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This is a Question? Prosody, Social Communication, and the N400 Effect

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Abstract

The present study examined electrophysiological responses, specifically the N400 effect, in typically developing adults (N = 37) to spoken questions and statements that contained prosodically congruous and prosodically incongruous contours. In particular, prosodic incongruities were created by cross-splicing the audio signal so that questions ended with a decreasing pitch and statements ended with an increasing pitch. Further, the study examined the extent to which the size of an individual's N400 effect was related to an applied score of social communication as measured by the Social Responsiveness Scale, Second Edition. Results revealed no main effect of sentence congruency, but a main effect of sentence type (question vs. statement). Implications for future research are discussed.

THIS IS A QUESTION? PROSODY, SOCIAL COMMUNICATION, AND THE N400
EFFECT

by

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Communication is the imparting or exchanging of information. Information can be communicated in many ways including visually through images (Machin, 2014), behaviorally through non-verbal gestures (Hinde, 1972), and verbally through spoken language (Searle, 1972). Spoken language, in particular, is inherently social in nature in that it requires both a speaker and a listener in order to function properly. As the function of spoken language is to communicate with others (Searle, 1972), there is important link between how adequately a person interprets spoken language and the extent to which they can capably engage in social communication. Understanding a speaker requires the rapid integration of multiple linguistic cues, which poses a challenge for the ways researchers can study the processes through which spoken language comprehension occurs. Measures with precise temporal resolution, such as electrophysiology, allow researchers to study the moment-to-moment processing of spoken language, affording investigations of how spoken language comprehension develops and how break-downs in these processes may contribute to subsequent social communication difficulties. The proposed study aims to examine the relationship between one aspect of spoken language comprehension, *how* an utterance is said, and social communication in order to test whether objective measures of spoken language processing are predictive of more subjective measures of social communication skills.

Pragmatics, Prosody and Social Communication

The study of language in a social context is known as *pragmatics*. Information conveyed through spoken language is much richer than the grammar (syntax) and word meanings (semantics) of the expression on their own (Leech, 1983). Most sentences are produced and heard within the context of preceding conversation, and how the speaker delivers an utterance

influences the listener's interpretation (Leech, 1983). In psycholinguistics, the term that refers to how a sentence is spoken is *prosody*. In a broad sense, prosody refers to features of the speech stream such as pitch, tempo, volume, and pauses (Cutler, Dahan, & von Donselaar, 1997). Together, these features of language are called *suprasegmental* features, indicating that they are above the segmental aspects of the sentence, such as the individual words or its syntax (Cutler et al., 1997).

Prosody plays an important role in the link between spoken language comprehension and social communication (Paul, Shriberg, et al., 2005). For example, a listener must make use of the prosodic contours of an utterance in order to understand that a speaker is saying something sarcastically. In typically developing populations, language comprehension and social communication abilities develop simultaneously (Miller, 1951), making it difficult to unpack their relationship. Research including populations that are atypically developing, such as individuals with autism spectrum disorder (ASD), diversifies the types of developmental trajectories studied and expands the range of social communication skills so that the relationship between them can be further examined. For example, many individuals with ASD achieve basic language abilities (e.g., vocabulary and grammar) that are indistinguishable from those of their neurotypical peers, yet still experience difficulties with social communication (Kelley, Paul, Fein, & Naigles, 2006). Research on prosodic processing in children (mean age = 8 years) with and without ASD, for example, has revealed that children's ability to recognize a speaker's emotion through prosodic cues is positively correlated with social communication skills, indicating that children who are better at using prosodic cues have better social communication skills (Wang & Tsao, 2015). Furthermore, in adults (mean age = 21 years) with high-functioning autism and Asperger syndrome, the ability to successfully produce prosodic cues in speech is

positively correlated with communication and socialability ratings (Paul, Shriberg, et al., 2005; Paul, Augustyn, Klin, & Volkmar, 2005). These studies demonstrate that an individual's social communication skills are related to their ability to process the prosodic features of an utterance; however, understanding the ways in which interpreting the prosodic contours of an utterance influences one's capacity for successful social communication remains unresolved.

The prosodic features of an utterance can carry out various different functions in spoken language comprehension including a *lexical* function, aiding in word recognition (Cutler & Carter, 1987), a *structural* function, aiding in syntax computation (Price, Ostendorf, Shattuck-Hufnagel, & Fong, 1991), an *emotional* function, indicating the attitude of the speaker (Scherer, Banse, & Wallbott, 2001), and a *modal* function, marking the type of speech act (Bassano & Mendes-Maillochon, 1994; Eady & Cooper, 1986). While each of these functions facilitate social communication in unique ways, the present investigation focuses on one function of prosody, the modal function, as a first step in understanding how prosodic cues contribute to social communication capacities. Prosody serves a modal function when a speaker indicates whether an utterance is a question or a statement through prosodic cues (Bolinger, 1998). Interpreting whether a speaker is making a statement or asking a question has implications for how the interlocutor should respond in a social context, and successful social communication would be dependent on the listener understanding the speaker's intent.

In many languages, including English, when the pitch contour of a sentence falls at the end, it indicates a statement; whereas when the pitch contour of the sentence rises at the end, it indicates a yes/no question (Bolinger, 1998; Pike, 1945). For example, if the pitch at the end of the sentence, *"You want to go to lunch"* falls at the end, the utterance would be interpreted as a declarative statement. If, however, the pitch at the end of the utterance contains an upsweep,

"You want to go to lunch?" the sentence is interpreted as an interrogative question (Uldall, 1962; Wales & Taylor, 1987). Though the words and word order are the same in both of these sentences, they are interpreted differently depending on the pitch contours.

As with any aspect of spoken language, prosody unfolds, is processed, and interpreted at an incredibly rapid rate. Originally, psycholinguistic research on prosody operationalized processing using end-state measurements such response time, ratings of sentence appropriateness, and familiarity judgements (Cutler et al., 1997). Though these measures were sensitive to experimental manipulations of prosody, they were not able to answer more detailed questions about the time course of prosodic processing. Understanding the time course of prosodic processing will afford a more complete exploration into the remarkable way that listeners quickly integrate the many different speech cues to arrive at an understanding of what the speaker was communicating. To do this, online measures that afford fine-grained temporal resolution are required. Fortunately, the advent of technologies, such as electrophysiology, have allowed researchers to break into the moment-to-moment processing of prosody in spoken language comprehension.

Electrophysiology and Event Related Potentials (ERPs)

Electrophysiology is the study of electrical activity associated with the nervous system. In order to measure electroencephalogram (EEG) signals, electrodes are placed on the scalp and amplify the changes in voltage, also called electrical potential, over time. When the EEG signal is time-locked with the presentation of a stimulus, the resulting waveforms are known as event-related potentials (ERPs). One of the primary strengths of ERP techniques is that they have precise temporal resolution, measured in terms of milliseconds (Luck, 2014). The tight temporal link between stimulus presentation and a characteristic ERP waveform allows researchers to have a

continuous measure of processing; for instance, language processing that occurs as the speech signal is unfolding. The continuous aspect of the signal allows researchers to form and test specific hypotheses about the ways in which neurocognitive mechanisms unfold over time. It provides a crucial compliment to end-state behavioral measures, such as reaction time, because it affords a much more detailed account of human cognition.

ERP waveforms that have characteristic latencies, operationalized as time in milliseconds (ms), and amplitudes, operationalized as microvolts (μV), are called *components*. Conceptually, an ERP component is a measure of the electrical activity in the brain that is the result of a deployment of a specific cognitive operation. This conceptual definition, however, is impossible to use empirically because it does not allow researchers to operationalize the identification of components in the resulting waveforms. To be able to identify an ERP component, it is necessary to show that the resulting waveform is systematically related to a cognitive mechanism. Donchin and colleagues assert that the key to being confident that an observed waveform is a true indicator of a cognitive process is observable variability in the waveform resulting from controlled variability in the experimental design. "Through careful experimental dissection of the waveforms, relying on a combination of inspired, skillful observation and meticulous measurement procedures, it should be possible to partition the observed variance of the ERP waveform into the sources of controlled variance we call components" (Donchin et al., 1978; p. 354).

Equipped with an operational definition of what an ERP component is, it is possible to construct experiments using ERP techniques to study a large range of cognitive processes. Of particular interest for the proposed study is the use of ERP methodologies to study spoken language comprehension. ERPs are an especially useful tool for studying language because

language comprehension is a set of dynamic processes that unfold incredibly rapidly in real time (Swinney, 1981), and ERPs have the ability to provide an online measure of how these processes occur (Osterhout & Holcomb, 1995). ERP techniques have been used to answer fundamental questions of language comprehension at nearly every level of linguistic processing, ranging from word recognition (Bentin, McCarthy, & Wood, 1985; Holcomb & Neville, 1990) to syntactic processing in sentences (Hagoort, Brown, & Groothusen, 1993) and pragmatics (Nieuwland, Ditman, & Kuperberg, 2010; see reviews by Osterhout & Holcomb, 1995 and Swaab et al., 2012). One of the most well-studied language-related ERP components in the literature is the N400 effect.

The N400 Effect

The N400 effect is a negative deflection in the ERP waveform that is largest at centro-parietal regions of the scalp and peaks at roughly 400 ms after the stimulus onset (Kutas & Hillyard, 1983, 1984). The latency of the N400 effect is generally stable, beginning around 200 ms post onset, but the amplitude of the N400 is sensitive to experimental manipulations that alter the expectancy of information. Larger N400 amplitudes are elicited when information is unexpected than when information is expected (Kutas & Federmeier, 2011). The original discovery of the N400 component in 1980 (Kutas & Hillyard, 1980) was the first time that ERPs has been utilized to explore language-related processes (Swaab et al., 2012). Though the N400 is still predominantly researched in the context of language processing domains, the N400 effect has been broadly linked to the processing of meaning over a remarkable range of diverse non-linguistic contexts including picture sequences conveying a story, videos of faces, and mathematical symbols (see review by Kutas & Federmeier, 2011).

Discovery of the N400. In their groundbreaking 1980 paper published in *Science*, Marta Kutas and Steven Hillyard reported the finding of a new component, termed the N400, that occurred when a semantically inappropriate word appeared unexpectedly at the end of a sentence (Kutas & Hillyard, 1980). In their experiment, participants silently read seven-word sentences presented one word at a time. The final word of the sentences was either semantically plausible (e.g., *"It was his first day at work"*) or semantically deviant (e.g., *"He spread the warm bread with socks"*). Compared to the semantically plausible endings, semantically deviant words elicited a large, negative-going waveform that peaked at approximately 400 ms after the presentation of the final word in the sentence. In a follow-up experiment, the authors tested whether the observed N400 effect also occurred for a physically deviant stimulus (e.g., *"She put on her high heeled SHOES"*) and found that, in contrast to the semantically deviant stimuli, the physically deviant stimuli did not elicit the negative-going peak.

The Kutas & Hillyard (1980) paper was a catalyst for a burgeoning literature using the N400 to explore semantic processing. A subsequent study revealed that the amplitude of the N400 component is significantly correlated with the *Cloze* probability of a word, operationalized as the proportion of subjects using that word to complete a particular sentence (Kutas & Hillyard, 1984). The mean amplitude of the N400 effect was progressively larger (more negative) for words of decreasing Cloze probability, meaning that words that were less probable (more unexpected) elicited larger negative peaks in the resulting waveform. The N400 effect was also found to be indicative of semantic priming processes, with larger amplitudes elicited from unprimed words than semantically-primed words (Bentin et al., 1985). In these initial studies, however, all stimuli were presented visually, so it was unclear whether or not the N400 effect was modality specific. In order to use ERP methods to move beyond reading and study more

natural forms of language processing (i.e., spoken communication), it was necessary to show that the N400 effect was modality independent.

Modality general N400. In 1984, McCallum and colleagues conducted an auditory analogue of Kutas and Hillyard's (1980) original N400 study. Participants listened to spoken sentences with endings that were either semantically plausible (e.g., "*The pen was full of blue ink*") or semantically incongruous (e.g., *"He felt the rain on his height"*). Results of the study were similar to those of the original Kutas and Hillyard study: semantically incongruous endings elicited a larger negative peak at 400 ms post stimulus onset than semantically congruous endings. Further replicating the original results, the negative peak was not found when the last word of the spoken sentence was physically different (e.g., spoken by a speaker of a different sex) than the preceding context (McCallum, Farmer, & Pocock, 1984).

The N400 effect has been observed for unexpected words whether they are written (Kutas & Hillyard, 1980, 1984), spoken (Holcomb & Neville, 1991; McCallum et al., 1984), or signed (Kutas, Neville, & Holcomb, 1987), supporting it's modality independence.. The largely flexible nature of the N400 effect in the domain of language processing led other researchers to explore whether the N400 effect can extend into other processing domains. For example, Ganis and colleagues tested whether written sentences ending with line drawings that were either congruous or incongruous elicited and N400 effect. They found that although there were broad similarities in the waveform's latency, time course, and functional sensitivity, the scalp distribution for pictures was more frontally distributed (Ganis, Kutas, & Sereno, 1996). Extending even further beyond language-related processing, research has shown that the N400 effect is sensitive to manipulations of the congruousness motor actions (Shibata, Gyoba, & Suzuki, 2009; see review by Amoruso et al., 2013) and mathematical equations (Niedeggen, Rösler, & Jost, 1999). These

studies support the conclusion that the N400 effect is not an indicator of language processing, specifically, but instead reflects the cognitive processing of meaning in a more general sense. In regards to the domain of spoken language comprehension, it is well established that prosodic aspects of language can influence the interpretation of sentence meaning (Cutler et al., 1997). Thus, it is possible to use the N400 effect to answer questions regarding the nature of prosodic processing and its influence on spoken sentence comprehension.

Prosody and the N400

ERP methodologies have been used in studies exploring each of the four prosodic functions (lexical, structural, emotional and modal) in languages including German, Dutch, English and French. In all but one study, researchers report finding larger N400 amplitudes for auditory stimuli that are prosodically incongruous than for those that are prosodically congruous.

