-688-5550 x5588

This study has been reviewed by, and has received ethics clearance through the Office of Research Ethics, Brock University (REB file #: REB 13-282). Principle investigator: Dr. Veena Dwivedi, 905-688-5550 Ext. 5389 (vdwivedi@brocku.ca).
If you have any comments or concerns about your rights as a research participant, please contact the Research Ethics Office at (905) 688-5550 x 3035 or reb@brocku.ca

Neurolinguistics Study dwivedilab@gmail.com	Neurolinguistics Study dwivedilab@gmail.com	Neurolinguistics Study dwivedilab@gmail.com	Neurolinguistics Study dwivedilab@gmail.com	Neurolinguistics Study dwivedilab@gmail.com	Neurolinguistics Study dwivedilab@gmail.com	Neurolinguistics Study dwivedilab@gmail.com	Neurolinguistics Study dwivedilab@gmail.com	Neurolinguistics Study dwivedilab@gmail.com	Neurolinguistics Study dwivedilab@gmail.com	Neurolinguistics Study dwivedilab@gmail.com

Appendix B: SONA System Recruitment Post

Study Information

Study Name	An electrophysiological investigation of individual differences in language processing
Study Type	**Standard (lab) study** This is a standard lab study. To participate, sign up, and go to the specified location at the chosen time.
Study Status	**Visible to participants :** Approved **Active study :** Appears on list of available studies
Duration	180 minutes
credits	3 credits
Website	View Study Website
Abstract	Earn 3 research credits!
Description	You are invited to participate in an electrophysiological (EEG) study of language processing. Participants who meet the selection criteria will complete three brief preliminary questionnaires followed by the main EEG study lasting a total of approximately three (3) hours. Participation involves reading sentences on a computer screen and answering the corresponding comprehension questions. Electrical activity will be simultaneously recorded from your brain using non-invasive electroencephalography (EEG). You may earn up to three (3) hours of research credit. Email or text the researcher (jselvanayagam@brocku.ca or 289-697-1915) or email the Brain and Language lab at dwivedilab@gmail.com if you have any questions. In the case that none of the available time slots work for you, please email us and we would be happy to work with your schedule.
Eligibility Requirements	Monolingual speaker of English. 18-25 years of age. Right-handed. Normal or corrected-to-normal vision. Must not have been diagnosed with a neurological disorder.
Preparation	If you wear corrective lenses, wear glasses instead of contacts. Dress comfortably. Aim for a good night's sleep before coming into the study. Remove piercings on the head or hair ornaments, and ensure hair is free of products.

Appendix C: Consent Form

EEG Consent Form

Principal Investigator:	**Research Assistant:**
Dr. V. Dwivedi, PhD Department of Psychology, Centre for Neuroscience Brock University 905-688-5550 x5389 vdwivedi@brocku.ca	Janahan Selvanayagam Centre for Neuroscience Brock University 905-688-5550 x5588 jselvanayagam@brocku.ca

INVITATION

You are invited to participate in a study that involves research. The purpose of this study is to investigate electrophysiological signatures of reading/language perception.

WHAT'S INVOLVED

You will first be provided with a verbal overview of this form as well as of the tasks involved in the study. After completing the consent form, you will be asked to complete three questionnaires, with the first asking questions about demographic information and your reading preferences, the second asking questions about your handedness and the third asking about your mood. Following completion of the questionnaires, the researcher will fit you with the electrode cap that will measure brain activity during the computer-based reading task. Minimal bodily contact will occur at this time in the form of fitting you with the electrode cap, applying gel to the cap, and measuring the position of the electrodes on your head to ensure proper fitting. Following completion of the EEG set-up, you will complete the main computer-based reading study where you will read sentences presented word by word at a fixed rate on a computer screen, some of which will be followed by simple comprehension questions. This task is split into 6 blocks lasting 10-15 minutes each. Breaks are provided between each block. Following the study, minimal contact will again occur to remove the cap from your head. The fitting and removing of the cap will be pain-free. Instructions for the task will be explicitly provided to you by the research assistant, as well as by the program itself. If you encounter any difficulty, the research assistant will always be available for assistance. Upon completion of the computer task, the research assistant will explain the rationale behind the experiment and answer any questions (if necessary). Finally, the research assistant will provide you with your choice of participation compensation: $10 per hour, or 1 credit per hour. Participation will take approximately 3 hours of your time.

POTENTIAL BENEFITS AND RISKS

Possible benefits of participation include an increased awareness of the field of psycholinguistics, and the experimental methods employed therein. You are welcome to the results of the study if interested. There are no known or anticipated risks associated with participation in this study. Although a mood induction procedure does intend to make the participant feel a certain emotion (happy, angry, or neutral), it is not expected that you will experience these emotions with any more intensity than you would in response to personal experiences or similar events in the media. Should you feel uncomfortable in any way, you are free to withdraw from the experiment at any time.

CONFIDENTIALITY

All information you provide is considered confidential; your name will not be included or, in any other way, associated with the data collected in the study. Furthermore, you will not be identified individually in any way in written reports of this research. Other personal information collected during this study will be kept for less than one year and stored in secure filing cabinets in a controlled access laboratory. Only approved researchers in the Dwivedi Brain and Language Lab who are working on the analyses of these data will have access to the files. Completed consent forms will be stored in secure separate files in a cabinet. Once data collection and necessary analyses are completed, files containing personal information

will be shredded. Electronic coded data will be retained indefinitely should you agree to allow such information to be used in future studies further investigating psychological responses related to reading; otherwise, it will be deleted immediately following completion of the study. Participants are not permitted to withdraw their electronic data once they have left the lab as data are anonymous and cannot be linked to individuals.

VOLUNTARY PARTICIPATION

Participation in this study is voluntary. If you wish, you may decline to answer any questions or participate in any component of the study. Furthermore, you may decide to withdraw from this study at any time. However, full study compensation will not be awarded should you choose to withdraw from the study before completion; rather, you will receive pro-rated compensation, as determined by the research assistant, for the time that you do participate.

PUBLICATION OF RESULTS

Results of this study may be published in professional journals and presented at conferences. Feedback about this study will be available after 6 months by contacting the principal investigator, Dr. V. Dwivedi (vdwivedi@brocku.ca), or members of the lab at dwivedilab@gmail.com

CONTACT INFORMATION AND ETHICS CLEARANCE

If you have any questions about this study or require further information, please contact the Faculty Supervisor (where applicable) using the contact information provided above. This study has been reviewed and received ethics clearance through the Research Ethics Board at Brock University (REB 13-282). If you have any comments or concerns about your rights as a research participant, please contact the Research Ethics Office at (905) 688-5550 Ext. 3035, reb@brocku.ca. Thank you for your participation in this project.

CONSENT

I agree to participate in the study described above. I have made this decision based on the information I have read in the Information-Consent Letter. I have had the opportunity to receive any additional details I wanted about the study and understand that I may ask questions in the future. I understand that I may withdraw this consent at any time.

Name: _____

Signature: _____ Date: _____

I agree that this information can be used in future analyses (this pertains to the use of this data for future research that conforms to the original research intent. We note again that data are coded in such a way that they are anonymous and cannot be linked to individuals) Yes□ No□

If you are interested in taking part in future studies in our lab, please indicate your contact information (e.g., email or telephone number): _____

Researcher

Name: _____

Signature: _____ Date: _____

Appendix D: Feedback Letter

Revised on: August 23, 2016

Syntactic and Semantic complexity effects on sentence perception

Thank you very much for participating in our study, which would not have been possible without volunteers like you. As you are aware, this research study was conducted by Dr. V. Dwivedi of the Department of Psychology/Centre for Neuroscience at Brock University. The purpose of the study was to investigate the effect of dispositional affect on sentence interpretation for sentences of different complexity.

We hypothesize that sentences that use different levels of syntactic and semantic complexity require more time to read and/or elicit lower levels of accuracy in reading comprehension questions. In addition, these sentences elicit very specific brain wave responses which we are interested in studying. Furthermore, negative mood is thought to evoke deeper levels of sentence processing, whereas a positive mood is thought to evoke shallow, more heuristic processing. We will be looking to see if differences in sentence interpretation are associated with dispositional affect.

This research has been approved by ethics file # REB 13-282. The Brock Research Ethics Board can be contacted at 905-688-5550 ext. 3035 or email them at reb@brocku.ca. The Research Ethics Office at Brock University is located at MCD250 A. If you have any questions or wish to find out about the results of this study, please feel free to contact:

Principal Investigator:
Dr. V. Dwivedi, PhD
Department of Psychology and Centre for Neuroscience, Brock University
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vdwivedi@brocku.ca

Research Assistant:
Janahan Selvanayagam
Centre for Neuroscience, Brock University
905-688-5550 x5588
jselvanayagam@brocku.ca

Appendix E: Preliminary Questionnaire

Preliminary Questionnaire

1) How old are you? ___ years

2) Gender (circle one): Male Female Prefer not to disclose

3) Right Handed or Left Handed? _____

4) What is your native (primary) language? _____

How fluent? **Non-fluent** 1 2 3 4 5 6 7 8 9 10 **Fluent**

5) What is your second language (if any)? _____

How fluent? **Non-fluent** 1 2 3 4 5 6 7 8 9 10 **Fluent**

6) What is your third language (if any)? _____

How fluent? **Non-fluent** 1 2 3 4 5 6 7 8 9 10 **Fluent**

7) How often do you read per week (in hours) in the following scenarios?

a. Leisure:_____
b. Work/student obligation:_____
c. Other:_____

8) How much do you enjoy reading?

Hate it 1 2 3 4 5 6 7 8 9 10 **Love it**

9) How attentive are you to written material in everyday life?

Oblivious 1 2 3 4 5 6 7 8 9 10 **Focused**

10) Have you ever been diagnosed with a reading/learning or neurological disability?

Yes (please specify) _____

No

11) Have you ever been diagnosed with a disability related to hearing or speech-language?

Yes (please specify) _____

No

12) How many hours of sleep did you get last night? _____

Appendix F: Handedness Questionnaire

Handedness Questionnaire

Briggs, G.G. & Nebes, R.D. (1975). Patterns of hand preference in a student population. *Cortex, 11*, 230-238.

Hand preference (check or X):	**Always LEFT**	**Usually LEFT**	**No preference**	**Usually RIGHT**	**Always RIGHT**
1. To write a letter legibly					
2. To throw a ball to hit a target					
3. To play a game requiring the use of a racquet					
4. At the top of a broom to sweep dust from the floor					
5. At the top of a shovel to move sand					
6. To hold a match when striking it					
7. To hold scissors to cut paper					
8. To hold thread to guide through the eye of a needle					
9. To deal playing cards					
10. To hammer a nail into wood					
11. To hold a toothbrush while cleaning teeth					
12. To unscrew the lid of a jar					

Are either of your parents left-handed? If yes, which? _____

How many siblings of each sex do you have? Male ____ Female ____

How many of your siblings are left-handed? Male ____ Female ____

Which eye do you use when using only one eye (e.g. telescope, keyhole)? _____

TOTAL SCORE = _____

Appendix G: Positive and Negative Affect Schedule

Positive and negative affect schedule ppt #:

(Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of personality and social psychology*, *54*, 1063-1070.)

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. Indicate to what extent you felt this way **this past week.**

Circle the extent felt this way **this past week.**		Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
1	Interested	1	2	3	4	5
2	Distressed	1	2	3	4	5
3	Excited	1	2	3	4	5
4	Upset	1	2	3	4	5
5	Strong	1	2	3	4	5
6	Guilty	1	2	3	4	5
7	Scared	1	2	3	4	5
8	Hostile	1	2	3	4	5
9	Enthusiastic	1	2	3	4	5
10	Proud	1	2	3	4	5
11	Irritable	1	2	3	4	5
12	Alert	1	2	3	4	5
13	Ashamed	1	2	3	4	5
14	Inspired	1	2	3	4	5
15	Nervous	1	2	3	4	5
16	Determined	1	2	3	4	5
17	Attentive	1	2	3	4	5
18	Jittery	1	2	3	4	5
19	Active	1	2	3	4	5
20	Afraid	1	2	3	4	5

Appendix H: Experiment 1 Critical Sentences

Critical sentences from Experiment 1

The following 160 items were presented in a 2x2 design: determiner (*the/that*) by anomaly (**control/semantically anomalous**) counterbalanced across four pseudorandomized lists.

1. The actor used *the/that* **prop/hour** in the scene.
2. The adult demonstrated *the/that* **talent/number** in the contest.
3. The designer decorated *the/that* **mansion/poverty** before the deadline.
4. The drummer pounded *the/that* **rhythm/dinner** in the rehearsal.
5. The contestant solved *the/that* **puzzle/liquid** on the show.
6. The forecaster predicted *the/that* **flood/bench** despite the sunshine.
7. The plumber fixed *the/that* **pipe/lace** with a wrench.
8. The dancer performed *the/that* **show/foot** for the audience.
9. The charity organized *the/that* **benefit/shotgun** for the cause.
10. The guard entered *the/that* **code/beam** on the keypad.
11. The driver missed *the/that* **exit/wrap** during the whiteout.
12. The cook prepared *the/that* **feast/brick** under time restrictions.
13. The purchaser dialed *the/that* **hotline/picture** during the commercial.
14. The scholar wrote *the/that* **paper/creek** in the library.
15. The botanist classified *the/that* **plant/porch** during the outing.
16. The mechanic checked *the/that* **plane/curse** in the hanger.
17. The captain navigated *the/that* **boat/mind** through the water.
18. The professor edited *the/that* **textbook/doughnut** over the summer.
19. The performer choreographed *the/that* **routine/convent** with a passion.
20. The chef avoided *the/that* **recipe/shield** during the cook-off.
21. The parent chaperoned *the/that* **dance/alarm** out of concern.
22. The student borrowed *the/that* **book/wage** during reading week.
23. The soldier saluted *the/that* **flag/name** before the flight.
24. The cheater copied *the/that* **essay/lemon** before the due-date.
25. The neighbour lent *the/that* **tool/oath** to the man.
26. The speaker quoted *the/that* **phrase/papaya** in the auditorium.
27. The jogger joined *the/that* **club/rock** with a friend.
28. The climber scaled *the/that* **cliff/money** with a partner.
29. The tourist visited *the/that* **statue/ladder** on an excursion.
30. The nurse administered *the/that* **drug/snow** under close supervision.
31. The accountant discovered *the/that* **error/ivory** during the audit.
32. The person avoided *the/that* **park/oval** in the evening.
33. The employee completed *the/that* **project/science** within four months.
34. The relative took *the/that* **vacation/mischief** to get away.
35. The resident survived *the/that* **storm/beard** until help arrived.
36. The king hosted *the/that* **banquet/bedroom** out of kindness.
37. The detective examined *the/that* **clue/pomp** before the hearing.
38. The girl hummed *the/that* **melody/lumber** in the playground.
39. The musician played *the/that* **song/jeep** during the recital.
40. The scientist asked *the/that* **question/driveway** during the seminar.
41. The friend grieved *the/that* **death/cloth** for two years.

