PROSODY, POETRY and PROCESSING:

an Event Related Potential Investigation of Auditory Imagery

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DEDICATION

To my grandmothers, Milagros Fuentebella Oraa and Masooma Ali.

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Michelle ‘Misha’ Oraa Ali

ABSTRACT

The aim of the current study is to understand the role of metrical structure in implicit prosody during silent reading as an attempt to draw parallels between auditory imagery and auditory perception. Implicit prosody can direct readers' real-time linguistic interpretations of text; manipulation of implicit prosodic cues affects linguistic ambiguity resolution, thereby providing insight into the nature of auditory imagery and language processing. Event related potentials (ERPs) of nineteen participants were recorded using continuous electroencephalography as they read a series of 320 couplets derived from limericks, which had manipulated lexical stress patterns of the target word (trochaic or iambic) and metrical consistency (metrically consistent or metrically inconsistent). Using the Bucknell Auditory Imagery Scale (BAIS) and Varieties of Inner Speech Questionnaire (VISQ), we obtained measures of the participants' levels of auditory imagery. Apart from a moderate negative correlation with the VISQ Dialogic subscale score, there was no significant relationship between evoked ERP responses and the auditory imagery scales. We found that metrically inconsistent trochaic targets elicited a negativity between 325-400ms over left and medial-frontocentral scalp regions relative to consistent trochaic targets. This result suggests that internally generated prosodic structures do, indeed, impact real-time language processing during silent reading and that, specifically, metrical structure in language creates temporal expectancies during implicit prosody.

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INTRODUCTION

In all likelihood, when you are reading these letters, there is a small voice in your head which is sounding these words out – essentially, you are 'hearing' without actually hearing. In other words, you are constructing an auditory image by perceiving speech without any corresponding external sound stimulus. This imagined 'inner voice' or auditory imagery is crucial to our ability to process and understand the meaning of these written words. Philosophers and cognitive scientists alike have been engrossed and fascinated with the idea of mental imagery since time immemorial; we can trace the evolution of ideas and theories about mental imagery from (at least) 350 B.C.E. Starting with Artistotle's preoccupation with the concept of '*phantasmata'* (a mental impression of an actual perception) and his view that it is fundamentally impossible to think without an image (Turnbull, 1994), to this day, with the work of Stephen Kosslyn, who argues that imagery is cognitively represented as pictures in the brain (Kosslyn , 1980).

In this study, we seeked to understand the nature of auditory imagery through an exploration of implicit prosody. We explored the impact of internally generated prosodic structures of rhythm and metrical stress on real-time language processing during silent reading. Specifically, we used event-related potentials (ERPs) to record the neural responses evoked when participants read limerick couplets which varied in their rhythmic consistency and metrical stress pattern. Additionally, we collected data about participants' self-reported levels of auditory imagery. Together, this information will give us important insights into the neurocognitive phenomena which are crucial to language processing.

Overview of Research in Cognitive Imagery

In cognitive psychology and neuroscience, there have several studies which provide evidence that, in the visual modality, perception and imagery, in the absence of a physical stimulus, are cognitively similar (Atwood, 1971; Kosslyn, Ganis, & Thompson, 2001). Behavioral experiments which focused on mental rotation of three dimensional objects demonstrated similarities in reaction time between imagery and visual perception (Shepard & Metzler, 1971). Additionally, neuroimaging techniques such as functional magnetic resonance imaging (fMRI) and event-related potentials have allowed scientists to study and confirm similarities in brain regions involved in visual imagery and perception (Ganis et al., 2004), as well as temporal parallels between the cognitive processing of perception and that of imagery (Farah et al., 1988). Also, studies have shown that participants' self-reported visual imagery vividness can be used as an accurate predictor of performance on imagery-dependent behavioral tasks (Rodway et al., 2006).

However, the bulk of scientific attention about imagery has been fixated on the visual realm (Anderson, 1978; Richardson, 2013); it is not hard to imagine why one of the most commonly used expressions in the English language to elicit imagery is "Picture this!" Auditory imagery, on the other hand, has not been subjected to the same levels of empirical scrutiny. This paucity of scientific investigation in auditory imagery means there is much left to be discovered, as it gives cognitive scientists an avenue to explore fundamental facets of cognition like working memory, as well as higher order processes such as reading and associative learning (Baddeley & Logie, 1992; Reisberg, 2014; Hubbard, 2010). As in the case of visual imagery, behavioral experiments that used ratings of pitch have revealed that there are parallels between auditory imagery and auditory perception (Intons-

Peterson et. al., 1992). Likewise, there is electrophysiological evidence of an overlap between imagined/expected sound and perceived sound (Janata, 2001). Similar to studies focusing solely on the visual modality, assessment of individual's vividness of auditory imagery have been shown to correlated with their performance on pitch memory tasks (Hishitani, 2009). Drawing upon the wealth of psycholinguistics literature, language stands out as an excellent candidate because it routinely appears in both visual and auditory channels, as well as the wide variety of empirical investigation methods and techniques we have at our disposal.

Language and Ambiguity

Investigating the cognitive science of auditory imagery through the lens of language offers a powerful cross-modal method of comparison between auditory code (silent reading which evokes speech) and visual perception (text). Additionally, language facilitates experimental versatility by allowing researchers to make comparisons between auditory perception and auditory imagery through ERPs, eye-tracking and a variety of other behavioral measures (Ahlsén, 2006).

In an experimental context, another interesting aspect of language is how we are able to resolve ambiguity when using language. Each language has a limited set of phonemes and symbols which its users manipulate in a variety of permutations to create words with which to express concepts, feelings and events (Crystal, 2010); American English is estimated to have 44 phonemes (Labov, Ash, & Boberg, 2005). However, as in the case of English among many other languages, the entire vocabulary is exponentially bigger than the number of available phonemes (Jackson & Etienne, 2007)- this leads to linguistic ambiguity, causing the same word to have multiple meanings in different contexts (*break* = an interruption; *break* = an act of destruction; *break* = unexpected piece of good luck, etc.). Ambiguity can also arise in a syntactic manner, as in the sentence "The boy saw his friend with the camera". Reading this isolated sentence, we might wonder: did the boy spy his peer through a camera lens or did he observe his buddy holding a camera?

Language comprehension is influenced by our familiarity with previous syntactic and semantic patterns; often, this set-up leads to cases in which expected interpretations of sentences or phrases are incorrect. The aforementioned example is an instance of a globally ambiguous sentence– regardless of the number of times you read it, the meaning cannot be determined without context. Garden-path sentences, on the other hand, are syntactically acceptable sentences which lure or deceive the reader into a creating a momentarily ambiguous meaning, usually through using words or phrases which can be interpreted in different ways, as demonstrated in the following example (1) :

1) "The old man the boats."

How might one interpret this sentence? At first glance, one might read this sentence thinking that *old* is an adjective of *man*, but then the reader encounters *the* after *man* instead of a verb. Upon realizing that they have been misled, the reader then recognizes that *old* is a noun and that *man* is a verb in this sentence. The reader's initial misinterpretation of the sentence is a cognitively costly misanalysis of syntactic information, necessitating reanalysis which can be quantified and measured behaviorally (Langacker, 1977). In an eye-tracking experiment where participants were shown sentences which contained structural ambiguities such as the example above, it was found that subjects had longer reading times for ambiguous garden-path like sentences which violated common parsing strategies than more syntactically conventional control sentences (Frazier & Rayner, 1982). However, when articulated out loud, prosodic cues can help disambiguate this sentence quite effectively. It is much easier to accurately interpret the sentence if one were to say "the old // man the boats" as opposed to "the old man // the boats" as the pauses will indicate the correct parse of the sentence.

Language comprehension and, indeed, resolution of ambiguity are significantly aided through the perception and understanding of phrasing, intonational contours and applied lexical stress patterns – all features of speech which can be encompassed as elements of prosody (Frazier, Carlson, & Clifton, 2006).

Prosody

Coming from the Ancient Greek word προσῳδίᾱ (prosōidíā) meaning "song sung to music; tone or accent of a syllable", prosody can be understood as the sound or auditory representation of language (Crystal & Quirk, 1964; Liddell, Scott, & Drisler, 1894). Prosodic cues are considered "suprasegmental" (Lehiste & Lass, 1976), which means they are properties not of individual segments like phonemes (the smallest unit of speech) but rather encode information about more complex structures like syllables or words extended over multiple phonemes (Palmer, 1970; Bussmann, 2006). In their review of cognitive and psycholinguistic investigations of prosody, Wagner and Watson (2010) provide the following definition:

> Prosody is often used to refer to those phonetic and phonological properties of speech that are crucially not due to the choice of lexical items, but rather depend on other factors such as how these items relate to each other semantically and/or

syntactically, how they are grouped rhythmically, where the speaker places emphasis, what kind of speech act the utterance encodes, whether turn taking in conversation is being negotiated, and they can reflect the attitude and emotional state of the speaker.

A distinction must be made between phonetics and prosody. While phonetics is primarily concerned with the specific sounds which create a word (the phonemes /f/ /aI/ /r/ combine to make up the word *fire*), prosody uses acoustic information to indicate the semantic context of a word or the intention of the speaker or written text (Nygaard, Herold, & Namy, 2009; Wiethoff, et al., 2008). For example, varying the prosody of the word 'bear' (with identical phonetic structure, /'beə/) can change its semantic understanding: either as a statement (Bear.), a question (Bear?) or an exclamation (Bear!) as illustrated in Figure 1. Without prosodic features and the pragmatic cues of context, the word 'bear' simply elicits the cognitive representation of the shaggy carnivoran mammal but not comprehension of its role in the situation being articulated by the interlocutor or speaker.

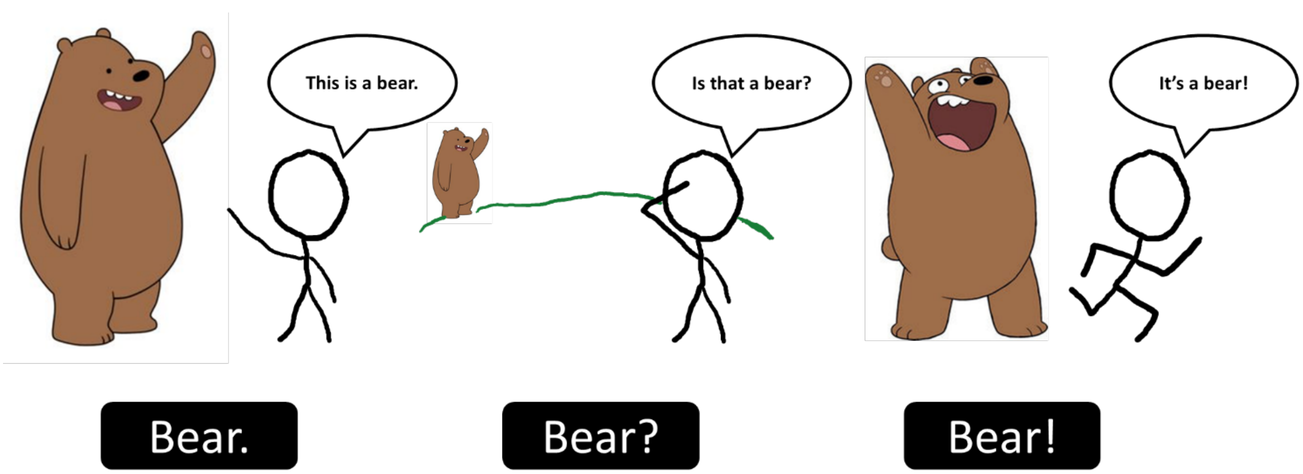


Figure 1: Illustrations of prosodic variations of the word *bear* (and their respective pragmatic contexts), which leads to differences in semantic understanding of the word. Grizzly bear cartoon from We Bare Bears by Daniel Chong, comic by Michelle 'Misha' Oraa Ali.

Cues such as intonation, phrasing, stress (or accent) and rhythm are the building blocks of prosody (Collins & Mees, 2013). Intonation primarily describes the variations of pitch movements of a vocalization (Wells, 2006). In spoken English, certain inflections or shifts in tone are associated with emotionally or semantically distinct expressions (Crystal & Quirk, 1964), as illustrated below:

Intonation	Written Expression	Interpretation
Falling Pitch	"This is a bird."	A statement
Rising Pitch	"This is a bird?"	A question

Phrasing uses sound cues to perceptually group words (Cowie, 1998), illustrated by the difference between the phrase "Let's eat, grandma!" versus "Let's eat grandma!". The pause delineated by the comma in the former instance lends itself to the interpretation that the grandmother is being called to dinner. However, without the prosodic phrasing cue in the latter case, the sentence may be interpreted as an invitation to dine *on* Grandma, as opposed to *with* Grandma.

Stress indicates the emphasis on syllables that lend meaning to a phrase or word (Ashby & Maidment, 2005; Crystal D. , 1976). Take, for example, the word 'present'. In a trochaic format, in which the first syllable is stressed strongly while the second syllable is relatively weakly stressed, *PREsent* denotes 'gift' or 'offering' as might be expected as a noun in the sentence, "Jane is giving her friend a present". However, in an iambic form, in which the latter syllable is stressed more strongly compared to the first one, *preSENT* means 'to exhibit or show' as might be used as a verb in the sentence, "Jane will present her final project to the classroom tomorrow".

Rhythm describes the regularity of timing in successive units of speech, such as the temporal structures underlying the perception and production pattern of strong and weak syllables (Wells, 2006). The Prosodic Hierarchy theory, developed by Selkirk (1986, 1984) and elaborated by Nespor & Vogel (1989), proposes that utterances are *phrased* in a manner similar to musical phrasing, i.e. in a hierarchical manner such that the lowest units are grouped into small phrases which are then combined into larger phrases and so on (Hayes, 1989). This hierarchy, while derived from syntactic structure, is based on prosodic features because the global prosodic structure determins which syntactic (and, indeed, semantic) interpretation is most accurate (Nespor & Vogel, 2007). Typically, in spoken speech, there is a tendency to avoid strings of similarly stressed syllables adjacent to each other (Nespor & Vogel, 1989). Consider the following two sentences 2(A) and 1(B) which are rhythmically distinguishable from each other.

1) A) Jenny's clever sister's pastry crumbled quickly.

   B) Jen's older sister's pink cake crumbled fast.

Sentence 2(A) consists exclusively of trochees (words in which the first syllable is stressed more strongly than the second, such as *pas*try or *quick*ly) – this trochaic meter, with its strong initial emphasis of each word, lead to antecedently biased beat resulting in a rhythmic production at regular temporal intervals. Sentence 2(B), however, with instances of strong syllables adjacent each other, is relatively less suitable for rhythmic production. In an experimental context, metric rhythmic patterns are fundamental to the semantic processing of language (Rothermich, Schmidt-Kassow, & Kotz, 2012). Dilley and McAuley (2008) investigated the role of nonlocal prosodic features (not immediately adjacent to target word) in lexical processing and word segmentation. To test this, they presented participants with auditory stimuli of eight-syllable sequences in which the last three of syllables were lexically ambiguous, and then asking them to report back what words they heard. For example, they would here a word sequence such as "skirmish princess side" for which they altered the prosodic stress, immediately followed by "kick stand still" – the researchers would then quantify the rate at which participants grouped the last three syllables into bisyllabic words such as *sidekick, kickstand* or *standstill.* This work demonstrated that nonlocal prosodic characteristics established a perceived rhythmic pattern which, in turn, affects our ability to parse words and semantic comprehension (Dilley & McAuley, 2008). Prosody is, hence, necessary for accurate interpretation of sentences and enables us to resolve ambiguity in language (Snedeker & Trueswell, 2003; Frazier, Carlson, & Clifton, 2006; Cohen, Douaire, & Elsabbagh, 2001; Hirschberg, 2002; Salverda, Dahan, & McQueen, 2003; Langus, Marchetto, Bion, & Nespor, 2012).

Implicit Prosody

In linguistic and cognitive investigations of prosody, much attention has been devoted to understanding the nature of real-time language processing of verbalized speech or *explicit* prosody (Zubizarreta, 1998; Couper-Kuhlen & Selting, 2006). Not unlike the relationship between visual and auditory imagery, only a limited amount of empirical attention has been devoted to implicit prosody when compared to the relatively vast body of psycholinguistics research on auditory perception of spoken language (Wagner & Watson, 2010). Implicit prosody refers to the *internal* representation of spoken speech complete with prosodic cues, i.e. it refers to the nature of the voice inside someone's head while they are silently reading (Breen, 2014). Using a host of cognitive and neurolinguistic approaches, scientists are attempting to understand and characterize implicit prosody, seeking to answer questions like: What is this inner voice like? Specifically, does this inner voice play a role in cross-modal language comprehension? If so, what features of this inner voice aid in this process? Does the inner voice share similarities to the phonetic and prosodic nature of spoken speech?

