

Received: 02.01.2023
Accepted: 30.03.2023

A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

DOI: 10.5604/01.3001.0028.7658

INVESTIGATING SPEECH PERLOCUTIONARY EFFECTS IN EEG/ERP-BASED NEUROPRAGMATIC STUDIES

Jatmika Nurhadi¹[A,B,C,D,E,F,G] , Dadang Sudana¹[A,B,D,E,F],
Wawan Gunawan¹[A,B,D,E,F], Nani Darmayanti²[A,B,D,E,F]

¹Linguistics Studies Program, Postgraduate, Universitas Pendidikan Indonesia, Jawa Barat, Indonesia

²Department of Linguistics, Faculty of Cultural Sciences, Universitas Padjadjaran, Jawa Barat, Indonesia

SUMMARY

This review contains a search for neuropragmatic studies related to the perlocutionary effects of speech acts on linguistic representations in the brain. This review study investigates the use of the electroencephalograph (EEG) with the event-related potentials (ERP) approach (method). This search was carried out by applying a number of criteria to the selection of articles using several search keywords, especially those related to the perlocutionary effects of speech acts and EEG/ERP. Of the 1,737 articles, 30 of them met the predetermined criteria. The results of this review are that there are three focuses of EEG/ERP-based neuropragmatic studies related to (1) the effect of stimulation of short sentences/ speech in the context of conversation; (2) the effect of stimulation of literal and non-literal speech acts (irony and metaphor), and (3) the effect of stimulation of continuous speech acts in the context of discourse.

Key words: effect, speech, neuropragmatic, electroencepalography (EEG), event related potential (ERP)

INTRODUCTION

The development of a multidisciplinary approach in linguistic studies has enriched linguistic studies, including pragmatics. Current pragmatic studies utilize the use of neurocognitive methods, such as electroencephalography (EEG), magnetoencephalography (MEG), and functional magnetic resonance imaging (fMRI) (van Berkum, 2009). Utilization of these various methods in pragmatics can generate a new understanding, especially regarding observable brain responses. This makes pragmatics more open to experimental research. Some literature mentions a term related to this which is referred to as neuropragmatics. Neuropragmatics refers to the study of nerves related to pragmatic abilities, namely mental processes involved in linguistic and extralinguistic communicative interactions. Neuropragmatics is also an interdisciplinary field that utilizes observational techniques and modern brain imaging approaches, especially dealing with the way the brain as a communicative agent represents intentions, understanding situations, and various contexts to infer the meaning of speakers involved in communication. Neuropragmatics itself aims to describe the architectural function of nerves when the pragmatic process takes place as a system that supports all the appropriate domains of communicative behavior in the context of natural language usage (Bambini, 2010).

Neuropragmatics is also closely related to experimental pragmatics. Experimental pragmatics studies how people construct contextual meaning in communication. Specifically how the brain processes the contextual meaning in the mind. One of the neuropragmatic studies related to how the brain works can be studied through electroencephalography (EEG) recording. EEG is an electrophysiological monitoring method to record the electrical activity of the brain. With noninvasive monitoring, through electrodes placed on several parts of the scalp, although in some cases invasive electrodes are sometimes used. In a clinical context, EEG refers to the recording of the brain's spontaneous electrical activity over a period of time (Tatum, 2008).

EEG diagnostics generally focus on measuring brain waves using electroencephalography. Through electroencephalography (EEG) recording and measurements, the frequency of the waves in the activity in the working memory area can be known. In general, the description of the EEG waves is viewed based on parameters that include place, voltage (amplitude), shape (morphology), frequency, rhythm, continuity, number of visible waves, and where certain clinical states occur (awake or sleep). Rhythms within certain frequency types employ the terms delta, theta, alpha, and beta which are defined as delta waves with a frequency range of 0.1 to < 4 Hz, theta waves with a range of 4 to < 8 Hz, alpha waves with a range of 8 to < 13 Hz, and beta waves with a range > 13-30 Hz. (Libenson, 2012).

The use of EEG is related to neuropragmatics, one of which is: Politzer-Ahles (2020) in his research entitled "What can electrophysiology tell us about the cognitive processing of scalar implicatures?". From this study, electrophysiological feedback from the brain can indicate the cognitive process of scalar implicatures.

Brain responses that appear neuroscientific are useful for seeing how respondents actually perceive speech and how meaning is formed in the brain. Therefore, neuropragmatics is important to provide a broader interpretation than existed before (Meibauer and Steinbach, 2011; Noveck, 2018).

The results of the EEG recording can be studied further using the Event-Related Potentials (ERP) method. This method can measure the brain's response to a given stimulus. Regarding neuropragmatics, one thing that can be studied is the effect of speech acts. This ERP method has been presented in various kinds of literature although it is not only limited to the effects of speech acts, but also to the effects of stimuli outside the language stimulus, for example, Luck (2014); Luck and Kappenman (2013). Meanwhile, studies related to linguistics, such as the influence of accents, speech understanding, and various mental representations that can be described with ERP have been conducted by Ferretti, et al., 2020; Jiang, et al., 2019; Rasenberg, et al., 2019; Rigoulot, et al., 2020.