Lexical function of prosody. Prosodic contours of syllables aid in the recognition of single lexical items (i.e., words). To examine the lexical function of prosody using ERP techniques, Magne et al. (2007) manipulated spoken French stimuli so that the last word of the sentence contained a misplaced accent. Specifically, for half of their auditory stimuli, the penultimate syllable of a trisyllabic word was lengthened. The metric structure of French is such that the second syllable of a trisyllabic word is never stressed, so lengthening this syllable resulted in a prosodic incongruity at a lexical level (Magne et al., 2007). The ERP data revealed that metrically incongruous words elicited a larger negativity than metrically congruous words in the 250-450 ms range, especially over the right hemisphere. This effect was found both in the condition where participants were asked to pay attention to the metric properties of the sentence and in the condition where the participants were asked to pay attention to semantic properties of the sentence (Magne et al., 2007). The presence of the N400 effect to prosodically incongruous

words supports the conclusion that prosodic properties at the syllabic level influence lexical access.

Structural function of prosody. Prosodic contours also carry out structural functions at both syntactic (i.e., phrasing) and pragmatic (i.e., prosodic focus) levels of sentence interpretation. Steinhauer, Alter, and Friederici (1999) conducted one of the first experiments using ERPs to study the structural function of prosody by manipulating the prosodic phrasing of spoken sentences. They presented native German speakers with pairs of spoken sentences constructed to create a garden-path effect, leading listeners to expect a different interpretation of a sentence than is ultimately indicated by the sentence. For instance, *"The young man the boat."* is a common example of a garden-path sentence because readers initially interpret "*young*" as an adjective, but in the context of the sentence it is functioning as a noun (as in, the young people are the crew of boat). Steinhaurer et al.'s (1999) stimuli were roughly equivalent to the examples in 1a through 1d (# indicates a prosodic pause):

(1a) *Since Jay always jogs a mile and a half # this seems like a short distance to him.*

(1b) *Since Jay always jogs # a mile and a half seems like a short distance to him.*

(1c) *Since Jay always jogs # a mile and a half this seems like a short distance to him.*

(1d) *Since Jay always jogs a mile and a half # seems like a short distance to him.*

ERPs revealed more negative amplitudes of the N400 waveforms for the prosodically incongruent trials compared to the prosodically congruent trials (Steinhauer, Alter, & Friederici, 1999). Steinhauer et al.'s (1999) study has been replicated in Dutch (Bögels, Schriefers, Vonk, Chwilla, & Kerkhofs, 2010) and in English (Pauker, Itzhak, Baum, & Steinhauer, 2011). These follow-up studies corroborated the original finding that the N400 effect is a useful component to

answer questions about the time courses and interaction of prosodic and syntactic processing in spoken sentence comprehension.

The studies above provide empirical evidence that the N400 effect can be reliably used to measure prosody's role in syntactic parsing; however, another structural function of prosody includes the pragmatic interpretation of a sentence. To explore this role, Hruska and Alter (2004) gave adult German speakers discourse context in the form of questions. The responding sentence contained either a prosodically congruous accent on the word that answered the question (pair 3a – 3b and pair 3c - 3d) or a prosodically incongruous accent on a word that was not the crucial information to answer the question (pair 3a - 3d and pair 3b - 3c).

(3a) *Who ate an apple?*

(3b) *ANNA ate an apple.*

(3c) *Did Anna eat a banana?*

(3d) *Anna ate an APPLE.*

Crucially, in this manipulation, the responses to the question (3b and 3d) are identical except for where the prosodic stress is placed. Consistent with the literature, accents that were prosodically incongruous (i.e., unexpected accents on words that were not crucial for answering the preceding question) elicited a large N400 effect. This was true of both responses containing a misplaced accent on an early, uninformative word (pair 3c – 3b) and those that were missing an accent on informative word (pair 3a - 3d; Hruska & Alter, 2004). Subsequent studies have replicated these results in German (Heim & Alter, 2006; Schumacher & Baumann, 2010) French, (Magne et al., 2005) and Dutch (Bögels, Schriefers, Vonk, & Chwilla, 2011a), supporting the conclusion that prosody plays an online role in pragmatic interpretations of referential processing in spoken language.

Emotional function of prosody. In addition to the more linguistically oriented lexical and structural roles of prosody, prosody also plays an important role in the interpretation of the emotional state of the speaker. Though it is difficult operationalize the acoustic properties of the speech stream involved in conveying emotion, participant judgements of basic emotional categories, such as happiness and anger, provide indirect measures of emotional quality that are sufficiently reliable to conduct empirical studies about the use of prosody to convey emotion. Schirmer, Kotz and Friederici (2002) presented German-speaking adults with semantically neutral sentences (e.g., *"Yesterday she had her final exam"*) that were either produced with a happy or a sad intonation. Following the sentences, a visual target word appeared whose valence either matched the preceding sentence prosody (e.g., 'success' following the happy intonation) or whose valence did not match the preceding sentence prosody (e.g., 'failure' following the happy intonation). When the inter-stimulus interval (ISI) between the end of the sentence and the appearance of the target word was 200 ms, ERP data that were time locked to the presentation of the visual target revealed that females, but not males, exhibited an increased negativity between 300-550 ms to targets whose valance did not match the preceding sentence prosody. Interestingly, when the ISI was increased to 750 ms, the effect was reversed: males showed a larger N400 response to targets that mismatched the preceding sentence prosody and female ERPs did not differ between conditions (Schirmer, Kotz, & Friederici, 2002). These results highlighted an intriguing dissociation between the sexes in the processing of emotional prosody, and other researchers quickly put out the call for further investigation (Besson, Magne, & Schön, 2002).

In a Stroop-like task, Schirmer and Kotz (2003) presented German-speaking participants with positive, neutral, and negative valence words that were spoken with either happy, neutral, or

angry prosody. All participants, regardless of gender, indicated the valence of positive and negative words more quickly when it was spoken with congruent emotional prosody (e.g., a positive valance word spoken with happy prosody). ERP data, however, revealed differences by listener gender; emotionally incongruous stimuli (e.g., a positive valence word spoken with angry prosody) elicited an larger N400 amplitude than emotionally congruous stimuli, but this effect occurred earlier female listeners than male listeners (Schirmer & Kotz, 2003). Further studies (Kotz & Paulmann, 2007; Paulmann & Kotz, 2008) have corroborated these results, supporting the conclusion that an N400 effect is elicited when the prosodic cues indicating emotion are incongruous with the semantic valence of the sentence, but the effect occurs earlier for female listeners than it does for male listeners.

Modality function of prosody. Finally, the prosodic contours of a speech signal function to indicate the type of speech act of the utterance (e.g., statement or question). Astésano, Besson and Alter (2004) constructed 240 French sentences so half were semantically congruous (e.g., *"The light was flashing"*) and the other half semantically incongruous (e.g., *"The roof was translating"*). Within each of the semantic conditions, half of the sentences contained natural prosody and half contained incongruous prosodic contours. Half of these semantically and prosodically congruent stimuli were Statements and the other half were Questions. Crucially, all stimuli, whether Statements or Questions, had the same syntactic structure: a three-syllable noun phrase followed by a three-syllable verb phrase. The only difference between prosodically congruous statements and prosodically congruous questions was the prosodic contour of the speech signal. Prosodically incongruous sentences were created by cross-splicing the speech signals at the verb phrases. All of Astésano et al.'s (2004) analyses were collapsed across sentence modality. This created four conditions: semantically congruous and prosodically

congruous (S+P+), semantically congruous and prosodically incongruous (S+P*), semantically incongruous and prosodically congruous (S*P+), and semantically incongruous and prosodically incongruous (S*P*).

In the experiment, participants listened to these stimuli in two counterbalanced blocks, one where they were asked to decide whether the sentences were semantically congruous or incongruous and the other where they were asked to decide whether the intonation contour of the sentence was congruous or incongruous. When participants directed attention to the prosody of the stimuli, prosodically incongruous (P*) stimuli elicited a larger positive-going waveform peaking around 800 ms post-verb phrase onset compared to prosodically congruous (P+) stimuli (Astésano, Besson, & Alter, 2004). This effect was much more pronounced for semantically incongruous (S*P*) than semantically congruous stimuli (S+P*). Further, when the participants directed attention to the semantic content of the stimuli, prosody (P+ vs. P*) was not found to have any effect. Semantically incongruous sentences (S*) elicited a larger N400 amplitude than semantically congruous sentences (S+) regardless of where participants focused their attention (Astésano et al., 2004). On the surface, these findings suggest that, unlike all other functions of prosody, incongruities in the modal function do not appear to elicit an N400 effect; however, there are some problems with the methodology in the Astésano et al., 2004 study that render this conclusion premature.

The primary concern with the methods in Astésano et al. (2004) is that their prosodically incongruous stimuli did not contain true pragmatic violations that would cause participants to reevaluate the modality of the sentence and elicit an N400 effect. The speech stimuli for both statements and questions in Astésano et al. (2004) were syntactically identical: a three-syllable noun phrase followed by a three-syllable verb phrase. This facilitated cross-splicing, but means

that the question stimuli were not syntactically created as grammatical questions. In other words, there was nothing about the structure of the question stimuli, such as beginning with a verb or interrogative word, that necessitated their modality. For example, a spoken statement *"the light was flashing"* could be converted into an acceptable question *"the light was flashing?"* simply by changing the prosodic contour of the statement. As the authors point out in their introduction, pragmatically, there is nothing incongruous about conveying a question exclusively through the use of rising pitch at the end of the sentence: "these sentences comprise the exact same words and syntactic structures but are clearly perceived as a statement or as a yes/no (or total) question in spoken language, only because of their intonation contours" (p. 173, Astésano et al., 2004). However, in order for the prosody of a sentence to be incongruous with its modality, the sentence structure must independently indicate a modality with which the prosody of the utterance can be incongruous.

A second concern of the analyses conducted in Astésano et al. 2004 is that the authors collapsed their statistical analyses across sentence modalities to compare prosodically congruous and prosodically incongruous sentences, regardless of the mode of the sentence (i.e., question or statement). Questions and statements serve different functions during discourse (Miller, 1951); an interrogative sentence generally indicates that the listener is expected to provide a response to the question, whereas a declarative sentence does not necessarily carry the same assumption. The differing functions of questions and statements raise the possibility that these sentences are processed differently, thus collapsing across sentence modalities likely masks an important source of variation in the data.

Current Study

The purpose of the current study was threefold. First was to reexamine the modality function of prosody with a design very similar to that of Astésano et al. (2004), but using stimuli that are constructed to necessitate incongruity between the prosodic contour and the syntactic construction. All question stimuli began with common yes/no question words in English (e.g., *are, should, does*). This ensured that the sentence modality of the questions was indicated grammatically, so the prosodic contours of the stimuli were either congruous or incongruous with the sentence modality. The statement stimuli in the current study faced the same concern as the stimuli in Astésano et al. (2004). Chiefly, it is not pragmatically incongruous, and may in fact be relatively common, for a speaker to use a rising pitch at the end of a grammatical statement to indicate that they are asking a question (e.g., *"You want to go to lunch?"*). As such, we analyzed prosodically incongruous statements and prosodically incongruous questions separately.

A second, more minor, contribution of the current study is that it used ERP techniques to examine prosodic functions in spoken English. The majority of the literature exploring prosody's function in spoken language comprehension using ERPs has been conducted in German (Heim & Alter, 2006; Hruska & Alter, 2004; Kotz & Paulmann, 2007; Paulmann & Kotz, 2008; Schirmer et al., 2002; Schumacher & Baumann, 2010), Dutch (Bögels et al., 2011a, 2010), or French (Astésano et al., 2004; Magne et al., 2005, 2007). To my knowledge, there is only one study, (Pauker et al., 2011), that replicates these findings in English, and it specifically explores the structural function of prosody. Language generalization was not the primary motivation for conducting the present study, but it was nonetheless interesting to explore whether and how prosody functions in similar ways across different languages.

Finally, the current study aimed to explore whether ERP indicators of spoken language processing are related to more global measures of social communication. Most of the literature

using ERP techniques to study prosody was motivated by questions about the underlying structure of linguistic processing (e.g., are sematic information and prosodic information processed independently). In contrast, the current study explored whether or not an online measure of spoken language processing was correlated with an applied index of social communication. Though it seems reasonable to assume that successful social communication depends on the ability to decode suprasegmental features of language, it is important to empirically analyze the roles these features play in order to better understand and explain how different spoken language processes contribute to global social communication abilities. This line of work has implications for an improved understanding of the specific challenges that individuals who struggle with social communication, such as individuals with ASD, face on a daily basis.

Method

Participants

37 monolingual English speakers (20 females) between the ages of 18 and 22.5 years (mean age = 19.4 years) participated in the study. Previous subject samples for research studies examining prosody and the N400 effect have ranged from 14 participants (Magne et al., 2007) to 56 participants (Steinhauer et al., 1999). Sample size for the current study was determined based on a power analysis using G-Power software (Faul, Erdfelder, Lang, & Buchner, 2007), assuming a modest effect size (Cohen's $f = 0.2$), an alpha of 0.05, and three within-subject measurements (ERP amplitude, behavioral response and social communication score). Participants were recruited through the undergraduate psychology research pool (SONA) at Syracuse University. Exclusion criteria included any history of a hearing disorder, seizures, or any other neurological disorders. Participants received course credit for participating in the

study. The study procedures were explained to each participant, and each signed an informed

consent form before participating. All consent forms and testing procedures were approved by

Syracuse University's Institutional Review Board prior to use.

Stimuli

All auditory stimuli were presented using MATLAB through two BOSE® Companion2,

Series II Multimedia Speaker System speakers adjacent to the left and right side of the monitor.

A total of 100 sentences were created for the study. The sentences were constructed in question-

statement pairs such that each pair was comprised of a grammatical statement (e.g., *"I wanted a*

cool bike.") and a grammatical question (e.g., *"Have you ridden a bike?"*) that had the same

final one-syllable word (e.g., *"bike"*) and were both six syllables long. All questions began with

an interrogative (e.g., was, are, did, etc.) to ensure that the modality of the sentence was

indicated in the grammatical construction, independent of how the sentence was spoken, and

specific interrogatives were balanced across the set of stimuli.