Fodor's (2002) Implicit Prosody Hypothesis maintains that, even during silent reading, readers generate prosodic structures that can direct their real-time interpretations of text, as articulated below:

> "In silent reading, a default prosodic contour is projected onto the stimulus, and it may influence syntactic ambiguity resolution. Other things being equal, the parser favors the syntactic analysis associated with the most natural (default) prosodic contour for the construction."

Based on this hypothesis as well as the implications of studies which examined features of overt prosody, implicit prosodic cues could be vital to ambiguity resolution because the reader relies on existing prosodic expectations to interpret the written information (Snedeker & Trueswell, 2003; Kjelgaard & Speer, 1999). Snedeker and Trueswell (2003) performed an experiment to understand whether speakers would disambiguate their production of globally ambiguous sentences depending on what objects were present in a display. In one scenario, participants were shown a toy frog, a toy frog holding a flower, a toy giraffe, a Lego block and a flower. "Speaker" participants were asked to read an ambiguous instruction like "Tap the frog with a flower" to "Effector" participants who would then manipulate the objects accordingly – the effectors would find it difficult to disambiguate and, consequently, perform the correction action. In other trials, experimenters would demonstrate the action to the speakers, who would then read the instructions out again. Experimenters observed that the speakers would then adjust the way they articulated the either as "Tap the frog // with the flower", i.e. use the flower to tap the frog, or "Tap // the frog with the flower", i.e. tap the frog holding the flower. With these effective prosodic cues, effectors were then able to perform the appropriate and correct actions. Therefore, participants' tendencies to resolve semantic ambiguities can be manipulated simply by altering the prosodic properties of language, such as phrasing, intonation and meter (Zubizarreta, 1998).

Ambiguity Resolution through Implicit Prosody

Taking advantage of the ambiguity of accents and rhythm in the language of written text, we can investigate the implicit representation of prosodic features. Previous research using eye-tracking methods shows that subjects activate syntactic representations of words during silent reading, i.e. participants demonstrated longer fixation times and regressions to previously viewed material when reading sentences with ambiguous words (Meseguer, Carreiras, & Clifton, 2002). Compare, for example, the linguistically unambiguous sentence 3(A) to the ambiguous garden-path sentence 3(B):

3. (A) The pilot steers the boats.
   (B) The old man the boats.

3(A) is an unambiguous sentence which readers are able to interpret and comprehend easily. However, for 3(B), prior linguistic experience primes fluent English speakers to, in most likelihood, interpret *old man* in the second sentence as an adjective-noun pair, but the presence of *the boats* causes confusion and necessitates a reanalysis of the interpretation of the words *old* and *man* as a noun and verb respectively (Di Sciullo, 2005). Expanding on this, we can manipulate prosodic information to see how it influences linguistic ambiguity resolution to explore auditory imagery in the form of implicit prosodic representations during silent reading, as well as its temporal characteristics and repercussions on the reader's understanding and interpretation of the text (Fodor, 2002).

A category of words called *stress alternating noun-verb/adjective homographs* are particularly useful in cases in which researchers need to manipulate sentences in a semantic and rhythmic manner. Stress alternating noun-verb/adjective homographs are orthographically identical words in which the lexical stress shifts syllable position with a change in grammatical class (Pitt & Samuel, 1990). Consider the word *rebel*. In a trochaic format, *re*bel, the word can be interpreted as a noun which could be used as a term for a revolutionary, dissident or iconoclast as in the lyrics of the classic Bikini Kill song 'Rebel Girl' : "Rebel girl, you are the queen of my world!" On the other hand, with an iambic stress pattern, to re*bel* may be understood as a verb which means to challenge, resist, defy or disobey, as used in the sentence: "The guerilla forces re*belled* against the authoritarian government".

How can we explore the relationship between implicit prosody and ambiguity resolution in an experimental format? Specifically, what literary tools do researchers have at their disposal in which prosodic features play an important role? Moreover, are there any particular literary devices which would be suited to elicit similar effects in auditory presentation and silent reading methodologies in order to provide support for the Implicit Prosody Hypothesis (Fodor, 2002)?

Poetry

Linguistic ambiguity can be used to study the effects of implicit rhythm on sentence processing through the literary form of poetry (Breen & Clifton, 2011; Levin, 1962; Kiparsky & & Youmans, 2014). In poetry, meter serves as the basic building block for the rhythmic structure of lines in a verse (Turner & Pöppel, 1983; Carper & Attridge, 2003). Among poetic forms, limericks stand out as excellent contenders for stimuli in psycholinguistic experiments due to their pithy nature and relatively simple phrasing. Gaining popularity in the 19th century through the publishing of Edward Lear's anthology of 212 limericks, *Book of Nonsense*, in 1846, limericks are staples of grade school-level creative writing courses and fixtures in nonsense verse and children's rhymes (Baring-Gould & Baring-Gould, 1967; Lear, 1846). A particularly famous example of a limerick, with anonymous origins, is given below:

> There one was a man from Peru,
> Who dreamed of eating his shoe,
> he awoke with a fright,
> in the middle of the night,
> and found that his dream had come true!

Limericks are especially suitable candidates with which to study linguistic ambiguity due to their strict rhyming and metrical structures. Most limericks follow an anapestic meter, with a regular sequence of two unstressed syllables followed by a stressed syllable, and follow a rigid five-line AABBA rhyming structure (Cuddon, 1999). The rhythmic regularity and the saliency of the metrical expectation of limericks gives us a prime opportunity to manipulate the consistency of the stimulus rhythm.

Motivation for Current Study: Eye-Tracking Evidence for Implicit Representations of Rhythm

Taking advantage of stress-alternating noun-verb homographs, a previous eye-tracking study using limericks found that participants' silent reading was disrupted when they encountered limericks which had an inconsistent rhythm – thus offering evidence that readers generate implicit rhythmic representations (Breen & Clifton, 2011). A rhythmically inconsistent limerick contained a mismatch between the stress patterns of rhyme target, i.e. the last word of the second line of the limerick and the predicted stress pattern of the limerick as established by the rhyme prime which is the last word of the first line of the limerick.

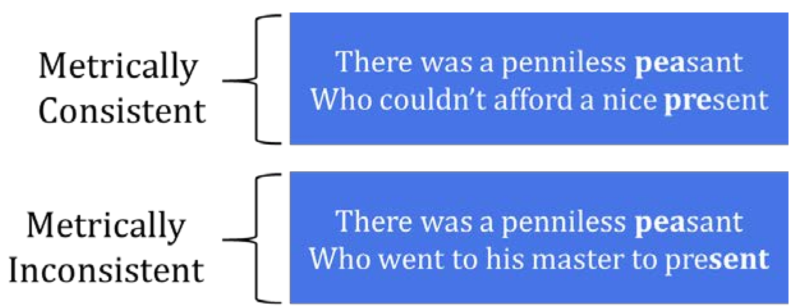


Figure 2: Example of the first two lines of a limerick with an Iambic or Weak-Strong stress pattern. In the second limerick, the last word of the second line follows a Trochaic or Strong-Weak stress pattern which does not conform to the rhythmic context.

Despite being exposed to graphemically or orthographically identical or visual symbols (as in the word present in Figure 2), the participants took longer read the limericks which contained metric violations, suggesting that they were assigning prosodic information about stress in their auditory images of the presented words. However, this study demonstrated readers took longer to read and process only the limerick stimuli which had a metric violation by an iambic (Weak-Strong) target in an established trochaic (Strong-Weak) metrical context but not when there was a metric inconsistency caused by a target word with a trochaic stress pattern in an iambic context, suggesting that there is an interaction between prosodic rhythm and lexical stress. This shows that implicit prosodic representations can, indeed, direct and influence readers' real-time linguistic interpretations of text, giving us a great foundation to investigate the nature of implicit representations themselves and, moreover, the opportunity to explore the extent to which implicit prosodic representations resemble explicit prosody in auditory perception (Breen & Clifton, 2011).

While this study provides evidence for the effect of metrical inconsistency on participants' eye-movements and reading patterns, it opens the door to now ask questions about the neural responses to these limerick stimuli. Given the rhythmic consistency of limericks, readers can predict and imagine the stress pattern of the upcoming rhyme target based on the words presented to them – they can generate expectations based on their internal representations or auditory images of the written material. How can a researcher access a participants' representations of 'inner speech' in an experimental approach? While eye-tracking allows us to make inferences on variables which participants' reading patterns and reading speeds, we are still faced with the question of what are the underlying neurocognitive processes occurring in situations when prosodic predictions are challenged? Are there neural markers of the disruptive effect of the metrical inconsistencies? What is the time course of the brain's response to linguistic stimuli which do not conform to prosodic expectations?

Event-Related Potential (ERPs)

Given how central timing is to the nature of metrical structure, event-related potentials are the most suitable tool to pursue an understanding of the on-line processing of implicit prosodic cues in auditory imagery compared to techniques like eye-tracking or fMRI which do not provide the same precision of temporal resolution (Hillyard & Anllo-Vento, 1998). ERPs are an averaged waveform of electrical activity in response to a timed stimulus, usually with a temporal resolution of milliseconds (Handy, 2005). ERPs provide both temporal and spatial multi-dimensionality by averaging neural signals recorded by electrodes distributed across the subject's scalp (Luck, 2014). ERPs are especially useful as they give us insight into participants' brain activity and on-line cognitive processing of a variety of stimuli in a non-invasive manner (Fabiani, Gratton, & Coles, 2000; Friederici, 2002; Besson & Macar, 1987). Additionally, ERPs have been widely used to understand and measure cognitive responses to linguistic phenomena (Brown & Hagoort, 1999; Zani & Proverbio, 2003). ERPs also have a library of well-documented components which are elicited by particular phenomena or stimuli, which, in turn, can give us insights into why, when, which and how certain neurocognitive processes are occurring in a variety of experimental settings.

As rhythm and meter are important features of both language and music, several studies have been conducted to draw parallels between language and musical production (Thaut, 2005). In the context of our study, some of the most relevant studies in this realm have looked at how violation of musical and linguistic structures are reflected in ERPs. In a study that was conducted in German by Koelsch, Gunter, Wittfoth & Sammler (2005), researchers used visually presented sentences and auditorily presented musical chord sequences. The scientists varied the regularity of chord functions with syntactic congruity of presented words and found that syntactically anomalous words elicited an anterior negativity with a left-biased laterality, while musically irregular metrical chord patterns elicited an early anterior negativity. This demonstrated that there was an interaction between musical and linguistic processing (Koelsch, Gunter, Wittfoth, & Sammler, 2005). ERP has also been used to investigate the language-specificity of syntactic processing by comparisons between linguistic and musical structural incongruities, suggesting that the neural responses to the two conditions were indistinguishable from each other in the P600 range (Patel, Gibson, Ratner, Besson, & Holcomb, 1998).

The plethora of ERP studies which demonstrate the relationship between linguistic and music facilitated the natural advent of electrophysiological experiments which aimed at uncovering the underlying neural processing of prosodic features in language (Pratarelli, 1990; Steinhauer, 2003).

Event Related Potential and Prosodic Processing

ERP investigations of prosodic cues have shown that the brain is responsive to semantic and rhythmic violations during speech processing through several well-characterized ERP components (McCarthy & Donchin, 1981; Luck, 2014). In an ERP study by Astésano and colleagues (2004), which explored the online processing of semantic and prosodic information, participants were aurally presented with stimuli in French which varied on their semantic congruity and prosodic congruity. The presentation of semantically congruous material "La lumière clignotait" ("The light was flashing") was counterbalanced with the presentation of semantically incongruous materials like "La toiture traduisait" ("The roof was translating"). There was a concurrent variation in prosodic congruity in which prosodically congruous stimuli comprised of statements and questions with natural intonation, while prosodically incongruous material consisted of the statements and questions from the previous set which were then edited and cross-spliced at the syntactic boundary between the noun phrase and verb phrase, leading to an unexpected intonation. Researchers found that prosodically congruent but semantically mismatched stimuli elicited a centro-parietal negative component, an N400, suggesting that there is an interaction between prosodic cues and semantic comprehension.

Building on this, an ERP study which evaluated the relationship between semantics and rhythm in overtly produced sentences in French is of particular interest to our study (Magne, et al., 2007). In this experiment, participants were asked to listen to sentences which featured words which were semantically expected or unexpected; these words were pronounced either with a correct or incorrect stress pattern (examples of experimental stimuli with English translations in Table 1). Researchers found that when participants heard trials which contained semantically expected but incorrect pronunciation, it elicited a heightened electrophysiological negativity, known as the N400 effect (discussed in more detail on the facing page). We predict that implicit prosodic production during silent reading is similar to perception of overt prosody, as employed in this study. This then gives us cause to hypothesize that the N400 ERP component will be the appropriate neural signature for our study which aims to look at the effect of metrical structure in implicit prosody.

Table 1: Examples of stimuli used in the four experimental conditions (Magne et al., 2007).

	Semantically congruous (S+)	***Semantically incongruous (S-)***
Metrically congruous (M+)	*Le concours a regroupé mille candi<u>dats</u>*	*Le concours a regroupé mille bigou<u>dis</u>*
	"The competition hosted a thousand candidates"	"The competition hosted a thousand (hair) curlers"
Metrically incongruous (M-)	*Le concours a regroupé mille can<u>di</u>dats*	*Le concours a regroupé mille bi<u>gou</u>dis*
	"The competition hosted a thousand candidates"	"The competition hosted a thousand (hair) curlers"

Note: The lengthened syllable is underlined.

The N400

The N400 ERP component was originally characterized by an experiment in which participants were asked to read sentences in which scientists manipulated the last word to render it semantically (but not grammatically) anomalous (Kutas & Hillyard, 1980). At the onset of the study, Kutas and Hillyard had hypothesized that they would observe a P300 component, a well-established ERP component that has been characterized as a marker for brain activity in response to unexpected stimuli which is exemplified by a positively-directed waveform starting about 300ms after stimulus onset (Chapman & Bragdon, 1964). Instead, they found the N400 (a negatively oriented waveform) which occurred, specifically, in response to semantically unexpected stimuli. In their experiment, participants were instructed to read sentences such as "*She spread the bread with butter*", a semantically plausible sentence, as well as sentences like "*She spread the bread with socks*", a syntactically sound but semantically implausible scenario. Kutas and Hillyard found that the latter case elicited a more negative waveform between 200-600 ms post-stimulus onset.

Electrophysiologically, the N400 is characterized by a negatively-directed waveform deflection which typically crests at about 400ms after the stimulus onset (Kutas & Federmeier, 2011; Kutas & Federmeier, 2009). Though age has been shown to affect the latency of the peak, its time window, between 300-500ms, has been shown to be stable and consistent across a variety of tasks which investigated pictures, faces, smells, as well as both auditory and visually presented words (Kutas & Federmeier, 2000). Typically varying between ± 5 mV, the N400 is distributed maximally over centro-parietal electrode sites and, specifically, is usually most apparent on the left side of the brain during visually processed linguistic paradigms such as silent reading of words and sentences (Kutas & Federmeier, 2011).

The novelty of the N400 effect was later corroborated by Osterhout & Holcomb (1992), who performed a study in which aimed at disentangling neural signatures in response to syntactic and semantic ambiguity. It was found that stimuli which had syntactic errors elicited a P600 ERP component, while contextually (semantically) inappropriate words elicited an increased N400 effect when compared to electrophysiological responses towards stimuli which were semantically acceptable. Thus, researchers were able to neurophysiologically distinguish ERP sensitivity to syntactic anomalies, pertaining especially anomalies which are generated by erroneous analysis of syntactically ambiguous strings like garden-path sentences, from neural signatures in response to semantic violations (Osterhout & Holcomb, 1992). From this study, we can then make a prediction than an N400 is much more likely to be observed in the neural processing responses of participants when reading case B vs case A as articulated below:

4. A) "I take coffee with cream and sugar."
   B) "I take coffee with cream and dog."

In more recent years, studies it has been found that subtle rhythmic deviation– specifically, prosodically anomalous rhythmic violations, also consistently evoke an N400 effect, giving further support to Fodor's Implicit Prosody Hypothesis. Specifically, two studies by Böcker, Bastiaansen, Vroomen, Brunia, & De Gelder (1999) and Magne, Gordon, & Midha (2010) are particularly relevant. Böcker and colleagues conducted a study of rhythmic properties of spoken Dutch in which participants were asked to listen to and read sequences of bisyllabic words which had varied metrical stress patterns (either trochaic or iambic prosodic emphasis). Researchers found iambic words evoked a larger negativity than trochaic words; this negativity was greater when an iambic word followed a set of trochaic words than when it followed a sequence of words with a similar metrical stress pattern (Böcker et al. , 1999). This result suggested that there is an effect of metrical structure on neurocognitive processing during language comprehension, which provides motivation for our current study to empirically evaluate the effect of metrical structure in an implicit prosodic context.

