

# The effect of background noise on semantic and syntactic processing in monolingual adults

Megan Fink, B.A., Ilse Wambacq, Ph.D., Maryrose McInerney, Ph.D., & Faith Mogila, Sc.D.

Montclair State University, Montclair, NJ

## Purpose of the study

The goal of this study is to determine if semantic and syntactic errors elicit ERP measures with significant differences in the presence of background noise. We hypothesize that there will be a significant difference between the linguistic ERP amplitudes and latencies for semantic and syntactic errors, suggesting different neural systems at work for each linguistic violation processing

## Introduction

- Event-Related Potential (ERP) studies have been used to study linguistic processing for decades
- Linguistic processing is often studied through ERP responses to linguistic errors or infelicitous word use, especially in the areas of semantics and syntax
- In classical models, semantic errors elicit the N400 effect (negative peak amplitude at about 400ms post stimulus onset), and syntactic errors elicit the P600 effect (positive peak amplitude at about 600ms post stimulus onset)
- Modern research suggests that the N400 effect and P600 effect are not so exclusively linked to semantic and syntactic errors respectively
- Previous studies have found greater context elicits greater ERP responses

## Subjects

- 15 monolingual right-handed adults aged 18-35 with normal hearing and middle ear function, as well as no history of neurological, language, or auditory processing disorders

## Procedure

- Participants sat in a sound-treated booth wearing a 64-electrode cap and were informed before each story what story would be presented
- Participants were not told of upcoming errors so to ensure retained attention without alerting them to the errors, they were given a button and instructed to press every time they heard the target word

## Stimuli

- 6 short public domain fairy tales containing sentences with semantic, syntactic, and combined semantic and syntactic errors were presented in a randomized order
- Errors occurred in various positions within the sentences as familiar context extended throughout the entire story
- 48 errors of each type across each story for a total of 144 errors
- Triggers placed at start of erroneous words, or the first erroneous word in the combined error condition
- Each story had a commonly used word that was labeled the target word
- Stories were recorded and analyzed using Adobe Audition and RMS normalization, so each story had an RMS amplitude of 21 RMS on Audacity software
- Stories were presented via soundfield speaker at 0° azimuth and background noise was presented via soundfield speakers at ±90° azimuth at SNR +4

## Results

- Cross-correlation analyses using Scan 4.5 Edit software were ran to establish the timeframe needed to correct for the lag time due to trigger positioning
- Shifting the grand averaged ERPs by 209-282ms, the combined condition correlates significantly with the semantic condition
- These two error conditions alone elicited a clear negative component
- While the syntactic error was significantly different from the other error conditions, no ERP effect was measured

## Summary & Conclusion

- As N400 effects were elicited in both semantic and combined error conditions, and a P600 effect was not elicited in either syntactic or combined conditions, the classical model does not explain our data
- The classical linguistic violation processing model may be too simplified and rigid to accurately account for the actual processing of linguistic errors, while the modernized model lines up with our data more closely
- This calls for further investigation into developing a new standard of linguistic violation processing that can account for the unexpected results seen in various studies

## References

Amichetti, N. M., White, A. G., & Wingfield, A. (2016). Multiple solutions to the same problem: Utilization of plausibility and syntax in sentence comprehension by older adults with impaired hearing. *Frontiers in Psychology, 7*. <http://doi.org/10.3389/fpsyg.2016.00769>

Aydelott, J. & Bates, E. (2004). Effects of acoustic distortion and semantic context on lexical access. *Language and Cognitive Processes, 19*, 29-56. <http://doi.org/10.1080/01690960344000099>

Brouwer, H., Crocker, M. W., Venhuizen, N. J., & Hoeks, J. C. J. (2017). A neurocomputational model of the N400 and the P600 in language processing. *Cognitive science, 41*(6), 1318-1352. <http://www.doi.org/10.1111/cogs.12461>

Brouwer, H., Fitz, H., & Hoeks, J. (2012). Getting real about semantic illusions: Rethinking the functional role of the P600 in language comprehension. *Brain research, 1446*, 127-143. <https://doi.org/10.1016/j.brainres.2012.01.055>

Carey, D., Mercure, E., Pizzilli, F., & Aydelott, J. (2014). Auditory semantic processing in dichotic listening: Effects of competing speech, ear of presentation, and sentential bias on N400s to spoken words in context. *Neuropsychologia, 65*, 102-112. <http://doi.org/10.1016/j.neuropsychologia.2014.10.016>

Federmeier, F. D., Wlotko, E. W., De Ochoa-Dewald, E., & Kutas, M. (2007). Multiple effects of sentential constraint on word processing. *Brain Research, 1146*, 75-85. <http://doi.org/10.1016/j.brainres.2006.06.101>

Hagoort, P. & Brown, C. M. (2000). ERP effects of listening to speech compared to reading: the P600/SPS to syntactic violations in spoken sentences and rapid serial visual presentation. *Neuropsychologia, 38*, 1531-1549

Hoeks, J. C. J., Stowe, L. A., & Doedens, G. (2004). Seeing words in context: The interaction of lexical and sentence level information during reading. *Cognitive Brain Research, 19*, 59-73. <https://doi.org/10.1016/j.cogbrainres.2003.10.022>

