Electrocorticographic Study of Semantic Processing in Patients with Temporal Lobe Epilepsy

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Abstract

Individuals with Temporal Lobe Epilepsy (TLE) show numerous language deficits including semantic paraphasias, anomia, and difficulty with pragmatic language and inference. The current study examines a patient with severe, intractable TLE in the left hemisphere to determine whether normal semantic priming can occur behaviorally and in the cortical network recorded using EEG during a paired word priming task. The patient was shown 104 words that were either semantically, associatively, and semantically related or control words that were unassociated. The EEG was time locked to the onset of the second word, and Event-related Potentials were formed. ERP's were processed in EGGlab using the SIFT Toolbox and resulting network transfer functions were created. 3-D information flow models indicate that word processing is occurring in the participant. Further research is needed to better define the language network impairment.

Introduction

With the use of an electrocardiogram, similar studies have been able to examine different pathways and different cortical areas that are engaged during word stimuli in both epileptic and non-epileptic individuals. In one study, participants were given a specific set of words from certain categories to study and then recall to determine if the order of the recalled words were in the same category in which they were originally learned (Morton et al., 2012). With the use of both scalp and cortically implanted electrodes in medically untreated epileptic patients, both the Morton et al. (2012) and the current study presented in this review were able to have a more focalized view of the exact spot of cortical usage during word stimulation. Manning, Sperling, Sharan, Rosenberg, and Kahana (2012) studied the pathways in which 46 neurosurgical patients recalled words with similar relations and then showed that the participants organized the words in order of semantic similarity, thus causing different areas of the brain to become more functional just before the similar word was remembered. It was hypothesized that this patient would show impaired semantic priming.

Methods

Participant

Subject presented with intractable TLE with poor response to treatment. Individual presented for EEG monitoring at USA Comprehensive Epilepsy Monitoring Unit and underwent diagnostic monitoring for 48 hours.

Apparatus

The EEG was recorded using a modified 10-20 electrode system with 25 Ag/AgCl electrodes placed evenly across the scalp (See Figure 1). EEG was sampled at 500 Hz and digitized using a Compumedics Synamps 2 System running ProFusion 4. Data was notch filtered at 60Hz prior to digitization. Data was cut into epochs from -1000 to 2000 milliseconds for frequency analyses and re-baselined from -100 to 1000 milliseconds for ERP averaging.

Procedure

Subject was presented with 104 common, English word pairs with a duration of 500 milliseconds per word and an inter-stimulus interval of 500 milliseconds. The Subject was instructed to read each word pair and press the “1” key with the right index finger if they believed that the word pairs were related to each other, or the “2” key with the right middle finger if they believed that the word pairs were not related. The next trial began when the Subject made a relatedness response. Stimuli were presented using E-Prime 1.41 on a Dell Laptop with LCD monitor. Stimuli were 6.1 words in length on average and the relatedness was normalized using the Florida Norms of Word Association.

Results

Figure 1. 10-20 Electrode System Locations utilized in the current study. EMG leads were not analyzed and are not pictured. Eye movements were captured using the VEOG and HEOG leads placed above the superior infra-orbital ridge and the left canthus, respectively.

Figure 2. Source Information Flow Toolbox (SIFT) Images of the Semantic Priming Task

Figure 3. Mean global field power of Source 1 (Left frontal pole)

Figure 5. Event-related Potential (ERP) response to Unrelated (Blue) and Related words (Red) averaged across all trials for the subject.

Conclusions

A preliminary electrical source flow model was created for the TLE patient. The solution defined 5 current dipoles with intermittent source transfer functions ranging from .01 to .81. The Diopole (1) in the inferior temporal cortex displayed a peak mean global field power of 1.1 microvolts at the time region of 490 to 500 ms (Figure 3), consistent with the onset of the peak N400 component observed in Figure 5. This indicates that source 5 is reliably active prior to the peak of semantic information processing, as indexed by the N400, and recorded from scalp sensors. While no statistical analyses were possible for one patient, Figure 5 indicates that Pt’s brain was sensitive to the differential priming status induced by the primed and unprimed words.

Future Directions

Five additional patients have been recorded, and additional analyses will be undertaken to model the current flow in the new Pts. Group analyses will then be performed to determine the relative stability of the semantic priming across Pts. These data will be used to develop techniques for enhanced seizure and language network mapping in normal and disordered individuals. The identification of cortical language network boundaries, and how they interact with epileptogenic networks will permit more precise cortical resection procedures, with a minimum of damage to healthy Pt cortex.

Literature Cited