Sentences were recorded in a soundproof room using Adobe Audition by male and

female native English speakers and digitized at 44.1 kHz sampling rate and 16-bit resolution. As

each sentence was spoken twice, by one female and one male speaker, a total of 200 prosodically

congruent sentences were created. Recordings were processed for audible breaths and excess

silence in Adobe Audition and subsequently analyzed using the speech analysis tool PRAAT

(Boersma & Weenick, 2017). Each sentence was segmented into its six syllables, and for each

syllable the average fundamental frequency (measured in hertz), amplitude (measured in

decibels), and duration (measured in milliseconds) were computed (see Figures 1 and 2 for

graphical representations of the acoustic properties for male and female stimuli). After the

acoustic prosperities of the sentence were analyzed, the sentence was spliced immediately

preceding the final word of the sentence, creating a sentence beginning that was five syllables long and a sentence ending that was one syllable.

Prosodically congruent sentences were created by cross-splicing a sentence beginning with its original sentence ending (e.g., *"I wanted a cool bike."* and *"Have you ridden a bike?"*). Prosodically incongruent sentences were created by cross-splicing a sentence beginning with the ending of the other item of the question-statement pair (e.g., *"I wanted a cool bike?"* and *"Have you ridden a bike."*). Similar cross-splicing procedures have been used in many previous ERP studies to create prosodically incongruent stimuli while controlling for other aspects of the speech signal (Astésano et al., 2004; Heim & Alter, 2006; Kotz & Paulmann, 2007; Magne et al., 2007; Paulmann & Kotz, 2008; Steinhauer et al., 1999). This cross-splicing technique ensures that the stimuli in Prosodically Congruent and Prosodically Incongruent conditions will be identical up until the initiation of the final syllable. Cross-splicing created a total of 400 spoken language stimuli used in the study; a breakdown of the stimuli is included in Table 1.

Behavioral Measure

Brief written instructions and the behavioral task prompt were all presented using MATLAB on a VPixx Technologies® VIEWPixx monitor with a screen resolution of 1920 by 1200 pixels. Previous studies examining prosodic congruity and the N400 effect have included off-line behavioral measures to encourage participants to attend to changes in the prosodic contour of speech stimuli. Typically, these behavioral measures consist of explicitly asking participants to decide whether prosodic contour of the sentence was congruous or incongruous (Astésano et al., 2004; Magne et al., 2007; Steinhauer et al., 1999). However, it is likely that offline judgements of sentence prosody encourage participants to be more attuned to the prosodic features of the auditory stimulus than would be typically expected in natural spoken language

processing (Bögels, Schriefers, Vonk, & Chwilla, 2011b). It has yet to be tested wether or not explicitly drawing participants' attention to the prosodic features of a spoken stimulus has any effect on the resulting ERP waveforms that are subsequently analyzed.

In the present study, participants were asked to identify the sex of the speaker after each auditory stimulus was presented. This behavioral measure was chosen in an effort to balance the cost of unnaturally constraining a laboratory study with the reality that many participants would not pay attention to the stimuli if they are not explicitly asked to perform some behavioral task. In contrast to previous behavioral measures in ERP examinations of prosodic processing (Astésano et al., 2004; Magne et al., 2007; Steinhauer et al., 1999), asking participants to identify the sex of the speaker does not explicitly draw their attention to the prosodic contours or the modality (question or statement) of the sentence. Though certainly not the most naturalistic of situations, this manipulation is a step in a more generalizable direction because participants are not being primed to pay attention to the manipulation of interest. Future research should empirically investigate to what, if any, extent behavioral measures may affect resulting ERP waveforms.

Social Communication Measure

An additional aim of the proposed study was to examine the relationship between spoken language comprehension and more applied social communication abilities. Towards this aim, each participant completed the adult self-report form of the Social Responsiveness Scale – Second Edition (SRS-2; Constantino & Gruber, 2012). The SRS-2 consists of 65 items scored on a 4-point Likert-scale, ranging from *not true* = 1, *sometimes true* = 2, *often true* = 3, to *almost always true* = 4. The measure generates standard scores for six treatment subscales – Social Awareness, Social Cognition, Social Communication, Social Motivation and Restricted Interests

and Repetitive Behavior – as well as an overall Total Score. The survey has strong internal consistency and inter-rater reliability as well as good predictive and concurrent validity (Bruni, 2014). The various rating forms for distinct age groups are a notable strength of this questionnaire because it allows for future research to use the same measure to extend the current study to children.

EEG Recording

EEG activity was recorded continuously at 1024 Hz using Net Station Software from Electrical Geodesics, Inc. (EGI; Electrical Geodesics, 2003). A HydroCel GSN (HCGSN) Net with 128 electrode sensors was fitted to each participant's head based on head circumference. Electrodes were referenced to the Cz electrode. Impedances were kept below 50 kΩ.

Procedure

Testing took place in the 426 Ostrom Ave building at Syracuse University. Participants were first taken through the informed consent procedure and then measured for their head circumference in order to determine the correct HCGSN Net size. In order to standardize cap placement across participants, the apex of each participant's head was located by finding and marking the horizontal midpoint between the left and right mastoids (back part of the temporal bone located behind each ear) and the vertical midpoint between the nasion (bridge of the nose) and the inion (bony bump located at the back of the skull). The intersection of these midpoints is where the vertex electrode of the HCGSN Net, the Cz electrode, was placed. Once the cap was placed, participants were instructed to make themselves comfortable in the testing chair and asked to minimize their movements and blinking while the experiment is in progress.

After reading written instructions, participants listened to the auditory stimuli and responded to the behavioral task (i.e., "Was the speaker male (m) or female (f)?"), presented

visually on the computer screen. Participants pressed one of two keys (i.e., "m" or "f") to indicate their response. Participants listened to a total of 400 stimuli, 50 prosodically congruent questions, 50 prosodically congruent statements, 50 prosodically incongruent questions, and 50 prosodically incongruent statements, each spoken one time by a male speaker, and a second time by a female speaker. After the ERP task, participants completed the SRS-2. The social communication measure was given after the experimental task in order to minimize any performance bias that might occur if participants were first primed on social communication questions and then asked to perform a spoken language comprehension task. In total, the experiment took approximately 1.5 hours to complete, including breaks.

Preparing EEG data. EEG data were analyzed using a combination of EGI, EEGLAB (Delorme & Makeig, 2004), and ERPLAB (Lopez-Calderon & Luck, 2014) software. Each participant's continuous EEG data were first filtered high-pass low-pass filters, set at 0.1 Hz and 30 Hz, respectively. After filtering, the continuous EEG data were re-referenced to the average of the left and right mastoids (Duncan et al., 2009).

Next, the continuous EEG data were segmented into epochs that were time-locked to the onset of the start of the auditory stimulus. Though different from the original proposed analysis, time-locking the ERP signal to the onset of the sentence, rather than the onset of the last word, was determined to yield more reliable baselines, which facilitated the interpretation of the resulting waveform. Baseline correction of ERP data is important because the process establishes a near zero voltage at the onset of the trigger, which allows for the ERPs to be equated across trials and conditions; time-locking the ERP signal to the onset of the last word was problematic because the EEG data that would have been analyzed as the baseline was reflective of processing the preceding auditory information, which may have differed between sentence structures. As

such, it was decided that the most conservative approach to epoch the data was to time-lock the EEG data to the onset of the sentence and conduct statistical analyses on the ERP waves later in the epoch. This method has been used in previous ERP literature examining prosodic processing in naturally spoken language (Astésano et al., 2004; Bögels et al., 2011a). Each epoch began 200 ms before the onset of the sentence and ended 2300 ms after the sentence onset, making the total segment a total of 2500 ms. 2300 ms was chosen as the ERP window length because the maximum sentence beginning length for all stimuli was 1489ms, so the window was adjusted to be approximately 800ms longer than the maximum of the longest sentence beginning to ensure that the relevant N400 window could be analyzed.

One challenge of time-locking the ERP signal to the onset of the sentence is that the spoken sentences are of variable length, contributing additional noise in searching for an N400 effect; however, because the planned analysis was to examine the mean amplitude of the waveforms over a time window, it was determined that variable onsets to the final word would not preclude the N400 mean amplitude analysis. Average sentence beginning length was computed for questions and statements for male and female stimuli separately in order to ensure that the analysis window could be specified for each stimulus type and are presented in Table 2.

Following baseline correction, an artifact detection operation was used to find and mark epochs containing artifacts such as eye blinks, eye movements, and large motor movements such as jaw movements. Artifact detection was conducted over the entire 2500 ms epoch period. The threshold parameter for artifact detection was set at 100 microvolts (µV) for eye blinks and 55 µV for eye movements. Further, a threshold parameter for the detection of bad channels (electrodes) was manually set to 101 µV. If an epoch contained more than 10 bad channels, it

was marked for removal. If any channel was marked for removal for over 40% of the epochs, it was excluded entirely from the analyses.

For each participant, all epochs that were not marked for removal were averaged together by speaker, sentence type, and condition at each electrode site after artifact detection was completed. Participants were excluded entirely if less than 15% of the trials were included per condition (n = 3) as their data would not reliably reflect the controlled variation in the experiment. Participants were also excluded if the recording reference electrode was compromised (n = 9), which would affect all of the resulting electrodes recordings, making them uninterpretable. Once average waves for each condition had been created for each participant, a grand-average wave was created for each condition by combining all of the participants' average waveforms. This created a single output file of the ERPs at each electrode site for all subjects for each speaker, sentence type and condition.

Results

Behavioral Results

Mean accuracy for all participants (N = 37) the behavioral measure was 97.9% (SD = 1.7%), indicating that participants were paying attention to the stimuli and engaged in the task. Across all participants, accuracy ranged from 93.0 to 99.8%, suggesting that even the worst performing participants still correctly answered with high accuracy. Behavioral task accuracy did not differ as a function of congruency (M_C= 0.9792, SD_C = 0.1428; M_I = 0.9786, SD_I = 0.1446; $t(14796)$ = 0.229, p = 0.819)[1]. Mean accuracy for participants included in the ERP analyses (n = 25) did not differ significantly from the total participant sample (M_{ERP} = 0.9776, SD_{ERP} = 0.1480; M_{Total} = 0.9789, SD_{Total} = 0.1437; $t(21026)$ = -0.6966, p = 0.486).

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[1] Welsh's two sample t-tests were used to compare all behavioral and social communication data to adjust degrees of freedom in order to account for unequal variances

Social Communication Results

Overall, participants' mean SRS-2 Total scores were in the average range based on the measure's standardization ($M = 50.59$, $SD = 9.51$). Interestingly, though the sample consisted of non-clinical adults, there was a substantial spread in the SRS-2 Total scores, with t-scores ranging from 38 to 77. Participants' scores on the Social Communication subscale of the SRS-2 were very similar to the Total Scores ($M = 49.43$, $SD = 9.51$). Additionally, participant's scores for the Social Communication subscale ranged from t-scores of 37 to t-scores of 77. These score ranges lend support to the sensitivity of the SRS-2, as it was able to detect potentially meaningful variation in self-reported social communication abilities amongst a group of typically developing adults. A Wilcoxon signed rank test indicated that SRS-2 Social Communication t-scores for participants included in the ERP analyses ($n = 25$) did not differ significantly from those of the total participant sample ($M_{ERP} = 51.20$, $SD_{ERP} = 10.28$; $M_{Total} = 49.43$, $SD_{Total} = 9.51$; $W = 416.5$, $p = 0.5128$).

Electrophysiological Results

12 participants' ERP data were excluded from analyses due to falling below the cutoff of percent accepted trials ($n = 3$) or because of a bad reference ($n = 9$) during EEG recording, which made the resulting EEG data uninterpretable. Because ERP's were time-locked to the onset of the sentence, rather than the onset of the last word, and the length of the sentence differed by speaker and sentence type, the N400 analysis window needed to be set separately for male and female questions and statements. This was done by taking the average length of the sentence beginnings for each stimulus type (Table 2) and adding the recommended (Duncan et al., 2009) time window of 220 – 640 ms. A table of the time windows analyzed for each type of stimulus is

included in Table 3. ERP waves at each electrode, organized by speaker and sentence type, comparing congruent and incongruent sentences are included in Figures 3 – 6.

Based on published guidelines and previous research for the N400 component, electrode clusters were grouped into five regions: Frontal (electrodes E4, E5, E6, E11, E12, E13, E19, E20, E24, E112, E118, and E124), Left Central (electrodes E36, E39, E40, E41, E45, E46, and E50), Right Central (electrodes E101, E103, E103, E104, E108, E109, and E115), Left Parietal (electrodes E37, E42, E47, E52, E53, E54, and E60), and Right Parietal (electrodes E79, E85, E86, E87, E92, E93, and E98). An illustration depicting the HydroCel Geodesic Sensor Net and highlighting the regions of electrode clusters can be found in Figure 7 . ERP waves for each cluster comparing congruent and incongruent sentences are included in Figures 8 – 11.

First, a series of t-tests were conducted to assess whether the speaker's sex had any effect on the ERP waveforms in the N400 time window. Effects of stimulus sex needed to be analyzed for each factor, so as such, p-values were adjusted using the Bonferroni correction for multiple comparisons (Table 4). Given the number of t-tests (20) and a specified p-value of .05, it was statistically expected that at least one of the analyses would result in a false-positive (Type 1 error). As the purpose of examining the effects of speaker on the averaged ERP waveforms was so that the data could be collapsed across stimuli, Bayesian t-tests were also conducted to test for evidence in support of the null hypothesis. These tests provided anecdotal to moderate support for the null hypothesis that the average amplitudes did not differ as a function of the speaker's sex (Table 4).

Mean amplitudes for the N400 time windows for each condition were submitted to a repeated measures analysis of variance (RM-ANOVA) with the factors of region (Frontal, Left Central, Right Central, Left Parietal, and Right Parietal), sentence type (questions vs. statements)

and congruency (congruent vs. incongruent). Violations of the sphericity assumption of the RM-ANOVA were corrected by adjusting the degrees of freedom with the Greenhouse-Geisser correction method. The RM-ANOVA returned a large main effect region ($F_{1.87, 44.94} = 20.54$, p <.0001, $\eta^2_G = 0.24$) and a small main effect of sentence type ($F_{1, 24} = 4.99$, $p = .04$, $\eta^2_G = 0.02$). No main effect was found for the factor of congruency, and no two-way or three-way interactions were found between any of the variables. Full results of the RM-ANOVA are presented in Table 5.