These ERP components can be further categorized based on stimulus processing. Generally, the early ERP components (N100, N200, or P200) are usually associated with attention selection mechanisms, while later ERP components (P300 or later) deal with the interpretation or categorization of stimuli. N100 reflects the initial orientation of attention to stimuli. N200 is an endogenous component associated with conflict detection and stimulus processing (Sokhadze et al., 2017). P200 reflects attentional and discriminatory processes and variables related to task difficulty (Conley et al., 1999). P300 is the most studied component of endogenous ERP, which relates to various stimulus categorizations (Gentili et al., 2014). All of the ERPs mentioned above show responsiveness to attention demands and have been used to evaluate cognitive workload.

Another method that can be used to investigate neuropragmatics is the Standardized Low Resolution Electromagnetic Brain Tomography (sLORETA) method (Pascual-Marqui, 2002). This method is able to show activity in the part of the brain according to the Brodmann area so that the function of the mental aspect can be interpreted correctly. Studies using the sLORETA method have been conducted on aspects of language, including Selpien et al. (2015) with the title "Left dominance for language perception starts in the extrastriate cortex: An ERP and sLORETA study" and Shibata et al. (2016) with the title "Time course and localization of brain activity in humor comprehension: an ERP/sLORETA study".

METHOD

Inclusion and Exclusion Criteria

Data collection articles in this study were collected using the software Harzing's Publish or Perish 7 on Google Scholar search. This search ignores citations, books, and patents. Researchers used keywords such as "effect", "speech", "speech act", "continuous speech", "comprehension", "pragmatics", "neurolinguistics, and "neuropragmatics" in all available years which were narrowed down to words containing EEG and ERP.

Research Article Selection

After removing duplicates, researchers reviewed titles and abstracts. The decision to include articles cannot be made based only on the title and abstract. The researcher then reads the method and the findings in the review process. A number of selected articles met the main research criteria, namely the study of the effects of speech acts that were studied using EEG/ERP covered in neuro-linguistic or neuropragmatic studies.

Data Extraction

The acquired information was extracted based on: study characteristics, participant information, experimental setting, outcome variables, and main findings.

RESULTS

As many 1,737 articles were found based on the results of an electronic search with predetermined keywords, the keywords then were narrowed down to articles containing EEG and ERP and obtained 105 articles. After that, the researcher found 30 selected articles that match the criteria. The following are articles that fall into the criteria related to neuropragmatic studies related to the effects of speech acts, namely: Bastiaansen, van Berkum, and Hagoort (2002a); Bastiaansen, van Berkum, and Hagoort (2002b); Schirmer and Kotz (2003); van Berkum, et al. (2003); Roehm, et al. (2004); Davidson and Indefrey (2007); Amenta and Balconi (2008); Nieuwland and Kuperberg (2008); Coulson and Lovett (2010); Nieuwland, Ditman, and Kuperberg (2010); Regel, Coulson, and Gunter (2010); Bastiaansen, Magyari, and Hagoort (2010); Egorova, Shtyrov, and Pulvermüller (2013); Lau, Holcomb, and Kuperberg (2013); Gisladdottir, Chwilla, and Levinson (2015); Kong, Somarowthu, and Ding (2015); Bambini, et al. (2016); Masia, et al. (2017); Gisladdottir, Bögels, and Levinson (2018); Bambini, et al. (2019); Jiang, Keenan, and Pell (2020); Lui, et al. (2020); Rigoulot, et al. (2020); Sarrett, McMurray, and Kapnoula (2020); Llanos, et al. (2021); Gillis, et al. (2021); Sokoliuk, et al. (2021); Bröhl and Kayser (2021); Broderick, et al. (2021); and Sauppe, et al. (2021).

Stimulus Effects of Short Sentences/Speech in Conversation Context

There are articles related to stimulation in the form of short sentences by Bastiaansen, van Berkum, and Hagoort (2002); Roehm, et al. (2004); Davidson and Indefrey (2007); Amenta and Balconi (2008); Nieuwland and Kuperberg (2008); Coulson and Lovett (2010); Nieuwland, Ditman, and Kuperberg (2010); Regel, Coulson, and Gunter (2010); and Bastiaansen, Magyari, and Hagoort (2010). Regarding the effect of stimulation of short sentences/speech in the context of conversation, it was found that: (1) The tentative effect was related to the construction of working memory traces from linguistic input. This relates to gradual knowledge that emerges in conversation. The data show that syntactic unification is reflected by neuronal synchronization in the lower beta frequency bands; (2) Negation does not create a principal obstacle for readers to immediately connect

the words that enter with what they think is true; (3) Pragmatic scalar meaning can gradually contribute to sentence understanding, this contribution depends on contextual factors. (4) Pragmatic knowledge of speakers can influence language comprehension 200 ms after critical word initiation, as well as neurocognitive processes underlying later stages of comprehension (500-900 ms post-onset); (5) The first type of effect is related to the detection of violations (word categories) in syntactically structured sentences and is found in the alpha and gamma frequency bands. The second type of effect is very sensitive to syntactic manipulation, and (6) The temporal development of the presupposition effect is earlier in the subordinate clause than in the parent clause.