42. The reporter verified *the/that* **rumour/retina** without any evidence.
43. The patient left *the/that* **hospital/doorknob** in the daytime.
44. The runner finished *the/that* **marathon/mortuary** within two hours.
45. The believer practiced *the/that* **ritual/needle** with undivided attention.
46. The ranger cleared *the/that* **trail/music** with a machete.
47. The janitor washed *the/that* **floor/labor** with a mop.
48. The researcher published *the/that* **journal/theater** within a year.
49. The jeweler appraised *the/that* **diamond/surgery** before being certified.
50. The individual celebrated *the/that* **holiday/cabinet** with bright lights.
51. The president ignored *the/that* **warning/stomach** with little remorse.
52. The witch cast *the/that* **spell/skirt** in the woods.
53. The hunter fired *the/that* **gun/gas** at the herd.
54. The thief grabbed *the/that* **sack/room** during the robbery.
55. The singer gave *the/that* **concert/morning** with tremendous enthusiasm.
56. The scout earned *the/that* **badge/grass** with a smile.
57. The volunteer provided *the/that* **service/college** without any complaints.
58. The contractor inspected *the/that* **site/hair** to assess damage.
59. The reviewer criticized *the/that* **novel/wrist** with brutal honesty.
60. The producer financed *the/that* **movie/brain** with much difficulty.
61. The applicant wanted *the/that* **job/lap** to pay tuition.
62. The criminal escaped *the/that* **prison/drawer** after the riots.
63. The leader sought *the/that* **resolution/atmosphere** with utmost care.
64. The artist painted *the/that* **mural/dough** without a break.
65. The wizard refused *the/that* **wish/yard** without any regret.
66. The archer shot *the/that* **target/lesson** with great precision.
67. The schoolgirl crossed *the/that* **road/film** during lunch time.
68. The ghost haunted *the/that* **cemetery/sunshine** in the fog.
69. The participant carved *the/that* **pumpkin/history** with a knife.
70. The notary signed *the/that* **contract/language** with a pen.
71. The baby banged *the/that* **pot/fog** with a rattle.
72. The adolescent rode *the/that* **bus/jar** on bumpy roads.
73. The gambler lost *the/that* **bet/mud** with much shame.
74. The librarian reshelved *the/that* **magazine/laughter** to stay organized.
75. The donor created *the/that* **scholarship/imagination** following the recession.
76. The secretary translated *the/that* **document/doorstep** before the conference.
77. The insider revealed *the/that* **secret/peanut** to the press.
78. The salesperson hailed *the/that* **taxi/dump** in the rain.
79. The connoisseur tasted *the/that* **wine/roof** during the tour.
80. The celebrity supported *the/that* **cause/cheek** with a donation.
81. The therapist updated *the/that* **report/beacon** in a rush.
82. The couple frequented *the/that* **restaurant/basketball** on Friday night.
83. The traveler read *the/that* **sign/shop** despite language barriers.
84. The intern filed *the/that* **manuscript/friendship** into the cabinet.
85. The committee discussed *the/that* **bill/nose** at the meeting.
86. The journalist described *the/that* **event/mercy** to the editor.
87. The accountant audited *the/that* **company/wrapper** for the government.

88. The group toured *the/that* **country/chemical** with the guide.
89. The magician presented *the/that* **trick/fight** on the street.
90. The officer chased *the/that* **van/bed** during the blitz.
91. The skier conquered *the/that* **hill/card** during the day.
92. The lawyer pleaded *the/that* **case/week** before the judge.
93. The analyst identified *the/that* **solution/darkness** to the problem.
94. The hiker ascended *the/that* **mountain/passport** in the sunlight.
95. The husband ordered *the/that* **meal/lake** from a waitress.
96. The referee worked *the/that* **tournament/government** as a hobby.
97. The doctor diagnosed *the/that* **illness/evening** during an appointment.
98. The association enforced *the/that* **policy/parlor** through routine checks.
99. The woman sewed *the/that* **quilt/truth** with steady hands.
100. The entertainer accepted *the/that* **award/earth** at the ceremony.
101. The player kicked *the/that* **ball/work** into the net.
102. The army bombed *the/that* **town/word** in the night.
103. The coach devised *the/that* **play/cash** during the practice.
104. The pupil rehearsed *the/that* **poem/wing** with the teacher.
105. The vehicle caused *the/that* **accident/baseball** before the recall.
106. The retiree booked *the/that* **cruise/powder** despite the cost.
107. The judge made *the/that* **decision/suitcase** to uphold justice.
108. The banker locked *the/that* **vault/story** after closing time.
109. The backpacker loved *the/that* **city/heel** at first sight.
110. The cyclist rounded *the/that* **corner/hammer** with great speed.
111. The technician repaired *the/that* **computer/midnight** at no charge.
112. The architect designed *the/that* **building/mustache** on rough paper.
113. The electrician tested *the/that* **circuit/message** with the device.
114. The waiter served *the/that* **drink/break** on the patio.
115. The teacher graded *the/that* **exam/fire** in the staffroom.
116. The shopper squeezed *the/that* **melon/crate** in the supermarket.
117. The farmer harvested *the/that* **crop/jail** in the fall.
118. The knight raised *the/that* **sword/honey** in the forest.
119. The sailor tied *the/that* **knot/vase** with the rope.
120. The astronomer found *the/that* **planet/credit** with a telescope.
121. The gardener watered *the/that* **shrub/world** on Saturday morning.
122. The advocate fought *the/that* **injustice/afternoon** with strong arguments.
123. The grandmother baked *the/that* **dessert/conduct** in the afternoon.
124. The mayor inaugurated *the/that* **memorial/bracelet** on the anniversary.
125. The realtor showed *the/that* **house/grape** to the clients.
126. The competitor thanked *the/that* **sponsor/painting** after the competition.
127. The seamstress mended *the/that* **dress/water** for the family.
128. The athlete recited *the/that* **anthem/outfit** before the game.
129. The guest sang *the/that* **tune/puck** at the party.
130. The stockbroker advised *the/that* **client/tuxedo** before the down-turn.
131. The comedian did *the/that* **impression/ammunition** on the stage.
132. The murderer terrorized *the/that* **community/particles** in the state.
133. The warrior defended *the/that* **kingdom/disease** during the war.

134. The bridesmaid composed *the/that* **speech/street** before the wedding.
135. The union negotiated *the/that* **deal/hand** in top secrecy.
136. The receptionist answered *the/that* **phone/bonus** on Tuesday afternoon.
137. The executive attended *the/that* **conference/television** to gain knowledge.
138. The interviewer requested *the/that* **explanation/coincidence** on national television.
139. The pedestrian exited *the/that* **tunnel/cannon** during rush hour.
140. The man photographed *the/that* **monument/internet** for the magazine.
141. The spy received *the/that* **assignment/destruction** in the mail.
142. The rider jumped *the/that* **fence/bribe** before the race.
143. The citizen endured *the/that* **hurricane/telephone** in the shelter.
144. The businessman explored *the/that* **possibility/anniversary** after the tradeshow.
145. The alumnus coordinated *the/that* **reunion/sausage** under time constraints.
146. The stylist chose *the/that* **shirt/blood** in a hurry.
147. The delinquent scratched *the/that* **car/war** with a key.
148. The customer returned *the/that* **item/inch** after buying it.
149. The entrepreneur opened *the/that* **store/smell** to increase revenue.
150. The landscaper trimmed *the/that* **hedge/trial** before lunch time.
151. The supervisor disciplined *the/that* **worker/moment** with quiet discretion.
152. The maid mopped *the/that* **hallway/package** in the hotel.
153. The tailor altered *the/that* **jacket/racket** following the payment.
154. The camper carried *the/that* **canoe/party** to the river.
155. The carpenter built *the/that* **barn/coat** in the spring.
156. The kid climbed *the/that* **tree/jade** in the autumn.
157. The bully punched *the/that* **wall/beer** with great frustration.
158. The engineer remixed *the/that* **soundtrack/volleyball** before the deadline.
159. The pirate attacked *the/that* **ship/wind** during the night.
160. The teenaged failed *the/that* **quiz/leaf** despite having studied.

Appendix I: Experiment 2 Critical Sentences

Critical sentences from Experiment 2

The following 120 items were presented in a 2x2 design: verb type (*intransitive/transitive*) by anomaly (short vs *[long]*) counterbalanced across four pseudorandomized lists. The question presented for the item in each condition is included with the correct answer in **bold**. The conditions are long intransitive (LI), long transitive (LT), short intransitive (SI) and short transitive (ST).

1. The broker *planned/persuaded* to conceal the transaction *[was sent to jail]*.
   LI: Was the broker concealed? 1) Yes **2) No**
   LT: Was the broker persuaded? **1) Yes** 2) No
   SI: Did the broker plan something? **1) Yes** 2) No
   ST: Did the broker persuade someone? 1) Yes **2) No**
2. The man *attempted/hired* to help the store *[was fired for theft]*.
   LI: Did the man attempt something? **1) Yes** 2) No
   LT: Did the man hire someone? 1) Yes **2) No**
   SI: Was the man helped? 1) Yes **2) No**
   ST: Was the man hired? **1) Yes** 2) No
3. The doctor *agreed/advised* to see the patient *[had left the hospital]*.
   LI: Was the doctor seen? 1) Yes **2) No**
   LT: Was the doctor advised? **1) Yes** 2) No
   SI: Did the doctor agree to do something? **1) Yes** 2) No
   ST: Did the doctor advise someone? 1) Yes **2) No**
4. The reporter *struggled/selected* to get the story *[was given a raise]*.
   LI: Did the reporter struggle to do something? **1) Yes** 2) No
   LT: Did the reporter select someone? 1) Yes **2) No**
   SI: Was the reporter fired? 1) Yes **2) No**
   ST: Was the reporter selected? **1) Yes** 2) No
5. The woman *agreed/advised* to see the play *[was leaving the theater]*.
   LI: Was the woman seen? 1) Yes **2) No**
   LT: Was the woman advised? **1) Yes** 2) No
   SI: Did the woman agree to do something? **1) Yes** 2) No
   ST: Did the woman advise someone? 1) Yes **2) No**
6. The senator *attempted/forced* to chair the committee *[was sent the money]*.
   LI: Did the senator attempt something? **1) Yes** 2) No
   LT: Did the senator force someone? 1) Yes **2) No**
   SI: Was the senator sent flowers? 1) Yes **2) No**
   ST: Was the senator forced? **1) Yes** 2) No
7. The judge *hoped/bribed* to sentence the defendant *[was reluctant to proceed]*.
   LI: Was the judge sentenced? 1) Yes **2) No**
   LT: Was the judge bribed? **1) Yes** 2) No
   SI: Did the judge hope something? **1) Yes** 2) No
   ST: Did the judge bribe someone? 1) Yes **2) No**
8. The tailor *began/hired* to fix the suit *[had repaired the rip]*.
   LI: Did the tailor begin something? **1) Yes** 2) No
   LT: Did the tailor hire someone? 1) Yes **2) No**

SI: Was the tailor fixed? 1) Yes **2) No**
ST: Was the tailor hired? **1) Yes** 2) No

9. The swimmer *decided/urged* to lose some weight *[was beginning a diet]*.
   LI: Was the swimmer lost? 1) Yes **2) No**
   LT: Was the swimmer urged? **1) Yes** 2) No
   SI: Did the swimmer decide something? **1) Yes** 2) No
   ST: Did the swimmer urge someone? 1) Yes **2) No**
10. The general *refused/permitted* to leave the army *[had received an award]*.
   LI: Did the general refuse something? **1) Yes** 2) No
   LT: Did the general permit someone? 1) Yes **2) No**
   SI: Was the general retired? 1) Yes **2) No**
   ST: Was the general permitted? **1) Yes** 2) No
11. The minister *started/invited* to give the sermon *[was about to arrive]*.
   LI: Was the minister leaving? 1) Yes **2) No**
   LT: Was the minister invited? **1) Yes** 2) No
   SI: Did the minister start something? **1) Yes** 2) No
   ST: Did the minister invite someone? 1) Yes **2) No**
12. The mechanic *refused/trusted* to repair the car *[had quit his job]*.
   LI: Did the mechanic refuse something? **1) Yes** 2) No
   LT: Did the mechanic trust someone? 1) Yes **2) No**
   SI: Was the mechanic repaired? 1) Yes **2) No**
   ST: Was the mechanic trusted? **1) Yes** 2) No
13. The singer *decided/allowed* to perform the opera *[was past her prime]*.
   LI: Was the singer young? 1) Yes **2) No**
   LT: Was the singer allowed? **1) Yes** 2) No
   SI: Did the singer decide something? **1) Yes** 2) No
   ST: Did the singer allow someone? 1) Yes **2) No**
14. The teacher *planned/urged* to improve his teaching *[had taken a vacation]*.
   LI: Did the teacher plan something? **1) Yes** 2) No
   LT: Did the teacher urge someone? 1) Yes **2) No**
   SI: Was the teacher improved? 1) Yes **2) No**
   ST: Was the teacher urged? **1) Yes** 2) No
15. The burglar *schemed/compelled* to rob the bank *[was caught red handed]*.
   LI: Was the burglar robbed? 1) Yes **2) No**
   LT: Was the burglar compelled? **1) Yes** 2) No
   SI: Did the burglar scheme something? **1) Yes** 2) No
   ST: Did the burglar compel someone? 1) Yes **2) No**
16. The policeman *intended/ordered* to watch the bank *[had caught the thieves]*.
   LI: Did the policeman intend something? **1) Yes** 2) No
   LT: Did the policeman order someone? 1) Yes **2) No**
   SI: Was the policeman watched? 1) Yes **2) No**
   ST: Was the policeman ordered? **1) Yes** 2) No
17. The dentist *hoped/invited* to meet the actress *[was nervous last night]*.
   LI: Was the dentist relaxed? 1) Yes **2) No**
   LT: Was the dentist invited? **1) Yes** 2) No