Correlation between ERP and Social Communication Measures

Though no significant main effects or interactions were found for sentence congruency in the difference wave RM-ANOVA, it was possible that there were individual differences in the N400 effect, lost at the group level, that may have been related to social communication abilities. This potential was tested by correlating the N400 effect with individual scores on the SRS-2 Social Communication subscale. First, average difference wave amplitudes were calculated for each of the 5 regions (Frontal, Left Central, Right Central, Left Parietal and Right Parietal). Next, the averaged region N400 difference wave amplitudes were compared to SRS-2 Social Communication scores. Correlations for questions and statements were calculated separately, given that there was a significant main effect of sentence type revealed in the RM-ANOVA. After using Bonferroni corrections to adjust for multiple comparisons, there were no significant correlations found between N400 difference wave amplitudes and individuals' SRS-2 Social Communication Scores (see Table 6). Visual inspection of the correlations revealed no non-linear trends that may have contributed to a lack of correlation (Figure 12).

Discussion

The goal of the current study was to reexamine the electrophysiological effects of processing spoken sentences that contained prosodic contours that were incongruous with the syntactic modality of the sentence. The RM-ANOVA revealed a main effect of electrode region and sentence type (i.e., questions or statements), but no effect of congruency. Contrary to the initial hypotheses, these data indicate that incongruous prosodic contours did not elicit an N400 effect for either questions or statements. A lack of effect may suggest that, unlike other functions of prosody, the modal function of prosody does not create linguistic incongruities significant enough to produce the N400 effect; however, an alternate explanation is that the behavioral measure used in the present study drew participant's attention away from the prosodic contours of the sentences such that they were not salient to listeners (see below for further discussion). Participants were very accurate at identifying the sex of the speaker, which did not differ as a function of congruency, suggesting that participants were attending to the sex of the speaker during the audio stimuli, potentially at the expense of attending to the prosodic contours of the sentence.

Though there was a sizable spread in the SRS-2 Social Communication scores, indicating that the typically developing participants reported a range of social communication skills, no correlation was found between the N400 difference wave amplitudes and SRS-2 Social Communication scores. Given the lack of N400 effect found in the ERP data, it is unsurprising that no correlations were found. Prior research has revealed that social communication, as measured by the Communication subscale of the Autism Quotient (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001), is related to an individual's N400 effect size to counterfactual clauses (Kulakova & Nieuwland, 2016), suggesting that global social

communication abilities can be related to online processing indicators, such as ERP effect size. Future research should explore this relationship further in order to begin to understand how foundational abilities, such as spoken language processing, contribute to an individual's social communication capacities.

Though there have been previous explorations of the modal function of prosody and its relation to the N400 effect (Astésano et al., 2004), methodological limitations call some of the study's conclusions into question, and the current study differed from earlier explorations of the N400 effect in the domain of prosodic processing. First, although minor, the current study included stimuli that were recorded by both male and female speakers. Previous experiments that have tested later (i.e., more than 200 ms post stimulus onset) electrophysiological effects of spoken language processing have used only one speaker in constructing stimuli (Astésano et al., 2004; Bögels, Schriefers, Vonk, Chwilla, & Kerkhofs, 2013; Magne et al., 2005; Pauker et al., 2011), yet there had not previously been evidence that male and female prosodic contours are processed in similar ways. Bayesian analyses of the ERP waves to male and female in the present study found anecdotical to moderate evidence that there were not differences for male and female speakers at the relatively late the N400 time windows. Though further investigation is necessary to provide further support for the finding, the data collected for the present study suggest that speaker sex does not meaningfully influence late ERP components thought to underlie cognitive processing of spoken language.

A critical investigation of the effects of stimuli on experimental results is an important, yet often underrecognized, aspect of electrophysiological research, and one limitation of the current study is that it did not fully analyze the ways in which the specific stimuli used in the experiment effected the resulting ERP data. Stimulus effects are important because they impact

results of inferential statistics commonly used to draw conclusions about the significance of an experimental effect, and failing to account for this impact can lead to an substantial increase of Type 1 error rates (Baayen, Davidson, & Bates, 2008; Judd, Westfall, & Kenny, 2012; Westfall, Kenny, & Judd, 2014). In the same way that inferential statistics are used to describe the likelihood that a finding in a particular participant sample can be generalized to a population, relatively new methods, such as mixed-effect modeling , can be used to describe how the specific set of encounters of participants and stimuli can be generalized to populations of both people and stimuli categories (Barr, 2017). Though the current study did not fully delve into stimulus effects as thoroughly as possible, testing for the comparability of using male and female stimuli is an initial step towards generalizing findings of spoken language comprehension research. Future investigations would benefit from a more in-depth analysis of the ways in which stimuli play a role in research using ERP methodologies to study spoken language processing.

Second, the current study aimed to resolve the methodological concerns of Astésano et al. (2004) by constructing stimuli that indicated modality through the grammatical construction of the sentence, independent of the prosodic contours of the stimuli. The consideration is crucial because an N400 effect would only be expected if the prosodic contours of the sentence were incongruous with its grammatical construction. Though, similar to Astésano et al. (2004), the present study did not find any significant effect of the congruence of the prosodic contours of the sentence, a significant main effect of sentence type was found. This effect indicates spoken questions and statements may have differential influence on late ERP effects such as the N400, and should be examined separately, rather than collapsing these conditions. The effect is theoretically relevant when studying the effects of prosody that is incongruous with the modality

of the sentence, because sentences of different modalities are not necessarily processed in the same way.

Another limitation of the current study is that it departs from previous literature using electrophysiological methods to study the online processing of incongruous prosody due to the nature of the behavioral task that participants were asked to complete. In previous studies, which found N400 effects to incongruous prosodic contours (Magne et al., 2007; Steinhauer et al., 1999), participants were explicitly asked to judge the prosodic contours of the sentence. In contrast to those studies, the current study asked participants to identify the sex of the speaker. While this behavioral question served as an offline check that participants were attending to the stimuli, it did not explicitly direct participants to attend to and judge the prosodic features of the auditory stimulus. It is possible that an offline judgement of the prosodic contours of the sentence may prime participants to attune to the prosodic features of spoken language more than would be expected in natural language processing (Bögels et al., 2011b). An N400 effect may have been observed had the participants been primed with an offline judgment of sentence prosody. It will be useful for future research to empirically test the effects of offline behavioral judgements on the online ERP measures of spoken language processing.

Appendix

Table 1

Experimental Design (Stimuli)

Congruency	Male Speaker		Female Speaker	
	Questions	Statements	Questions	Statements
Prosodically Congruous	50	50	50	50
Prosodically Incongruous	50	50	50	50

Table 2

Average Sentence Beginning Length

	Male Speaker	Female Speaker
Questions	888 ms (SD = 167 ms)	1,027 ms (SD = 156 ms)
Statements	987 ms (SD = 165 ms)	1,137 ms (SD = 138 ms)

Table 3

Analyzed Time Windows for Each Stimulus Type

	Male Speaker	Female Speaker
Questions	1,108 – 1,528 ms	1,247 – 1,667 ms
Statements	1,207 – 1,668 ms	1,357 – 1,777 ms

Table 4

Comparison of Male and Female Stimuli N400 Mean Amplitudes

	t	df	Adjusted p-value	BF_{01}
Frontal				
Congruent				
Question	-0.439	595.02	1.000	4.589
Statement	1.228	580.51	1.000	4.055
Incongruent				
Question	0.168	472.11	1.000	4.721
Statement	0.801	597.05	1.000	4.311
Left Central				
Congruent				
Question	0.020	338.41	1.000	4.743
Statement	-1.260	339.36	1.000	4.127
Incongruent				

Question	-0.121	308.42	1.000	4.737
Statement	-2.151	339.82	0.644	2.572

Right Central

Congruent

Question	1.518	347.88	1.000	3.464
Statement	3.536***	343.12	0.009**	1.631

Incongruent

Question	-0.403	342.66	1.000	4.677
Statement	0.401	346.26	1.000	4.620

Left Parietal

Congruent

Question	1.036	347.96	1.000	4.159
Statement	-1.264	342.71	1.000	4.024

Incongruent

Question	1.288	346.46	1.000	0.093
Statement	-2.616**	344.02	0.186	1.610

Right Parietal

Congruent

Question	3.563***	320.7	0.008**	1.384
Statement	2.768**	335.2	0.119	2.154

Incongruent

Question	-0.826	344.13	1.000	4.253
Statement	0.543	348	1.000	4.583

Note: p < .001 '***', p < .01 '**', p < .05 '*'. n = 25 for all analyses.

Table 5

Repeated Measures Analysis of Variance for N400 Time-Windows

Effect	df	MSE	F	η^2_G
Sentence	1, 24	13.79	4.99*	.02
Congruency	1, 24	15.86	2.09	.008
Region	1.87, 44.94	33.41	20.54***	.24
Sentence x Congruency	1, 24	12.38	0.00	<.0001
Sentence x Region	2.44, 58.52	3.59	1.53	.003
Congruency x Region	2.44, 53.81	5.32	1.73	.005
Sentence x Congruency x Region	1.98, 47.60	6.61	0.93	.003

Note: p < .001 '***', p < .01 '**', p < .05 '*'. Sphericity correction: Greenhouse-Geisser

Table 6

Individual N400 Effects Correlation to SRS-2 Social Communication Scores

	Pearson's r	t	df	Adjusted p-value
Frontal				

Question	-0.3914*	-2.0401	23	0.5299
Statement	0.0462	0.2218	23	1.0000
Left Central				
Question	0.1885	0.9204	23	1.0000
Statement	-0.1269	-0.6136	23	1.0000
Right Central				
Question	-0.0808	-0.3890	23	1.0000
Statement	0.00587	0.0281	23	1.0000
Left Parietal				
Question	0.1385	0.6711	23	1.0000
Statement	-0.1780	-0.8674	23	1.0000
Right Parietal				
Question	0.02018	0.0968	23	1.0000
Statement	-0.1030	-0.4966	23	1.0000