Stimulus Effects of Literal and Non-literal Speech Acts (Irony and Metaphor)

There are two titles related to the processing of literal and non-literal (irony) speech acts, namely Bastiaansen, van Berkum, and Hagoort (2002); Davidson and Indefrey (2007); Amenta and Balconi (2008); Regel, Coulson, and Gunter (2010); Nieuwland, Ditman, and Kuperberg (2010); Bambini, et al. (2016); Bambini, et al. (2019); Lui, et al. (2020); Sarrett, McMurray, and Kapnoula (2020); and Sokoliuk, et al. (2021). From several studies related to literal and non-literal speech act stimuli (irony and metaphor) especially related to semantic processing (N400) and syntactic processing (P600) it was found that (1) words that were a violation showed a greater increase in power than the same word. in the context of the correct sentence, within 300–500 ms intervals after word onset; (2) Quartile analysis shows that for both types of violations, a larger mean violation effect is associated with a lower relative amplitude of oscillatory activity, implying an inverse relationship between ERP amplitude and event-related power magnitude changes in sentence processing. (3) An increase in N400 associated with ironic sentences was observed even though there was no statistically significant difference between ironic and non-ironic sentences. (4) The observed N400 for metaphors is related to contextual aspects, likely indexing contextual expectations on future words that guide lexical access and retrieval, whereas P600 appears to reflect the truly pragmatic interpretive processes required to understand metaphors and derivespeaker meaning, and (5) N400 exhibits typical lexical/semantic processes of metaphor and amplified by literary context, sustained negativity may reflect manipulation of some meaning in working memory, possibly responsible for the poetic effect.

Stimulus Effects of Continuous Speech Acts in the Context of Discourse

There are studies related to the effects of stimuli originating from continuous speech contained in audio books, the focus of which is the study of how the brain mechanism processes the story, which is carried out by van Berkum, et al. (2003); Kong, Somarowthu, and Ding (2015); Llanos, et al. (2021); Gillis, et al. (2021); and Broderick, et al. (2021). Regarding the stimulating effect of continuous speech acts (story) in the context of discourse, several things were found, namely: (1) Lis-

teners connected spoken words that unfolded with wider discourse very quickly, after hearing only the first two or three phonemes, and in many cases long before the end of the word; (2) Neural discrimination occurs when different accent stimuli occur at a latency between 100 and 200 ms. Within the same latency, native listeners exhibited stronger accent-tone contrast processing than non-native listeners in processing stories; and (3) The linguistic representation that appears in the brain is the same in different stories even though it is spoken by different readers.

CONCLUSION

All studies are experimental studies. This study focuses on the problem of electroencephalography, especially the effects of speech acts, both the use of short utterances/sentences in the context of conversation, then the processing of literal and non-literal speech acts in the form of irony and metaphors, then the effect of stimulating speech acts in the context of discourse. The existing studies focus on discussing EEG with ERP methods mainly to investigate N400 related to semantic aspects and P600 related to syntactic aspects, as well as some perceptual processing such as in N200, P300. Based on this, it can be described that the ERP method for studying the phenomenon of linguistic representation in the brain has been widely discussed, especially with regard to pragmatics. However, there have not been many studies focusing on the effects of speech acts and EEG showing linguistic representations through brain imaging using the sLORETA method. Even though it still uses ERP as the main method in investigating the phenomenon of linguistic expression in the brain.

REFERENCES

- Amenta, S., & Balconi, M. (2008). Understanding irony: An ERP analysis on the elaboration of acoustic ironic statements. *Neuropsychological Trends*.
- Bambini, V. (2010). Neuropragmatics: A foreword. *Rivista di Linguistica*, 22(1), 1-20.
- Bambini, V., Bertini, C., Schaeken, W., Stella, A., & Di Russo, F. (2016). Disentangling metaphor from context: an ERP study. *Frontiers in psychology*, 7, 559.
- Bambini, V., Canal, P., Resta, D., & Grimaldi, M. (2019). Time course and neurophysiological underpinnings of metaphor in literary context. *Discourse Processes*, 56(1), 77-97.
- Bastiaansen, M. C., Van Berkum, J. J., & Hagoort, P. (2002). Event-related theta power increases in the human EEG during online sentence processing. *Neuroscience letters*, 323(1), 13-16.
- Bastiaansen, M. C., Van Berkum, J. J., & Hagoort, P. (2002). Syntactic processing modulates the θ rhythm of the human EEG. *Neuroimage*, 17(3), 1479-1492.
- Bastiaansen, M., Magyari, L., & Hagoort, P. (2010). Syntactic unification operations are reflected in oscillatory dynamics during on-line sentence comprehension. *Journal of cognitive neuroscience*, 22(7), 1333-1347.
- Broderick, M. P., Di Liberto, G. M., Anderson, A. J., Rofes, A., & Lalor, E. C. (2021). Dissociable electrophysiological measures of natural language processing reveal differences in speech comprehension strategy in healthy ageing. *Scientific reports*, 11(1), 1-12.
- Bröhl, F., & Kayser, C. (2021). Delta/theta band EEG differentially tracks low and high frequency speech-derived envelopes. *NeuroImage*, 233, 117958.
- Conley, E. M., Michalewski, H. J., & Starr, A. (1999). The N100 auditory cortical evoked potential indexes scanning of auditory short-term memory. *Clinical Neurophysiology*, 110(12), 2086-2093.