SI: Did the dentist hope something? **1) Yes** 2) No
ST: Did the dentist invite someone? 1) Yes **2) No**

18. The janitor *tried/persuaded* to fix the faucet *[had botched the job]*.
    LI: Did the janitor try something? **1) Yes** 2) No
    LT: Did the janitor persuade someone? 1) Yes **2) No**
    SI: Was the janitor fixed? 1) Yes **2) No**
    ST: Was the janitor persuaded? **1) Yes** 2) No
19. The nurse *hesitated/compelled* to leave the patient *[was reprimanded very severely]*.
    LI: Was the nurse rewarded? 1) Yes **2) No**
    LT: Was the nurse compelled? **1) Yes** 2) No
    SI: Did the nurse hesitate to do something? **1) Yes** 2) No
    ST: Did the nurse compel someone? 1) Yes **2) No**
20. The prince *yearned/advised* to marry the princess *[had proposed last night]*.
    LI: Did the prince yearn something? **1) Yes** 2) No
    LT: Did the prince advise someone? 1) Yes **2) No**
    SI: Was the prince proposed to? 1) Yes **2) No**
    ST: Was the prince advised? **1) Yes** 2) No
21. The journalist *attempted/encouraged* to write the story *[had missed the deadline]*.
    LI: Was the journalist early? 1) Yes **2) No**
    LT: Was the journalist encouraged? **1) Yes** 2) No
    SI: Did the journalist attempt something? **1) Yes** 2) No
    ST: Did the journalist encourage someone? 1) Yes **2) No**
22. The governor *hoped/encouraged* to meet the mayor *[was running for reelection]*.
    LI: Did the governor hope something? **1) Yes** 2) No
    LT: Did the governor encourage someone? 1) Yes **2) No**
    SI: Was the governor withdrawing? 1) Yes **2) No**
    ST: Was the governor encouraged? **1) Yes** 2) No
23. The nephew *hesitated/persuaded* to borrow the money *[was in substantial debt]*.
    LI: Was the nephew rich? 1) Yes **2) No**
    LT: Was the nephew persuaded? **1) Yes** 2) No
    SI: Did the nephew hesitate to do something? **1) Yes** 2) No
    ST: Did the nephew persuade someone? 1) Yes **2) No**
24. The salesman *tried/compelled* to leave the company *[was known for dishonesty]*.
    LI: Did the salesman try something? **1) Yes** 2) No
    LT: Did the salesman compel someone? 1) Yes **2) No**
    SI: Was the salesman hired? 1) Yes **2) No**
    ST: Was the salesman compelled? **1) Yes** 2) No
25. The executive *planned/ordered* to balance the budget *[was fired for incompetence]*.
    LI: Was the executive balanced? 1) Yes **2) No**
    LT: Was the executive ordered? **1) Yes** 2) No
    SI: Did the executive plan something? **1) Yes** 2) No
    ST: Did the executive order someone? 1) Yes **2) No**
26. The professor *tried/allowed* to teach the course *[was preparing his lectures]*.
    LI: Did the professor try something? **1) Yes** 2) No
    LT: Did the professor allow someone? 1) Yes **2) No**

SI: Was the professor taught? 1) Yes **2) No**
ST: Was the professor allowed? **1) Yes** 2) No

27. The writer *decided/urged* to edit the novel *[had requested more money]*.
    LI: Was the writer editing a magazine? 1) Yes **2) No**
    LT: Was the writer urged? **1) Yes** 2) No
    SI: Did the writer decide something? **1) Yes** 2) No
    ST: Did the writer urge someone? 1) Yes **2) No**
28. The woman *struggled/hired* to prepare the meal *[had burned the meat]*.
    LI: Did the woman struggle to do something? **1) Yes** 2) No
    LT: Did the woman hire someone? 1) Yes **2) No**
    SI: Was the woman prepared? 1) Yes **2) No**
    ST: Was the woman hired? **1) Yes** 2) No
29. The wife *agreed/permitted* to adopt the child *[had told her husband]*.
    LI: Was the wife adopted? 1) Yes **2) No**
    LT: Was the wife permitted? **1) Yes** 2) No
    SI: Did the wife agree to do something? **1) Yes** 2) No
    ST: Did the wife permit someone? 1) Yes **2) No**
30. The senator *schemed/bribed* to sell the secrets *[was arrested for espionage]*.
    LI: Did the senator scheme something? **1) Yes** 2) No
    LT: Did the senator bribe someone? 1) Yes **2) No**
    SI: Was the senator sold? 1) Yes **2) No**
    ST: Was the senator bribed? **1) Yes** 2) No
31. The scientist *aspired/selected* to win the prize *[had arrived by plane]*.
    LI: Was the scientist won? 1) Yes **2) No**
    LT: Was the scientist selected? **1) Yes** 2) No
    SI: Did the scientist aspire to do something? **1) Yes** 2) No
    ST: Did the scientist select someone? 1) Yes **2) No**
32. The doctor *began/implored* to perform the surgery *[had left the country]*.
    LI: Did the doctor begin something? **1) Yes** 2) No
    LT: Did the doctor implore someone? 1) Yes **2) No**
    SI: Was the doctor home? 1) Yes **2) No**
    ST: Was the doctor implored? **1) Yes** 2) No
33. The baker *started/trusted* to bake the cake *[had won many awards]*.
    LI: Was the baker a failure? 1) Yes **2) No**
    LT: Was the baker trusted? **1) Yes** 2) No
    SI: Did the baker start something? **1) Yes** 2) No
    ST: Did the baker trust someone? 1) Yes **2) No**
34. The lawyer *declined/selected* to take the case *[was very highly regarded]*.
    LI: Did the lawyer decline something? **1) Yes** 2) No
    LT: Did the lawyer select someone? 1) Yes **2) No**
    SI: Was the lawyer taken? 1) Yes **2) No**
    ST: Was the lawyer selected? **1) Yes** 2) No
35. The grandmother *intended/implored* to buy the presents *[had forgotten her purse]*.
    LI: Was the grandmother prepared? 1) Yes **2) No**
    LT: Was the grandmother implored? **1) Yes** 2) No

SI: Did the grandmother intend something? **1) Yes** 2) No
ST: Did the grandmother implore someone? 1) Yes **2) No**

36. The policeman *struggled/ordered* to arrest the man *[had hurt his hand]*.
LI: Did the policeman struggle to do something? **1) Yes** 2) No
LT: Did the policeman order someone? 1) Yes **2) No**
SI: Was the policeman arrested? 1) Yes **2) No**
ST: Was the policeman ordered? **1) Yes** 2) No
37. The teacher *schemed/bribed* to steal the money *[was fined for incompetence]*.
LI: Was the teacher competent? 1) Yes **2) No**
LT: Was the teacher bribed? **1) Yes** 2) No
SI: Did the teacher scheme something? **1) Yes** 2) No
ST: Did the teacher bribe someone? 1) Yes **2) No**
38. The student *hesitated/forced* to do the assignment *[was failing the course]*.
LI: Did the student hesitate to do something? **1) Yes** 2) No
LT: Did the student force someone? 1) Yes **2) No**
SI: Was the student eager to do the assignment? 1) Yes **2) No**
ST: Was the student forced? **1) Yes** 2) No
39. The senator *aspired/encouraged* to run for president *[had written the article]*.
LI: Was the senator writing a book? 1) Yes **2) No**
LT: Was the senator encouraged? **1) Yes** 2) No
SI: Did the senator aspire to do something? **1) Yes** 2) No
ST: Did the senator encourage someone? 1) Yes **2) No**
40. The waitress *refused/forced* to help the customer *[was ready to quit]*.
LI: Did the waitress refuse something? **1) Yes** 2) No
LT: Did the waitress force someone? 1) Yes **2) No**
SI: Was the waitress promoted? 1) Yes **2) No**
ST: Was the waitress forced? **1) Yes** 2) No
41. The writer *started/allowed* to write the book *[had received a letter]*.
LI: Was the writer reading a book? 1) Yes **2) No**
LT: Was the writer allowed? **1) Yes** 2) No
SI: Did the writer start something? **1) Yes** 2) No
ST: Did the writer allow someone? 1) Yes **2) No**
42. The ballerina *aspired/invited* to perform the dance *[was practicing every day]*.
LI: Did the ballerina aspire to do something? **1) Yes** 2) No
LT: Did the ballerina invite someone? 1) Yes **2) No**
SI: Was the ballerina hoping to sing? 1) Yes **2) No**
ST: Was the ballerina invited? **1) Yes** 2) No
43. The butler *schemed/bribed* to unlock the safe *[was caught last night]*.
LI: Was the butler innocent? 1) Yes **2) No**
LT: Was the butler bribed? **1) Yes** 2) No
SI: Did the butler scheme something? **1) Yes** 2) No
ST: Did the butler bribe someone? 1) Yes **2) No**
44. The electrician *attempted/hired* to repair the furnace *[had finished the job]*.
LI: Did the electrician attempt something? **1) Yes** 2) No
LT: Did the electrician hire someone? 1) Yes **2) No**

SI: Was the electrician repairing a fridge? 1) Yes **2) No**
ST: Was the electrician hired? **1) Yes** 2) No

45. The athlete *hoped/compelled* to sign the contract *[had injured his leg]*.
LI: Was the athlete uninjured? 1) Yes **2) No**
LT: Was the athlete compelled? **1) Yes** 2) No
SI: Did the athlete hope something? **1) Yes** 2) No
ST: Did the athlete compel someone? 1) Yes **2) No**
46. The politician *began/invited* to give a speech *[was given an award]*.
LI: Did the politician begin something? **1) Yes** 2) No
LT: Did the politician invite someone? 1) Yes **2) No**
SI: Was the politician punished? 1) Yes **2) No**
ST: Was the politician invited? **1) Yes** 2) No
47. The librarian *decided/trusted* to buy the books *[had completed the purchases]*.
LI: Was the librarian buying dishes? 1) Yes **2) No**
LT: Was the librarian trusted? **1) Yes** 2) No
SI: Did the librarian decide something? **1) Yes** 2) No
ST: Did the librarian trust someone? 1) Yes **2) No**
48. The photographer *began/persuaded* to take the pictures *[had loaded the camera]*.
LI: Did the photographer begin something? **1) Yes** 2) No
LT: Did the photographer persuade someone? 1) Yes **2) No**
SI: Was the photographer loading the truck? 1) Yes **2) No**
ST: Was the photographer persuaded? **1) Yes** 2) No
49. The artist *declined/implored* to sell the painting *[had moved to Chicago]*.
LI: Was the artist moving to France? 1) Yes **2) No**
LT: Was the artist implored? **1) Yes** 2) No
SI: Did the artist decline something? **1) Yes** 2) No
ST: Did the artist implore someone? 1) Yes **2) No**
50. The philanthropist *intended/encouraged* to donate the money *[was eager to help]*.
LI: Did the philanthropist intend something? **1) Yes** 2) No
LT: Did the philanthropist encourage someone? 1) Yes **2) No**
SI: Was the philanthropist selfish? 1) Yes **2) No**
ST: Was the philanthropist encouraged? **1) Yes** 2) No
51. The banker *planned/bribed* to steal the money *[had moved to Australia]*.
LI: Was the banker moving to Europe? 1) Yes **2) No**
LT: Was the banker bribed? **1) Yes** 2) No
SI: Did the banker plan something? **1) Yes** 2) No
ST: Did the banker bribe someone? 1) Yes **2) No**
52. The worker *refused/permitted* to go on vacation *[was given a raise]*.
LI: Did the worker refuse something? **1) Yes** 2) No
LT: Did the worker permit someone? 1) Yes **2) No**
SI: Was the worker fired? 1) Yes **2) No**
ST: Was the worker permitted? **1) Yes** 2) No
53. The judge *tried/ordered* to stop the trial *[was asked to resign]*.
LI: Was the judge given an award? 1) Yes **2) No**
LT: Was the judge ordered? **1) Yes** 2) No

SI: Did the judge try something? **1) Yes** 2) No
ST: Did the judge order someone? 1) Yes **2) No**