Note: $p < .05$ '*'. $n = 25$ for all analyses.
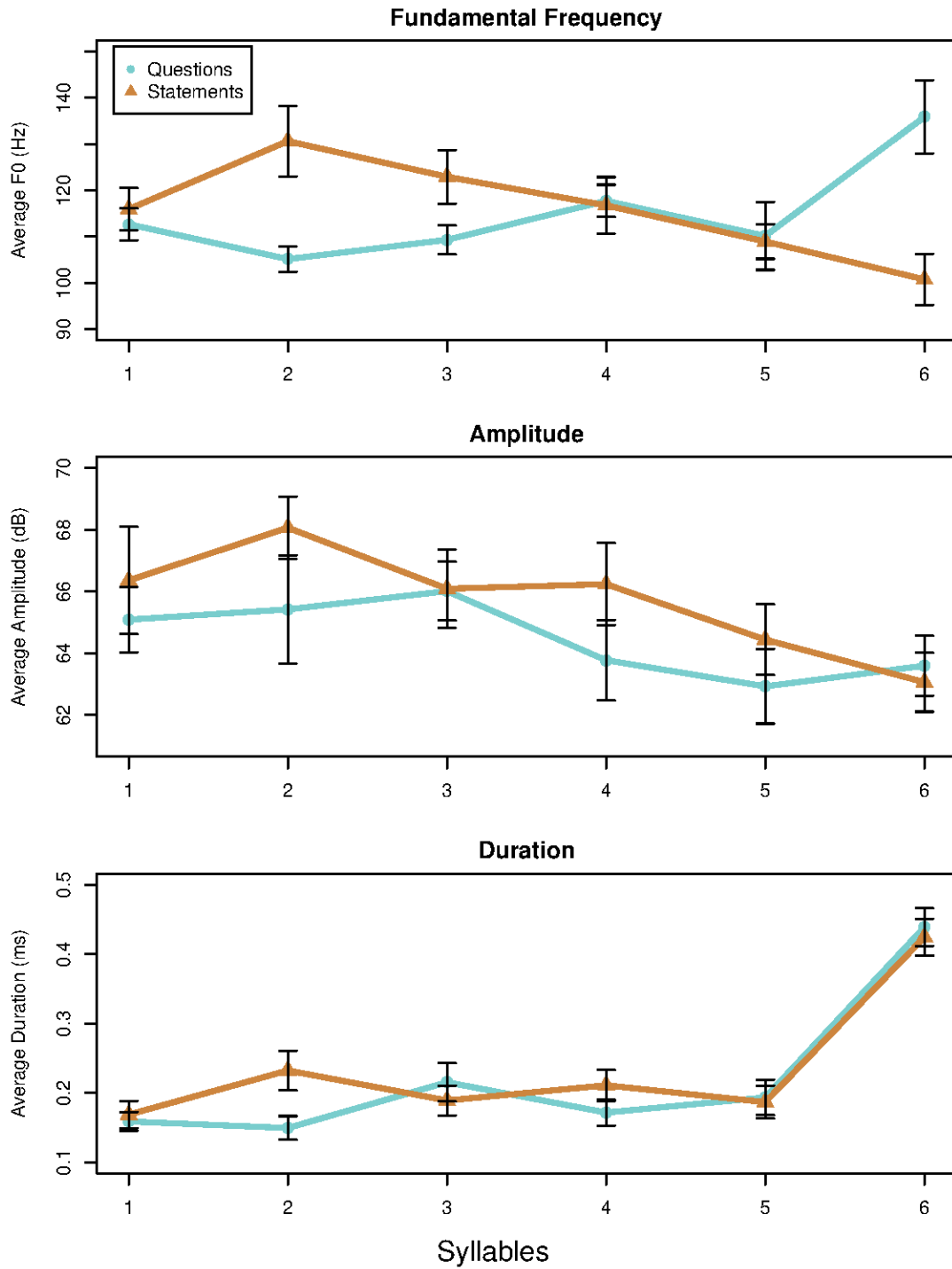
Figure 1. Acoustic properties of male stimuli.
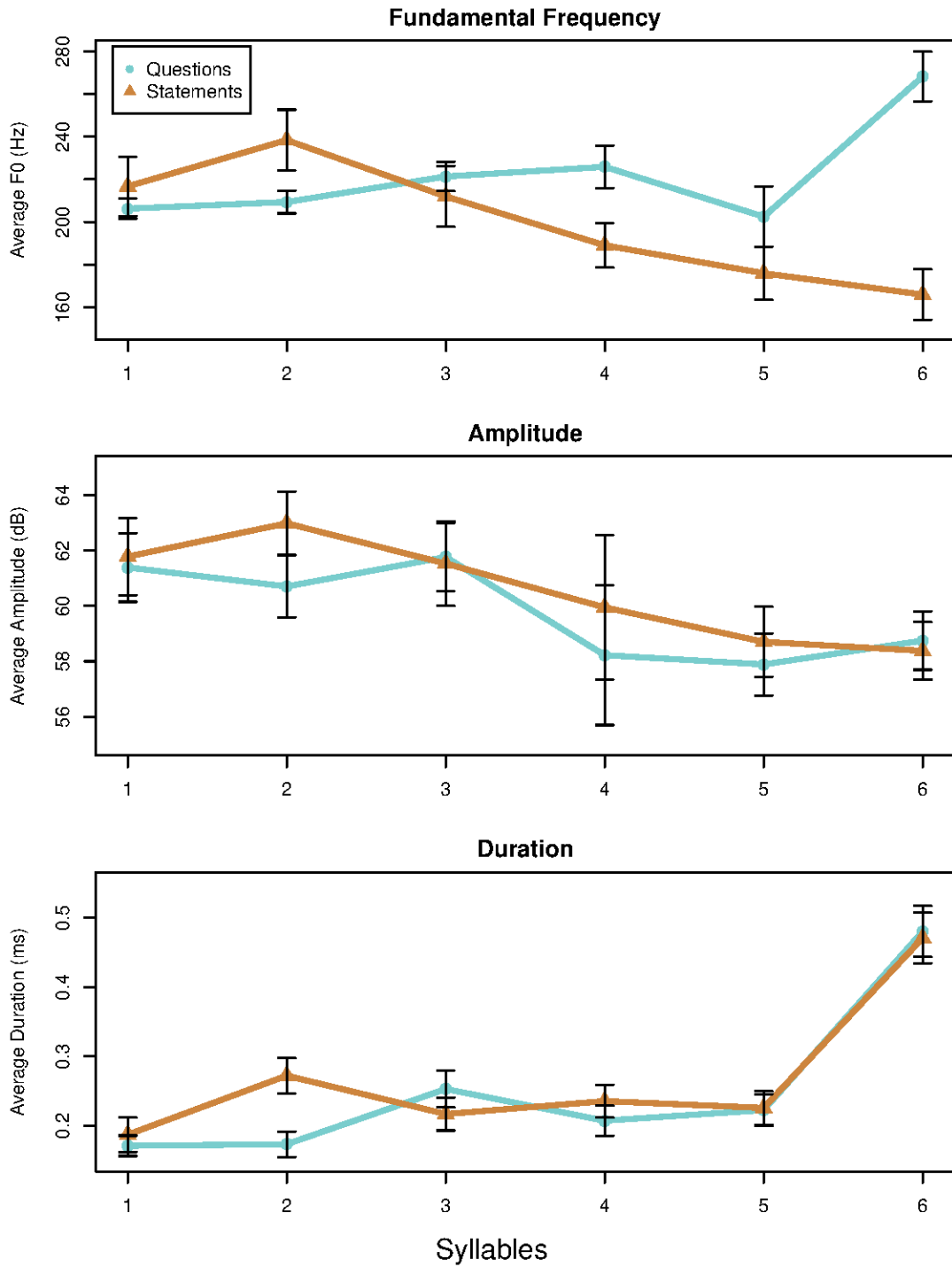
Figure 2. Acoustic properties of female stimuli.
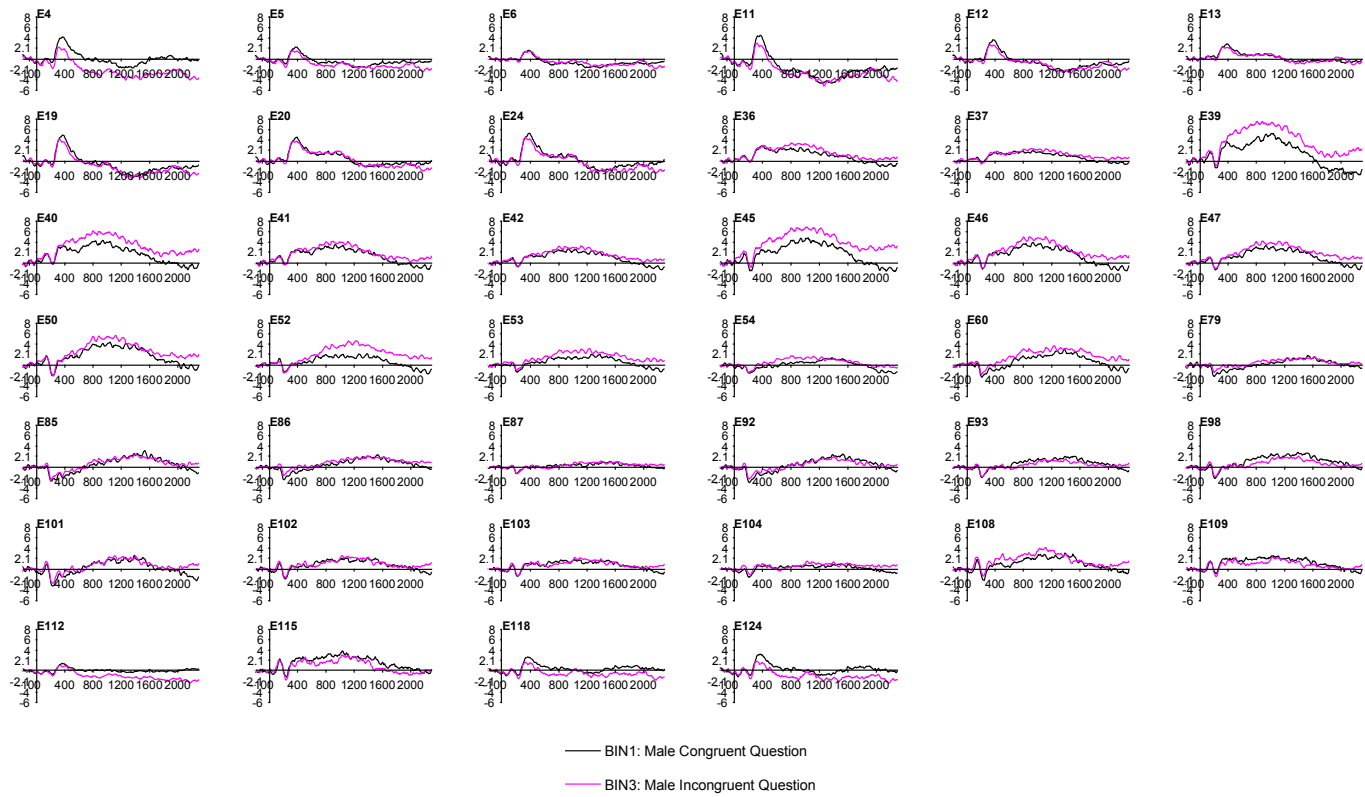
Figure 3. ERP Waves for Questions Spoken by Male Speaker.

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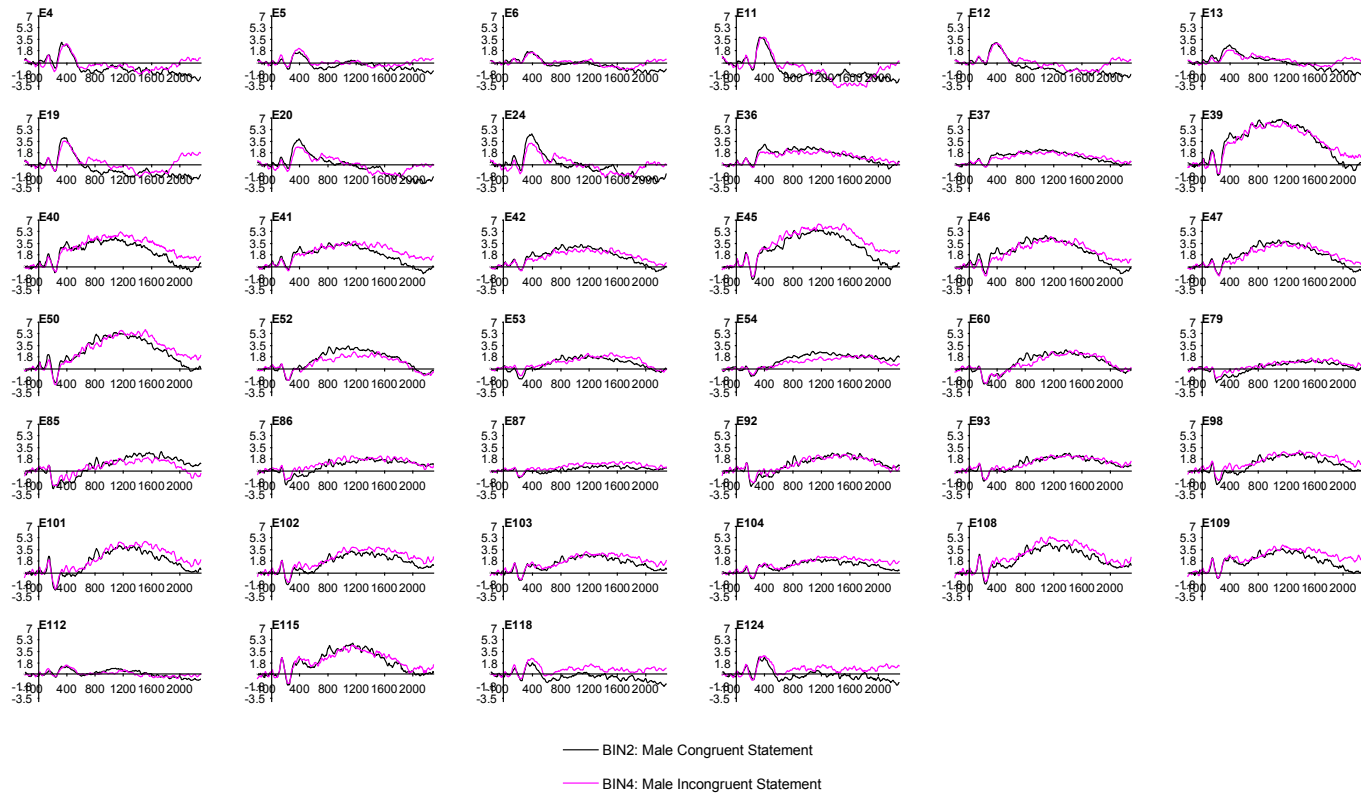
Figure 4. ERP Waves for Statements Spoken by Male Speaker.
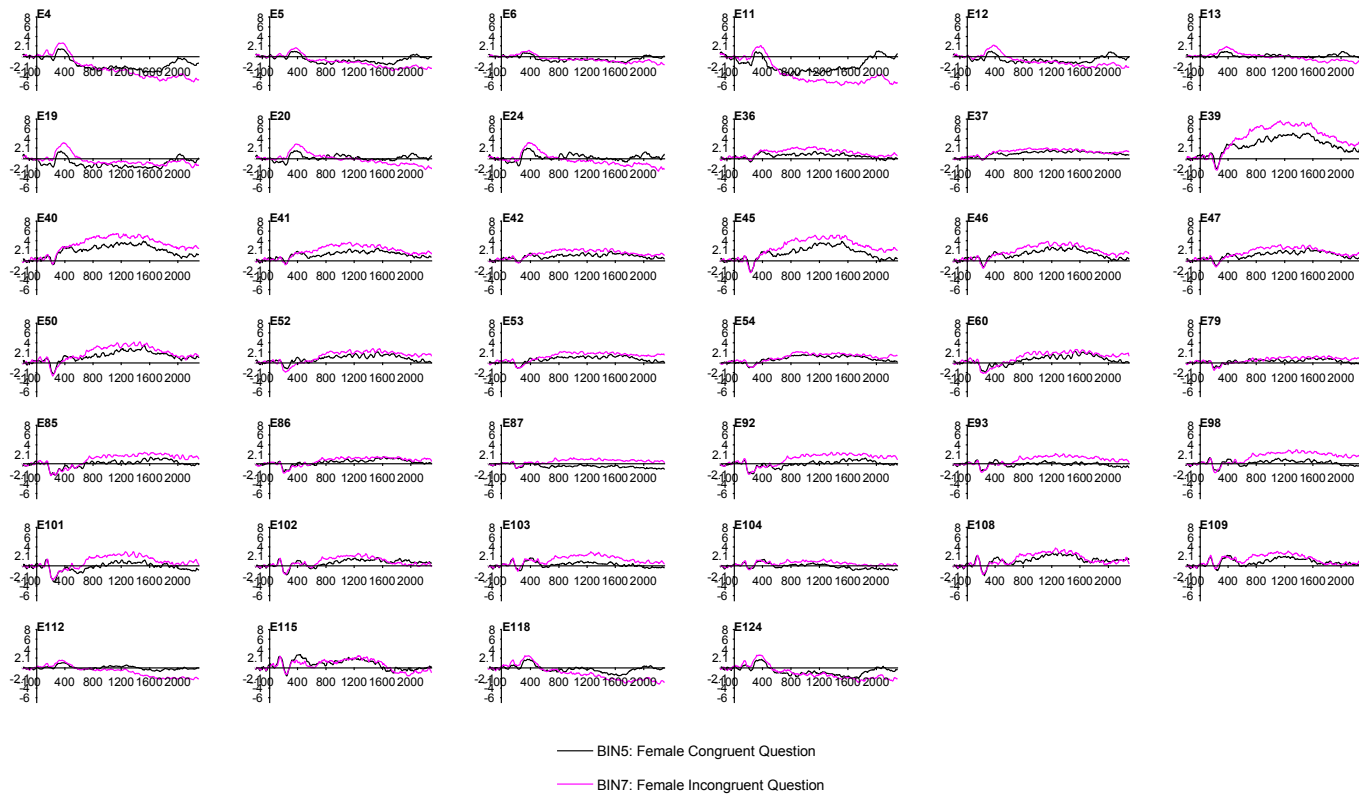
Figure 5. ERP Waves for Questions Spoken by Female Speaker.