- Coulson, S., & Lovett, C. (2010). Comprehension of non-conventional indirect requests: An event-related brain potential study. *Italian Journal of Linguistics*, 22(1), 107-124.
- Davidson, D. J., & Indefrey, P. (2007). An inverse relation between event-related and time-frequency violation responses in sentence processing. *Brain research*, 1158, 81-92.
- Egorova, N., Shtyrov, Y., & Pulvermuller, F. (2013). Early and parallel processing of pragmatic and semantic information in speech acts: neurophysiological evidence. *Frontiers in human neuroscience*, 7, 86.
- Ferretti, T. R., Katz, A. N., Schwint, C. A., Patterson, C., & Pradzynski, D. (2020). How discourse constraints influence neurolinguistic mechanisms during the comprehension of proverbs. *Cognitive, Affective, & Behavioral Neuroscience*, 20, 604-623.
- Gentili, R. J., Jaquess, K. J., Shuggi, I. M., Shaw, E. P., Oh, H., Lo, L. C., ... & Hatfield, B. D. (2018). Combined assessment of attentional reserve and cognitive motor effort under various levels of challenge with a dry EEG system. *Psychophysiology*, 55(6), e13059.
- Gillis, M., Vanthornhout, J., Simon, J. Z., Francart, T., & Brodbeck, C. (2021). Neural markers of speech comprehension: measuring EEG tracking of linguistic speech representations, controlling the speech acoustics. *bioRxiv*.
- Gisladottir, R. S., Bögels, S., & Levinson, S. C. (2018). Oscillatory brain responses reflect anticipation during comprehension of speech acts in spoken dialog. *Frontiers in human neuroscience*, 12, 34.
- Gisladottir, R. S., Chwilla, D. J., & Levinson, S. C. (2015). Conversation electrified: ERP correlates of speech act recognition in underspecified utterances. *PLoS one*, 10(3), e0120068.
- Jiang, X., Gossack-Keenan, K., & Pell, M. D. (2020). To believe or not to believe? How voice and accent information in speech alter listener impressions of trust. *Quarterly Journal of Experimental Psychology*, 73(1), 55-79.
- Kong, Y. Y., Somarowthu, A., & Ding, N. (2015). Effects of spectral degradation on attentional modulation of cortical auditory responses to continuous speech. *Journal of the Association for Research in Otolaryngology*, 16(6), 783-796.
- Lau, E. F., Holcomb, P. J., & Kuperberg, G. R. (2013). Dissociating N400 effects of prediction from association in single-word contexts. *Journal of cognitive neuroscience*, 25(3), 484-502.
- Libenson, M. H. (2012). *Practical Approach to Electroencephalography E-Book*. Elsevier Health Sciences.
- Llanos, F., German, J. S., Gnanateja, G. N., & Chandrasekaran, B. (2021). The neural processing of pitch accents in continuous speech. *Neuropsychologia*, 107883.
- Luck, S. J. (2014). *An introduction to the event-related potential technique*. MIT press.
- Luck, S. J., & Kappenman, E. S. (2013). ERP Components and Selective Attention. *The Oxford Handbook of Event-Related Potential Components*, 295.
- Lui, M., Li, X., Sommer, W., Hildebrandt, A., Lau, G. K. B., & Zhou, C. (2020). Sex differences in behavioral and brain responses to incongruity in emotional speech controlling for autistic traits. *Biological Psychology*, 157, 107973.
- Masia, V., Canal, P., Ricci, I., Vallauri, E. L., & Bambini, V. (2017). Presupposition of new information as a pragmatic garden path: Evidence from Event-Related Brain Potentials. *Journal of Neurolinguistics*, 42, 31-48.
- Meibauer, J., & Steinbach, M. (Eds.). (2011). *Experimental pragmatics/semantics* (Vol. 175). John Benjamins Publishing.
- Nieuwland, M. S., & Kuperberg, G. R. (2008). When the truth is not too hard to handle: An event-related potential study on the pragmatics of negation. *Psychological Science*, 19(12), 1213-1218.
- Nieuwland, M. S., Ditman, T., & Kuperberg, G. R. (2010). On the incrementality of pragmatic processing: An ERP investigation of informativeness and pragmatic abilities. *Journal of memory and language*, 63(3), 324-346.
- Noveck, I. (2018). *Experimental pragmatics: The making of a cognitive science*. Cambridge University Press.