54. The student *aspired/selected* to organize the party *[had begun the preparations]*.
LI: Did the student aspire to do something? **1) Yes** 2) No
LT: Did the student select someone? 1) Yes **2) No**
SI: Was the student organizing a study session? 1) Yes **2) No**
ST: Was the student selected? **1) Yes** 2) No
55. The soldier *schemed/bribed* to leave his post *[was reprimanded last week]*.
LI: Was the soldier given a medal? 1) Yes **2) No**
LT: Was the soldier bribed? **1) Yes** 2) No
SI: Did the soldier scheme something? **1) Yes** 2) No
ST: Did the soldier bribe someone? 1) Yes **2) No**
56. The quarterback *tried/forced* to throw the ball *[was intercepted three times]*.
LI: Did the quarterback try something? **1) Yes** 2) No
LT: Did the quarterback force someone? 1) Yes **2) No**
SI: Was the quarterback thrown? 1) Yes **2) No**
ST: Was the quarterback forced? **1) Yes** 2) No
57. The politician *decided/urged* to run for office *[was meeting with voters]*.
LI: Was the politician alone? 1) Yes **2) No**
LT: Was the politician urged? **1) Yes** 2) No
SI: Did the politician decide something? **1) Yes** 2) No
ST: Did the politician urge someone? 1) Yes **2) No**
58. The secretary *started/trusted* to write the letter *[was given a raise]*.
LI: Did the secretary start something? **1) Yes** 2) No
LT: Did the secretary trust someone? 1) Yes **2) No**
SI: Was the secretary dismissed? 1) Yes **2) No**
ST: Was the secretary trusted? **1) Yes** 2) No
59. The activitist *hoped/invited* to address the audience *[had prepared all night]*.
LI: Was the activitist addressed? 1) Yes **2) No**
LT: Was the activitist invited? **1) Yes** 2) No
SI: Did the activitist hope something? **1) Yes** 2) No
ST: Did the activitist invite someone? 1) Yes **2) No**
60. The accountant *attempted/implored* to balance the books *[had discovered an error]*.
LI: Did the accountant attempt something? **1) Yes** 2) No
LT: Did the accountant implore someone? 1) Yes **2) No**
SI: Was the accountant careless? 1) Yes **2) No**
ST: Was the accountant implored? **1) Yes** 2) No
61. The pilot *hesitated/compelled* to fly the plane *[had boarded the plane]*.
LI: Was the pilot flown? 1) Yes **2) No**
LT: Was the pilot compelled? **1) Yes** 2) No
SI: Did the pilot hesitate to do something? **1) Yes** 2) No
ST: Did the pilot compel someone? 1) Yes **2) No**
62. The actress *struggled/implored* to learn her lines *[was ready to quit]*.
LI: Did the actress struggle to do something? **1) Yes** 2) No
LT: Did the actress implore someone? 1) Yes **2) No**

SI: Was the actress struggling to lose weight? 1) Yes **2) No**
ST: Was the actress implored? **1) Yes** 2) No

63. The teacher *began/urged* to help the child *[had prepared the lesson]*.
LI: Was the teacher helped? 1) Yes **2) No**
LT: Was the teacher urged? **1) Yes** 2) No
SI: Did the teacher begin something? **1) Yes** 2) No
ST: Did the teacher urge someone? 1) Yes **2) No**
64. The shopper *declined/encouraged* to buy the coat *[was given a discount]*.
LI: Did the shopper decline something? **1) Yes** 2) No
LT: Did the shopper encourage someone? 1) Yes **2) No**
SI: Was the shopper buying a TV? 1) Yes **2) No**
ST: Was the shopper encouraged? **1) Yes** 2) No
65. The child *agreed/trusted* to clean his room *[had fallen asleep instead]*.
LI: Was the child awake? 1) Yes **2) No**
LT: Was the child trusted? **1) Yes** 2) No
SI: Did the child agree to do something? **1) Yes** 2) No
ST: Did the child trust someone? 1) Yes **2) No**
66. The musician *started/invited* to sing the song *[was not very good]*.
LI: Did the musician start something? **1) Yes** 2) No
LT: Did the musician invite someone? 1) Yes **2) No**
SI: Was the musician dancing? 1) Yes **2) No**
ST: Was the musician invited? **1) Yes** 2) No
67. The sheriff *attempted/ordered* to arrest the man *[had been tricked again]*.
LI: Was the sheriff arrested? 1) Yes **2) No**
LT: Was the sheriff ordered? **1) Yes** 2) No
SI: Did the sheriff attempt something? **1) Yes** 2) No
ST: Did the sheriff order someone? 1) Yes **2) No**
68. The doctor *agreed/selected* to perform the operation *[was ready to begin]*.
LI: Did the doctor agree to do something? **1) Yes** 2) No
LT: Did the doctor select someone? 1) Yes **2) No**
SI: Was the doctor delayed? 1) Yes **2) No**
ST: Was the doctor selected? **1) Yes** 2) No
69. The chairman *refused/persuaded* to answer the question *[was preparing to resign]*.
LI: Was the chairman forthcoming? 1) Yes **2) No**
LT: Was the chairman persuaded? **1) Yes** 2) No
SI: Did the chairman refuse something? **1) Yes** 2) No
ST: Did the chairman persuade someone? 1) Yes **2) No**
70. The detective *planned/hired* to follow the suspect *[had lost the trail]*.
LI: Did the detective plan something? **1) Yes** 2) No
LT: Did the detective hire someone? 1) Yes **2) No**
SI: Was the detective followed? 1) Yes **2) No**
ST: Was the detective hired? **1) Yes** 2) No
71. The criminal *struggled/permitted* to escape from jail *[was captured last night]*.
LI: Was the criminal escaping from a bank? 1) Yes **2) No**
LT: Was the criminal permitted? **1) Yes** 2) No

SI: Did the criminal struggle to do something? **1) Yes** 2) No
ST: Did the criminal permit someone? 1) Yes **2) No**

72. The golfer *aspired/advised* to play for money *[had lost the match]*.
LI: Did the golfer aspire to do something? **1) Yes** 2) No
LT: Did the golfer advise someone? 1) Yes **2) No**
SI: Was the golfer a winner? 1) Yes **2) No**
ST: Was the golfer advised? **1) Yes** 2) No
73. The student *intended/allowed* to have a party *[had bought new albums]*.
LI: Was the student buying books? 1) Yes **2) No**
LT: Was the student allowed? **1) Yes** 2) No
SI: Did the student intend something? **1) Yes** 2) No
ST: Did the student allow someone? 1) Yes **2) No**
74. The writer *agreed/advised* to sign the contract *[was given a deadline]*.
LI: Did the writer agree to do something? **1) Yes** 2) No
LT: Did the writer advise someone? 1) Yes **2) No**
SI: Was the writer given a prize? 1) Yes **2) No**
ST: Was the writer advised? **1) Yes** 2) No
75. The cannibal *declined/forced* to eat the minister *[had set the table]*.
LI: Was the cannibal eaten? 1) Yes **2) No**
LT: Was the cannibal forced? **1) Yes** 2) No
SI: Did the cannibal decline something? **1) Yes** 2) No
ST: Did the cannibal force someone? 1) Yes **2) No**
76. The athlete *began/permitted* to play the game *[was injured last time]*.
LI: Did the athlete begin something? **1) Yes** 2) No
LT: Did the athlete permit someone? 1) Yes **2) No**
SI: Was the athlete played? 1) Yes **2) No**
ST: Was the athlete permitted? **1) Yes** 2) No
77. The diplomat *hesitated/allowed* to discuss the treaty *[was threatened this morning]*.
LI: Was the diplomat discussed? 1) Yes **2) No**
LT: Was the diplomat allowed? **1) Yes** 2) No
SI: Did the diplomat hesitate to do something? **1) Yes** 2) No
ST: Did the diplomat allow someone? 1) Yes **2) No**
78. The scientist *hoped/hired* to conduct the experiment *[was given a computer]*.
LI: Did the scientist hope something? **1) Yes** 2) No
LT: Did the scientist hire someone? 1) Yes **2) No**
SI: Was the scientist given a phone? 1) Yes **2) No**
ST: Was the scientist hired? **1) Yes** 2) No
79. The soldier *refused/ordered* to push the button *[had closed his eyes]*.
LI: Was the soldier pushed? 1) Yes **2) No**
LT: Was the soldier ordered? **1) Yes** 2) No
SI: Did the soldier refuse something? **1) Yes** 2) No
ST: Did the soldier order someone? 1) Yes **2) No**
80. The secretary *planned/permitted* to attend the meeting *[had made the coffee]*.
LI: Did the secretary plan something? **1) Yes** 2) No
LT: Did the secretary permit someone? 1) Yes **2) No**

SI: Was the secretary making tea? 1) Yes **2) No**
ST: Was the secretary permitted? **1) Yes** 2) No

81. The carpenter *intended/persuaded* to build the table *[had been given money]*.
LI: Was the carpenter built? 1) Yes **2) No**
LT: Was the carpenter persuaded? **1) Yes** 2) No
SI: Did the carpenter intend something? **1) Yes** 2) No
ST: Did the carpenter persuade someone? 1) Yes **2) No**
82. The executive *declined/implored* to sell the company *[was fired last week]*.
LI: Did the executive decline something? **1) Yes** 2) No
LT: Did the executive implore someone? 1) Yes **2) No**
SI: Was the executive sold? 1) Yes **2) No**
ST: Was the executive implored? **1) Yes** 2) No
83. The girlfriend *struggled/trusted* to keep the secret *[had threatened her lover]*.
LI: Was the girlfriend kept? 1) Yes **2) No**
LT: Was the girlfriend trusted? **1) Yes** 2) No
SI: Did the girlfriend struggle to do something? **1) Yes** 2) No
ST: Did the girlfriend trust someone? 1) Yes **2) No**
84. The astronomer *attempted/urged* to watch the comet *[was too busy reading]*.
LI: Did the astronomer attempt something? **1) Yes** 2) No
LT: Did the astronomer urge someone? 1) Yes **2) No**
SI: Was the astronomer watched? 1) Yes **2) No**
ST: Was the astronomer urged? **1) Yes** 2) No
85. The gangster *began/selected* to plan the robbery *[had no experience stealing]*.
LI: Was the gangster experienced? 1) Yes **2) No**
LT: Was the gangster selected? **1) Yes** 2) No
SI: Did the gangster begin something? **1) Yes** 2) No
ST: Did the gangster select someone? 1) Yes **2) No**
86. The astronaut *aspired/allowed* to touch the moon *[was wearing a helmet]*.
LI: Did the astronaut aspire to do something? **1) Yes** 2) No
LT: Did the astronaut allow someone? 1) Yes **2) No**
SI: Was the astronaut touched? 1) Yes **2) No**
ST: Was the astronaut allowed? **1) Yes** 2) No
87. The refugee *schemed/encouraged* to cross the border *[had bribed the guard]*.
LI: Was the refugee given a bribe? 1) Yes **2) No**
LT: Was the refugee encouraged? **1) Yes** 2) No
SI: Did the refugee scheme something? **1) Yes** 2) No
ST: Did the refugee encourage someone? 1) Yes **2) No**
88. The monk *decided/forced* to pray for peace *[was secretly a soldier]*.
LI: Did the monk decide something? **1) Yes** 2) No
LT: Did the monk force someone? 1) Yes **2) No**
SI: Was the monk praying for war? 1) Yes **2) No**
ST: Was the monk forced? **1) Yes** 2) No
89. The highschooler *decided/invited* to recite the poem *[had been very nervous]*.
LI: Was the highschooler confident? 1) Yes **2) No**
LT: Was the highschooler invited? **1) Yes** 2) No

SI: Did the highschooler decide something? **1) Yes** 2) No
ST: Did the highschooler invite someone? 1) Yes **2) No**

90. The dancer *tried/encouraged* to join the ballet *[was talented in music]*.
LI: Did the dancer try something? **1) Yes** 2) No
LT: Did the dancer encourage someone? 1) Yes **2) No**
SI: Was the dancer reprimanded? 1) Yes **2) No**
ST: Was the dancer encouraged? **1) Yes** 2) No
91. The pilot *hesitated/compelled* to change his course *[had seen the gun]*.
LI: Was the pilot safe? 1) Yes **2) No**
LT: Was the pilot compelled? **1) Yes** 2) No
SI: Did the pilot hesitate to do something? **1) Yes** 2) No
ST: Did the pilot compel someone? 1) Yes **2) No**
92. The dentist *planned/advised* to buy new equipment *[was sued by patients]*.
LI: Did the dentist plan something? **1) Yes** 2) No
LT: Did the dentist advise someone? 1) Yes **2) No**
SI: Was the dentist buying a car? 1) Yes **2) No**
ST: Was the dentist advised? **1) Yes** 2) No
93. The zookeeper *intended/urged* to train the animals *[had seen the circus]*.
LI: Was the zookeeper trained? 1) Yes **2) No**
LT: Was the zookeeper urged? **1) Yes** 2) No
SI: Did the zookeeper intend something? **1) Yes** 2) No
ST: Did the zookeeper urge someone? 1) Yes **2) No**
94. The mailman *agreed/implored* to deliver the mail *[was afraid of dogs]*.
LI: Did the mailman agree to do something? **1) Yes** 2) No
LT: Did the mailman implore someone? 1) Yes **2) No**
SI: Was the mailman delivered? 1) Yes **2) No**
ST: Was the mailman implored? **1) Yes** 2) No
95. The umpire *refused/bribed* to change his mind *[had been warned before]*.
LI: Was the umpire compliant? 1) Yes **2) No**
LT: Was the umpire bribed? **1) Yes** 2) No
SI: Did the umpire refuse something? **1) Yes** 2) No
ST: Did the umpire bribe someone? 1) Yes **2) No**
96. The accountant *declined/forced* to erase the numbers *[was arrested last week]*.
LI: Did the accountant decline something? **1) Yes** 2) No
LT: Did the accountant force someone? 1) Yes **2) No**
SI: Was the accountant having a party? 1) Yes **2) No**
ST: Was the accountant forced? **1) Yes** 2) No
97. The photographer *attempted/persuaded* to take the portrait *[had disliked the model]*.
LI: Was the photographer taken? 1) Yes **2) No**
LT: Was the photographer persuaded? **1) Yes** 2) No
SI: Did the photographer attempt something? **1) Yes** 2) No
ST: Did the photographer persuade someone? 1) Yes **2) No**
98. The nurse *struggled/ordered* to empty the bedpans *[was given a raise]*.
LI: Did the nurse struggle to do something? **1) Yes** 2) No
LT: Did the nurse order someone? 1) Yes **2) No**