Building on this, Magne and colleagues investigated neural signatures for implicit prosody by studying the metrical stress expectations of participants as they read sets of five bisyllabic words. The first four words for each sequence had a uniform stress pattern, i.e. they were either all strong-weak/trochees (eg. Body, Level, Study, Woman) or all weak-strong/iambs (eg. Result, Today, Effect, Control). The metrical stress pattern of the last word was varied such that it was either consistent (iamb following set of iambs or trochee following set of trochees) or inconsistent (trochee following set of iambs and vice versa) with the previous pattern (as illustrated in Table 2). They found that, in the conditions with final words which were inconsistent with the preceding set of words, there was a relatively more negative N400. This N400 effect was most pronounced in a centro-frontal distribution over the scalp, which paralleled the findings of the previous ERP study on the effect of metrical violations in overt prosodic contexts by Magne and colleagues (Magne, et al., 2007). By demonstrating initial ERP evidence that there seems to be an effect of metrical structure in an implicit context, this experiment motivates our current study in which we hypothesize that we will see an N400 in response to metrically inconsistent stimuli.

Table 2: Examples of stimuli used in the four experimental conditions (Magne, Gordon, & Midha, 2010).

Condition	**Word 1**	**Word 2**	**Word 3**	**Word 4**	**Word 5**	**Metrical Expectancy**
1	SW	SW	SW	SW	**SW**	Expected
	Body	Level	Study	Woman	**Table**	
2	WS	WS	WS	WS	**WS**	Expected
	Result	Today	effect	Control	**Idea**	
3	SW	SW	SW	SW	**WS**	Unexpected
	Body	Level	Study	Woman	**Idea**	
4	WS	WS	WS	WS	**SW**	Unexpected
	Result	Today	Effect	Control	**Table**	

Note: SW = Strong-Weak stress pattern (trochaic), WS – Weak-Strong pattern (iambic)

In a study which utilized explicit prosody, irregular but not implausible rhythmic structures have been shown to elicit an N400 when compared to their rhythmically regular control counterparts (Bohn, Knaus, Wiese, & & Domahs, 2013). An experiment by Rothermich, Schmidt-Kassow and Kotz (2012) investigated the effect of metric structure on lexico-semantic processing in German and found that listeners were sensitive to discrepancies in metrical structure and semantic expectancy. Participants' electrophysiological responses were recorded as they listened to five word sentences in which the noun varied on its metrical stress pattern and semantic congruity. Knowing that, as Dutch and English, German has a preponderance of trochaic words ((Domahs, Plag, & Carroll, 2014)), the researchers replaced the expected trochaic stress pattern of the target word with a metrically unexpected iambic stress pattern (as demonstrated in Table 3). Rothermich and colleagues manipulated semantic congruity by altering the target noun such that it was a syntactically acceptable but semantically unexpected word. Specifically, metrically irregular and semantically unexpected words elicited an increased N400 effect compared to its metrically regular counterparts.

This experiment gives us reason to predict that we will see an N400 in response to not simply words but sentences which are metrically inconsistent. Additionally, our current study builds upon this experiment by utilizing lexically identical and locally syntactically correct experimental stimuli. Furthermore, our stimuli contain global ambiguities which can only be comprehended correctly only if participants are, indeed, utilizing prosodic stress patterns in their internal representation of the read text.

Table 3: Experimental stimuli used by Rothermich, Schmidt-Kassow, & Kotz, 2012. The target noun is showcased in bold, while stressed syllables are represented with emphasized capital letters.

	Semantically congruous	**Semantically incongruous**
Metrically congruous	Norbert 'pflückte 'letzten 'Dienstag 'Ginas '**Rosen** und 'Nelken.	Stefan pflückte letzten Dienstag Marens '**Rohre** und Kabel.
Metrically incongruous	Norbert pflückte letzten Dienstag 'Ginas **Ro'SEN** und Nelken.	Stefan pflückte letzten Dienstag Marens **Roh'RE** und Kabel.
Translation	"Norbert picked last Tuesday Gina's roses and carnations."	"Stefan picked last Tuesday Maren's pipes and cables."

Individual Trait Differences

Returning to the idea of imagination, it is not unreasonable to then ponder the relationship between individuals' own ability to engage in imagery and their ability to process and perceive stimuli. Studies have shown that individuals who engage in higher levels of imagery do indeed demonstrate experimentally distinguishable cognitive processing - in an EEG phase synchrony analysis study, artists had significantly enhanced low frequency (mostly delta) bands and substantive reductions in alpha phase synchrony when engaged in visual imagery tasks with paintings when compared to the responses of non-artists (Bhattacharya & Petsche, 2002).

Like visual imagery, there are differences in the extent to which individuals engage in auditory imagery (Hishitani, 2009). ERP amplitude difference across individuals have been shown to index auditory imagery accuracy - Cebrian and Janata (2010) noted that subjects who formed more accurate mental images of musical scales, measured through tests of pitch accuracy, showed smaller amplitudes of the N100 component, an ERP marker typically elicited by unpredictable stimuli in absence of task demands, of auditorily evoked electrophysiological potential in response to target tones (Vaughan & Ritter, 1970).

Two measures of auditory imagery are the Varieties of Inner Speech Questionnaire, and the Bucknell Auditory Image Scale. The VISQ was developed by McCarthy-Jones and Fernyhough in 2011 to evaluate the phenomenological properties of inner speech on the basis of quality, motivation, incorporation of external voices and dialogicality (the ability to create internal representations of social exchanges). It aims to address the full range of qualitative and functional aspects of inner speech, allowing us to measure the salience of participants' inner voices (McCarthy-Jones & Fernyhough, 2011). The VISQ is based on Vygotsky's (1987) theory that inner speech is inherently social, as it is a product of the internalization of the external dialogues between children and their guardians during development.

The VISQ features four subscales, the first of which is called Condensed Inner Speech which attempts to address the processes of syntactic and semantic abbreviation which occur concurrently with the internalization of verbalized speech in childhood (Vygotsky & Rieber, 1987; Fernyhough C. , 2004; Martínez-Manrique & Vicente, 2010). In the questionnaire, participants are asked the extent to which they agreed with statements such as "My thinking to myself in words is like shorthand notes, rather than full, proper, grammatical English".

The second subscale, Dialogic Inner Speech, measures the internalization of social exchanges and the importance of the interplay of different imagined perspectives (Wertsch, 1980; Fernyhough C. , 2008). Relevant items in the questionnaire were statements such as "When I am talking to myself about things in my mind, it is like I am having a conversation with myself". The third subscale is dubbed "Other People in Inner Speech"; it attends to the question of whether the voices of other individuals are present in the participant's inner speech, in congruence with the Vygotskian view (Fernyhough, 1996). Some items relevant to this subscale were "I experience the voices of other people asking me questions in my head" and "I hear other people's voices nagging me in my head". The last subscale, Evaluative/Motivational Inner Speech, focuses on exploring the role of self-evaluation and awareness as mediated by inner speech, as well as the function that inner speech may play in motivation and self-determination (Hardy, Hall, & Hardy, 2005; Morin, 1993). This is evaluated through measuring participants' agreement with statements like "I think in inner speech about what I have done, and whether it was right or not".

The BAIS was developed by Halpern in 2015 and aims to target three main domains of auditory imagery: musical, verbal and environmental, and to capture potential differences between the auditory and visual domains. The scale aims to measure an individual's vividness of auditory imagery, as well as the amount of control they have over changing the imagined sound (Halpern, 2015). The Vividness (BAIS-V) scale probes the rate at which individuals can construct mental auditory images in their head. This is done by asking participates the extent to which they are able to imagine certain sounds and auditory situations in their head – an example (A) of this is given below. The Ease of Change (BAIS-C) is based the notion of the control of imagery which is, according to Gordon (1949), defined as the ability to not only conjure up new images, but also discard old images and manipulate and alter these mental images. This is done by presenting the participant a scenario based on which they are asked to imagine the relevant sound in their head, following which they are shown a second item and then asked to rate how easily they could change their image from the first sound to the latter one, as illustrated with example (B).

A. For the next item, consider being at the beach.
The sound of the waves crashing against nearby rocks.

B. For the next pair, consider being at the beach.
a. The sound of the waves crashing against nearby rocks.
b. The waves are now drowned out by the loud sound of a boat's horn out at sea.

Using both these measures in conjunction with electrophysiological techniques will allow us to determine whether our participants' self-reports of auditory imagery correlate with ERP measures of real-time processing of implicit prosody. Considering previous studies which have established that individuals' self-reported measures of imagery can predict heightened sensitivity to salient changes in imagery-dependent behavioral tasks (Rodway, Gillies, & Schepman, 2006), the BAIS and VISQ are excellent candidates to investigate individual differences in auditory imagery in comparison with their ERP responses to the presented experimental stimuli. The BAIS has been used to correlate subjects' respective abilities to internally generate acoustic images to their brain activity as measured through functional magnetic resonance imaging (fMRI), demonstrating that individuals who scored higher on the vividness subscale have more activity in the anterior part of the right superior temporal gyrus in response to songs (Herholz, Halpern, & Zatorre, 2012).

The Current Study

In this study, we are broadly interested in whether implicit prosody (auditory imagery during silent reading) is similar to overt prosody (auditory perception). We aimed to explore this question by investigating whether metric violations are processed similarly to overt metric violations. The majority of the aforementioned studies have demonstrated these effects of prosody on language comprehension through auditorily presented stimuli. Taking into account the existing body of evidence of studies of overt prosody, we can study the potential parallels between the neurocognitive processing of prosody and language in overt prosody and that of implicit prosody. Our study is the first, to our knowledge, to show ERP evidence for the relationship of rhythm in implicit prosody during silent reading in the context of poetry.

Experimentally, we predicted larger N400s, which is a marker for semantic and rhythmic unexpectancy, when participants were silently reading limerick couplets with a mismatch between the stress pattern of the target word and the stress pattern of the limericks compared to the ERP response evoked by their metrically consistent counterparts. In our experiment, participants were shown a series of the first two lines of about 320 limericks (160 fillers and 160 experimental stimuli), a quarter of which end with a word with a lexical stress pattern which was inconsistent and unexpected with the established rhyme structure. We then compared their electrophysiological responses to these stimuli and checked to see if there was a difference in their reactions to the metrically consistent and inconsistent couplets. Specifically, we expected that iambic metrically inconsistent stress patterns will elicit a more pronounced N400 component based on a previous eye-tracking study using the same stimulus material which demonstrated that participants took longer to read limericks which contained iambic inconsistency (Breen & Clifton, 2011). In conjunction with the evidence from the eye-tracking study by Breen & Clifton (2011) as well as the relative infrequency of iambs in the American English lexicon, we hypothesized that rhythmically inconsistent stimuli with an iambic stress pattern will elicit a more pronounced N400 effect than their trochaic counterparts.

In addition to ERP, we predict that a correlation between participant's self-reports of auditory imagery, as measured by the VISQ and BAIS, with any potential difference in electrophysiological response to metrically consistent vs. metrically inconsistent limericks. We hypothesized that participants who have higher scores on the BAIS and VISQ, i.e. higher levels of auditory imagery, would be more likely to have a larger N400 in response to the rhythmically inconsistent stimuli.

Measuring the ERPs of participants as they silently read the limericks of different conditions may demonstrate explicit evidence of the effect of rhythm on implicit prosodic cues, which will have further implications for the neurocognitive processing during linguistic processing. If we do, indeed, see N400 effects for the rhythmically inconsistent stimuli, this will provide evidence that rhythm is crucial to the implicit processing of language.

METHODS

This study used human electroencephalography and event related potentials to understand whether there are neural differences in participants' reactions to written stimuli which have rhythmic violations versus rhythmically consistent stimuli. This project was approved by the Institutional Review Board of Mount Holyoke College.

Participants

Twenty-two participants were recruited from Mount Holyoke College, South Hadley, Massachusetts, United States. The participants were recruited via the Department of Psychology's SONA research website as well as flyers placed around campus (Appendix A). Twenty-one participants identified as female and one participant identified as nonbinary/genderqueer. Data from three participants was discarded as they did not complete the experiment or there were technical difficulties with experimental software or equipment. Therefore, in the final data analyses, we included data from 19 participants with an average age of 20.1 years (*SD* = 1.1 years).

The criteria for participation were that the individual must be right-handed (to ensure that their language functions are all lateralized in the left hemisphere) and a native speaker of American English, to limit dialectical variation in the pronunciation of target words, which was operationalized as whether they have been speaking English in the USA since the age of 5 years. Additionally, we stipulated that participants must be between the ages of 18-35 years old to limit cognitive variability in the subject pool. Additionally, we requested that the participants declare whether they had taken psychoactive medications in the 24 hours prior to the experiment and did not carry on data collection for those who replied affirmatively. For the two-hour experimental period, participants received compensation with two Psychology research credits or $20 cash.

All participants reported having normal to normal-to-corrected vision – those who reported the latter were wearing their prescribed corrective lenses for the duration of the experiment. Additionally, sixteen participants reported being neurotypical. Of the participants whose data we included, one participant reported being diagnosed with an essential tremor and had taken Armour Thyroid and Levothyroxine medication in the day prior to the experiment. A second participant reported being diagnosed with anxiety, depression and attention deficit hyperactivity disorder (ADHD) and had been prescribed Zoloft and Foculin but not taken this medication in the 24 hours preceding the experiment. A third participant reported being diagnosed with bipolar disorder (type unknown) and suffering from migraines and did not report taking any medication.

Materials

The experimental stimuli that were presented to participants during the recording of EEG waves were couplets derived from limericks. Following this, participants were asked to respond to two questionnaires. Details about the written stimuli and experimental conditions and questionnaires are elucidated below.

Limericks

Limericks were chosen as an appropriate literary stimulus to use when measuring electrophysiological response due to their relative ease of understanding and strict rhyming and rhythmic constraints.

A pool of 320 limericks was used – we implemented a 2X2 design with the first factor being lexical stress pattern (Trochaic or Iambic) and the second factor being rhythmic consistency (metrically consistent or metrically inconsistent). These items were derived from materials used in Breen and Clifton (2011). Modifications were made to some of the items to ensure semantic coherence and that the couplet did not end in the middle of a sentence as we displayed only the first two lines of the limerick to the participants. In this experiment, we are only interested in the set up or framing of the initial rhyme, and its eventual resolution. Thus, it was adequate to only show the first two lines of the limerick; this also allowed us to limit the duration of the experiment to a little less than two hours.

The first line of the limerick allowed us to establish a rhythm or rhyming constraint. In the second half of the stimulus pool, we varied the lexical stress pattern of the rhyme target, i.e. the last word of the second line; specifically, we varied whether the word had a Trochaic or Strong-Weak stress pattern (ADDress = the particular location of a person's home or organization) or an Iambic or Weak-Strong stress pattern (addRESS = a formal speech). The earlier regions of the couplet contained a strong syllable which was preceded by one to two weak syllables.

In each of these lexical stress pattern groups, half of the limericks had rhythmically consistent target words while the other half had rhythmically inconsistent words. Consistency was evaluated by whether the rhyme target word matched the metrical stress pattern of the rhyme prime, i.e. the end word of the previous verse. As in the examples presented in Table 4, the metrical stress pattern of the rhyme target matched that of the rhyme prime in the consistent conditions, whereas, in the inconsistent conditions trochaic rhyme primes were follow by mismatched iambic rhyme targets and vice versa.

Table 4: Metrical structure of experimental limericks in each of the four conditions. Italics indicates metrically strong syllables while bold indicates target words.

Condition	**Limerick**
Trochaic; Consistent	There *once* was a *penn*iless *pea*sant, Who *could* not af*ford* a nice ***pre*sent.**
Trochaic; Inconsistent	There *once* was a *cle*ver young *gent,* Who *gave* to his *girl* a ***pre*sent.**
Iambic; Consistent	There *once* was a *cle*ver young *gent,* Who *had* a nice *talk* to **pre*sent.***
Iambic; Inconsistent	There *once* was a *penn*iless *pea*sant, Who *went* to his *mas*ter to **pre*sent.***

There were 160 fillers, all of which were rhythmically consistent. This was to ensure that inconsistency was unexpected as only a quarter of all stimulus items had a rhythmically inconsistent stress pattern.

A quarter of the fillers (12.5% of all trials) were followed by a comprehension question to ensure that participants were attending to the meaning of the couplets – participants were instructed to answer with a simple binary "Yes" or "No". For example, an experimental stimulus such as "A bashful young man named Sty // With girls was exceedingly shy" may be followed by the single question "Did Sty avoid young women?".

These experimental conditions are summarized in Figure 3 and Table 4. All stimuli were programmed in EPrime, a stimulus presentation program.