- Pascual-Marqui, R. D. (2002). Standardized low-resolution brain electromagnetic tomography (sLORETA): technical details. *Methods Find Exp Clin Pharmacol*, 24(Suppl D), 5-12.
- Politzer Ahles, S. (2020). What can electrophysiology tell us about the cognitive processing of scalar implicatures?. *Language and Linguistics Compass*, 14(10), 1-22.
- Rasenberg, M., Rommers, J., & Van Bergen, G. (2020). Anticipating predictability: an ERP investigation of expectation-managing discourse markers in dialogue comprehension. *Language, Cognition and Neuroscience*, 35(1), 1-16.
- Regel, S., Coulson, S., & Gunter, T. C. (2010). The communicative style of a speaker can affect language comprehension? ERP evidence from the comprehension of irony. *Brain research*, 1311, 121-135.
- Rigoulot, S., Jiang, X., Vergis, N., & Pell, M. D. (2020). Neurophysiological correlates of sexually evocative speech. *Biological Psychology*, 154, 107909.
- Roehm, D., Schlesewsky, M., Bornkessel, I., Frisch, S., & Haider, H. (2004). Fractionating language comprehension via frequency characteristics of the human EEG. *Neuroreport*, 15(3), 409-412.
- Sarrett, M. E., McMurray, B., & Kapnoula, E. C. (2020). Dynamic EEG analysis during language comprehension reveals interactive cascades between perceptual processing and sentential expectations. *Brain and Language*, 211, 104875.
- Sauppe, S., Choudhary, K. K., Giroud, N., Blasi, D. E., Norcliffe, E., Bhattamishra, S., ... & Bickel, B. (2021). Neural signatures of syntactic variation in speech planning. *PLoS biology*, 19(1), e3001038.
- Schirmer, A., & Kotz, S. A. (2003). ERP evidence for a sex-specific Stroop effect in emotional speech. *Journal of cognitive neuroscience*, 15(8), 1135-1148.
- Selpien, H., Siebert, C., Genc, E., Beste, C., Faustmann, P. M., Güntürkün, O., & Ocklenburg, S. (2015). Left dominance for language perception starts in the extrastriate cortex: an ERP and sLORETA study. *Behavioural brain research*, 291, 325-333.
- Shibata, M., Terasawa, Y., Osumi, T., Masui, K., Ito, Y., Sato, A., & Umeda, S. (2017). Time course and localization of brain activity in humor comprehension: An ERP/sLORETA study. *Brain research*, 1657, 215-222.
- Sokhadze, E. M., Casanova, M. F., Casanova, E. L., Lamina, E., Kelly, D. P., & Khachidze, I. (2017). Event-related potentials (ERP) in cognitive neuroscience research and applications. *NeuroRegulation*, 4(1), 14-14.
- Sokoliuk, R., Degano, G., Banellis, L., Melloni, L., Hayton, T., Sturman, S., ... & Cruse, D. (2021). Covert speech comprehension predicts recovery from acute unresponsive states. *Annals of Neurology*, 89(4), 646-656.
- Tatum IV, W. O. (Ed.). (2014). *Handbook of EEG interpretation*. Demos Medical Publishing.
- Van Berkum, J. J. (2009). The neuropragmatics of simple utterance comprehension: An ERP review. In *Semantics and pragmatics: From experiment to theory* (pp. 276-316). Palgrave Macmillan.
- Van Berkum, J. J., Zwitserlood, P., Hagoort, P., & Brown, C. M. (2003). When and how do listeners relate a sentence to the wider discourse? Evidence from the N400 effect. *Cognitive brain research*, 17(3), 701-718.

Corresponding Author:

Jatmika Nurhadi

Linguistics Studies Program, Postgraduate,

Universitas Pendidikan Indonesia, Jawa Barat, Indonesia

e-mail: jatmikanurhadi@upi.edu

Orcid: <https://orcid.org/0000-0002-6229-8186>

Author	Year	Title	Participants	Trigger	Findings
Bastiaansen, van Berkum, and Hagoort	2002	Syntactic Processing Modulates the Rhythm of the Human EEG	Eighteen right-handed native Dutch speakers (5 males, aged 19-25, mean age 21)	A total of 180 Dutch triplet sentences consist of correct control sentences, derivative variants that include gender violations, and derivative variants including total agreement violations.	Words containing violation represent a greater increase in strength than the same word in the context of the correct sentence, within 300-500 ms intervals after onset.
Bastiaansen, van Berkum, and Hagoort	2002	Event-related theta power increases in the human EEG during online sentence processing	23 native Dutch speakers (9 males and 14 females).	A total of 180 triplets of Dutch sentences. The first condition is that the correct sentence consists of grammatically correct Dutch sentences varying in length from 6 to 10 words. The second condition is the condition of the violation of the word category, that is, the violation of the word category is introduced to the noun after the main verb.	The tentative effect is related to the construction of working memory traces from linguistic input. The data show that syntactic unification is reflected by neuronal synchronization in the lower beta frequency bands.
Schirmer and Kotz	2003	ERP Evidence for a Sex-Specific Stroop Effect in Emotional Speech	Seventy-one subjects were invited to participate in the experiment. A total of 36 listened to the stimulus material spoken by a female speaker.	The stimulus material consists of 74 positive verbs, 74 neutral verbs, and 74 negative verbs.	Although emotional prosody and word valence may have an equal influence on emotional judgment in both sexes, ERP exhibits gender differences in the underlying processing. Women, but not men, show interactions between prosody and word valence during the semantic processing stage.
van Berkum, et al.	2003	When and how do listeners relate a sentence to the wider discourse? Evidence from the N400 effect	24 right-handed native Dutch speakers (19 female subjects, mean age 23, aged 19-36).	80 Dutch short stories depicting easily imaginable situations and events.	Listeners associate spoken words with wider discourse very quickly, after hearing only the first two or three phonemes, and in many cases long before the end of the word.
Roehm, et al.	2004	Fractionating language frequency comprehension via characteristics of the human EEG	16 participants	Participants read 40 sentences randomly interspersed with 160 similar filler sentences.	The data differentiate the neural processing mechanisms involved in different types of conflict resolution based on frequency characteristics (strength vs. phase locking).
Davidson and Indefrey	2007	An inverse relation between event-related and time-frequency violation responses in sentence processing	20 participants	Sentences with matching semantics, phrase structure, or number and control violations are presented sequentially (1.25 words/sec)	Quartile analysis indicated that for both types of violations, a larger mean violation effect was associated with a lower relative amplitude of oscillatory activity, implying an inverse relationship between ERP amplitude and event-related power magnitude changes in sentence processing.
Amenta and Balconi	2008	Understanding irony: An ERP analysis on the elaboration of acoustic ironic statements	12 right-handed students (9 women, 3 men; mean age = 23 years, SD = 0.56)	Stimuli consist of a series of literal and ironic sentences presented in auditory modality. All statements of the type "X is Y", the first part is a concrete noun which is the same in every condition, while the ending can be literal (congruent with neutral prosody) or ironic (congruent with ironic prosody or incongruent with ironic prosody).	An increase in N400 associated with ironic sentences was observed although there was no statistically significant difference between ironic and non ironic sentences. The absence of the N400 effect may indicate that irony is not treated as a semantic anomaly thus rejecting the standard pragmatic hypothesis.