SI: Was the nurse giving injections? 1) Yes **2) No**
ST: Was the nurse ordered? **1) Yes** 2) No

99. The hunter *began/selected* to track the moose *[had sold his gun]*.
LI: Was the hunter tracked? 1) Yes **2) No**
LT: Was the hunter selected? **1) Yes** 2) No
SI: Did the hunter begin something? **1) Yes** 2) No
ST: Did the hunter select someone? 1) Yes **2) No**

100. The waitress *hoped/hired* to serve the banquet *[was wearing a uniform]*.
LI: Did the waitress hope something? **1) Yes** 2) No
LT: Did the waitress hire someone? 1) Yes **2) No**
SI: Was the waitress served? 1) Yes **2) No**
ST: Was the waitress hired? **1) Yes** 2) No

101. The guard *decided/compelled* to free the prisoners *[had been paid off]*.
LI: Was the guard freed? 1) Yes **2) No**
LT: Was the guard compelled? **1) Yes** 2) No
SI: Did the guard decide something? **1) Yes** 2) No
ST: Did the guard compel someone? 1) Yes **2) No**

102. The embezzler *started/trusted* to confess his crime *[was leaving the country]*.
LI: Did the embezzler start something? **1) Yes** 2) No
LT: Did the embezzler trust someone? 1) Yes **2) No**
SI: Was the embezzler staying silent? 1) Yes **2) No**
ST: Was the embezzler trusted? **1) Yes** 2) No

103. The salesman *schemed/ordered* to sell bad cars *[had a guilty conscience]*.
LI: Was the salesman honest? 1) Yes **2) No**
LT: Was the salesman ordered? **1) Yes** 2) No
SI: Did the salesman scheme something? **1) Yes** 2) No
ST: Did the salesman order someone? 1) Yes **2) No**

104. The musician *aspired/allowed* to join the orchestra *[was not very good]*.
LI: Did the musician aspire to do something? **1) Yes** 2) No
LT: Did the musician allow someone? 1) Yes **2) No**
SI: Was the musician joining the circus? 1) Yes **2) No**
ST: Was the musician allowed? **1) Yes** 2) No

105. The referee *tried/permitted* to make the decision *[had to think fast]*.
LI: Was the referee asleep? 1) Yes **2) No**
LT: Was the referee permitted? **1) Yes** 2) No
SI: Did the referee try something? **1) Yes** 2) No
ST: Did the referee permit someone? 1) Yes **2) No**

106. The sailor *hesitated/ordered* to fire the torpedo *[was afraid of war]*.
LI: Did the sailor hesitate to do something? **1) Yes** 2) No
LT: Did the sailor order someone? 1) Yes **2) No**
SI: Was the sailor fired? 1) Yes **2) No**
ST: Was the sailor ordered? **1) Yes** 2) No

107. The librarian *agreed/invited* to give a speech *[had drunk too much]*.
LI: Was the librarian sober? 1) Yes **2) No**
LT: Was the librarian invited? **1) Yes** 2) No

SI: Did the librarian agree to do something? **1) Yes** 2) No
ST: Did the librarian invite someone? 1) Yes **2) No**

108. The runner *struggled/urged* to finish the race *[was awarded a medal]*.
LI: Did the runner struggle to do something? **1) Yes** 2) No
LT: Did the runner urge someone? 1) Yes **2) No**
SI: Was the runner swimming? 1) Yes **2) No**
ST: Was the runner urged? **1) Yes** 2) No

109. The driver *refused/implored* to stop the taxi *[had threatened the passenger]*.
LI: Was the driver easy-going? 1) Yes **2) No**
LT: Was the driver implored? **1) Yes** 2) No
SI: Did the driver refuse something? **1) Yes** 2) No
ST: Did the driver implore someone? 1) Yes **2) No**

110. The manager *decided/encouraged* to hire the man *[was impressed by him]*.
LI: Did the manager decide something? **1) Yes** 2) No
LT: Did the manager encourage someone? 1) Yes **2) No**
SI: Was the manager hired? 1) Yes **2) No**
ST: Was the manager encouraged? **1) Yes** 2) No

111. The electrician *tried/hired* to install the light *[had a good reputation]*.
LI: Was the electrician installing a switch? 1) Yes **2) No**
LT: Was the electrician hired? **1) Yes** 2) No
SI: Did the electrician try something? **1) Yes** 2) No
ST: Did the electrician hire someone? 1) Yes **2) No**

112. The prisoner *schemed/permitted* to escape from captivity *[was seized this morning]*.
LI: Did the prisoner scheme something? **1) Yes** 2) No
LT: Did the prisoner permit someone? 1) Yes **2) No**
SI: Was the prisoner free? 1) Yes **2) No**
ST: Was the prisoner permitted? **1) Yes** 2) No

113. The coach *planned/compelled* to forfeit the game *[had several sick players]*.
LI: Was the coach giving a speech? 1) Yes **2) No**
LT: Was the coach compelled? **1) Yes** 2) No
SI: Did the coach plan something? **1) Yes** 2) No
ST: Did the coach compel someone? 1) Yes **2) No**

114. The repairman *began/trusted* to fix the television *[was selling bad parts]*.
LI: Did the repairman begin something? **1) Yes** 2) No
LT: Did the repairman trust someone? 1) Yes **2) No**
SI: Was the repairman selling tools? 1) Yes **2) No**
ST: Was the repairman trusted? **1) Yes** 2) No

115. The model *declined/persuaded* to work long hours *[had to sign papers]*.
LI: Was the model on vacation? 1) Yes **2) No**
LT: Was the model persuaded? **1) Yes** 2) No
SI: Did the model decline something? **1) Yes** 2) No
ST: Did the model persuade someone? 1) Yes **2) No**

116. The engineer *intended/selected* to build the bridge *[was paid very well]*.
LI: Did the engineer intend something? **1) Yes** 2) No
LT: Did the engineer select someone? 1) Yes **2) No**

SI: Was the engineer underpaid? 1) Yes **2) No**
ST: Was the engineer selected? **1) Yes** 2) No

117. The chauffeur *aspired/allowed* to drive the limousine *[had wrecked two cars]*.
LI: Was the chauffeur a good driver? 1) Yes **2) No**
LT: Was the chauffeur allowed? **1) Yes** 2) No
SI: Did the chauffeur aspire to do something? **1) Yes** 2) No
ST: Did the chauffeur allow someone? 1) Yes **2) No**

118. The protestor *hesitated/forced* to stop the march *[was threatened by observers]*.
LI: Did the protestor hesitate to do something? **1) Yes** 2) No
LT: Did the protestor force someone? 1) Yes **2) No**
SI: Was the protestor stopped? 1) Yes **2) No**
ST: Was the protestor forced? **1) Yes** 2) No

119. The spy *started/advised* to tell the truth *[had lied for years]*.
LI: Was the spy starting to lie? 1) Yes **2) No**
LT: Was the spy advised? **1) Yes** 2) No
SI: Did the spy start something? **1) Yes** 2) No
ST: Did the spy advise someone? 1) Yes **2) No**

120. The florist *hoped/invited* to decorate the church *[was good at weddings]*.
LI: Did the florist hope something? **1) Yes** 2) No
LT: Did the florist invite someone? 1) Yes **2) No**
SI: Was the florist decorated? 1) Yes **2) No**
ST: Was the florist invited? **1) Yes** 2) No

Appendix J: Filler Sentences

Filler items used in all Experiments

The filler items are presented with questions (and correct answer in **bold**) where applicable. The items in the FPP and FQP conditions were used in the pre-testing of stimuli. All conditions excluding the last 40 items in FS were used in the Experiment 1 and all items were used in Experiment 2. Filler items were presented in all pseudorandomized lists (i.e. not counterbalanced).

Fillers Prepositional Phrase (FPP)

1. After repeated losses the gambler was very unhappy.
   Q: The gambler was excited. **1) True** 2) False
2. After thirty minutes the impatient audience threw tomatoes.
   Q: The audience threw cabbage. **1) True** 2) False
3. Among the tourists gulls dove to snatch food.
   Q: The children snatched food. **1) True** 2) False
4. During his breaks Josh ran errands.
   Q: Josh ran a marathon. **1) True** 2) False
5. During the commercials Sharon painted her nails.
   Q: Sharon painted her house. **1) True** 2) False
6. Given her circumstances Susan accepted the first offer.
   Q: Susan denied the first offer. **1) True** 2) False
7. In the mornings Jack always watered his lawn.
   Q: Jack never watered his lawn. **1) True** 2) False
8. On the weekends Karen liked to sleep in.
   Q: Karen hated sleeping in. **1) True** 2) False
9. Over the bushes the dog caught a Frisbee.
   Q: The dog caught the tennis ball. **1) True** 2) False
10. Over the buses a stuntman rode a motorcycle.
    Q: The stuntman jumped over a canyon. **1) True** 2) False
11. Between the cities an expressway was built.
    Q: An expressway was built between the cities. 1) True **2) False**
12. Over their heads the batter hit a home-run.
    Q: The batter hit a home-run. 1) True **2) False**
13. Under their umbrellas the beach-goers avoided the sun.
    Q: The beach-goers avoided the sun. 1) True **2) False**
14. Between his classes Isaac read a book.
    Q: Isaac read a book. 1) True **2) False**
15. Under his sneakers Sam accidentally crushed a snail.
    Q: Sam crushed a snail. 1) True **2) False**
16. On the school grounds the principal forbade vulgar language.
    Q: The principal banned cursing. 1) True **2) False**
17. Among his teammates Eric looked short.
    Q: Eric was shorter than his teammates. 1) True **2) False**

18. After her surgery Anita slept for two days.
    Q: Anita had a vacation. 1) True **2) False**
19. Above the porch a robin built a nest.
    Q: The robin built a nest. 1) True **2) False**
20. Above the clouds an airplane flew to Hawaii.
    Q: The airplane flew to Hawaii. 1) True **2) False**

Filler Quantifier Plural (FQP)

1. Five shops ordered the new products in the spring.
   Q: Did five shops order the new products? 1) Yes **2) No**
2. Each woman visited the fruit stands on Wednesday.
   Q: Did each woman visit the beauty salon? **1) Yes** 2) No
3. Four toddlers banged the toy pots in the playroom.
   Q: Did four toddlers bang the stuffed toys? **1) Yes** 2) No
4. Many deer jumped the new fences at the farm.
   Q: Did many deer jump the new hedges? **1) Yes** 2) No
5. Most stores extend their business hours at Christmas time.
   Q: Did most stores extend the special sales? **1) Yes** 2) No
6. Most gardeners water their house plants in the evening.
   Q: Do most gardeners water house plants in the morning? **1) Yes** 2) No
7. Most bacteria killed the captive lizards in the zoo.
   Q: Did most bacteria kill the monkeys? **1) Yes** 2) No
8. Several tourists admired the jumping dolphins from the shore.
   Q: Did several tourists admire the fireworks? **1) Yes** 2) No
9. Many pages addressed the null findings in the manuscript.
   Q: Did many pages address the significant findings? **1) Yes** 2) No
10. All spectators heard the national anthem before the game.
    Q: Did all spectators hear the VIP? **1) Yes** 2) No
11. Four actors attended the film openings in costume.
    Q: Did four actors attend the film openings? 1) Yes **2) No**
12. Most scouts reviewed the young athletes at the college.
    Q: Did most scouts review the young athletes? 1) Yes **2) No**
13. Many photographs covered the painted walls in the family home.
    Q: Did many photographs cover the walls? 1) Yes **2) No**
14. Many curators admired the native sculptures in the gallery.
    Q: Did many curators admire the native sculptures? 1) Yes **2) No**
15. Most families attended the memorial services on Remembrance day.
    Q: Did most families attend the memorial services? 1) Yes **2) No**
16. Most lobbyists opposed the policy revisions during the press conference.
    Q: Did most lobbyists oppose the policy revisions? 1) Yes **2) No**
17. All students completed the easy assignments before the deadline.
    Q: Did all students complete the assignments before the deadline? 1) Yes **2) No**

18. Several people thanked the local heroes after the fire.
    Q: Did several people thank the local heroes? 1) Yes **2) No**
19. Three friends attended the yoga classes in the fall.
    Q: Did three friends attend the yoga classes? 1) Yes **2) No**
20. Several couples walked the sandy shores at sunset.
    Q: Did several couples walk along the shores? 1) Yes **2) No**
21. Each resident left the nursing home for the weekend.
    Q: Did each resident leave the trailer park for the weekend? **1) Yes** 2) No
22. Five pucks missed the hockey net during the warm-up.
    Q: Did five pucks land in the net during the warm-up? **1) Yes** 2) No
23. Many manuscripts reached the editor's desk after the deadline.
    Q: Did many manuscripts reach the editor before the deadline? **1) Yes** 2) No
24. Many investors lost a small fortune during the depression.
    Q: Did many investors lose a small fortune during the depression? 1) Yes **2) No**
25. Seven plants lined the garden path on the farm.
    Q: Did seven plants line the garden path? 1) Yes **2) No**
26. Each pirate examined the treasure map before the storm.
    Q: Did each pirate examine the sail? **1) Yes** 2) No
27. Seven campers left the roaring fire after the ghost story.
    Q: Did seven campers leave the fire? 1) Yes **2) No**
28. Several newspapers reported the political scandal before the election.
    Q: Did several newspapers cover up the political scandal? **1) Yes** 2) No
29. Several kittens shared the small cage in the animal shelter.
    Q: Did several kittens share the cage? 1) Yes **2) No**
30. Several clients skipped the welcome brunch on Monday.
    Q: Did several clients skip dinner? **1) Yes** 2) No
31. Most athletes represented the United Kingdom in the race.
    Q: Did most athletes represent France in the race? **1) Yes** 2) No
32. Six bottles filled the wooden crate in the cellar.
    Q: Did six bottles fill the crate in the cellar? 1) Yes **2) No**
33. Several employees visited the grocery store after work.
    Q: Did several employees visit the pharmacy? **1) Yes** 2) No
34. Six trees had the new disease in the orchard.
    Q: Did six trees have the new disease? 1) Yes **2) No**
35. Several exhibits featured an interactive element in the museum.
    Q: Did several exhibits feature an interactive element? 1) Yes **2) No**
36. Several comedians mentioned the celebrity's death in their monologues.
    Q: Did several comedians mention the death in their monologues? 1) Yes **2) No**
37. Three jocks asked the head cheerleader to the prom.
    Q: Did three jocks ask the cheerleader to the prom? 1) Yes **2) No**
38. All co-workers attended the staff party at Christmas.
    Q: Did all co-workers attend the game at Christmas? **1) Yes** 2) No