40
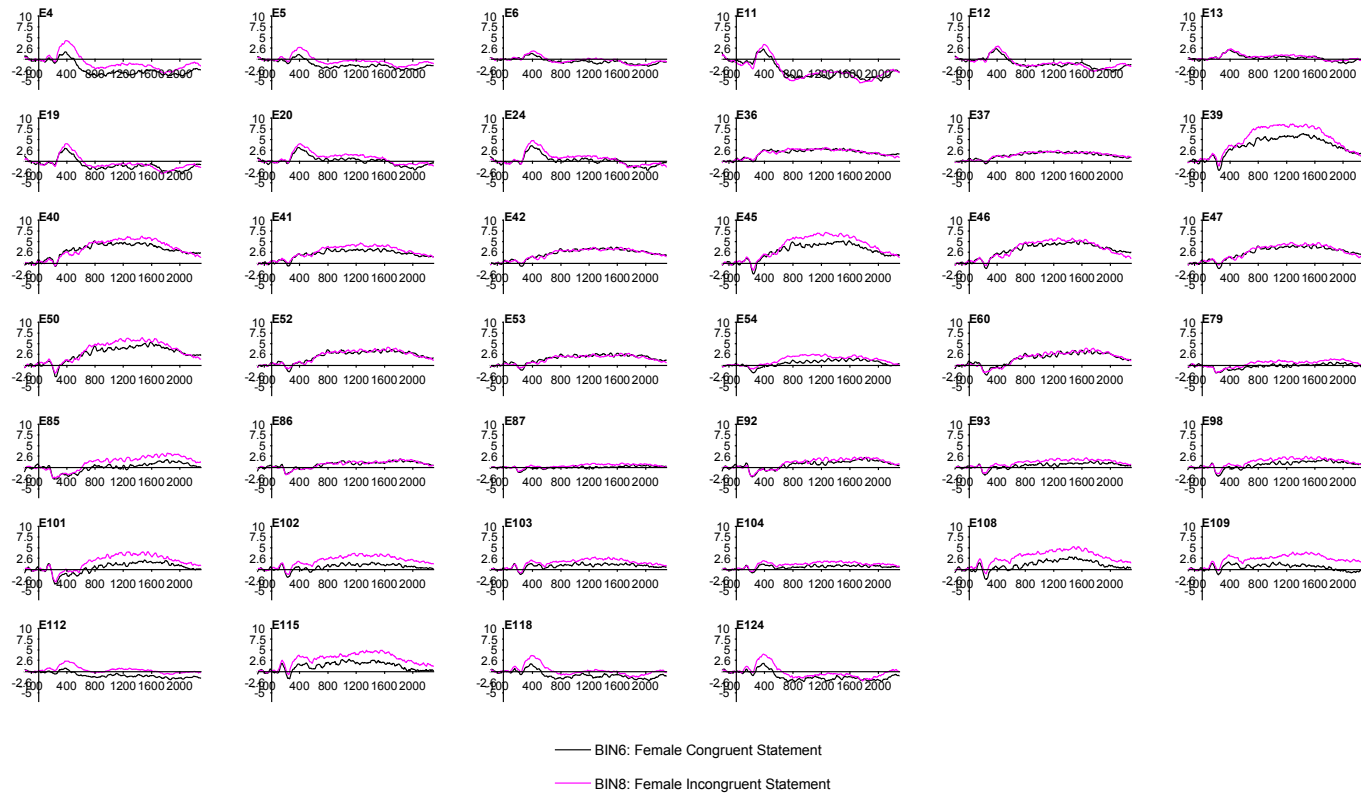
Figure 6. ERP Waves for Statements Spoken by Female Speaker.

Figure 7. HydroCel Geodesic Sensor Net with highlighted electrode cluster regions.
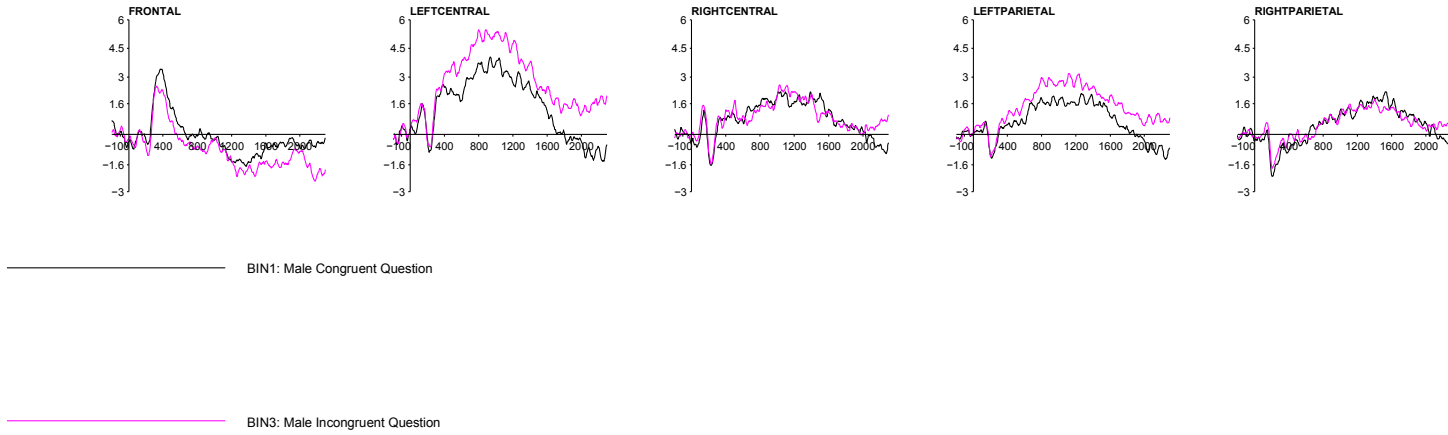
Figure 8. ERP Region Cluster Waves for Questions Spoken by Male Speaker.
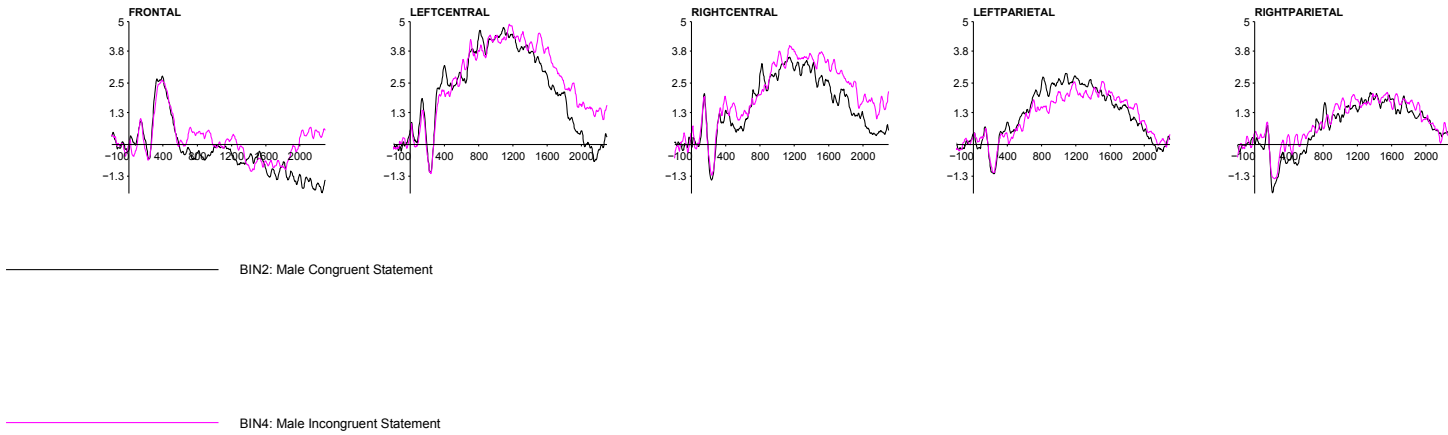

Figure 9. ERP Region Cluster Waves for Statements Spoken by Male Speaker.
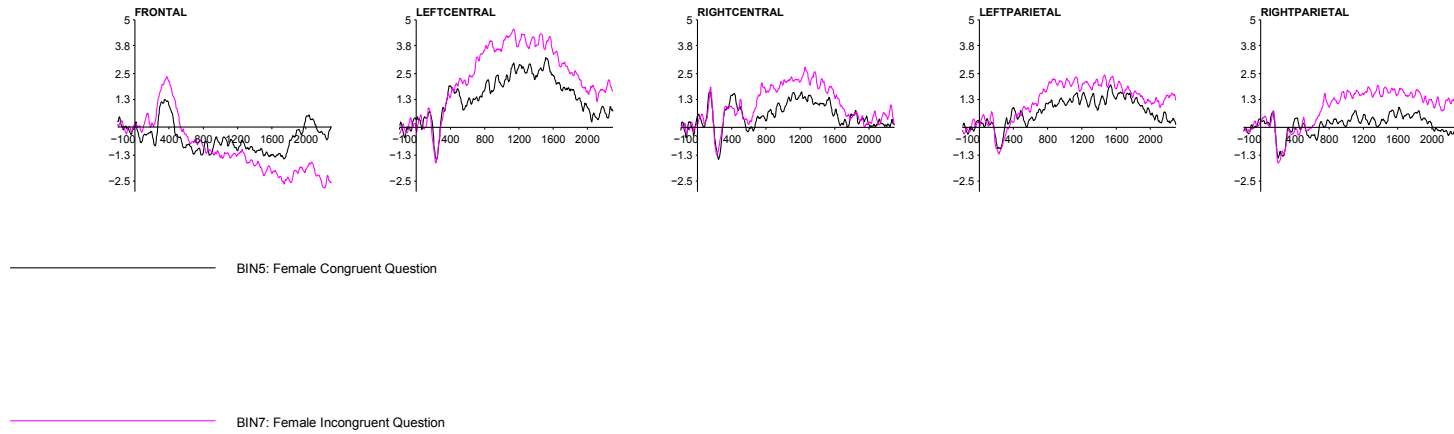
43

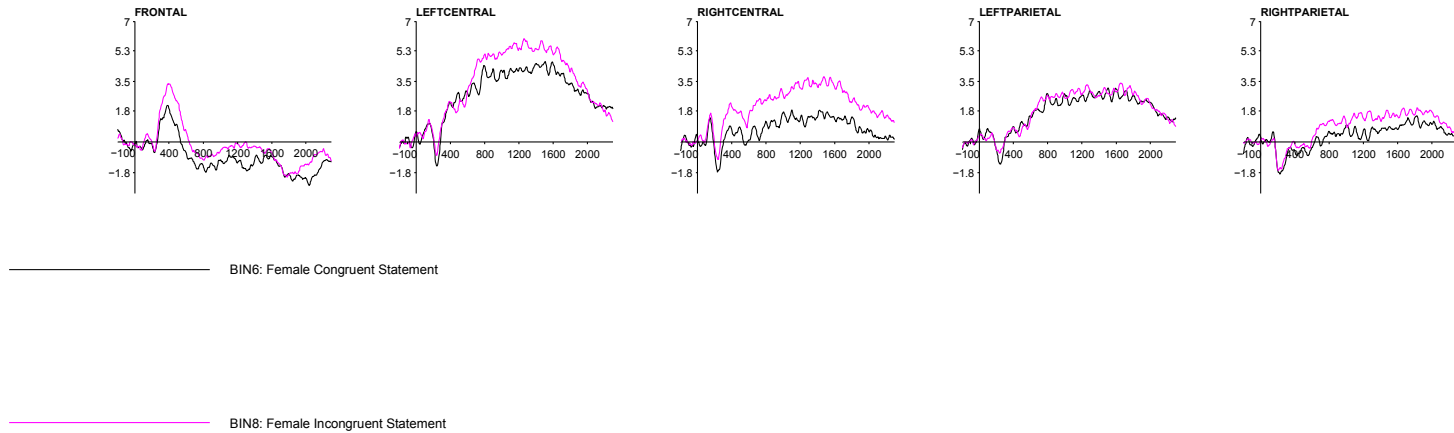*Figure 10.* ERP Region Cluster Waves for Questions Spoken by Female Speaker.

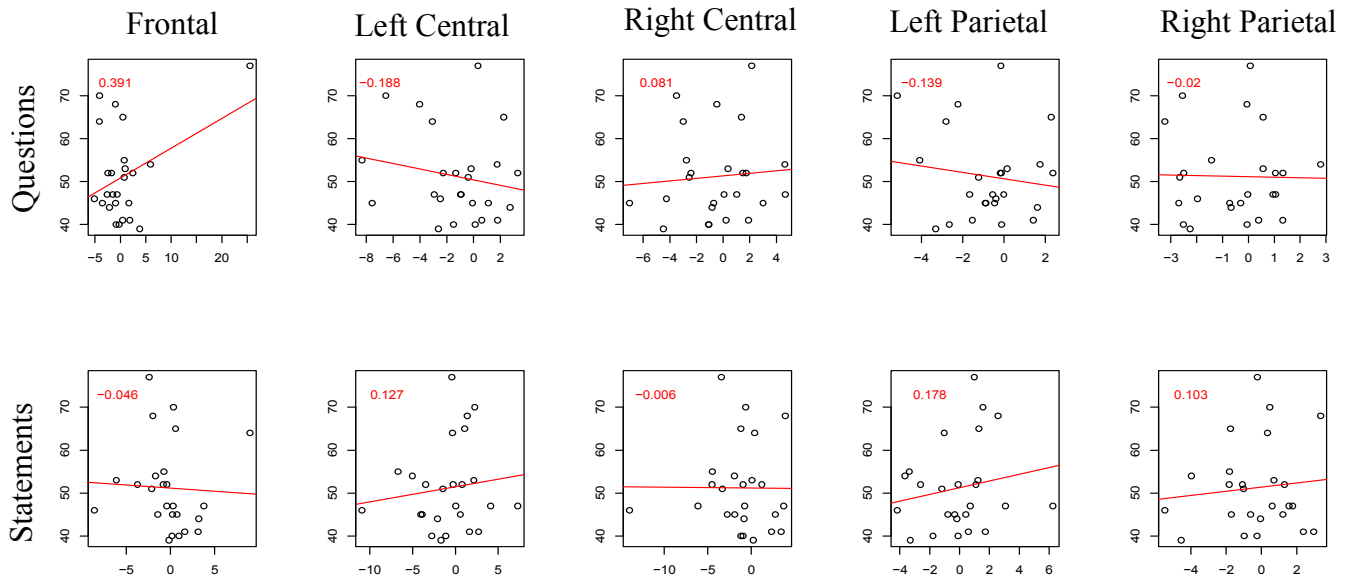*Figure 11.* ERP Region Cluster Waves for Statements Spoken by Female Speaker.