Nieuwland and Kuperberg	2008	When the Truth Is Not Too Hard to Handle: An Event-Related Potential Study on the of Negation Pragmatics	28 students (9 boys, 19 girls; mean age 20.7 years)	A total of 320 quadruplet sentences, each with two complementary predicates that produce opposite truth values in affirmative and negation sentences.	The results show that negation does not pose a principle barrier for readers to immediately associate the incoming words with what they think is true.
Coulson and Lovett	2010	Comprehension of non-conventional indirect requests: An event-related brain potential study	20 participants (10 women, aged 18 to 29 years, mean age 21.2, SD = 2.94, SE = 0.80)	The stimulus consists of 60 pairs of short scenarios (3-4 sentences), each followed by a target speech and comprehension inquiry.	The results support the claim that pragmatic cues have an early influence on sentence processing, and that earlier figurative language processing models, such as those from the Standard Pragmatic Model, are insufficient to describe indirect request processing.
Nieuwland, Ditman, and Kuperberg	2010	On the incrementality of pragmatic processing: An ERP investigation of informativeness and pragmatic abilities	31 right-handed Tufts students (17 boys; mean age = 20.2 years) gave written informed consent	70 sentences are paired in such a way that the duration is less informative and informative; each pair of sentences is identical except for the critical word.	The results show that pragmatic scalar meaning can gradually contribute to sentence understanding, this contribution depends on contextual factors.
Regel, Coulson, and Gunter	2010	Can the communicative style of a speaker affect language comprehension? ERP evidence from the comprehension of irony	40 participants (19 women, mean age 24.1 years (SD 2.61))	A total of 100 experimental sentences such as "The game was fantastic" are embedded in two types of discourse contexts, which can be ironic or literal.	These findings suggest that pragmatic knowledge of speakers can influence language comprehension 200 ms after critical word initiation, as well as the neurocognitive processes underlying later stages of comprehension (500-900 ms post-onset). Thus, the dynamic perceived characteristics of the speaker influence the construction of the correct interpretation of ironic utterances.
Bastiaansen, Magyari, and Hagoort	2010	Syntactic Unification Operations Are Reflected in Oscillatory Dynamics during On-line Sentence Comprehension	23 native Dutch speakers (9 males and 14 females).	The experimental stimulus material consisted of 180 triplets of Dutch sentences. A triplet of sentences contains the following three conditions (see Table 1 for an example of stimulus material).	The first type of effect is related to the detection of violations (word categories) in syntactically structured sentences, and is found in the alpha and gamma frequency bands. The second type of effect is particularly sensitive to syntactic manipulation: A linear increase in beta strength across sentences is present for correct sentences, is interrupted upon occurrence of word category violations, and is absent in syntactically unstructured random word sequences. Therefore, we attribute this effect to the syntactic unification operation.
Egorova, Shtyrov, and Pulvermüller	2013	Early and parallel processing of pragmatic and semantic information in speech acts: neurophysiological evidence	20 participants	The stimuli consisted of two sets of 16 experimental videos featuring one trial sequence. Each video shows two people ("Partner" and "Speaker") sitting at a table in front of each other and there are 12 objects on the table.	The results of the analysis provide the first evidence for surprisingly early access to pragmatic and socially interactive knowledge, which may occur in parallel with other types of linguistic processing, and thus support near-simultaneous access to various subtypes of psycholinguistic information.