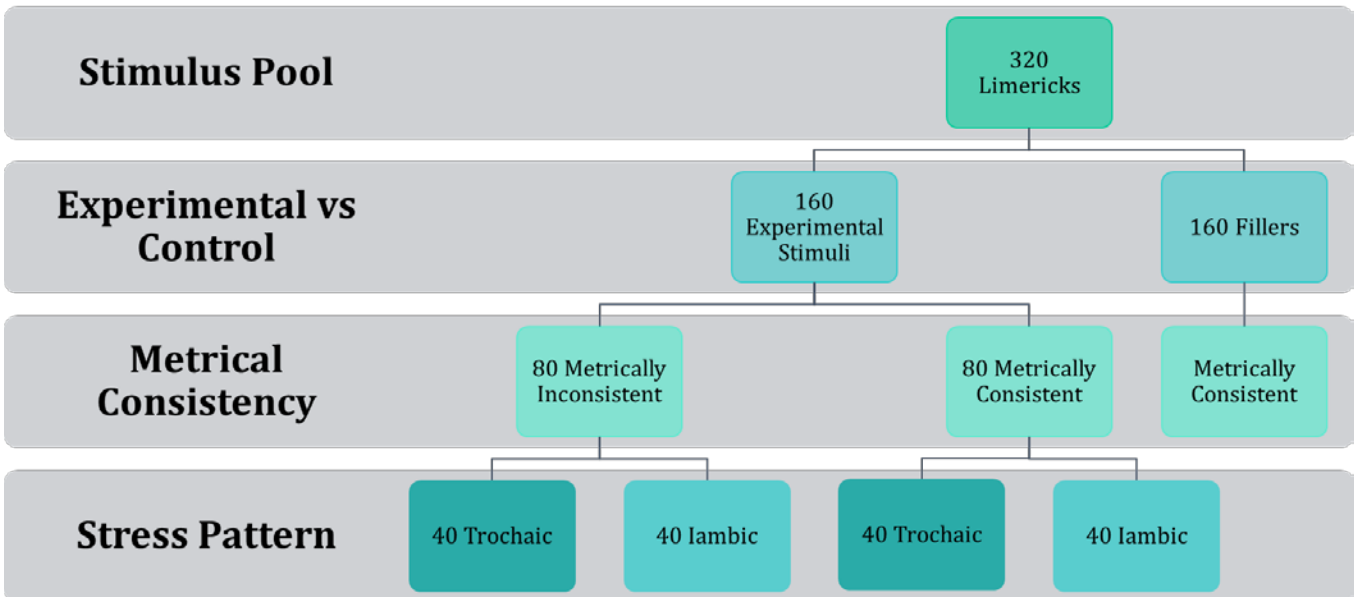


Figure 3: Flowchart describing experimental conditions of 2X2 design in which we varied lexical stress pattern (Trochaic or Iambic) and metrical consistency (consistent, inconsistent). In total, we had 320 limericks, half of which are rhythmically consistent control limericks. In the 160 experimental stimuli, half had Trochaic lexical stress patterns, while the rest had Iambic stress patterns. Within each stress pattern group, half of the items were rhythmically consistent and half were rhythmically inconsistent. This resulted in a total of 80 rhythmically inconsistent items in a pool of 320 (25% of the limerick couplets).

VISQ and BAIS

We used two questionnaires to measure participants' self-reported evaluations of their own auditory imagery, the Varieties of Inner Speech Questionnaire (VISQ) and the Bucknell Auditory Imagery Scale(BAIS) (McCarthy-Jones & Fernyhough, 2011; Halpern, 2015). The questionnaires were designed and implemented using the Google Forms platform.

The VISQ, with a Cronbach's reliability α = 0.80, comprises of a set of 14 items which the participants responded to using a six-point Likert scale, which had labels ranging from "6 – Certainly applies to me", "5 – Possibly applies to me", "4- If anything, applies to me slightly", "3 – If anything, slightly does not apply to me", "2 – Possibly does not apply to me", "1 – Certainly does not apply to me" (Appendix B).

The BAIS, with an overall Cronbach's reliability α = 0.83 , has two sections: Vividness and Control. Both components of the BAIS, i.e. the Vividness (BAIS-V) and Control (BAIS-C), comprise of a list of fourteen items (Appendix ABC). In the BAIS-V, participants were asked to rate the vividness of the auditory image evoked by an item using a seven point Likert scale, with 1 corresponding to "No image is present at all", 4 corresponding to "fairly vivid" and 7 corresponding to "Image is as vivid as the actual sound". In the BAIS-C, the participants were asked to rate how easily they were able to transition between the two described scenarios on a seven point Likert scale, with 1 meaning "No image present at all", 4 corresponding to "Could change the image, but with effort" while 7 meant "Extremely easy to change the image" (Appendix C).

Experimental Procedure

After gaining informed consent, participants were seated comfortably in an isolated room. Following the standard electroencephalogram (EEG) capping procedure and appropriate calibrations, they were shown a series of the first two lines of 320 limericks (each, their own trial) on a computer screen placed approximately 90 cm away from their face. The order of the limericks was randomized.

Each limerick couplet was presented in one to four word segments in the middle of the screen for 700 ms each, with the ending word of the first line presented for 1000ms (refer to Figure 4). Each region contained 2-5 syllables in order to ensure that participants did not receive too much written information. This was done to make sure that they would not move their eyes during a fixation to prevent artifacts in the EEG data. The rhyme target word for each item was always presented alone for 1000 ms. The timing triggers for the stimulus presentation was synchronized between the EPrime software used to display the experiment to the participant and the ActiView software used to record their continuous EEG.

Participants were given a response box which they held in their lap for the duration of the experiment; they were able to use this device to push buttons to answer comprehension questions, in addition to signaling that they were reading for the presentation of the next trial. They were given breaks in between trials to allow time for blinking, as well as a longer break after every 40 trials; the length of these breaks were determined by the participant. The whole process took approximately 2 hours per participant.

Electrical activity on the scalp was measured using the BioSemi Active-Two system.

A sixty-four channel Active-Two elastic cap of an appropriate size, in addition to four facial active electrodes and a pair of reference mastoid electrodes, were connected to Ag/AgCl electrodes and were used to measure the EEG signal. The electrode offsets were brought below 20 μV at the start of the recording, and kept below 50 μV throughout the recording. The EEG was recorded at 500Hz with a bandwidth of 0.01-100 Hz. It was then divided in 7qq00 ms epochs, beginning 100 ms before to 600 ms after the onset of each rhyme target stimuli.

Following the conclusion of the ERP experiment, participants were asked to fill out the VISQ and both sections of the BAIS. Participants then received a debriefing form and chosen form of compensation.

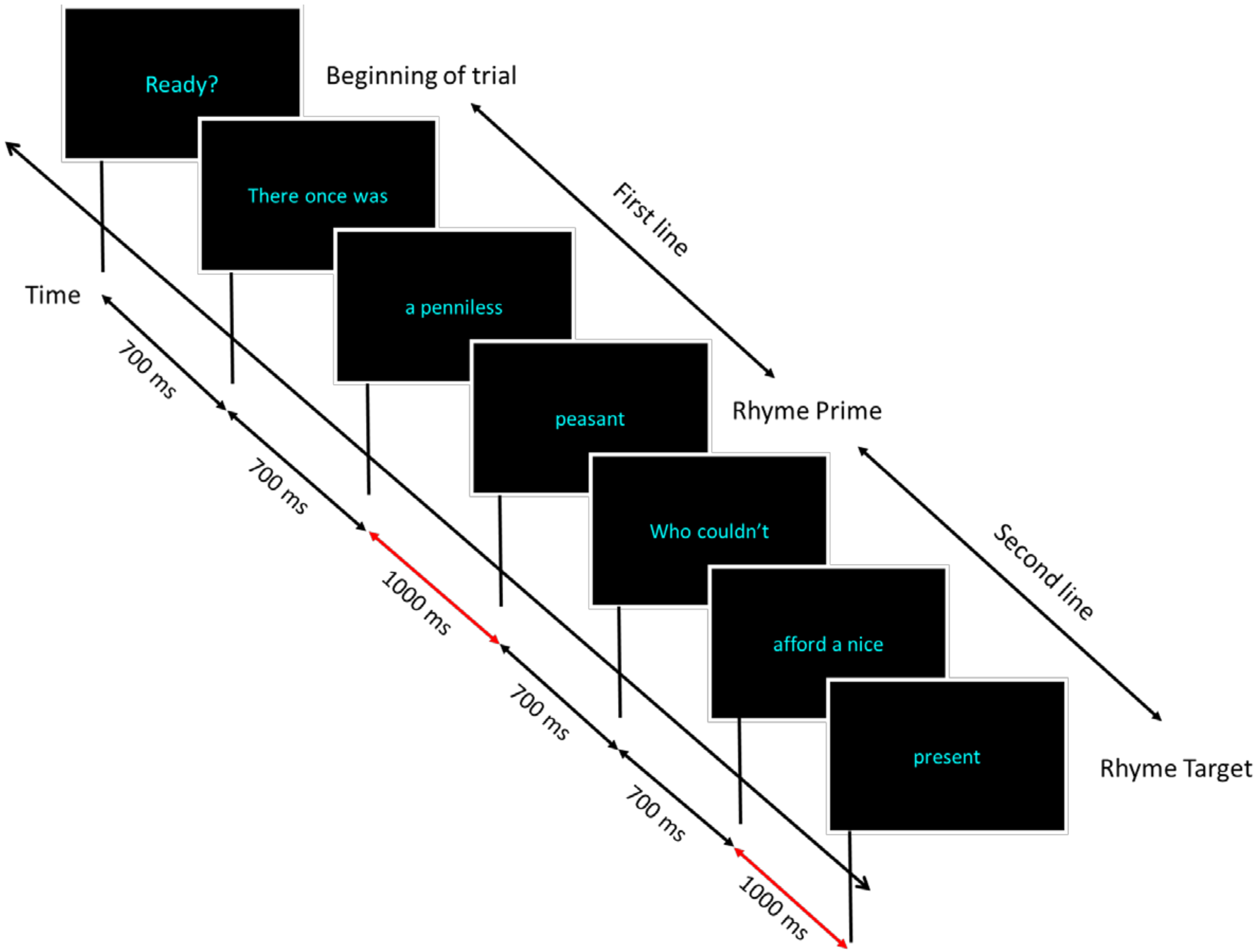


Figure 4: Presentation times in milliseconds of each region of the limerick couplets.

Data Analysis

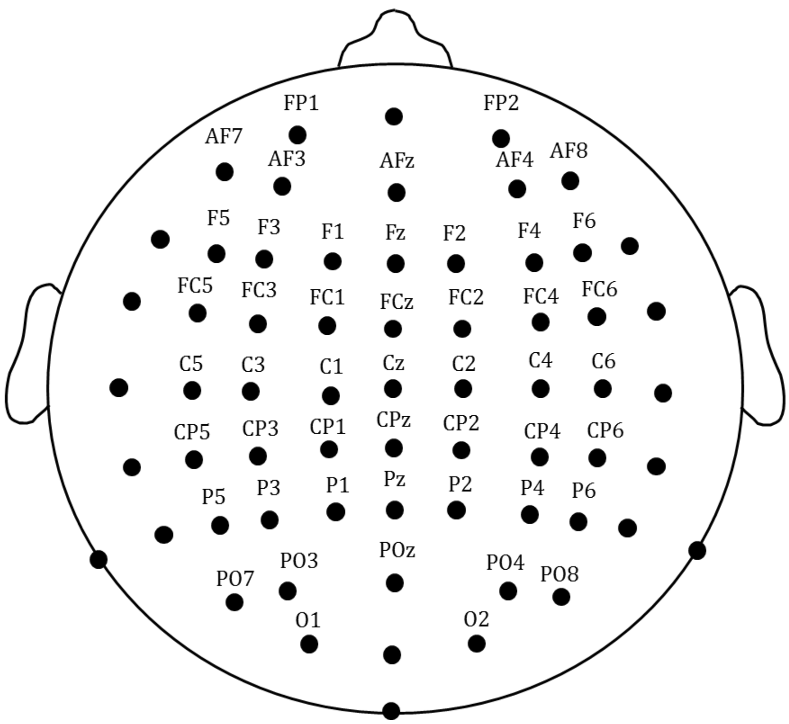
EEG data from each participant were inspected and trials that were contaminated by eye movements, eye blinks, muscular activity or electrical noise were excluded using an artifact rejection algorithm which utilized edge detection to parse out the components which corresponded to the specific stimulus presentation events. Data from the remaining trials were then averaged by participant and condition, and were referenced to the two mastoid electrodes. The processing of the EEG data was performed in MATLAB using the EEGLAB package (Swartz Center for Computational Neuroscience, University of California San Diego).

To compare the N400 effect across conditions, we extracted the average amplitude for each trial between 325 and 400 ms, which is the standard measurement window for the N400 (Magne et al., 2010). After eliminating the data from the electrodes located on the periphery of the scalp, we selected 49 electrodes for analysis (Figure 5). Scalp position was treated as two factors in the statistical model: Anterior-Posterior (AP) electrode position with seven levels (AF, FF, FC, CC, CP, PP and PO) which were distributed within 5 broader groups (A - Anterior, F- Frontal, C – Central, P – Posterior, O - Occipital) and Left-Right (LR) electrode position, with seven levels (L1, L3, L5, Mz, R2, R4, R6) which were distributed within 3 groups (L - Left, M - Medial and R - Right).

The two independent within-subject variables utilized in the experiment were stress pattern (Trochaic vs Iambic) and rhythmic consistency (Consistent vs Inconsistent). An initial 2 (stress pattern) x 2 (rhythmic consistency) X 7 (electrode laterality) x 7 (anterior-posterior electrode position) Analysis of Variance (ANOVA) was used to compare the mean amplitude across experimental conditions across the participants. Further ANOVAs and planned comparisons were used to investigate significant interactions. The significance value was set to an alpha level of p=0.05. All significant interactions were explored further with post hoc analyses.

Additionally, we ran a Pearson's product-moment correlation between the subscale values as measured by the VISQ and BAIS and the calculated N400 difference between the two rhythmic consistency groups across participants.

All the statistical analyses were done in RStudio (J.J. Allaire) with the *ez: Easy Analysis and Visualization of Factorial Experiments* and *plyr: Tools for Splitting, Applying and Combining Data* libraries (Michael A. Lawrence; Hadley Wickham), SPSS (International Business Machines Corporation) and Excel (Microsoft).



	AF	FF	FC	CC	CP	PP	PO
L1	FP1	F1	FC1	C1	CP1	P1	O1
L3	AF3	F3	FC3	C3	CP3	P3	PO3
L5	AF7	F5	FC5	C5	CP5	P5	PO7
Mz	AFz	Fz	FCz	Cz	CPz	Pz	POz
R2	Fp2	F2	FC2	C2	CP2	P2	O2
R4	AF4	F4	FC4	C4	CP4	P4	PO4
R6	AF8	F6	FC6	C6	CP6	P6	PO8

Figure 5: Distribution of electrodes included in initial data analysis. The vertical rows indicate the laterality level (L - Left, M - Medial, R - Right) while the horizontal column heads represent the Anterior-Posterior position (Antero-Frontal, Frontal, Fronto-Central, Central, Centro-Posterior, Posterior, Posterior-Occipital).

RESULTS

Accuracy

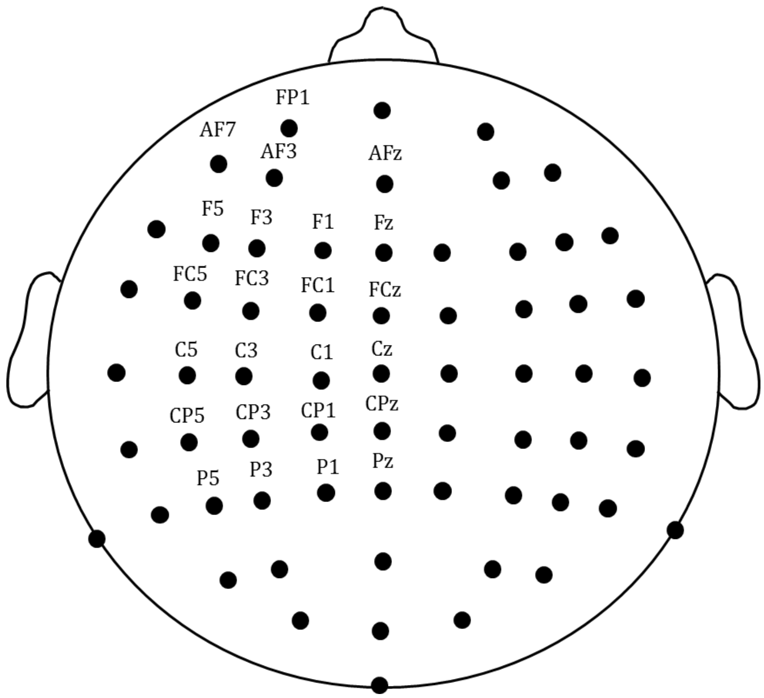
Participants had an accuracy rate of 96.71% (SD=3.9%) in response to binary questions. This high rate of accuracy demonstrates that participants were, indeed, attentive to the written stimuli.