Nieuwland, M. S. & Van Berkum, J. J. A. (2005). Testing the limits of the semantic illusion phenomenon: ERPs reveal temporary semantic change deafness in discourse comprehension. *Cognitive Brain Research, 24*(3), 691-701. <https://doi.org/10.1016/j.cogbrainres.2005.04.003>

Osterhout, L., McLaughlin, J., & Bersick, M. (1997). Event-related brain potentials and human language. *Trends in Cognitive Sciences, 1*(6), 203-209

Rhodes, S. M. & Donaldson, D. I. (2007). Association and not semantic relationships elicit the N400 effect: Electrophysiological evidence from an explicit language comprehension task. *Psychophysiology, 44*, 50-59. <http://doi.org/10.1111/j.1469-8986.2007.00508.x>

Romei, L., Wambacq, I. J. A., Besing, B., Koehnke, J., & Jerger, J. (2011). Neural indices of spoken word processing in background multi-talker babble. *International Journal of Audiology, 50*, 321-333. <http://doi.org/10.3109/14982027.2010.547875>

Rosen, S., Souza, P., Ekelund, C., Majeed, A. A. (2013). Listening to speech in a background of other talkers: Effects of talker number and noise vocoding. *Acoustical Society of America, 133*(4), 2431-2443. <http://doi.org/10.1121/1.4794379>

Schwanenflugel, P. J. & LaCount, K. L. (1988). Semantic relatedness and the scope of facilitation for upcoming words in sentences. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14*(2), 344-354

Stanley, N., Davis, T., & Estis, J. (2017). The effect of signal-to-noise ratio on linguistic processing in a semantic judgement task: An aging study. *Journal of American Academy of Audiology, 28*, 209-221. <http://doi.org/10.3766/jaaa.16025>

Van Os, M., Kray, J., & Demberg, V. (2022). Rational speech comprehension: Interaction between predictability, acoustic signal, and noise. *Frontiers in Psychology, 13*. <http://doi.org/10.3389/fpsyg.2022.914239>

Wendt, D., Dau, T., & Hjørrtkjær, J. (2016). Impact of background noise and sentence complexity on processing demands during sentence comprehension. *Frontiers in Psychology, 7*. <http://doi.org/10.3389/fpsyg.2016>

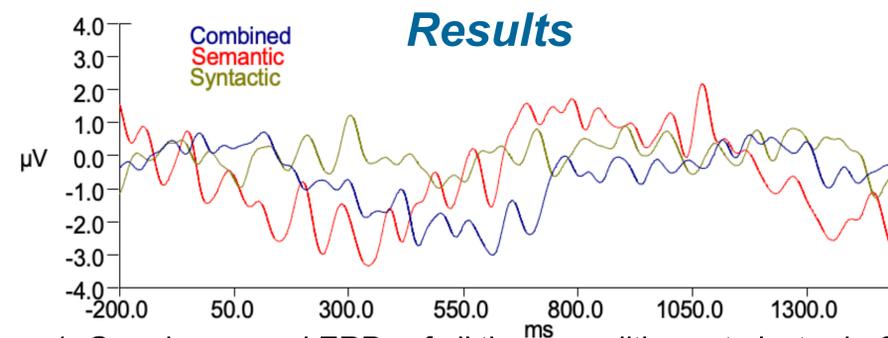


Figure 1: Grand averaged ERPs of all three conditions at electrode Cz.

- Grand averaged ERPs after being calculated for each error condition are shown here
- The combined error seems time-lagged compared to the semantic error
- This time lag may be due to trigger placement in the combined condition
- Syntactic error alone elicited a relatively flat waveform

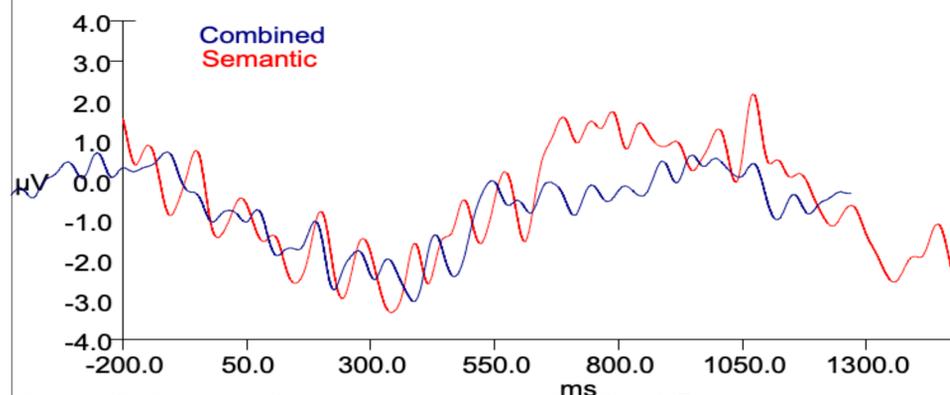


Figure 2. Time-shifted grand averaged ERPs at Cz.