39. All fish survived the long winter in the pond.
    Q: Did all fish die in the winter? **1) Yes** 2) No
40. All cadets saluted the prime minister during the tour.
    Q: Did all cadets salute the statue during the tour? **1) Yes** 2) No
41. All associates discussed work after the meal.
    Q: The students discussed work. **1) True** 2) False
42. Each explorer wanted to return home after the voyage.
    Q: The children wanted to go home. **1) True** 2) False
43. Many athletes were suspended after the fight.
    Q: The coaches were suspended. **1) True** 2) False
44. Most musicians hosted a party after the concert.
    Q: The graduates hosted a party. **1) True** 2) False
45. Several spectators lost interest after the twelfth goal.
    Q: The spectators were very interested in the game. **1) True** 2) False
46. Many girls rode horses at the farm.
    Q: The girls rode a bus. **1) True** 2) False
47. Most writers were picketing because of the strike.
    Q: The teachers were picketing. **1) True** 2) False
48. All pedestrians walked cautiously because of the construction.
    Q: The pedestrians walked cautiously. 1) True **2) False**
49. Many youths went bowling because they were bored.
    Q: The youths went to the movies. **1) True** 2) False
50. Each student cleared their desk before the test.
    Q: The students had a test. 1) True **2) False**
51. Many comedians performed new material before the audience.
    Q: The musicians played a new song. **1) True** 2) False
52. Each girl was working hard during gym class.
    Q: The girls were lazy in gym class. **1) True** 2) False
53. Each winner thanked their fans during the awards show.
    Q: The winners thanked their fans. 1) True **2) False**
54. Most preschoolers whispered about toys during nap time.
    Q: The preschoolers whispered about toys. 1) True **2) False**
55. Each driver felt frustrated during rush hour.
    Q: The drivers were frustrated. 1) True **2) False**
56. All people searched for safety during the earthquake.
    Q: The people searched for safety. 1) True **2) False**
57. All twins fooled their teachers in primary school.
    Q: The twins fooled their teachers. 1) True **2) False**
58. Each worker replaced the beams under the bridge.
    Q: The workers replaced the beams. 1) True **2) False**
59. All citizens were unhappy under the tyrant's rule.
    Q: The citizens were unhappy. 1) True **2) False**

60. Each child played baseball under the hot sun.
    Q: The children played baseball. 1) True **2) False**

Filler Irregular Plural (FIP)

1. The player lost his front teeth in the game.
   Q: Did the player lose his shoe? 1) Yes **2) No**
2. Jane pointed at the women in the audience.
   Q: Did Jane point at the sunset? 1) Yes **2) No**
3. The explosion startled the firemen during the night.
   Q: Did the explosion startle the animals? 1) Yes **2) No**
4. The couple fed the geese in the park.
   Q: Did the couple feed the deer? 1) Yes **2) No**
5. Stephanie had injured her feet during the try-out.
   Q: Did Stephanie injure her arm? 1) Yes **2) No**
6. Jeff spotted the new people in the hallway.
   Q: Jeff spotted the Easter egg. 1) True **2) False**
7. Claire found the busy saleswomen after an hour.
   Q: Claire found the treasure chest. 1) True **2) False**
8. The waiter served the businesswomen after his break.
   Q: The waiter served the tall man. 1) True **2) False**
9. The teenagers cursed the policemen after the incident.
   Q: The teenagers cursed the weather. 1) True **2) False**
10. The bartender served the men with a smile.
    Q: The bartender served the stout woman. 1) True **2) False**

Filler Irregular Singular (FIS)

1. The shark frightened the fisherman on the open water.
   Q: The shark frightened the fisherman. **1) True** 2) False
2. The children built the snowman in the schoolyard.
   Q: The children built the snowman. **1) True** 2) False
3. The cat caught the mouse in the basement.
   Q: The cat caught the mouse. **1) True** 2) False
4. Susie recently moved the cactus into the kitchen.
   Q: Susie recently moved the cactus. **1) True** 2) False
5. The scientist located the nucleus with the microscope.
   Q: The scientist located the nucleus. **1) True** 2) False
6. The professor reviewed the thesis in his office.
   Q: The professor reviewed the thesis. **1) True** 2) False
7. The wedding planner averted the crisis with a clever solution.
   Q: The wedding planner avoided the crisis. **1) True** 2) False
8. The astronomer reported the phenomenon in a scientific magazine.
   Q: The astronomer reported the phenomenon. **1) True** 2) False

9. The statistician conducted the analysis with the software bundle.
   Q: The statistician conducted the analysis. **1) True** 2) False
10. The computer presented the stimulus to the participant.
    Q: The computer presented the stimulus. **1) True** 2) False

Other Filler Stimuli (FS)

Only items 1-70 were in Experiment 1 whereas all items were included in Experiment 2.

1. The performer ate the bat wings in the circus show.
   Q: Did the performer eat fire? 1) Yes **2) No**
2. The teacher rewarded her best students before the break.
   Q: Did the teacher punish her best students? 1) Yes **2) No**
3. The president assisted the car companies during the recession.
   Q: Did the president ignore the car companies during the recession? 1) Yes **2) No**
4. The newscaster announced the winning numbers in the evening.
   Q: Did the newscaster omit the winning numbers? 1) Yes **2) No**
5. The printer smudged the blank lines while printing.
   Q: Did the printer smudge the coloured lines? 1) Yes **2) No**
6. The cowboy received the new boots on his birthday.
   Q: Did the cowboy receive new stirrups? 1) Yes **2) No**
7. The engineer inspected the tank engines after the crash.
   Q: Did the engineer inspect the submarines? 1) Yes **2) No**
8. The painter used his new brushes in the competition.
   Q: Did the painter use new techniques? 1) Yes **2) No**
9. The man lost his car keys in the bar.
   Q: Did the man lose his glasses? 1) Yes **2) No**
10. The mechanic fixed the wiper blades before the storm.
    Q: Did the mechanic fix the wiper blades? **1) Yes** 2) No
11. The businessmen built the new factories in Indonesia.
    Q: Did the businessman build new factories? **1) Yes** 2) No
12. The mother found their lost toys in the car.
    Q: Did the mother find their lost toys? **1) Yes** 2) No
13. The negotiators revised the latest offers at midnight.
    Q: Did the negotiators revise the latest offers? **1) Yes** 2) No
14. The truck passed the slow cars before the accident.
    Q: Did the truck pass the slow cars? **1) Yes** 2) No
15. The politician discussed the trade agreements during the press release.
    Q: Did the politician discuss the trade agreements? **1) Yes** 2) No
16. The manager chastised the slow servers after the shift.
    Q: Did the manager chastise the slow servers? **1) Yes** 2) No
17. The owner scolded the line chefs during the dinner rush.
    Q: Did the owner scold the line chefs? **1) Yes** 2) No
18. The coach cut the weakest players after the loss.
    Q: Did the coach cut the weakest players? **1) Yes** 2) No

19. The lawyer revealed the surprise witnesses during the trial.
    Q: Did the lawyer reveal the surprise witnesses? **1) Yes** 2) No
20. The doctor prescribed the new painkillers after the information session.
    Q: Did the doctor prescribe the new painkillers? **1) Yes** 2) No
21. The company advertised the special offer in the newspaper.
    Q: Did the company advertise the special offer? **1) Yes** 2) No
22. The twins wore the same outfit during the recital.
    Q: Did the twins wear the same outfit? **1) Yes** 2) No
23. The doctor knew the due date for the pregnancy.
    Q: Did the doctor know the due date? **1) Yes** 2) No
24. The workers liked the new foreman at the plant.
    Q: Did the workers like the new lunchroom? 1) Yes **2) No**
25. The guards saluted the royal couple in the motorcade.
    Q: Did the guards salute the veterans? 1) Yes **2) No**
26. The friends saw the new movie on Tuesday evening.
27. The custodian found the lost phone under the bench.
28. The cafeteria offered a vegetarian menu on weekends.
29. The man ordered the famous dish at the restaurant.
30. The woman began a new diet for the new year.
31. The secretary visited the office kitchen before leaving.
32. The couple booked their first vacation in the winter.
33. The Smiths had the biggest house in town.
34. The bartender had a rough night at the bar.
35. The hobbyist inherited the coin collection in the spring.
36. The hairdresser opened a new salon in Paris.
37. The teacher used an electronic board in the classroom.
38. The boy pitched a small tent in the forest.
39. The retiree visited the sunny south in the winter.
40. The bride carried the large bouquet down the aisle.
41. George wants to open a bank account.
42. Jenny played volleyball on the sandy beach.
43. She swept the porch with a broom.
44. The old lady sat in her chair.
45. Mark saw a clown at the circus.
46. He dipped his donut into his coffee.
47. The sad film made the woman cry.
48. Janice knocked on her neighbour's front door.
49. The campers cooked dinner over a fire.
50. A mansion is a very big house.
51. The plane crashed on a tropical island.
52. She unlocked the car with a key.
53. John sliced the tomato with a knife.
54. Marie went outside to mow the lawn.

55. Tim walked his dog on a leash.
56. Michael borrowed a novel from the library.
57. The businessman was late for a meeting.
58. There are 60 seconds in a minute.
59. The bank robber escaped with the money.
60. Mom baked the bread in the oven.
61. Mary raked the leaves into a pile.
62. Jenny served the food on a plate.
63. The hunter heard the lion's mighty roar.
64. The leader of Santa's reindeer is Rudolph.
65. Yesterday I ordered pasta with alfredo sauce.
66. The hockey player laced up his skate.
67. Michelle stirred the sauce with a spoon.
68. Donna bought bread at the corner store.
69. Peter is short but Bob is tall.
70. The police officer gave Jack a ticket.
71. Broccoli and carrots are types of vegetable.
72. Terry hung the picture on the wall.
73. The month following March is April.
74. Mitch likes to eat cheddar cheese.
75. They ordered chocolate cake for dessert.
76. We live on the planet earth.
77. She turned off all the lights.
78. We made a great homecooked meal.
79. July and August are hot months.
80. He likes listening to classical music.
81. The sailboats weren't getting enough wind.
82. The professors were working over the holidays.
83. The cooks were busy in the kitchen.
84. The bats were taking a day-time nap.
85. The bees were collecting pollen.
86. The suspects weren't afraid of the officers.
87. The students were solving a math problem.
88. The cats were stretching their legs.
89. The brides were hoping to find something blue.
90. The teachers were relaxing for the holiday.
91. The guards were locking the doors.
92. The teens were lying through their teeth.
93. The researchers were outlining their research goals.
94. The detectives were contemplating the evidence.
95. The exterminator was aiming at the corners.
96. The carpenter was measuring very carefully.
97. The waitress was writing it on her pad.

98. The toad was looking to catch a bug.
99. The cat was chasing a mouse.
100. The mother was looking for peaches.
101. The son was excited to start the fire.
102. The piano was sounding better already.
103. The daughter was amused by the joke.
104. The house was infested with termites.
105. A virus was damaging the hard drive.
106. A package was arriving on time.
107. The bird was flapping its wings loudly.
108. The wrestler was straining for another rep.
109. The sky became really cloudy suddenly.
110. The player was talking about the game.

Appendix K: Word frequency comparisons for Experiment 1

Controlling for word frequency

Control and anomalous words for the critical items in Experiment 1 were controlled for word frequency by comparing the log word frequencies in a paired samples *t*-test ($\alpha = .05$). No significant difference was found in log word frequencies between control and anomalous items, $t(159) = .625$, $p = .533$.