Analysis

Data from 49 electrodes (see Figure 5) were divided into seven groups of seven electrodes each based on scalp location. Waveforms from each group were averaged across all items for each participant for each bin (Consistency [Consistent vs Inconsistent] X Stress Pattern [Trochaic vs Iambic]), yielding per subject averages and grand averages for each condition (illustrated in Figures 8 and 9). Greenhouse-Geisser corrections were applied for comparisons that included factors with more than two levels.

Determining Region of Interest

Visual inspection of the waveforms led to a more concerted investigation through repeated measure ANOVAs of the data from the electrodes located in the left and medial antero-frontal, frontal and fronto-central regions. This successive winnowing of data was performed by creating a difference array between the amplitude of wave forms elicited by each of the separate conditions such that the amplitudes for these experimental bins for the consistent and inconsistent conditions of each respective stimulus set of stress patterns (Trochaic and Iambic) were subtracted from each other. The electrode positions with substantive difference values between the inconsistent and consistent values were compared with the results of qualitative evaluation of EEG waveforms and provided additional motivation to exclude data from peripheral electrodes (Right Laterality, and Posterior positioning) in our analysis. This approach was corroborated with statistical analyses which revealed a significant interaction between consistency and laterality (as reported below). The region of interest we obtained consisted of a 6 (AF, FF, FC, CC, CP, PP) X 4 (L5, L3, L1, Mz) electrode array, located primarily over the left frontal and fronto-central regions (Figure 6).



	AF	FF	FC	CC	CP	PP
L1	FP1	F1	FC1	C1	CP1	P1
L3	AF3	F3	FC3	C3	CP3	P3
L5	AF7	F5	FC5	C5	CP5	P5
Mz	AFz	Fz	FCz	Cz	CPz	Pz

Figure 6: Distribution of electrodes included in experimental region of interest. The vertical rows indicate the laterality level (L - Left, M - Medial, R - Right) while the horizontal column heads represent the Anterior-Posterior position (Antero-Frontal, Frontal, Fronto-Central, Central, Centro-Posterior and Posterior).

General Trends

There was no overall effect of rhythmic consistency, $F(1, 18)=0.208$, $p=0.654$, in the initial 7 X 7 ANOVA. Additionally, there was also no overall effect of stress pattern, $F(1, 18)=0.006$, $p=0.940$. However, there was a significant interaction between consistency and laterality, $F(6,108) =2.76$, $p=0.016$, as well as a trending interaction between consistency, stress pattern, Anterior-Poster position and laterality, $F(36, 648)=1.348$, $p =0.087$. Finding these interactions licensed us to narrow our region of interest. Subsequent analyses demonstrated that consistency interacted with lateral position from M1 to L5 and with Anterior-Posterior position from AF to PP.

Analyses over our aforementioned region of interest with a more constrained 6x4 electrode array revealed no significant main effect, *F*(1, 18)=0.0.004, *p*=0.950, for metrical stress pattern. Similarly, there was no significant effect, *F*(1, 18)=0.754, *p*=0.397, for rhythmic consistency. However, there was a significant interaction, *F*(3, 54)=3.073, *p*=0.035, between stress pattern, rhythmic consistency and laterality of electrode positions.

We found that rhythmically inconsistent trochaic targets elicited a negativity between 325-400ms relative to the response elicited by rhythmically consistent and trochaic targets, *F*(1, 18)=4.624, *p*=0.0454.; difference: 1.651 μV. Conversely, this effect was not found when comparing inconsistent and consistent targets in the iambic condition, *F*(1, 18)=0.451, *p*=0.511. We investigated the increased negativity found in the trochaically stressed and rhythmically inconsistent condition by conducting a Welch paired t-test to compare the mean amplitude averaged across electrodes for each participant between the trochaic inconsistent and trochaic consistent conditions. We found that there was indeed a significant difference, t(18)=2.136; *p*=0.047, for the mean amplitude voltage evoked by trochaic inconsistent stimuli (*M*=1.664, *SD*=2.972) and trochaic consistent condition (*M*=3.313, *SD*=2.981).

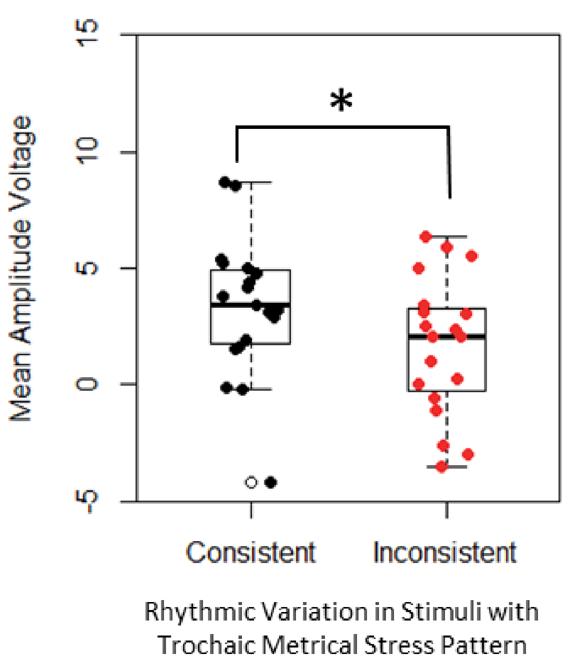


Figure 7: Box plot showing the average individual mean amplitude voltage levels (μV) for each participant in rhythmically consistent vs rhythmically inconsistent stimuli with trochaic metrical stress pattern.

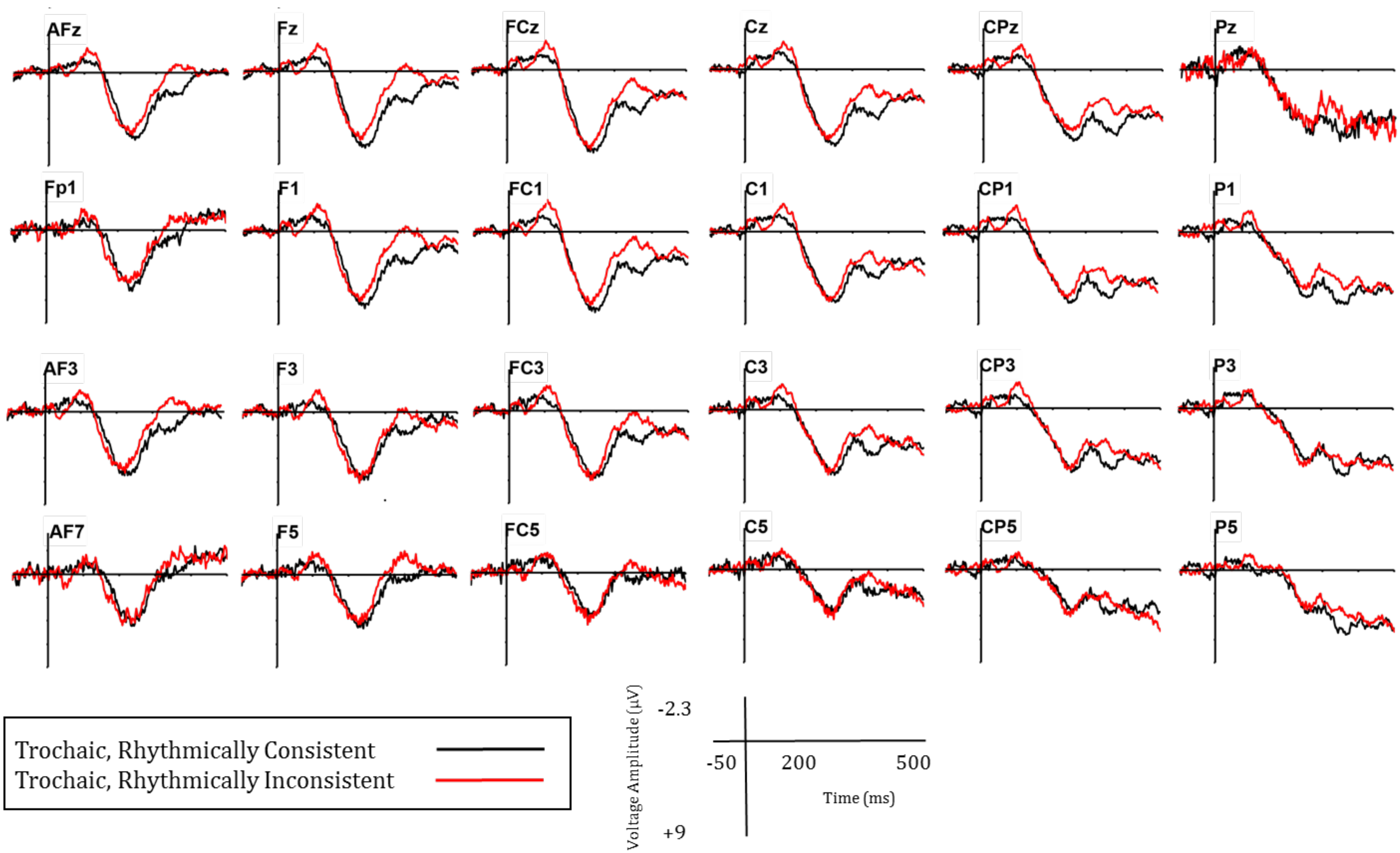


Figure 8: Waveforms depicting the ERPs for trochaic and rhythmically consistent (black line) and trochaic and rhythmically inconsistent (red line) conditions, from 50 ms before the rhyme target onset and 500 ms after the rhyme target onset. Data is shown for the twenty four recording sites depicted on the electrode map in Figure 6.

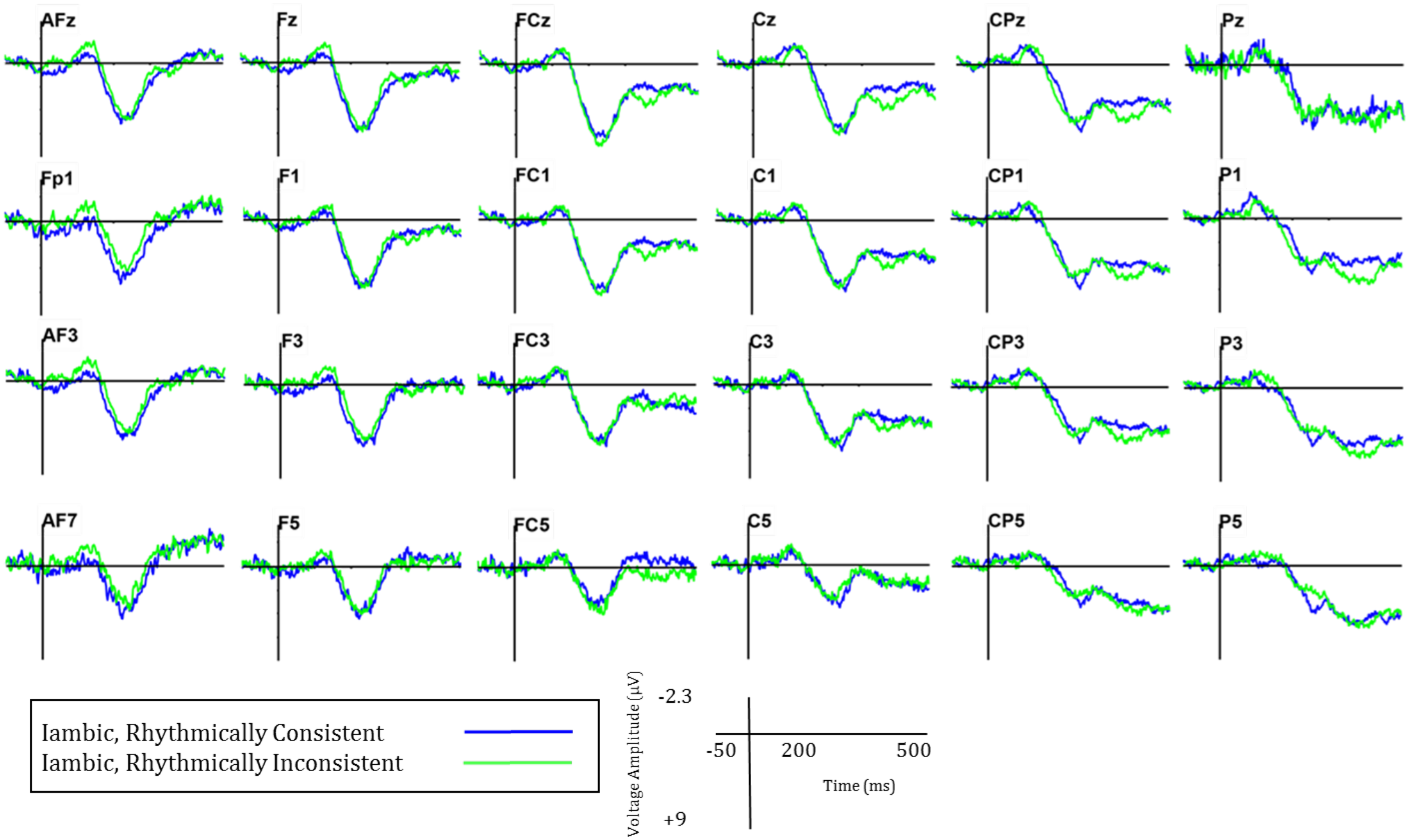


Figure 9: Waveforms depicting the ERPs for iambic and rhythmically consistent (blue line) and iambic and rhythmically inconsistent (green line) conditions, from 50 ms before the rhyme target onset and 500 ms after the rhyme target onset. Data is shown for the twenty four recording sites depicted on the electrode map in Figure 6.

Individual Trait Differences

In order to determine whether the ERP results varied with individuals' self-report auditory imagery, we calculated the "effect score" for each participant, which we then used to analyze the individual trait difference measures across participants. The effect score was obtained by subtracting the mean voltage amplitude data of the trochaic and metrically inconsistent condition from the mean voltage amplitude of trochaic and metrically consistent condition across all electrodes. Following this, we found the mean difference value across all the electrode channels in which we obtained a significant N400 effect for each participant, giving us the effect score. We ran correlations between the effect score and individual subscale scores for the Bucknell Auditory Imagery Scale (BAIS) and the Varieties of Inner Speech Questionnaire (VISQ); relevant scatterplots with trendlines and corresponding r^2 values can be found in Figure 10.

There was no relationship, $r(17)=0.085$, $p=0.728$, between the BAIS-Vividness subscale score ($M=4.658$, $SD=1.007$) and effect score ($M=1.651$ μV, $SD=3.363$ μV) with r^2 value of 0.007. There was a weakly positive but insignificant correlation, $r(17)=0.2334$, $p=0.336$, between the BAIS-Control or Ease of Change subscale score ($M=5.226$, $SD=0.786$) and effect score with r^2 value of 0.055.

There was no relationship, $r(17)=0.047$, $p=0.847$, between the VISQ Condensed Inner Speech subscale score ($M=3.032$, $SD=1.388$) and effect score with r^2 value of 0.002. Similarly, there was no significant relationship $r(17)=-0.057$, $p=0.815$ between the VISQ Other People in Inner Speech subscale score ($M=2.505$, $SD=1.221$) and effect score with r^2 value of 0.003. There was a weakly negative but insignificant correlation, $r(17)=-0.351$, $p=0.141$ between the VISQ Evaluative Inner Speech subscale score ($M=5.303$, $SD=0.739$) and effect score with r^2 value of 0.123. However, there was a moderate negative and significant correlation, $r(17)=-0.535$, $p=0.0183$ between the VISQ Dialogic Inner Speech subscale score ($M=4.539$, $SD=1.373$) and effect score with r^2 value of 0.286.