Lau, Holcomb, and Kuperberg	2013	Dissociating N400 Effects of Prediction from Association in Single-word Contexts	The data presented here are from 32 participants (13 men and 19 women, aged 19–24 years, mean age = 20.5 years).	Table 1 summarizes the set material design used in this study. The experiment consists of a 2 x 2 design (Related/Unrelated Proportions x Low/High)	A greater reduction of N400 to related targets was observed under conditions of high rather than low linkage proportions, consistent with the hypothesis that predictions about future stimuli contributed substantially to the N400 effect. The results show that predictability modulates the amplitude of the N400 to a greater extent than the semantic content of the context.
Gisladoitir, Chwilla, and Levinson	2015	Conversation electrified: ERP correlates of speech act recognition in underspecified utterances	44 participants (28 women, 16 men, mean age 20, aged 18-27).	There are 378 two-spoken naturalistic dialogues in Dutch that reflect everyday informal conversations between friends or relatives.	This indicates that the introduction of speech acts starts from the beginning when the speech is only partially processed. However, additional processing based on complete speech is required in more complex actions, as reflected by negative posteriors in final words when speech acts in less restrictive contexts and new action sequences begin. This finding shows that understanding sentences in a conversational context crucially involves recognizing verbal actions that begin as soon as possible.
Kong, Somarowithu, and Ding	2015	Effects of Spectral Degradation on Attentional Modulation of Cortical Auditory Responses to Continuous Speech	8 participants aged 20 and 28 years.	Auditory stimuli are continuous utterances drawn from two chapters in the public domain children's story book, <i>A Child's History of England</i> by Charles Dickens	These results suggest that severe spectral degradation and low TMR impede the separation of sound streams making it difficult to use top-down attention to process different sound streams differently.
Bambini, et al.	2016	Disentangling Metaphor from Context: An ERP Study	13 healthy volunteers (6 women; mean age = 25.92, SD = 3.75)	A total of 64 nouns function as target words (e.g., "squalo," shark). Nouns were matched for the main psycholinguistic variables, namely frequency, word length, orthographic difficulty.	These findings suggest that the observed N400 for metaphors is related to contextual aspects, likely indexing contextual expectations on future words that guide lexical access and retrieval, whereas P600 processes required to understand metaphors and derive speaker meaning. In short, prior information in the linguistic context is biased towards metaphorical interpretation but does not suppress interpretive pragmatic mechanisms to acquire the intended meaning.
Masia, et al.	2017	Presupposition of new information as a pragmatic garden path: Evidence from Event-Related Brain Potentials	29 participants (8 males, mean age 23, SD 4)	The stimulus consists of 80 pairs of three-sentence parts. Each part in the pair is formed by the context of the two sentences followed by the target sentence in which the experimental manipulation is carried out so as to display a presupposition or assertive construction.	The results prove the difference between presupposition and assertion processing, reflected in the improved N400 for the former. The results also show that the temporal development of the presupposition effect is earlier for the subordinate clause than for the definite description. Differing from some behavioral studies of presuppositions, but consistent with the theoretical literature and with other ERP studies on discourse processing, our data offer the first neurophysiological evidence that presuppositions are more expensive than affirmations when new information is presented, with differences in progression time affecting all trigger types.

Gisladottir, Bögel, and Levinson	2018	Oscillatory brain responses reflect anticipation during comprehension of speech acts in spoken dialog	47 native Dutch speakers (30 women, mean age D 21.2 years, aged 18-27).	The experimental dialogue consists of two oral utterances, the context speech (by speaker A) followed by the target utterance (speaker B).	Based on the role of alpha and beta desynchronization in the anticipatory process, the results show that anticipation plays a role in speech act recognition. Anticipation of speech acts can be important for efficient turn taking, enabling interacting actors to quickly recognize speech acts and respond within the tight time frames characteristic of conversation. The results showed that the anticipatory process can be triggered by the characteristics of the interaction, including for speech acts.
Bambini, et al.	2019	Time-course and neurophysiological underpinnings of metaphor in literary context	22 participants (14 females, mean age 22.32, SD 2.44)	Metaphorical stimuli were extracted from the metaphorical dataset of Italian literary texts scored for the main psycholinguistic variables.	N400 exhibits typical lexical/semantic processes of metaphor and is reinforced by literary context, sustained negativity may reflect manipulation of some meaning in working memory, may be responsible for the poetic effect. Interestingly, the final negative effect was driven by familiarity, with more negative responses to less familiar metaphors.
Jiang, Keenan, and Peil	2020	To believe or not to believe? How voice and accent information in speech alter listener impressions of trust	44 native Canadian English speakers (22 girls/22 boys, age: M=24.9 years, aged=18-36)	All stimuli are short statements of personal opinion (e.g., He doesn't have the right personality) or personal knowledge (He eats meat and cheese), spoken in a confident or hesitant voice.	For in-group speakers, the ERP effect revealed early differentiation of vocally expressed beliefs (i.e., N100, P200), highlighting the motivational significance of dubious voices to obtain credible conclusions.
Lui, et al.	2020	Sex Differences in Behavioral and Brain Responses to Incongruity in Emotional Speech Controlling for Autistic Traits	23 female and 23 male participants.	The stimulus consists of 240 auditory words containing 120 different two-syllable Chinese words spoken in happy or sad prosody.	Behaviorally, men are slower than women in making semantic valence judgments. At the neural level, males had a greater congruence effect in the N400 component, whereas females had a greater congruence effect in the 1150 - 1300 ms time window for happy prosodies. Our study reveals new findings about sex differences in the integration time between verbal and non-verbal signals.
Rigoulot, et al.	2020	Neurophysiological correlates of sexually evocative speech	24 native English speakers (13 men/11 women aged between 18 and 35 years; mean age 24 ± 5 years)	During the recording session, speakers were visually presented with individual target utterances and instructed to produce them in neutral and sexually suggestive tones.	The analysis revealed: (1) prosodic neutral vs sexual rapid neural differentiation from the beginning of speech; (2) N400-like response that distinguishes contextual-bounded utterances vs. without limitation after the critical word (reflects the integration of prosody and word meaning); and (3) an increase in selective negative responses to sexual innuendo about 600 ms after critical word. The findings suggest that the brain rapidly integrates prosodic and lexical-semantic information to form impressions of what the speaker communicates, triggering a unique response to sexual innuendo, consistent with its high social relevance.
Sarrett, McMurray, and Kapnoula	2020	Dynamic EEG analysis during language comprehension reveals interactive cascades between perceptual processing and sentential expectations	36 participants	Participants listen to a sentence and are shown with a gamepad whether the final target word starts with a /b/ or a /p/. The target words are chosen in such a way that each set of target words (bark/garden) contains a minimal pair that represents the end point of the VOT continuum.	Results showed: (1) perception and memory processing for fine-grained acoustics was maintained in brain activity up to 900 msec; (2) contextual analysis was initiated early and assessed on the basis of acoustic signals; and (3) top-down predictions affect perceptual processing in some cases, but these predictions are available concurrently with veridical signals. These mechanistic insights provide the basis for a better understanding of cortical language networks.