Calculating log word frequency

Log word frequency was calculated using the raw word frequency score from SUBTLEX using the following formula:

$$Log\ WF = \log(Raw\ WF + 1) \qquad \textit{Equation L1}$$

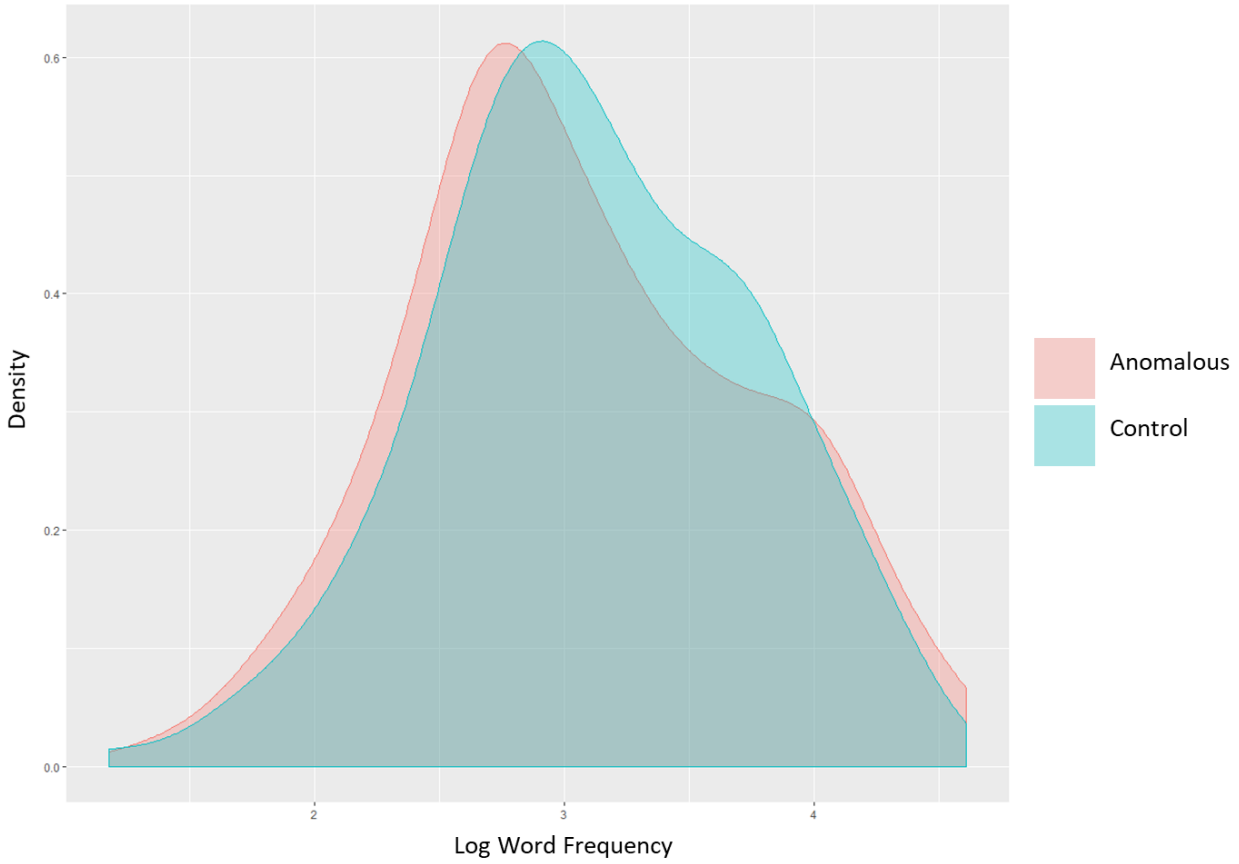


Figure L1. Density plot of log word frequencies for anomalous and control words.

Appendix L: Mix Protocol for Pseudorandomization

Protocol for Pseudorandomization

A tab delimited text file was prepared for each list with the following columns: A unique ID, condition name, item type (experiment vs filler). First, the mix utility was used to randomize the file without any constraints and the file was then sorted by condition to randomly assign an even number of items from each condition to each block. This file was then exported again as a tab delimited text file, separated into blocks with the block command and randomized using the script below.

Constraints

The lists Pseudorandomization was constrained such that:

- no items from the experimental conditions were repeated
- no more than two experimental items were ever presented in a row
- the first five items of the experiment were not experimental items
- the first three and last two items of each block were not experimental items

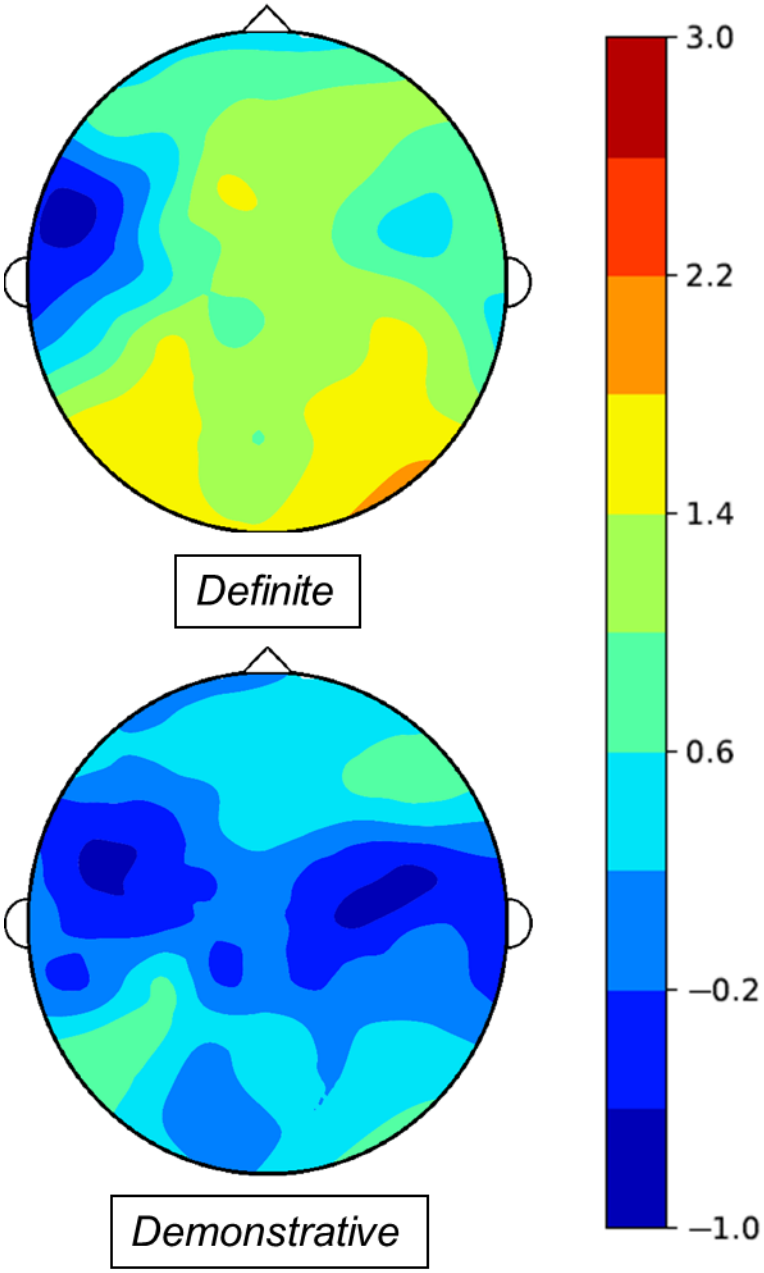
Mix Script

```
ItemFile        [INPUT FILE NAME]

LineType        expline 6       Exp
Property        Type    6
Property        Condition       4

BlockLineBan one        expline 1       2       3       4       5       54      55
BlockLineBan two        expline 1       2       3       54      55
BlockLineBan three      expline 1       2       3       54      55
BlockLineBan four       expline 1       2       3       54      55
BlockLineBan five       expline 1       2       3       54      55
BlockLineBan six        expline 1       2       3       54      55

Constraint      Type    MaxRep      Exp     2
Constraint      Condition       MaxRep      [ExpCond1]  1
Constraint      Condition       MaxRep      [ExpCond2]  1
Constraint      Condition       MaxRep      [ExpCond3]  1
Constraint      Condition       MaxRep      [ExpCond4]  1

OutputFile      [OUTPUT FILE NAME]
Block one rand
Block two rand
Block three rand
Block four rand
Block five rand
Block six rand
```

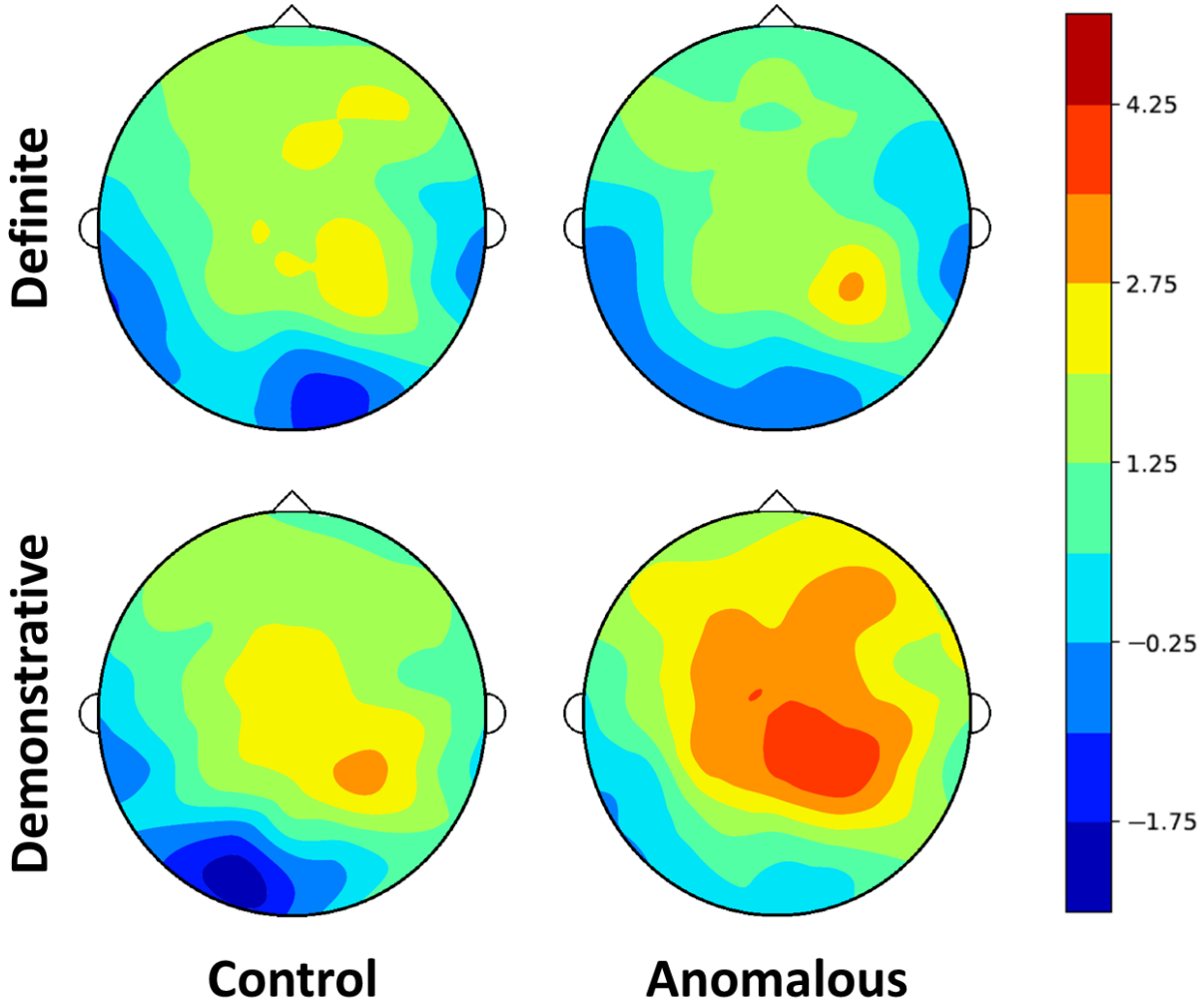
Appendix N: Topographic maps for all ERP effects in Experiment 1 and 2

Experiment 1

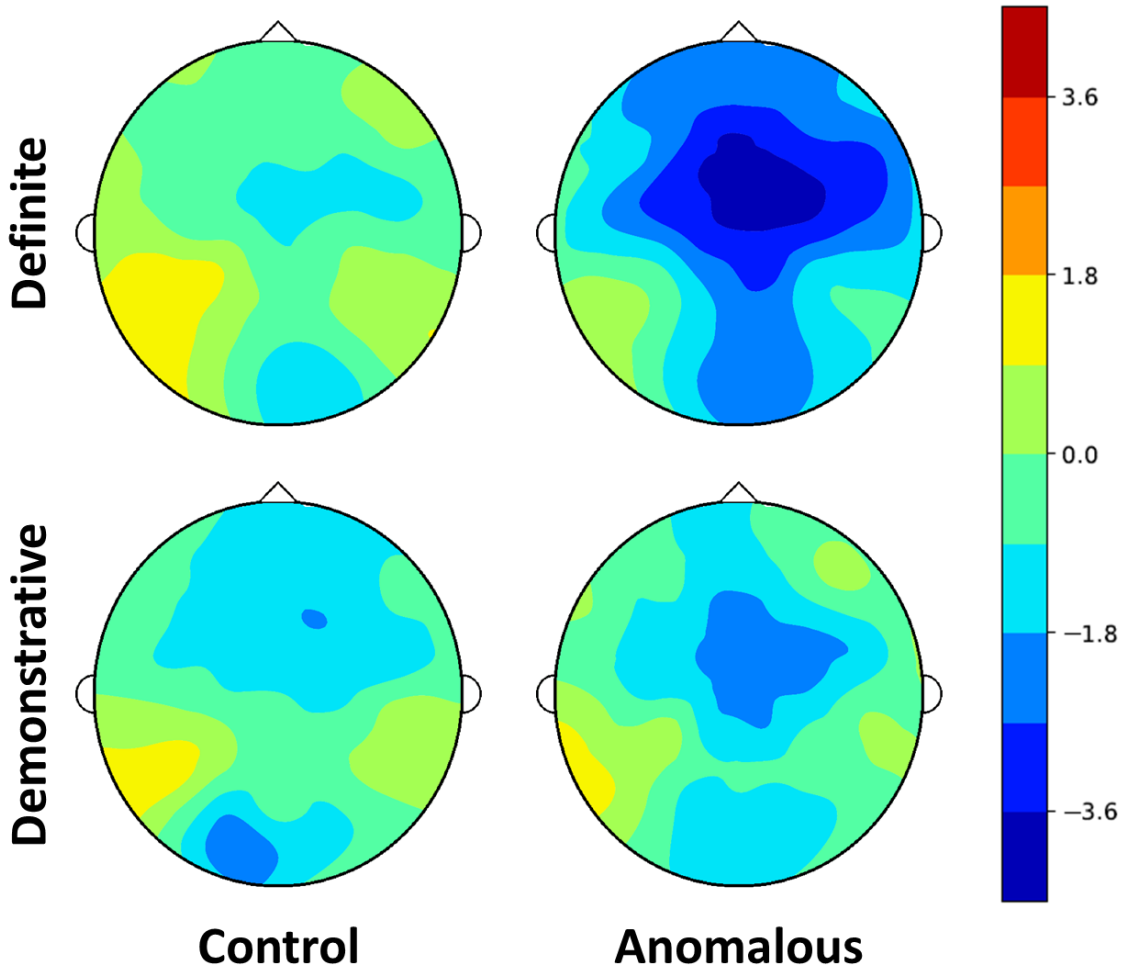
Determiner, 300-500ms. The negative going waveform observed at the determiner from 300-500ms appears to be distributed across the whole head for the demonstrative condition but is less negative in amplitude and localized to the left anterior region in the definite condition.