Figure 12. Individual N400 and SRS-2 Correlation Plots.

References

Amoruso, L., Gelormini, C., Aboitiz, F., Alvarez González, M., Manes, F., Cardona, J. F., & Ibanez, A. (2013). N400 ERPs for actions: building meaning in context. *Frontiers in Human Neuroscience*, *7*(March), 57. http://doi.org/10.3389/fnhum.2013.00057

Astésano, C., Besson, M., & Alter, K. (2004). Brain potentials during semantic and prosodic processing in French. *Cognitive Brain Research*, *18*(2), 172–184. http://doi.org/10.1016/j.cogbrainres.2003.10.002

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*(4), 390–412. http://doi.org/10.1016/j.jml.2007.12.005

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The Autism Spectrum Quotient : Evidence from Asperger syndrome/high functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders*, *31*(1), 5–17. http://doi.org/10.1023/A:1005653411471

Barr, D. J. (2017). Generalizing over encounters: Statistical and theoretical considerations., 1–12. http://doi.org/10.17605/OSF.IO/MCRZU

Bassano, D., & Mendes-Maillochon, I. (1994). Early grammatical and prosodic marking of utterance modality in French: A longitudinal case study. *Journal of Child Language*, *21*(1994), 649–675. http://doi.org/10.1017/S0305000900009491

Bentin, S., McCarthy, G., & Wood, C. C. (1985). Event-related potentials, lexical decision and semantic priming. *Electroencephalography and Clinical Neurophysiology*, *60*(4), 343–355. http://doi.org/10.1016/0013-4694(85)90008-2

Besson, M., Magne, C., & Schön, D. (2002). Emotional prosody: Sex differences in sensitivity to

speech melody. *Trends in Cognitive Sciences*, *6*(10), 405–407.

http://doi.org/10.1016/S1364-6613(02)01975-7

Boersma, P., & Weenick, D. (2017). Praat: Doing phonetics by computer. [Computer program].

Version 6.0.29, retrieved 24 May 2017 from http://www.praat.org/.

Bögels, S., Schriefers, H., Vonk, W., & Chwilla, D. J. (2011a). Pitch accents in context: How

listeners process accentuation in referential communication. *Neuropsychologia*, *49*(7),

2022–2036. http://doi.org/10.1016/j.neuropsychologia.2011.03.032

Bögels, S., Schriefers, H., Vonk, W., & Chwilla, D. J. (2011b). Prosodic breaks in sentence

processing investigated by event-related potentials. *Linguistics and Language Compass*,

5(7), 424–440. http://doi.org/10.1111/j.1749-818X.2011.00291.x

Bögels, S., Schriefers, H., Vonk, W., Chwilla, D. J., & Kerkhofs, R. (2010). The interplay

between prosody and syntax in sentence processing: The case of subject- and object-control

verbs. *Journal of Cognitive Neuroscience*, *22*(5), 1036–1053.

http://doi.org/10.1162/jocn.2009.21269

Bögels, S., Schriefers, H., Vonk, W., Chwilla, D. J., & Kerkhofs, R. (2013). Processing

consequences of superfluous and missing prosodic breaks in auditory sentence

comprehension. *Neuropsychologia*, *51*(13), 2715–2728.

http://doi.org/10.1016/j.neuropsychologia.2013.09.008

Bolinger, D. (1998). Intonation in American English. In D. Hirst & A. Di Cristo (Eds.),

Intonation Systems: A Survey of Twenty Languages (pp. 45–55). Cambridge, UK:

Cambridge Univeristy Press.

Bruni, T. P. (2014). Test Review: Social Responsiveness Scale-Second Edition (SRS-2). *Journal*

of Psychoeducational Assessment, *32*(4), 365–369.

http://doi.org/10.1177/0734282913517525

Constantino, J. N., & Gruber, C. P. (2012). *Social Responsiveness Scale (SRS) Second Edition*. Torrance: Western Psychological Services.

Cutler, A., & Carter, D. M. (1987). The predominance of strong initial syllables in the English vocabulary. *Computer Speech and Language*, *2*, 133–142.

Cutler, A., Dahan, D., & von Donselaar, W. (1997). Prosody in the comprehension of spoken language : A literature review. *Language and Speech*, *40*(2), 141–201.

Delorme, A., & Makeig, S. (2004). EEGLAB: an open sorce toolbox for analysis of single-trail EEG dynamics including independent component anlaysis. *Journal of Neuroscience Methods*, *134*, 9–21. http://doi.org/10.1016/j.jneumeth.2003.10.009

Donchin, E., Ritter, W., & McCallum, W. C. (1978). Cognitive psychophysiology: The endogenous components of the ERP. *Brain Event-Related Potentials in Man*. New York: Academic Press. http://doi.org/10.1016/B978-0-12-155150-6.50019-5

Duncan, C. C., Barry, R. J., Connolly, J. F., Fischer, C., Michie, P. T., Näätänen, R., … Van Petten, C. (2009). Event-related potentials in clinical research: Guidelines for eliciting, recording, and quantifying mismatch negativity, P300, and N400. *Clinical Neurophysiology*, *120*(11), 1883–1908. http://doi.org/10.1016/j.clinph.2009.07.045

Eady, S. J., & Cooper, W. E. (1986). Speech intonation and focus location in matched statements and questions. *The Journal of the Acoustical Society of America*, *80*(2), 402–415. http://doi.org/10.1121/1.394091

Electrical Geodesics Inc. (2003). *Net Station Acquisition Technical Manual*. Eugene, OR: Electrical Geodesics, Inc. Retrieved from http://cb3.unl.edu/dbrainlab/wp-content/uploads/sites/2/2013/12/Acquisition_Manual.pdf

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. http://doi.org/10.3758/BF03193146

Ganis, G., Kutas, M., & Sereno, M. I. (1996). The search for "'common sense'": An electrophysiological study of the comprehension of words and pictures in reading. *Journal of Cognitive Neuroscience*, *8*(2), 89–106. http://doi.org/10.1162/jocn.1996.8.2.89

Hagoort, P., Brown, C., & Groothusen, J. (1993). The syntactic positive shift (SPS) as an ERP measure of syntactic processing. *Language and Cognitive Processes*, *8*(4), 439–483. http://doi.org/10.1080/01690969308407585

Heim, S., & Alter, K. (2006). Prosodic pitch accents in language comprehension and production: ERP data and acoustic analyses. *Acta Neurobiologiae Experimentalis*, *66*(1), 55–68.

Hinde, R. A. (1972). *Non-Verbal Communication*. Cambridge, UK: Cambridge University Press.

Holcomb, P. J., & Neville, H. J. (1990). Auditory and visual semantic priming in lexical decision: A comparison using event-related brain potentials. *Language and Cognitive Processes*, *5*(4), 281–312. http://doi.org/10.1080/01690969008407065

Holcomb, P. J., & Neville, H. J. (1991). Natural speech processing: An analysis using event-related brain potentials. *Psychobiology*, *19*(4), 286–300. http://doi.org/10.3758/BF03332082

Hruska, C., & Alter, K. (2004). Prosody in dialogues and single sentences: How prosody can influence speech perception. *Information Structure: Theoretical and Empirical Aspects. Language, Context, and Cognition*, *1*, 211–226.

Judd, C. M., Westfall, J., & Kenny, D. A. (2012). Treating stimuli as a random factor in social psychology: A new and comprehensive solution to a pervasive but largely ignored problem. *Journal of Personality and Social Psychology*, *103*(1), 54–69.

http://doi.org/10.1037/a0028347

Kelley, E., Paul, J. J., Fein, D., & Naigles, L. R. (2006). Residual language deficits in optimal outcome children with a history of autism. *Journal of Autism and Developmental Disorders*, *36*(6), 807–828. http://doi.org/10.1007/s10803-006-0111-4

Kotz, S. A., & Paulmann, S. (2007). When emotional prosody and semantics dance cheek to cheek: ERP evidence. *Brain Research*, *1151*(1), 107–118. http://doi.org/10.1016/j.brainres.2007.03.015

Kulakova, E., & Nieuwland, M. S. (2016). Pragmatic skills predict online counterfactual comprehension: Evidence from the N400. *Cognitive, Affective and Behavioral Neuroscience*, *16*(5), 814–824. http://doi.org/10.3758/s13415-016-0433-4

Kutas, M., & Federmeier, K. D. (2011). Thirty years and counting: Finding meaning in the N400 component of the event related brain potential (ERP). *Annual Review of Psychology*, *62*, 621–647. http://doi.org/10.1146/annurev.psych.093008.131123.Thirty

Kutas, M., & Hillyard, S. A. (1980). Reading senseless sentences: Brain potentials reflect semantic incongruity. *Science*, *207*, 203–205.

Kutas, M., & Hillyard, S. A. (1983). Event-related brain potentials to grammatical errors and semantic anomalies. *Memory & Cognition*, *11*(5), 539–550. http://doi.org/10.3758/BF03196991

Kutas, M., & Hillyard, S. A. (1984). Brain potentials during reading reflect word expectancy and semantic association. *Nature*, *307*, 161–163. http://doi.org/10.1038/307161a0

Kutas, M., Neville, H. J., & Holcomb, P. J. (1987). A preliminary comparison of the N400 response to semantic anomalies during reading, listening and signing. *Electroencephalography and Clinical Neurophysiology, Supplement*, *39*, 325–330.

Leech, G. N. (1983). Semantics and Pragmatics. In *Principles of Pragmatics* (pp. 5–10). New York: Routledge.

Lopez-Calderon, J., & Luck, S. J. (2014). ERPLAB: An open-source toolbox for the analysis of event-related potentials. *Frontiers in Human Neuroscience*, *8*(April), 213. http://doi.org/10.3389/fnhum.2014.00213

Luck, S. J. (2014). *An Introduction to the Event-Related Potential Technique*. Cambridge, MA: The MIT Press.

Machin, D. (2014). Visual Communication. In *Handbook of Communication Science* (Vol. 4). Berlin: De Gruyter Mouton.

Magne, C., Astésano, C., Aramaki, M., Ystad, S., Kronland-Martinet, R., & Besson, M. (2007). Influence of syllabic lengthening on semantic processing in spoken French: Behavioral and electrophysiological evidence. *Cerebral Cortex*, *17*(11), 2659–2668. http://doi.org/10.1093/cercor/bhl174

Magne, C., Astésano, C., Lacheret-Dujour, A., Morel, M., Alter, K., & Besson, M. (2005). On-line processing of "pop-out" words in spoken French dialogues. *Journal of Cognitive Neuroscience*, *17*(5), 740–756. http://doi.org/10.1162/0898929053747667

McCallum, W. C., Farmer, S. F., & Pocock, P. V. (1984). The effects of physical and semantic incongruites on auditory event-related potentials. *Electroencephalography and Clinical Neurophysiology/*, *59*(6), 477–488. http://doi.org/10.1016/0168-5597(84)90006-6

Miller, G. A. (1951). *Language and Communication*. McGraw-Hill Book Company Inc.

Niedeggen, M., Rösler, F., & Jost, K. (1999). Processing of incongruous mental calculation problems: Evidence for an arithmetic N400 effect. *Psychophysiology*, *36*, 307–324. http://doi.org/10.1017/S0048577299980149

Nieuwland, M. S., Ditman, T., & Kuperberg, G. R. (2010). On the incrementality of pragmatic processing: An ERP investigation of informativeness and pragmatic abilities. *Journal of Memory and Language*, *63*(3), 324–346. http://doi.org/10.1016/j.jml.2010.06.005

Osterhout, L., & Holcomb, P. J. (1995). Event-related potentials and language comprehension. In M. D. Rugg & M. G. H. Coles (Eds.), *Electrophysiology of Mind* (pp. 171–215). Oxford: Oxford University Press.

Pauker, E., Itzhak, I., Baum, S. R., & Steinhauer, K. (2011). Effects of cooperating and conflicting prosody in spoken English garden path sentences: ERP evidence for the boundary deletion hypothesis. *Journal of Cognitive Neuroscience*, *23*(10), 2731–2751. http://doi.org/10.1162/jocn.2011.21610

Paul, R., Augustyn, A., Klin, A., & Volkmar, F. R. (2005). Perception and production of prosody by speakers with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *35*(2), 205–220. http://doi.org/10.1007/s10803-004-1999-1

Paul, R., Shriberg, L. D., McSweeny, J., Cicchetti, D., Klin, A., & Volkmar, F. (2005). Brief report: Relations between prosodic performance and communication and socialization ratings in high functioning speakers with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *35*(6), 861–869. http://doi.org/10.1007/s10803-005-0031-8

Paulmann, S., & Kotz, S. A. (2008). An ERP investigation on the temporal dynamics of emotional prosody and emotional semantics in pseudo- and lexical-sentence context. *Brain and Language*, *105*(1), 59–69. http://doi.org/10.1016/j.bandl.2007.11.005

Pike, K. L. (1945). *The intonation of American English*.