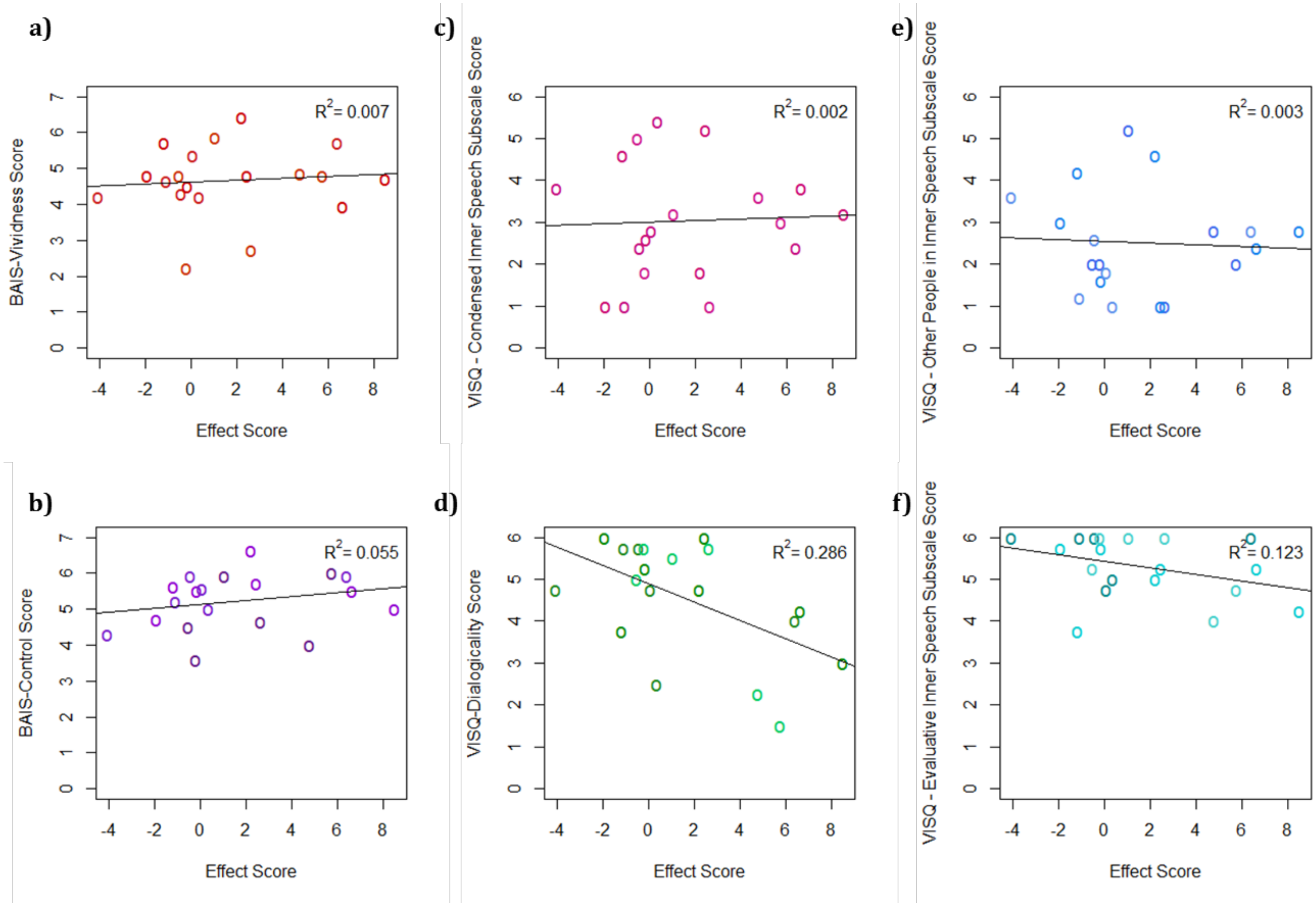


Figure 1: Scatterplots showing the correlation between the calculated effect score of each participant along with corresponding r^2 values. Scatterplots (a) and (b) are subscale of the Bucknell Auditory Imagery Scale (BAIS) which has a 1-7 score scale, while scatterplots (c-f) are subscales of the Varieties of Inner Speech Subscale (VISQ) which has a 1-6 score scale. (a) Relationship between effect score and BAIS-Vividness subscale score, (b) Relationship between effect score and BAIS-Control subscale score. (c) Relationship between effect score and VISQ – Condensed Inner Speech Subscale score. (d) Relationship between effect score and VISQ – Dialogic Inner Speech Subscale score. (e) Relationship between effect score and VISQ – Other People in Inner Speech Subscale score. (f) Relationship between effect score and VISQ – Evaluative Inner Speech Subscale score.

DISCUSSION

Event Related Potentials

This study aimed to investigate the activations of implicit metrical representations during silent reading. The results suggested that, during silent reading in English, metrical structure is processed automatically and that rhyming couplets elicit expectancies about the prosodic structure of forthcoming words. Evidence for this comes from an increased negative component elicited by stimuli which were metrically inconsistent and had a trochaic metrical stress pattern, as compared to the neural response elicited by the trochaic and rhythmically consistent stimuli.

This larger negative response elicited by the trochaic metrically unexpected rhyme targets share a similar temporal latency period (~300-400ms) and neural distribution over the scalp (frontal and fronto-central) as the N400 component that has been demonstrated in past studies (Kutas & Federmeier, 2011). The N400 has been characterized as a neural signature elicited by semantic unexpectancy as well as an ERP marker evoked by rhythmic mismatch in overt prosody studies (Magne, et al., 2007; Kutas & Federmeier, 2009; Kutas & Federmeier, 2000). Additionally, our results are supported by a finding by Magne and colleagues (2010) that the N400 component is elicited by metrically unexpected words in sets of words with regular stress patterns during silent reading.

It was surprising to note that iambic and rhythmically inconsistent stimuli did not evoke a similar (if not larger) N400 effect, given the findings from the eye-tracking investigation of the effect of rhythm consistency and metrical stress in implicit prosody which motivated this ERP study (Breen & Clifton, 2011; Cutler & Carter, 1987; Cutler & Norris, 1988). Specifically, Breen and Clifton (2011) found that readers experienced difficulty when reading words whose stress pattern was inconsistent with the rhyming structure of the presented limerick – but only when there was an iambic word in a context which created an expectation of a trochaic word (i.e. rhythmically inconsistent) and not in the trochaic rhythmically inconsistent condition. Contrary to their findings, our results demonstrate no significant difference in ERPs between the responses elicited by the iambic rhythmically consistent and the iambic rhythmically inconsistent conditions. An explanation of this discrepancy could be attributed to the possibility that internally generated representations of speech are crucial to accurately identify the rhyme target. Here, the participant reads the written text while taking into account contextual expectations and then internally 'listens' to a mentally constructed auditory image to accurately identify the word. It has been shown that word identification is obstructed in auditory listening experiments when typically trochaic words is pronounced iambically – but is only minimally disrupted when a typically iambic word is pronounced in a trochaic manner (Cutler & Clifton Jr, 1984). Our investigations seems to provide support for idea that individuals identify the orthographic characters of a word by 'listening' to the auditory image (replete with implicit prosodic information) they create. In their study, Magne and colleagues (2010) were perplexed by a similar finding in which trochaic stimuli generally elicited more negative N400s than iambic stimuli. They suggested that this could be remedied by time-locking the presentation of the first and second syllables of the bisyllabic words to determine whether the larger N400 effect was an effect of local morpheme level stress rather than an effect of the metrical stress pattern of the whole word.

In American English, the majority, estimated between 85-90%, of polysyllabic words have an initial primary trochaic stress pattern (Cutler & Carter, 1987). This relative paucity of iambic words in the English lexicon may potentially explain the stress pattern specific N400 effect we are observing. Due to their infrequency, it is possible that expectancies generated by iambic rhyme primes are stronger than predictions created by the more common trochaic rhyme primes, leading to a more pronounced N400 in the former condition. An analysis of stress patterns of the rhyme primes of the couplets of the filler stimuli could aid further exploration into potential frequency effects which may explain the interaction between metrical consistency and stress pattern that we see in our results.

The N400 effect has been demonstrated to be a marker of semantic integration difficulty as well as unexpetancies in metrical structure (Swaab, Ledoux, Camblin, & Boudewyn, 2011). Hagoort (2005) suggested that the N400 is a marker of the difficulty of the lexical-semantic integration process, i.e. words which are easily integrated will evoke reduced N400s while words which are harder to integrate (such as couplets with metrical inconsistencies) will generate more pronounced N400s (Hagoort, 2005). Kutas and colleagues (2006) have proposed an alternate theory on the processing nature of the N400; they have suggested that the N400 is an index of the difficulty of retrieving conceptual knowledge associated with a meaningful stimulus such as a word and this difficulty is modulated by the stored semantic retrieval, and influence of contextual cues (such as prosodic features). van Berkum (2009) expanded upon this theory by suggesting that the N400 amplitude is a reflection of the computational resources used in the retrieval of invariant coded meanings stored in semantic long-term memory and is modulated by factors such as linguistic focus and internal mental representations. In our results, the observed N400 demonstrates that participants face difficulty when silently reading trochaic and metrically inconsistent stimuli. This difficulty arises as they predict the wrong lexical item based on phonological representations from implcitily generated prosodic structures which are influenced by contextual metrical patterns. This, therefore, could possibly obstruct the lexical-semantic integration process which then further necessitates participants to reinitiate lexical access in order to derive the correct semantic understanding of the presented stimulus.

While our data provides some evidence about the role of rhythmin implicit prosody during silent reading, it is entirely possible that our finding does not generalize to normal reading. Limericks, by their anapestic nature and rhyming structure, have metrical patterns which are more conspicuous than non-poetic language (Harding, 1976). However, our study does provide an insight to the role of meter in implicit prosody. To see whether our result can be replicated in non-poetic contexts which do not have concomintantly high metrical expectancies, our lab is currently exploring differences in brain activity in response to sentences with variations in stress pattern in lexically ambiguous sentences.

Inspired by the work of Buxó-Lugo and colleagues as presented at the CUNY Human Sentence Processing 2017 Conference, it would be interesting to see if prosodic adaptation (i.e. attuning one's comprehension of stimuli to the prosodic features of the initially delivered sentences) during silent reading occurs over the temporal course of the experiment. Specifically, do we see a reduced difference in the amplitude magnitude of the N400 effect in the later trials of an experiment with metrically inconsistent stimuli, as compared to that of the initial trials? Recent work on phonetic adaptation and pragmatic interpretation of contrastive prosody (Kurumada, Brown, & Tanenhaus, 2012; Kraljic, Samuel, & Brennan, 2008; Clayards, Tanenhaus, Aslin, & Jacobs, 2008) have shown that listeners can adapt to prosodic heterogeneity to variations of pragmatic meaning as well as interlocutors' idiosyncrasies in verbal speech. This study presented novel evidence of a probabilistic adaptive mechanism between prosodic and syntactic structure (Buxó-Lugo, Kurumada, & Watson, 2017). In this study, participants heard stimuli with relative clause attachment ambiguities which could only be interpreted with the help of prosodic boundaries which were presented in an overt prosodic context. Following this, it would be exciting to see whether a similar effect will be seen in a reduction of electrophysiological responses elicited over the time course of an experiment; this may provide further support for Fodor's Implicit Prosody Hypothesis (2002) which posits that overt prosody is paralleled by implicit prosody.

This hypothetical experiment would necessitate more data, like increasing the number of trials from forty in each condition to sixty, to have sufficient statistical power in order to make a claim about implicit prosodic adaptation. We could then perform a within-subjects comparison of the ERP response elicited by trials in the first half of the experiment to that of the second half – specifically, we hypothesize that, over the time course of the session, we would see a decrease in the magnitude of the N400 negativity evoked by metrically inconsistent trials than consistent ones, with a potentially marked reduction in neurophysiological response elicited trochaic stimuli. Additionally, our study utilized fillers to prevent participants from adapting to the metrical manipulation – a redesigning of experimental stimuli would be necessary to explore the effect of prosodic adaptation in an implicit context.

In summary, our study built and expanded upon the foundation of previous psycholinguistic studies by employing stimuli which contained lexically identical words, were locally syntactically correct with inconsistencies in metrical structure that lead to global ambiguity which could only be disambiguated with implicit prosodic structures during reading (Breen & Clifton, 2011). Our results, which demonstrate a distinct N400 in response to trochaic and inconsistent stimuli, are significant as they contribute to the small but growing body of literature about the Implicit Prosody Hypothesis. Apart from providing empirical evidence of implicit prosody or the "*inner voice*", this study also has implications for auditory imagery by showcasing similarities with ERP experiments based on auditory perception (Böcker et al., 1999; Rothermich et al., 2012).

Individual Trait Differences

We explored the possibility of using individual trait differences in self-reported levels of auditory imagery as predictors for neural processing of implicit prosody. Two of the subscales, BAIS-C and the VISQ Evaluative/Motivational Inner Speech, respectively revealed weakly positive and weakly negative correlations respectively with effect score – however, these relationships were not significant. This could be due to the relatively small number of participants – a manifold increase in our sample size would allow us to tease out whether these correlations are genuine or simply a product of chance (Krejcie & Morgan, 1970; MacCallum, Widaman, Zhang, & Hong, 1999).

Curiously, we did see a significant and moderately negative correlation between the effect score and the VISQ Dialogic Inner Speech subscale score, i.e. trochaic and inconsistent targets elicited a less pronouncedly negative neural response in individuals who self-reported an increased tendency towards thinking in a conversational style. This is a surprising result which stands in contradiction to a host of previous literature which demonstrate the importance of prosodic cues for semantic and syntactic understanding between interlocutors and participants and general language comprehension (Aguert, Laval, Le Bigot, & Bernicot, 2010; Snedeker & Trueswell, 2003; Kraljic & Brennan, 2005; Ferreira, Slevc, & Rogers, 2005; Schafer, Speer, Warren, & White, 2005; Price, Ostendorf, Shattuck-Hufnagel, & Fong, 1991). Additionally, this result is contrary to the ideas of prosodic or phonological bootstrapping that language learners use prosodic features of speech to identify and comprehend other linguistic features such as syntactic structure and semantic meaning (Lust, 2006; Christophe, Nespor, Guasti, & Van Ooyen, 2003; Christophe, Guasti, Nespor, Dupoux, & Van Ooyen, 1997). Investigations of parameter accuracy have revealed that, in psychology, correlations stabilize when the sample size is, at least, 250 unique data points or individuals (Kelley & Maxwell, 2003; Maxwell, Kelley, & Rausch, 2008; Schönbrodt & Perugini, 2013); thus, to assess whether the weak relationship between the VISQ Dialogic subscale the effect score is real or spurious, future study is needed.

It is also possible that there are more effective and appropriate tests of auditory imagery than the VISQ and the BAIS. Revisiting previous literature about measures of internally generated linguistic, acoustic and, more generally, auditory representations may prove fruitful (Intons-Peterson, 1992). A possible alternative measure of individual trait differences in auditory imagery could be the Clarity of Auditory Imagery Scale, as proposed by Willander & Baraldi (2010). The Clarity of Auditory Imagery Scale was designed to address the issue of conflation of the clarity and vividness of auditory imagery in previous scales, and has been found to have high internal consistency (Campos & Pérez-Fabello, 2011).

I propose that a test which quantifies readers' comprehension of garden-path sentences may be useful to understand the rate at which an individual is able to construct inner prosodic representations of language (Ferreira & Henderson, 1991; Ferreira, Christianson, & Hollingworth, 2001). This test would need to be designed in a manner in which readers are allowed to read the garden-path sentence only once and somehow disrupt their ability to momentarily repair semantic or syntactic misnalayses with articulatory suppression. Articulatory suppression will prevent the visually presented garden-path sentences from being encoded into the phonological loop (auditory working memory store) (Saito, 1998). It is possible to digitally construct a task in which researchers can control the duration of the presentation of the stimulus while participants are instructed to repeat a syllable (such as constant repetition of "la-la-la"), followed by a multiple choice question about the interpretation of the sentence. I hypothesize that individuals who have a higher accuracy in the comprehension of garden-path sentences are quicker to generate 'inner speech' renditions of read material than those who have lower scores.

Implications

Finally, one may wonder about the purpose of studying auditory imagery though implicit prosody. Is the generation of implicit prosodic structures of words during silent reading simply an evolutionary by-product? We know that language has been rooted in auditory articulations and spoken utterances for much longer than the written word, as the oldest logographic script that has been discovered is from about 3,300 to 3,000 BC whereas work from historical linguistics suggests that vocal languages must first evolved at least 150,000 BC, which brings up the possibility that implicit prosody is simply epiphenomenal (Schmandt-Besserat, 1992; Gelb, 1952; Perreault & Mathew, 2012; Atkinson, 2011; Nichols, 1998). To even begin to answer this question, however, a lot of groundwork must be done to not only investigate the neural underpinnings of how language is processed in the brain, but also to explore potential parallels between perception and imagery.

Another possibility is that implicit prosody may actually *enhance* readers' processing and understanding of the written word. In the preceding sentence, the textual italicization may lead to a prosodic emphasis of the word *enhance* which ensures that you, the reader, accord semantic importance to that particular word (Naciscione, 2010; Hornby, 1975; Ebbitt, Ebbitt, & Perrin, 1978). Understanding the influence of features which contribute to the generation of implicit prosodic structures will allow us to explore how implicit prosody can help (or hinder) reading comprehension (Breen , 2014). Our results also contribute to a growing body of recent psycholinguistic literature which has looked particularly at the kind of prosodic features that individuals use to resolve ambiguity in language comprehension. Furthermore, this will also enable us to develop an understanding of how children develop reading and sentence processing abilities. Studies have shown a relationship between prosodic fluency and reading comprehension in high school students – those who demonstrates higher prosodic fluency also showed an increased comprehension ability (Breen, Kaswer, Van Dyke, Krivokapić, & Landi, 2016; Benjamin & Schwanenflugel, 2010). Our research about implicit prosody and the underlying neurocognitive processes occurring during language perception could have long term applications by building the methodological and empirical foundations from which we could develop prosodic interventions to improve children's reading comprehension abilities.

Conclusion

The results of this current study suggest that internally generated prosodic structures do, indeed, impact real-time language processing during silent reading. Furthermore, it provides evidence that rhythmic structure in language creates temporal expectancies during implicit prosody.