Llanos, et al.	2021	The neural processing of pitch accents in continuous speech	15 native English speakers (9 women; M = 24.73 years, SD = 3.59 years) and 15 Chinese native speakers (8 women; M = 22.53 years, SD = 3.66 years).	The stimuli created for the selective attention task consisted of 60 speech segments of approximately 1 minute in duration, taken from the English audio story book <i>Alice's Adventures in Wonderland</i> .	Optimal neural discrimination between tone accent categories occurs at latencies between 100 and 200 ms. During this latency, we found a strong structural congruence between the neural and phonetic representations of the tonal accent category. Within the same latency, native listeners exhibit stronger accent-tone contrast processing than did non-native listeners.
Gillis, et al.	2021	Neural markers of speech comprehension: measuring EEG tracking of linguistic speech representations, controlling the speech acoustics	29 participants	Each participant listened to five Dutch stories: De kleinezeemeermin (DKZ), De 101 wildezwijnen (DWZ), De oudelantaarn (DOL), Anna en de vorst (AEDV) and Eline.	However, phoneme shock, cohort entropy, word shock and word frequency were tracked significantly over and over the acoustic properties. Moreover, these linguistic representations are traced the same in different stories, spoken by different readers.
Sokoljuk, et al.	2021	Covert Speech Comprehension Predicts Recovery From Acute Unresponsive States	We screened all 139 hospitalized patients with severe TBI in the intensive care unit of Queen Elizabeth Hospital, Birmingham (UK), between April 2018 and October 2019.	Stimulus consists of 144 nouns, 72 adjectives and 72 verbs (details available upon request and will be shared via the OSF platform upon publication).	17 and 16 patients were available for assessment with the Glasgow Outcome Scale Extended (GOSE) at 3 months and 6 months, respectively. Results were significantly correlated with the patient's acute cortical tracking power of phrases and sentences ($r > 0.6$, $p < 0.007$), measured by inter-trial phase coherence.
Bröhl and Kayser	2021	Delta/theta band EEG differentially tracks low and high frequency speech-derived envelopes	The 24 participants were native German speakers (19 girls, mean age = 23.4 ± 3.6 SD).	Monophonic auditory stimuli were presented binaurally using Sennheiser headphones (Model HD200) from the Creative sound blaster z Soundcard at an average intensity of 68 dB SPL.	It is independent of the specific carrier frequency but is sensitive to attention manipulation, and may reflect context-dependent suppression of information from different spectral ranges of the speech envelope in low-frequency brain activity.
Broderick, et al.	2021	Dissociable electrophysiological measures of natural language processing reveal differences in speech comprehension strategy in healthy ageing	38 participants	The stimulus is an audiobook of popular mid-twentieth-century American fiction (<i>The Old Man and the Sea</i> , Hemingway, 1952), read by an American man.	The results reveal an inseparable neural correlation of these two measures that show differences in how younger and older adults manage to understand speech. In particular, the results show that while younger and older subjects both use context-based lexical prediction, larger subjects are less likely to activate semantic features related to future words.
Sauppe, et al.	2021	Neural signatures of syntactic variation in speech planning	50 participants (6 women, mean age = 20.47 years, SD = 3.35 years)	Participants draw 55 lines of drawings depicting 2 participant events (transitive), interspersed between 62 line drawings for 1 participant events (intransitive).	The findings contrast with observations that harmonized expression forms are simpler, and they suggest that the global preference for alignment is not driven by its neurophysiological effects on sentence planning but by other sources, perhaps by aspects of flexibility and fluency of production or by sentence comprehension. It challenges current theories of how production and understanding can influence the evolution and distribution of syntactic variants in world languages.