Price, P., Ostendorf, M., Shattuck-Hufnagel, S., & Fong, C. (1991). The use of prosody in syntactic disambiguation. *The Journal of the Acoustical Society of America*, *90*(6), 2956–

2970. http://doi.org/10.1121/1.401770

Scherer, K. R., Banse, R., & Wallbott, H. G. (2001). Emotion inferences from vocal expression correlate across languages and cultures. *Journal of Cross-Cultural Psychology*, *32*(1), 76–92. http://doi.org/10.1177/0022022101032001009

Schirmer, A., & Kotz, S. A. (2003). ERP evidence for a sex-specific Stroop effect in emotional speech. *Journal of Cognitive Neuroscience*, *15*(8), 1135–1148. http://doi.org/10.1162/089892903322598102

Schirmer, A., Kotz, S. A., & Friederici, A. D. (2002). Sex differentiates the role of emotional prosody during word processing. *Cognitive Brain Research*, *14*(2), 228–233. http://doi.org/10.1016/S0926-6410(02)00108-8

Schumacher, P. B., & Baumann, S. (2010). Pitch accent type affects the N400 during referential processing. *Neuroreport*, *21*(9), 618–622. http://doi.org/10.1097/WNR.0b013e328339874a

Searle, J. R. (1972). *Chomsky's Revolution in Linguistics*. *The New York Review of Books* (Vol. 18).

Shibata, H., Gyoba, J., & Suzuki, Y. (2009). Event-related potentials during the evaluation of the appropriateness of cooperative actions. *Neuroscience Letters*, *452*(2), 189–193. http://doi.org/10.1016/j.neulet.2009.01.042

Steinhauer, K., Alter, K., & Friederici, a D. (1999). Brain potentials indicate immediate use of prosodic cues in natural speech processing. *Nature Neuroscience*, *2*(2), 191–196. http://doi.org/10.1038/5757

Swaab, T. Y., Ledoux, K., Camblin, C. C., & Boudewyn, M. A. (2012). Language-related ERP components. In S. J. Luck & E. S. Kappenman (Eds.), *The Oxford Handbook of Event-Related Potential Components* (pp. 397–440). New York: Oxford University Press.

http://doi.org/10.1093/oxfordhb/9780195374148.013.0197

Swinney, D. (1981). The process of language comprehension; An approach to examining issues in cognition and language. *Cognition*, *10*(1–3), 307–312. http://doi.org/10.1016/0010-0277(81)90062-7

Uldall, E. T. (1962). Ambiguity: Question or statement? Or "Are you asking me or telling me?" In *Proceedings of the 4th International Congress of Phonetic Sciences* (pp. 779–783).

Wales, R., & Taylor, S. (1987). Intonation cues to questions and statements: How are they perceived? *Language and Speech*, *30*(3), 199–211. http://doi.org/10.1177/002383098703000302

Wang, J. E., & Tsao, F. M. (2015). Emotional prosody perception and its association with pragmatic language in school-aged children with high-function autism. *Research in Developmental Disabilities*, *37*(1), 162–170. http://doi.org/10.1016/j.ridd.2014.11.013

Westfall, J., Kenny, D. A., & Judd, C. M. (2014). Statistical power and optimal design in experiments in which samples of participants respond to samples of stimuli. *Journal of Experimental Psychology*, *143*(5), 2020–2045.

ELIZABETH A. KAPLAN

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EDUCATION

Ph.D. Student, School Psychology   Aug. 2016 – Present
Syracuse University, Syracuse, NY
APA, CAEP accredited, NASP approved
Advisor: Natalie Russo, Ph.D., Licensed Psychologist

B.A. with Honors, Cognitive Science   Aug. 2010 – Dec. 2013
Johns Hopkins University, Baltimore, MD
Minors: Psychology and Jewish Studies (GPA 3.83)

RESEARCH EXPERIENCE

Syracuse University Center for Autism Research and Electrophysiology   Aug. 2016 – Present
Graduate Researcher
PI: Natalie Russo, Ph.D., Licensed Psychologist

- Run participants in ERP studies studying perceptual and cognitive processes in children with autism spectrum disorders
- Administer ADOS-2, intelligence (WASI-II) and language (PPVT-IV) measures
- Collect and analyze behavioral and electrophysiological (EEG and ERP) data

University of California, Berkeley Language and Cognitive Development Lab   Jul. 2015 – Jul. 2016
Researcher and Lab Manager
PI: Mahesh Srinivasan, Ph.D.

- Analyze and interpret data for ongoing studies examining linguistic, cognitive and social development
- Foster new collaborations with local preschools, daycares, libraries, and museums
- Build recruitment database to organize recruitment efforts of four developmental psychology labs

Harvard University Lab for Developmental Studies   Jun. 2013 – Aug.2013 -and- Apr. 2014 – Jul. 2015
Summer Research Intern, Researcher and Lab Manager
PI: Jesse Snedeker, Ph.D.

- Manage research study examining prosodic and pragmatic deficits in children on the autism spectrum
- Run pre- and post-tests of study with ASD, LBLD, and TD children, using Tobii eye-tracking tasks
- Administer standardized testing assessments (KBIT, CELF, PPVT)
- Assist in development and design of prosodic and pragmatic language tasks used in study

Johns Hopkins Lab for Child Development   Dec. 2011 – Mar. 2014
Research Assistant at the Maryland Science Center
PI: Lisa Feigenson, Ph.D.; Mentor: Melissa Kibbe, Ph.D.

- Collaborate with Maryland Science Center staff to bring developmental psychology research to general public
- Run studies and games to evaluate children's sense of approximate number systems
- Engage families and explain study objectives in a non-technical, accessible manner

The Kennedy Krieger Institute at Johns Hopkins Hospital   Jan. 2011 – Dec. 2011
Research Trainee at Center for Genetic Disorders of Cognition and Behavior
PI: Walter Kaufmann, Ph.D.

- Responsible for 2011 recruitment for PING Project (Pediatric Imaging, Neurocognition and Genetics)
- Complete data entry, MRI uploading, and test-standardization of participant data for PING
- Organize patient files and multiple project databases

CLINICAL EXPERIENCE

Syracuse University Psychological Services Center   May 2018 – Present
Student Clinician
Supervisors: Afton Kapuscinski, Ph.D., Licensed Psychologist; Keven Antshel, Ph.D., Licensed Psychologist; Joseph
Himmelsbach, Ph.D., Licensed Psychologist
- Conduct weekly individual psychotherapy sessions with children, families, and college students
- Administer standardized psychological assessment batteries
- Write integrated psychological reports

Upstate Medical University, Department of Pediatrics   Sept. 2017 – Present
Patient Care Specialist at the Family Behavior Analysis Program
Supervisors: Henry Roane, Ph.D.; Nicole DeRosa, Psy.D., BCBA-D, Licensed Psychologist; William Sullivan, Ph.D.
- Implement applied behavioral analysis (ABA) therapy protocols for children with behavior problems including aggression, self-injurious behavior, and property disruption
- Conduct case management for clients under guidance of supervisors
- Administer cognitive measures (PPVT, WNV, WISC-IV) for all incoming clients

Upstate Medical University, Department of Pediatrics   Sept. 2017 – Present
Parent Skills Training Group Leader
Supervisors: Henry Roane, Ph.D.; Keven Antshel, Ph.D.
- Lead 2-hour weekly meetings for parents of children with autism spectrum disorder
- Conduct Motivational Interviewing as part of active control group
- Provide psychoeducation on common topics of concern for parents of children with ASD

Elmcrest Children's Center   Sept. 2017 – Dec. 2017
School Based Mental Health Practicum
Supervisors: Joshua Felver, Ph.D., Licensed Psychologist; Leah Phaneauf, Ph.D., Licensed Psychologist
- Plan and teach weekly lessons for *Merrell's Strong Kids* social and emotional learning curriculum
- Create activities for students to practice socioemotional skills such as emotion recognition, problem solving and anger management
- Facilitate discussion about relevancy of socioemotional skills in students' everyday lives and how to implement strategies practiced in class

Syracuse University, Department of Psychology   Sept. 2016 – Dec. 2017
Social Skills Group Leader
Supervisor: Kevin Antshel, Ph.D., Licensed Psychologist
- Assist with group-based counseling designed to improve social functioning in children experiencing social difficulties
- Lead break-out sessions to practice specific skills in small groups
- Facilitate discussions about aspects of appropriate conversation

TEACHING EXPERIENCE

Syracuse University, Department of Psychology   Aug. 2016 – May 2017
Teaching Assistant for Foundations of Human Behavior (PSY 205)
Supervisor: Shannon Houck, Ph.D.
- Independently teach seven, 80-minute sections of approx. 25 students each
- Construct and give lectures and facilitate class discussions
- Create and grade weekly quizzes, assignments, and exams

Syracuse University Center for Autism Research and Electrophysiology   Nov. 2016 – Present
Graduate Mentor for Undergraduate Research Assistants

PI: Natalie Russo, Ph.D., Licensed Psychologist
- Mentor undergraduate research assistants on research projects and data entry
- Assist undergraduate mentees through poster creation and presentation process for Psychology Department Annual Poster Session
- Review personal statements and resumes for undergraduate research assistants

PUBLICATIONS

Kaplan, E. A., Russo, N. & Iarocci, G. (submitted). Validating Three Common Self-Report Measures of Social Functioning: Implications for Autism Research. *Journal of Autism and Developmental Disorders.*

Kaplan, E. A., Russo, N., & Kellen, D. (revision invited). "The volume of your voice does not increase the validity of your argument," but a proper dataset might: Spoken language stimulus set with detailed acoustic features. *Psychiatry Research.*

Kaplan, E. A., Kopec, J., McKernan, E. P. & Russo, N. (revision invited). Attention in Individuals with Down Syndrome. In J. Burack, J. Edgin, L. Abbeduto, & J. Busciglio (Eds.), *Oxford Handbook of Down Syndrome and Development.* New York: Oxford University Press.

Srinivasan, M., **Kaplan, E. A.**, Dahl, A. (2018). Reasoning about the Scope of Religious Norms: Evidence from Hindu and Muslim Children in India. *Cognitive Development.*

Kaplan, E., Levari, T., & Snedeker, J. (2016). Eye tracking and spoken language comprehension. In C. A. Was, F. J. Sansosti, & B. J. Morris (Eds.), *Eye-tracking technology applications in educational research.* (88-105). Hershey, PA: IGI Global.

Gross, S., Chaisilprungraung, T., **Kaplan, E.**, Menendez, J., & Flombaum, J. (2014). Problems for the Purported Cognitive Penetration of Perceptual Color Experience and Macpherson's Proposed Mechanism." In Edouard Machery, Jesse Prinz, and Jurgis Skilters (eds.), *Perception and Concepts* (BalticInternational Yearbook of Cognition, Logic, and Communication, Vol. 9), New Prairie Press.

PRESENTATIONS

Kaplan, E. A., Russo, N., Kopec, J., McKernan, E. P., Koelmel, E. L., & Prawl, A. M. (2018). EEG Correlates of the Attentional Blink: Relationship to Autism Symptoms. International Society for Autism Research 2018 Annual Meeting, Rotterdam, Netherlands.

Kopec, J., Russo, N., McKernan, E. P., **Kaplan, E. A.**, Koelmel, E. L., & Prawl, A. M. (2018). Children and Adults with Autism Detect Rapidly Presented Temporal Information More Accurately than Typically Developing Individuals. International Society for Autism Research 2018 Annual Meeting, Rotterdam, Netherlands.

McKernan, E. P., Russo, N., Kopec, J., **Kaplan, E. A.**, Koelmel, E. L., & Prawl, A. M. (2018). The Relationship of Sensory Overresponsivity to Amplitude Discrimination. International Society for Autism Research 2018 Annual Meeting, Rotterdam, Netherlands.

McKernan, E. P., Russo, N., Burnette, C., **Kaplan, E. A.,** Kopec, J., Shea, N., & Kates, W. R. (2017). ASD Concordance of Twins Across DSM-IV-TR and DSM-5 Diagnostic Criteria. International Meeting for Autism Research, San Fransisco, CA.

Shea, N., Payne, E., McKernan, E. P., Kopec, J., **Kaplan, E. A.,** Antshel, K., Kates, W. R., Russo, N. (2017). The Relationship Between Socialization and Externalizing Problems in ASD and VCFS. International Meeting for Autism Research, San Fransisco, CA.

Srinivasan, M., Mughairy, S., **Kaplan E.**, & Dahl, A. (2015). Preschoolers' reactions to novel moral and conventional norm violations. 9th Biennial Meeting of the Cognitive Development Society, Columbus, OH.

Kaplan, E., Snedeker, J., Lee, E. K., Brookhyser, T. (2013). Prosodic and Pragmatic Training in Highly Verbal Children with Autism. Harvard Psychology Department Undergraduate Conference, Cambridge, MA

PROFESSIONAL DEVELOPMENT

Women in Science and Engineering Future Professionals Program   2018 – Present
Syracuse University

Trauma-Focused Cognitive Behavioral Therapy Online Training   2018
11 continuing education contact hours through The Medical University of South Carolina

Safer People, Safer Spaces Training   2018
Syracuse University, LGBT Resource Center

Future Professoriate Program   2017 – Present
Syracuse University, Department of Psychology, Syracuse, NY

Autism Diagnostic Observation Schedule (ADOS-2) Clinical Training   2017
Weill Cornell Medical College, Department of Psychiatry, White Plains, NY

Women in Science and Engineering Writing Workshop   2017

Syracuse University, Syracuse, NY

GRANTS & AWARDS

Syracuse University Interdisciplinary Neuroscience Program Travel Award	2018
Syracuse University Psychology Department Travel Award	2017
Syracuse University Graduate Student Organization Travel Award	2017
Johns Hopkins University Dean's List	2010, 2011, 2012, 2013
Carrie K. and Walter H. Church Scholarship	2011, 2012, 2013
Seidman Family Scholarship	2011, 2012, 2013
Harvard University Summer Internship	2013

PROFESSIONAL SERVICE

Department Service

Diversifying Psychology Weekend Graduate Student Liaison	2018
Syracuse University Be-Well Mental Health Expo	2018
Psychology Action Committee Events Coordinator	2016 – Present

Program Service

School Psychology Faculty-Graduate Student Liaison	Present
School Psychology Graduate Student Admissions Panel	2017 - Present
School Psychology Professional Development Committee	2017 – 2018
School Psychology Communications Committee	2016 - 2017

Ad Hoc Reviewer

- *Journal of Child and Family Studies*
- *Journal of Developmental and Physical Disabilities*

MEMBERSHIPS

International Society for Autism Research	Jan. 2017 – Present
Cognitive Development Society	Aug. 2015 – Present
American Psychological Association, Division 16 (School Psychology)	Aug. 2015 – Present
National Society of Collegiate Scholars	Apr. 2012 – Apr. 2014