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APPENDICES

APPENDIX A: Recruitment Poster

APPENDIX B: Experimental Stimuli

1a. Trochaic / Consistent

I know of an old man named Herbert,
Who's known around town as a pervert.
He searches the shops,
For girls in tight tops,
And stands there just too close for comfort.

1b. Trochaic / Inconsistent

The nun did her best to convert
A man whom they call a pervert.
She knows when he lies,
It's all in the eyes,
Her gaze they will always avert.

1c. Iambic / Consistent

That nun did her best to convert
Young kids who the truth do pervert.
She knows when they lie,
And I'll tell you why,
Her gaze they will always avert.

1d. Iambic / Inconsistent

I know of an old man named Herbert
Who always the truth tries to pervert.
I know when he lies,
It's all in the eyes.
At hiding it he is no expert.

2a. Trochaic / Consistent

The crew worked so hard for their paychecks
They thought they'd develop a complex
They went out for beer
In a bar by the pier
Then home to their wives in the projects.

2b. Trochaic / Inconsistent

There once was a young man named Rex
Who owned an apartment complex.
This wowed Rex's mother,
His sister and brother,
It earned him some large rental checks.

2c. Iambic / Consistent

There once was a young man named Rex
whose theories were big and complex
This wowed Rex's mother,
his sister and brother,
and failed to bring in any checks.

2d. Iambic / Inconsistent

The crew worked so hard for their paychecks
Their work was so terribly complex
They went out for beer
In a bar by the pier
Then home to their wives in the projects.

3a. Trochaic / Consistent

That man applies way too much hair grease.
A friend should suggest a big decrease.
If he's at the beach,
The oil will leach.
He soon will be hearing from Greenpeace.

3b. Trochaic / Inconsistent

Forgive me for stating my peace,
But you must commence a decrease
In foods that you eat,
Like sweets and red meat,
Or surely you'll soon be obese.

3c. Iambic / Consistent

Forgive me for stating my peace,
Your appetite you must decrease.
If you don't cut back
On sugar and fat,
You surely will soon be obese.

3d. Iambic / Inconsistent

That man applies way too much hair grease.
I think the amount he should decrease.
If he's at the beach,
the oil will leach.
He soon will be hearing from Greenpeace

4a. Trochaic / Consistent

The Soviet spy is a suspect.
The case has but one major defect.
His girlfriend will swear
That he was not there.
But other than that it is perfect.

4b. Trochaic / Inconsistent

The Soviet spy they suspect,
Has plans with a major defect
His accent's too thick,
It won't do the trick,
The bad guys a ruse will suspect.

4c. Iambic / Consistent

The Soviet spy they suspect,
Is planning quite soon to defect.
He closed his accounts,
Withdrew large amounts,
His family, they say, they'll protect.

4d. Iambic / Inconsistent

The Soviet spy is a suspect.
I heard that he's planning to defect.
He closed his accounts,
Withdrew large amounts,
Adopting a mistrustful affect.

5a. Trochaic / Consistent

We once had a tiresome house guest,
Who loved to read Birdwatcher's Digest.
We teased and we joked,
He was not provoked.
He still thinks that birds are the greatest.

5b. Trochaic / Inconsistent

We once had a friend as a guest,
Who loved to skim Reader's Digest
We teased and we joked,
He was not provoked.
The stories, he said, are the best.

5c. Iambic / Consistent

We once had a friend as a guest,
Whose cooking we could not digest.
We couldn't confess
Our gastric distress.
He still thinks his food is the best.

5d. Iambic / Inconsistent

We once had a tiresome house guest,
Whose humor was painful to digest.
He thinks he's a riot
But we have kept quiet
He still thinks his jokes are the greatest.

6a. Trochaic / Consistent

The gymnast requested a recount
Her score, she thought, rated no discount.
The Austrian judge,
He refused to budge.
He said she had bungled her dismount.

6b. Trochaic / Inconsistent

He could not afford the amount,
And asked for a modest discount.
They told him no way
And forced him to pay.
It emptied his savings account.

6c. Iambic / Consistent

He could not afford the amount.
The invoice they would not discount.
They told him no way
And forced him to pay.
It emptied his savings account.

6d. Iambic / Inconsistent

The gymnast requested a recount
She thought it was wrongful to discount
Her score, but the judge,
He refused to budge.
He said she had bungled her dismount.

7a. Trochaic / Consistent

He tried not to get badly sidetracked.
He needed some raspberry extract.
But in the big shop,
'Twas nary a drop.
His fancy dessert plans were highjacked.

7b. Trochaic / Inconsistent

The recipe seemed quite exact.
It called for some almond extract.
It should be a treat,
Just lovely to eat,
But mud was its taste, that's a fact.

7c. Iambic / Consistent

The recipe seemed quite exact.
Some essence you had to extract.
It should be a treat,
Just lovely to eat,
But mud was its taste, that's a fact.

7d. Iambic / Inconsistent

He tried not to get badly sidetracked
Some essence he wanted to extract
But try as he might,
No tactic worked right
His fancy dessert plans were highjacked.

8a. Trochaic / Consistent

The city must safeguard the seaports,
To save us from dangerous imports.
With so many ships,
There can be no slips.
The tankers will all now need escorts.

8b. Trochaic / Inconsistent

The panel is set to report
On how much we pay for imports
It's just as they fear,
Much more than last year.
The council will surely retort.

8c. Iambic / Consistent

The panel is set to report
On how much the city imports
It's just as they fear,
Much more than last year.
The council will surely retort.

8d. Iambic / Inconsistent

The city must safeguard the seaports,
Because of how much it now imports.
With so many ships,
There can be no slips.
The tankers will all now need escorts.

9a. Trochaic / Consistent

The man who asked you for a consult
Was given a horrible insult.
So this is the end,
He won't ask again,
It seems that you can't be an adult.

9b. Trochaic / Inconsistent

That woman who likes the occult,
Will tolerate no more insults.
She wields some black magic
Whose outcome is tragic
With death a potential result.

9c. Iambic / Consistent

That woman who likes the occult,
Is very unsafe to insult.
She wields some black magic
Whose outcome is tragic
With death a potential result.

9d. Iambic / Inconsistent

The man who asked you for a consult
Is no-one you wanted to insult.
So this is the end,
He won't ask again,
It seems that you can't be an adult.

10a. Trochaic / Consistent

The teacher assigned them a project
To find an unusual object.
The parents said "Wait,
she's not thinking straight."
The children think she is just perfect.

10b. Trochaic / Inconsistent

A woman that we might elect
Some say she's a risky object.
The voters say "Wait,
she's not thinking straight."
Her candidacy we reject.

10c. Iambic / Consistent

A woman that we might elect
Has views to which others object.
Some voters say "Wait,
she's not thinking straight."
Her candidacy we reject.

10d. Iambic / Inconsistent

The teacher assigned them a project
that forced many parents to object.
The parents said "Wait,
she's not thinking straight."
the children think she is just perfect.

11a. Trochaic / Consistent

There once was an old man named Kermit,
Who hunted without any permit.
He wouldn't obey,
They sent him away.
Now he lives alone as a hermit.

11b. Trochaic / Inconsistent

There once was an old man named Britt
Who hunted without a permit.
He wouldn't obey,
They sent him away
To live all alone for a bit.

11c. Iambic / Consistent

There once was an old man named Britt
Whose vices no wife could permit.
He wouldn't obey,
She sent him away,
To live all alone for a bit.

11d. Iambic / Inconsistent

There once was an old man named Kermit
Whose gambling his wife would not permit.
He wouldn't obey,
She sent him away.
Now he lives alone as a hermit.

12a. Trochaic / Consistent

He couldn't hide all of his misdeeds,
But made off with all of the proceeds.
From charity giving,
He has made a living.
Some jail time is what this guy needs.

12b. Trochaic / Inconsistent

In light of the man's dirty deeds,
He won't receive any proceeds.
From charity giving,
He has made a living.
Some jail time is what this guy needs.

12c. Iambic / Consistent

In light of the man's dirty deeds,
On Monday his trial proceeds.
I hope that the jury
Convicts in a hurry.
And I'd like to give him a nosebleed.

12d. Iambic / Inconsistent

He couldn't hide all of his misdeeds
On Monday his retrial proceeds.
I hope that the jury
Convicts in a hurry.
And I'd like to give him a nosebleed.

13a. Trochaic / Consistent

There once was a young man named Ernest,
Who sponsored a violent protest.
When they asked him why,
He said, with a sigh,
"I wanted to open a wasp's nest."

13b. Trochaic / Inconsistent

They put the man under arrest
For leading an angry protest.
He asked to be freed,
They said "No, indeed,
For you have severely transgressed."

13c. Iambic / Consistent

They put the man under arrest,
And gave him no time to protest.
He asked to be freed,
They said "no, indeed,
For you have severely transgressed."

13d. Iambic / Inconsistent

There once was a young man named Ernest,
Who rounded up people to protest.
When they asked him why,
He said, with a sigh,
"I wanted to open a wasp's nest."

14a. Trochaic / Consistent

That basketball star's like a bloodhound.
He seeks out and catches each rebound.
He always plays tough,
But never too rough,
Although it's just hoops on the playground.

14b. Trochaic / Inconsistent

The basketball star turned around,
and caught an amazing rebound.
He always plays tough,
But never too rough,
And always the fans does astound.

14c. Iambic / Consistent

The basketball star turned around,
and watched for the shot to rebound.
He always plays tough,
But never too rough,
And always the fans does astound.

14d. Iambic / Inconsistent

That basketball star's like a bloodhound.
he waits for each jumpshot to rebound.
He always plays tough,
But never too rough,
Although it's just hoops on the playground.

15a. Trochaic / Consistent

I met an old friend who played baseball,
Who warned of a new safety recall.
With all of the noise
About lead in toys,
We're all better off playing stickball.

15b. Trochaic / Inconsistent

I met an old friend at the mall,
Who warned of a safety recall.
With all of the noise
About lead in toys,
I'm giving kids nothing at all.

15c. Iambic / Consistent

I met an old friend at the mall,
Whose name I just could not recall.
I disclosed the gaff,
And we had a laugh.
She wasn't offended at all.

15d. Iambic / Inconsistent

I met an old friend who played baseball,
But what his name was I can't recall.
He told me “No worry,”
And left in hurry.
He said he was late for a phone call.

16a. Trochaic / Consistent

Last year I created a stock fund.
And managed to get a big refund.
But now there's no question,
We're in a recession.
Investors are all being cautioned.

16b. Trochaic / Inconsistent

I have to admit I am stunned,
You didn't give me my refund
I soon will be broke.
To me, that's no joke.
You know that I really am bummed.

16c. Iambic / Consistent

I have to admit I am stunned,
My payments you will not refund.
I soon will be broke
To me that's no joke
You know that I really am bummed.

16d. Iambic / Inconsistent

Last year I created a stock fund.
The fees they would happily refund
But now there's no question,
We're in a recession
Investors are all being cautioned.

17a. Trochaic / Consistent

I read an unusual essay
'Bout how they conducted a survey.
The polsters, how rude,
Showed up in the nude.
I burned it right up in the ashtray.

17b. Trochaic / Inconsistent

A lovely young woman named Fay
Was asked to complete a survey.
She did not like visitors,
Above all, inquisitors,
She told them to just go away.

17c. Iambic / Consistent

A lovely young woman named Fay
The future she liked to survey,
But something she saw,
Just stuck in her craw:
The date that she would pass away.

17d. Iambic / Inconsistent

I read an unusual essay
Describing how folks tried to survey.
The polsters, how rude,
Showed up in the nude.
I burned it right up in the ashtray.

18a. Trochaic / Consistent

The cops have a negative affect
Concerning their most recent suspect.
Stay out of their hair!
They won't treat you fair.
Their treatment may well leave you abject.

18b. Trochaic / Inconsistent

The cops didn't try to protect
A recently collared suspect.
Stay out of their hair!
They won't treat you fair.
Who said they just serve and protect?

18c. Iambic / Consistent

The cops didn't try to protect
The people they chose to suspect.
Stay out of their hair!
They won't treat you fair.
Who said they just serve and protect?

18d. Iambic / Inconsistent

The cops have a negative affect
Toward people they manage to suspect.
Stay out of their hair!
They won't treat you fair.
Their treatment may well leave you abject.

19a. Trochaic / Consistent

A striking young woman named Rembrandt,
From Portugal, she was a transplant.
She hated our food,
And found us quite rude.
Her choice to live here she did recant.

19b. Trochaic / Inconsistent

A striking young dame named van Zandt,
From Spain was a recent transplant.
She hated our food,
And found us quite rude.
"I want to go home," she would chant.

19c. Iambic / Consistent

A striking young dame named van Zandt
Had roses she hoped to transplant.
They withered and died.
She cried, and she cried.
"Come back, little bloom," she would chant.

19d. Iambic / Inconsistent

A striking young woman named Rembrandt
Had roses she wanted to transplant.
They withered and died.
She cried, and she cried.
"Come back to me, my little houseplant."

20a. Trochaic / Consistent

To get to the local gym's squash court,
You must take municipal transport
It will take some time,
And is hard to find.
I'm happy to serve as your escort.

20b. Trochaic / Inconsistent

The mafia tried to extort
The captain of public transport,
But he wouldn't pay,
And sent them away.
"Watch out!" was the mobster's retort.

20c. Iambic / Consistent

The mafia tried to extort
A man who had tried to transport
A shipment of drugs,
By sending some thugs.
"You'll pay!" was the poor man's retort.

20d. Iambic / Inconsistent

To get to the local gym's squash court,
Your gear should be ready to transport.
It will take some time,
And is hard to find.
I'm happy to serve as your escort.

21a. Trochaic / Consistent

You must hear my story, your highness.
I have the young princess's address.
Arrive there at two,
She's waiting for you.
Just be sure to treat her with kindness.

21b. Trochaic / Inconsistent

My workspace is such a big mess.
I lost an important address.
I must mail a letter.
The sooner, the better.
Or else I will be in distress.

21c. Iambic / Consistent

My workspace is such a big mess.
My clutter I have to address.
I must mail a letter.
The sooner, the better.
Or else I will be in distress.

21d. Iambic / Inconsistent

You must hear my story, your highness.
Your habits I find I must address.
It's not a good thing,
When our future king,
Behaves like a kiddie at recess.

22a. Trochaic / Consistent

The guy who got lost on a flyby
Dropped all of his bombs on an ally.
For him it was tragic,
And not the least magic.
The enemy cheered at the bull's eye.

22b. Trochaic / Inconsistent

I know a young woman from Rye,
Who'd make such a lovely ally.
It would be quite groovy
To go to a movie,
Or chit-chat while eating some Thai.

22c. Iambic / Consistent

I know a young woman from Rye,
With whom I would like to ally.
It would be quite groovy
To go to a movie,
Or chit-chat while eating some Thai.

22d. Iambic / Inconsistent

The guy who got lost on a flyby
Killed folks with whom we want to ally.
For them it was tragic,
And not the least magic.
Our friends shouldn't be in the bull's eye.

23a. Trochaic / Consistent
I just saw a dog and a tomcat,
Engaged in some furious combat,
But I was surprised,
And then hypnotized,
When into the fray walked a wombat.

23b. Trochaic / Inconsistent
I witnessed a dog and a cat,
Engaged in some angry combat,
But I was surprised,
And then hypnotized,
When into the fray walked a rat.

23c. Iambic / Consistent
I witnessed a dog and a cat,
Who seemingly tried to combat
Whatever came down
To their end of town.
I told the two rascals to scat.

23d. Iambic / Inconsistent
I just saw a dog and a tomcat,
That we must be ready to combat,
Or else they will bite,
With all of their might,
Our sweet little domestic wombat.

24a. Trochaic / Consistent
I heard someone say through the grapevine:
The farmer is driving his combine
To harvest the yields
Of all of his fields,
And have them all shipped on the rail line.

24b. Trochaic / Inconsistent
The farmer got caught drinking wine,
Then harvesting in his combine.
While this abdication
Will get him probation,
I don't believe he'll do hard time.

24c. Iambic / Consistent
The farmer got caught drinking wine,
And shotguns and booze don't combine.
While this abdication
Will get him probation,
I don't believe he'll do hard time.

24d. Iambic / Inconsistent
I heard someone say through the grapevine:
That farmer is hoping to combine
His own garden's yields,
With those from my fields,
And have them all shipped on the rail line.

25a. Trochaic / Consistent

I processed some prints in the darkroom
Of people I'd met on a commune.
They pray to the sun,
And have lots of fun,
And frolic like kids on the sand dunes.

25b. Trochaic / Inconsistent

I know some who worship the moon,
And live in a hippie commune.
They pray to the sun,
And have lots of fun,
And dance for the Solstice in June.

25c. Iambic / Consistent

I know some who worship the moon,
With nature they like to commune.
They pray to the sun,
And have lots of fun,
And dance for the Solstice in June.