Critical word, 100-300ms The P200 amplitude difference observed in the demonstrative anomalous condition appears to be a slightly right lateralized, anterior-central effect.

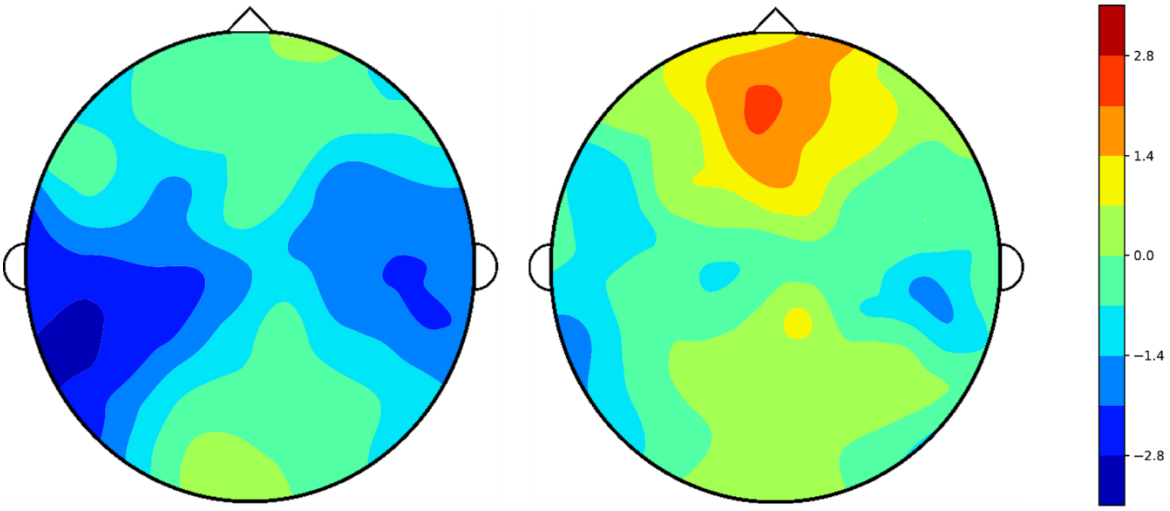


Critical word, 300-500ms The N400 effect observed primarily in the definite anomalous condition appears to be slightly right lateralized and maximal centrally.



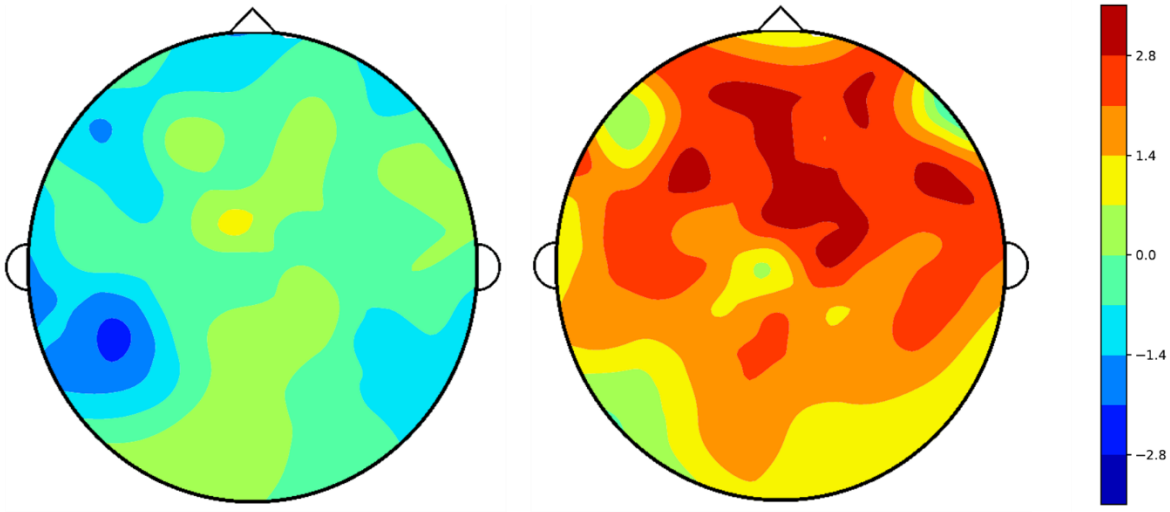
Experiment 2

Infinitive, 500-700ms. The P600 effect observed for the subcategorization violation appears to have a frontal distribution.



The broker planned ***to…*** The broker persuaded ***to…***

Auxiliary, 500-700ms. The P600 effect observed for the phrase structure constraint violation appears to have a more distributed but still frontal distribution. It is also greater in amplitude than the P600 for the subcategorization violation.



…persuaded to sell the stock **was**… …planned to sell the stock **was**…

Appendix O: Analysis of Comprehension Question Accuracy in Experiment 2

The factors for the comprehension question accuracy in critical items for Experiment 2 are in a 2x2x2 design: length (short vs long) by verb type (transitive vs intransitive) by question type (active vs passive). Recall the questions could be: “Did the broker persuade someone?” (Active) or “Was the broker persuade” (Passive). The accuracy for these conditions are listed below:

Length	Verb Type	Question Type	Accuracy
Long	Intransitive	Active	82.67%
		Passive	88.33%
	Transitive	Active	83.33%
		Passive	86.67%
Short	Intransitive	Active	98.33%
		Passive	97.33%
	Transitive	Active	78.67%
		Passive	95.00%

Note that accuracy is lower across the board for longer sentences. Accuracy is lower for the active than for the passive questions. Additionally, the accuracy in the short transitive condition was much lower for active than for passive questions. All differences were significant (p’s < .05) in simultaneous multiple logistic regression.

Appendix P: Analysis of Sentence Final ERPs in Experiment 2

N400 at the sentence final position for short conditions. A repeated measures 2-way ANOVA was conducted at final word of short sentences on mean voltage at the traditional N400 time window (300-500ms) for the independent variables of verb type (transitive vs intransitive) and electrode site (Fz, FCz, Cz, CPz, Pz). No significant or marginally significant main effects or interaction were observed ($p > .406$)

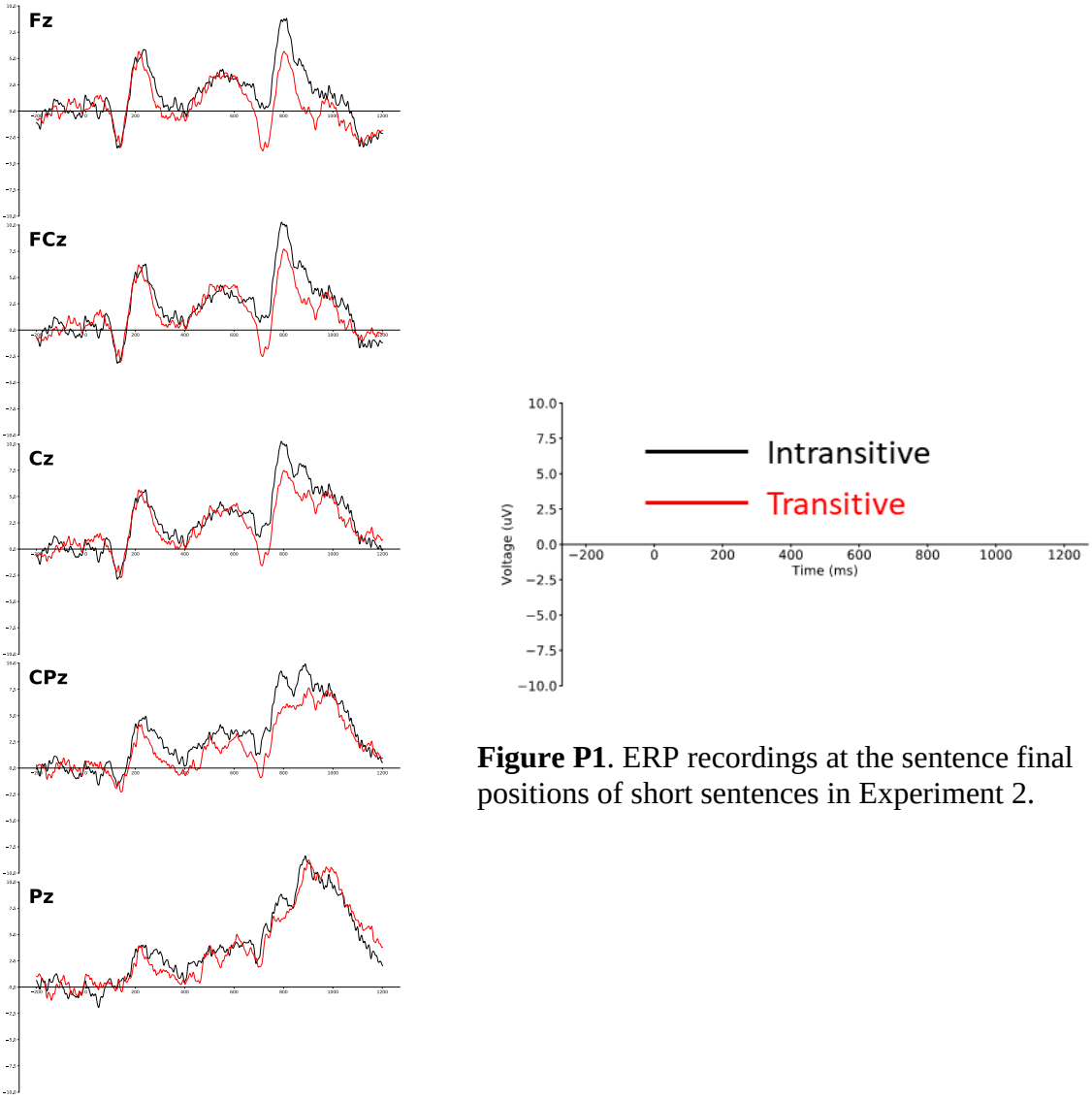
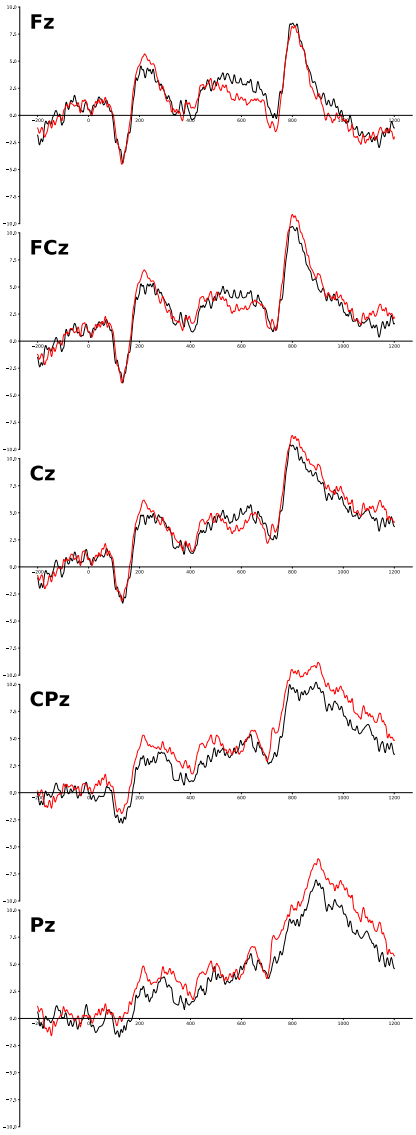


Figure P1. ERP recordings at the sentence final positions of short sentences in Experiment 2.

N400 at the sentence final position for long conditions. A repeated measures 2-way ANOVA was conducted at final word of long sentences on mean voltage at the traditional N400 time window (300-500ms) for the independent variables of verb type (transitive vs intransitive) and electrode site (Fz, FCz, Cz, CPz, Pz). No significant or marginally significant main effects were observed ($p > .291$). A trend to significance was observed in the verb type by electrode interaction, $F(4, 32) = 1.925$, $MSE = 1.479$, $p = .167$, $\eta_p^2 = .194$. However, this appears to be driven by differences between electrodes within the same condition.



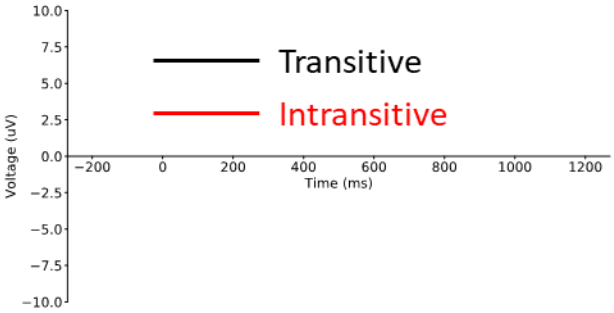


Figure P2. ERP recordings at the sentence final positions of long sentences in Experiment 2.

Discussion. No differences were observed in wave forms for the N400 time window at the sentence final position for short or long sentences. The prediction to replicate the end of sentence N400 effect for unacceptable sentence was not confirmed. This end of sentence N400 effect to unacceptable sentences was observed both by Osterhout and Holcomb (1992) where a metalinguistic acceptability task was employed and by Hagoort and colleagues (1993) where there was no task. This suggests that either the asking of questions abolishes this N400 effect, the small sample size resulted in insufficient power to replicate this effect or because the participants in the present work differ from those 25 years ago. Following completion of Experiment 2, this experiment will be conducted again but without any task on the critical sentences to further explore this failure to replicate.