25d. Iambic / Inconsistent

I processed some prints in the darkroom
Of folks who just wanted to commune
On clothing-free seashores,
The Caymans, or Azores,
And frolic like kids on the sand dunes.

26a. Trochaic / Consistent

If out in the mountains you backpack,
Your team must agree to this compact:
Don't cut down the trees,
Or bother the bees.
You don't want to make a big impact.

26b. Trochaic / Inconsistent

Before you head out with that pack,
Your team has to sign this compact:
Don't cut down the trees,
Or bother the bees.
We want to leave Nature intact.

26c. Iambic / Consistent

Before you head out with that pack,
Be sure that your gear is compact.
Don't cut down the trees,
Or bother the bees.
We want to leave Nature intact.

26d. Iambic / Inconsistent

If out in the mountains you backpack,
Your gear must be basic and compact.
Don't cut down the trees,
Or bother the bees.
You don't want to make a big impact.

27a. Trochaic / Consistent

We stayed in the woods at a campground,
Which wasn't too far from a compound
Where there was a crowd
That drank and was loud.
Their rudeness our party did dumbfound.

27b. Trochaic / Inconsistent

We got that old dog at the pound
He came from a private compound
But now he is sick,
Can do no more tricks,
And soon will be put in the ground.

27c. Iambic / Consistent

We stayed in the woods at a campground,
Our pleasure in nature to compound.
But there was a crowd
That drank and was loud.
Their rudeness our party did dumbfound.

27d. Iambic / Inconsistent

We got that old dog at the pound
Our sadness will surely compound
For now he is sick,
Can do no more tricks,
And soon will be put in the ground.

28a. Trochaic / Consistent

There was a young heroin addict,
Who ended up causing a conflict.
His auto was stopped,
And he shot a cop,
And now he's a federal convict.

28b. Trochaic / Inconsistent

My parents are being quite strict.
Our views are in open conflict.
They're making a rule,
That I go to school.
Their bossiness has me quite ticked.

28c. Iambic / Consistent

My parents are being quite strict.
Their wishes and mine do conflict.
They're making a rule,
That I go to school.
Their bossiness has me quite ticked.

28d. Iambic / Inconsistent

There was a young heroin addict,
Whose habits and others did conflict.
His auto was stopped,
And he shot a cop,
And now he's a federal convict.

29a. Trochaic / Consistent

The athlete who just failed a drugtest,
Will soon face a challenging contest.
His one last resort,
To take it to court,
By filing a certified protest.

29b. Trochaic / Inconsistent

The athlete who thinks he's the best
Just lost an important contest.
He'll need a fast pace
To win next week's race,
The key to fulfilling his quest.

29c. Iambic / Consistent

The athlete who thinks he's the best
Holds titles that others contest.
He'll need a fast pace
To win next week's race,
The key to fulfilling his quest.

29d. Iambic / Inconsistent

The athlete who just failed a drugtest,
Is planning the charges to contest.
His one last resort,
To take it to court,
By filing a certified protest.

30a. Trochaic / Consistent

Although that young man is an addict,
He really should not be a convict.
He needs some support,
It's better than court,
And jail time will cause too much conflict.

30b. Trochaic / Inconsistent

I think that the judge was too strict
In sentencing that young convict.
When freed from the jail,
He will, without fail,
Go back into crime, I predict.

30c. Iambic / Consistent

I think that the judge was too strict,
The jury too quick to convict.
When freed from the jail,
He will, without fail,
Go back into crime, I predict.

30d. Iambic / Inconsistent

Although that young man is an addict,
I think that the judge shouldn't convict.
He needs some support,
It's better than court,
And jail time will cause too much conflict.

31a. Trochaic / Consistent

In nothing but jeans and a t-shirt,
That man took a trip 'cross the desert.
He soon was quite beat,
Succumbed to the heat,
He wasn't a survival expert.

31b. Trochaic / Inconsistent

The fighting he tried to avert,
By running off through the desert.
He soon was quite beat,
Succumbed to the heat,
But happily came out unhurt.

31c. Iambic / Consistent

The fighting he tried to avert,
By choosing his squad to desert.
He soon was quite beat,
Succumbed to the heat,
But happily came out unhurt.

31d. Iambic / Inconsistent

In nothing but jeans and a t-shirt,
A soldier his squad chose to desert.
He soon was quite beat,
Succumbed to the heat,
He wasn't a survival expert.

32a. Trochaic / Consistent

I know of an elegant female
Her outfits lack no fashion detail.
She gave me advice:
I don't pay full price.
I buy all my clothing at wholesale.

32b. Trochaic / Inconsistent

There once was a woman named Gail
Whose fashion had every detail.
She gave me advice:
"I don't pay full price.
I buy all my clothing on sale."

32c. Iambic / Consistent

I know of an elegant female
Who wanted her auto to detail.
A nice guy said he
Would do it for free,
And later they met for a cocktail.

32d. Iambic / Inconsistent

There once was a woman named Gail
Who wanted her car to detail.
A nice guy said he
Would do it for free,
And later they went out for ale.

33a. Trochaic / Consistent

There was a young woman whose nude dance
Made everyone flock to the entrance.
The men, it drove wild,
Whenever she smiled,
But she says she's not seeking romance.

33b. Trochaic / Inconsistent

This gorgeous young woman from France
Made everyone jam the entrance.
Whenever she smiled,
The men all went wild.
She says she's not seeking romance.

33c. Iambic / Consistent

This gorgeous young woman from France
Would often the young men entrance.
Whenever she smiled,
The men all went wild.
She says she's not seeking romance.

33d. Iambic / Inconsistent

There was a young woman whose nude dance
Would always the gentlemen entrance.
She drove them just wild,
Whenever she smiled,
But she says she's not seeking romance.

34a. Trochaic / Consistent

There once was a penniless peasant,
Who couldn't afford a nice present.
For so little yield,
He worked in the field,
And work there was really unpleasant.

34b. Trochaic / Inconsistent

There once was a clever young gent,
Who bought for his girl a present.
But then he got scared,
His speech was impaired.
She couldn't discern what he meant.

34c. Iambic / Consistent

There once was a clever young gent,
Who had a nice talk to present.
But then he got scared,
His speech was impaired.
And nobody knew what he meant.

34d. Iambic / Inconsistent

There once was a penniless peasant,
Who went to his master to present
His gripes and complaints.
He showed no restraint.
The outcome was rather unpleasant.

35a. Trochaic / Consistent

There once was a crusty old recluse,
Who grew the most wonderful produce.
His lemons and limes
Were truly sublime,
And made the most wonderful fruit juice.

35b. Trochaic / Inconsistent

There simply is no good excuse
For failing to eat your produce.
Those veggies and fruits,
They really are beauts,
And yummy when made into juice.

35c. Iambic / Consistent

There simply is no good excuse
For failing to work and produce.
You say that you're tired,
But soon you'll be fired,
If you don't get off your caboose.

35d. Iambic / Inconsistent

There once was a crusty old recluse,
Whose garden great harvests would produce.
His lemons and limes
Were truly sublime,
And made the most wonderful fruit juice.

36a. Trochaic / Consistent

With all of their time spent at recess,
The children make no forward progress.
They won't be succeeding,
In writing and reading,
While working on physical fitness.

36b. Trochaic / Inconsistent

The efforts at peace, I confess,
Are making no forward progress.
I'm not at all sure,
We'll bypass a war.
The locals are now in distress.

36c. Iambic / Consistent

The efforts at peace, I confess,
Will simply no longer progress.
I'm not at all sure,
We'll bypass a war.
The locals are now in distress.

36d. Iambic / Inconsistent

With all of their time spent at recess,
The children will soon fail to progress.
They won't be succeeding,
In writing and reading,
While working on physical fitness

37a. Trochaic / Consistent

I noticed a ruinous defect
In one of the candidate's projects.
If he can't explain,
He'll garner disdain.
The voters will find the man suspect.

37b. Trochaic / Inconsistent

The man we will likely elect
Endorses some wacky projects.
He says he's for change,
But I find him strange.
He doesn't yet have my respect.

37c. Iambic / Consistent

The man we will likely elect
According to what polls project
Proclaims he's for change,
But I find him strange.
He doesn't yet have my respect.

37d. Iambic / Inconsistent

I noticed a ruinous defect
In what that new candidate projects.
He oftens looks dour,
And out-and-out sour.
The voters are finding him suspect.

38a. Trochaic / Consistent

In a voice that was piercing and treble,
The serfs were inspired by a rebel.
Then facing the troops,
In small tight-knit groups,
They let fly a volley of pebbles.

38b. Trochaic / Inconsistent

The infantry failed to repel
The followers of the rebel.
They're tough to persuade,
As they're so well-paid,
With funds from the Juarez cartel.

38c. Iambic / Consistent

The infantry failed to repel
The fighters who want to rebel.
They're tough to persuade,
As they're so well-paid,
With funds from the Juarez cartel.

38d. Iambic / Inconsistent

In a voice that was piercing and treble,
The leader urged peasants to rebel.
Then facing the troops,
In small tight-knit groups,
They let fly a volley of pebbles.

39a. Trochaic / Consistent

There once was a young man named Eckerd
Who broke an old pole-vaulting record.
His star rose so fast,
But fame would not last.
It turned out his past was quite checkered.

39b. Trochaic / Inconsistent

The athlete won quite an award
For breaking the scoring record.
But we were confounded,
And really astounded;
The rest of the team was ignored.

39c. Iambic / Consistent

The athlete won quite an award
The cameras were there to record.
But we were confounded,
And really astounded;
The rest of the team was ignored.

39d. Iambic / Inconsistent

There once was a young man named Eckerd
Whose pole-vaulting feats they did record
His star rose so fast,
But fame would not last.
It turned out his past was quite checkered.

40a. Trochaic / Consistent

The judges must all watch the replay
To find out which team won the relay.
To my unskilled eye,
It looked like a tie.
The runners all wait on the raceway.

40b. Trochaic / Inconsistent

A messenger came by today
To find out who won the relay.
To my unskilled eye,
It looked like a tie.
The runners all wait on the raceway.

40c. Iambic / Consistent

A messenger came by today;
A message he had to relay.
"Dear sir, please excuse,
But I have bad news:
Your grandmother has passed away."

40d. Iambic / Inconsistent

The judges must all watch the replay.
Results to the coach they will relay
To my unskilled eye,
It looked like a tie.
The runners all wait on the raceway.

APPENDIX C: Individual Difference Questionnaires

Varieties of Inner Speech Questionnaire (VISQ)

Please complete this short questionnaire about your preferences and behaviors.

1	**2**	**3**	**4**	**5**	**6**
Certainly applies to me	**Possibly Applies to me**	**If anything, applies to me slightly**	**If anything, slightly does not apply to me**	**Possibly does not apply to me**	**Certainly does not apply to me**

I think to myself in words using brief phrases and single words rather than full sentences

When I am talking to myself about things in my mind, it is like I am going back and forward asking myself questions and then answering them

I hear the voice of another person in my head. For example, when I have done something foolish, I hear my mother's voice criticising me in my mind.

I experience the voices of other people asking me questions in my head

I hear other people's voices nagging me in my head

My thinking in words is more like a dialog with myself, rather than my own thoughts in a monolog

I think to myself in words using full sentences

My thinking to myself in words is like shorthand notes, rather than full, proper, grammatical English

I think in inner speech about what I have done, and whether it was right or not

When I am talking to myself about things in my mind, it is like I am having a conversation with myself

I talk silently to myself telling myself to do things

I hear other people's actual voices in my head, saying things that they have never said to me before

I talk back and forward to myself in my mind about things

My thinking in words is shortened compared to my normal out-loud speech. For example, rather than saying to myself things like 'I need to go to the shops', I will just say 'shops' to myself in my head

If I were to write down my thoughts on paper, they would read like a normal grammatical sentence

I hear other people's actual voices in my head, saying things that they actually once said to me.

I talk silently to myself telling myself not to do things.

I evaluate my behavior using my inner speech. For example, I say to myself, ''that was good'' or ''that was stupid''

Bucknell Auditory Imagery Scale

The Bucknell Auditory Imagery Scale—Vividness (BAIS-V)

The following scale is designed to measure auditory imagery, or the way in which you "think about sounds in your head." For the following items you are asked to do the following: Read the item and consider whether you think of an image of the described sound in your head. Then rate the vividness of your image using the following "Vividness Rating Scale."

If no image is generated, give a rating of 1. Please feel free to use all of the levels in the scale when selecting your ratings.

Vividness Rating Scale

1	**2**	**3**	**4**	**5**	**6**	**7**
No Image Present at All			**Fairly Vivid**			**As Vivid as Actual Sound**

Vividness Rating
1. For the first item, consider the beginning of the song "Happy Birthday."

The sound of a trumpet beginning the piece._____

2. For the next item, consider ordering something over the phone.

The voice of an elderly clerk assisting you._____

3. For the next item, consider being at the beach.

The sound of the waves crashing against nearby rocks. _____

4. For the next item, consider going to a dentist appointment.

The loud sound of the dentist's drill.______

5. For the next item, consider being present at a jazz club.

The sound of a saxophone solo.______

6. For the next item, consider being at a live baseball game.

The cheer of the crowd as a player hits the ball._____

7. For the next item, consider attending a choir rehearsal.

The sound of an all-children's choir singing the first verse of a song. ______

8. For the next item, consider attending an orchestral performance of Beethoven's Fifth.

The sound of the ensemble playing. ______

9. For the next item, consider listening to a rain storm.

The sound of gentle rain. ______

10. For the next item, consider attending classes.

The slow-paced voice of your English teacher.______

11. For the next item, consider seeing a live opera performance.

The voice of an opera singer in the middle of a verse.______

12. For the next item, consider attending a new tap-dance performance.

The sound of tap-shoes on the stage.______

13. For the next item, consider a kindergarten class.

The voice of the teacher reading a story to the children.______

14. For the next item, consider driving in a car.

The sound of an upbeat rock song on the radio.______

The Bucknell Auditory Imagery Scale—Control (BAIS-C)

The following scale is designed to measure auditory imagery, or the way in which you "think about sounds in your head." For the following pairs of items you are asked to do the following: Read the first item (marked "a") and consider whether you think of an image of the described sound in your head. Then read the second item (marked "b") and consider how easily you could change your image of the first sound to that of the second sound and hold this image. Rate how easily you could make this change using the "Ease of Change Rating Scale." If no images are generated, give a rating of 1. Please read "a" first and "b" second for each pair. It may be necessary to cover up "b" so that you focus first on "a" for each pair.

Please feel free to use all of the levels in the scale when selecting your ratings.

Ease of Change Rating Scale

1	**2**	**3**	**4**	**5**	**6**	**7**
No Image Present at All			**Fairly Vivid**			**As Vivid as Actual Sound**

Change Rating

1. For the first pair, consider attending a choir rehearsal.

a. The sound of an all-children's choir singing the first verse of a song.

b. An all-adults' choir now sings the second verse of the song. ______

2. For the next pair, consider being present at a jazz club.

a. The sound of a saxophone solo.

b. The saxophone is now accompanied by a piano.______

3. For the next pair, consider listening to a rain storm.

a. The sound of gentle rain.

b. The gentle rain turns into a violent thunderstorm.______

4. For the next pair, consider driving in a car.

a. The sound of an upbeat rock song on the radio.

b. The song is now masked by the sound of the car coming to a screeching halt. ______

5. For the next pair, consider ordering something over the phone.

a. The voice of an elderly clerk assisting you.

b. The elderly clerk leaves and the voice of a younger clerk is now on the line.______

6. For the next pair, consider seeing a live opera performance.

a. The voice of an opera singer in the middle of a verse.

b. The opera singer now reaches the end of the piece and holds the final note. ______

7. For the next pair, consider going to a dentist appointment.

a. The loud sound of the dentist's drill.

b. The drill stops and you can now hear the soothing voice of the receptionist.______

8. For the next pair, consider the beginning of the song "Happy Birthday."

a. The sound of a trumpet beginning the piece.

b. The trumpet stops and a violin continues the piece.______

9. For the next pair, consider attending an orchestral performance of Beethoven's Fifth.

a. The sound of the ensemble playing.

b. The ensemble stops but the sound of a piano solo is present.______

10. For the next pair, consider attending a new tap-dance performance.

a. The sound of tap-shoes on the stage.

b. The sound of the shoes speeds up and gets louder.______

11. For the next pair, consider being at a live baseball game.

a. The cheer of the crowd as a player hits the ball.

b. Now the crowd boos as the fielder catches the ball._____

12. For the next pair, consider a kindergarten class.

a. The voice of the teacher reading a story to the children.

b. The teacher stops reading for a minute to talk to another teacher. ______

cite

13. For the next pair, consider attending classes.

a. The slow-paced voice of your English teacher.

b. The pace of the teacher's voice gets faster at the end of class. ______

14. For the next pair, consider being at the beach.

a. The sound of the waves crashing against nearby rocks.

b. The waves are now drowned out by the loud sound of a boat's horn out at sea. _____