Developing a Neurocognitive Model of Spoken Language Perception using High Density EEG: First Step

Summary of Pilot Work to Date

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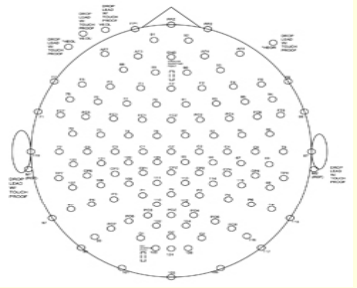
Background

- Whereas there has been progress in describing the representation of the speech signal in the auditory periphery and in delineating the cortical regions associated with semantic processing of comprehended speech, there is little known about the ***processes*** involved in the mapping of the auditory signal to word or semantic representations

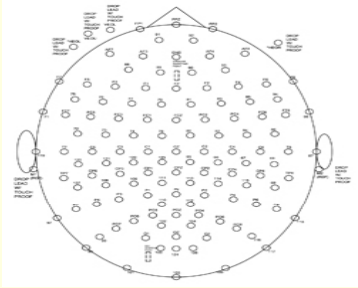
- This project incorporates behavioral data on speech perception and production with neurophysiological data to develop and test a model of how listeners map from auditory to semantic representations
- We are interested in those processes that *make* the speech intelligible, especially if it is degraded in some form.
- The focus is on cortical regions active immediately prior to the comprehension of the speech and segregated from those regions that are active subsequent to perception (e.g., activation related to conceptual processing).

Data Acquisition



- Neuroscan™ system high density electroencephalography (128 channels)
- Data acquisition at 1000 Hz, 1-200 Hz bandpass with 12dB roll-off
- Stimulus presentation with STIM™ system with coded triggers to neuroscan ACQUIRE™
- Continuous data recording during paradigm
- Data stored for off-line analysis

EEG DATA ANALYSIS



- Event-Related Bandpower (ERBP) analysis by complex demodulation in neuroscan EDIT™ off-line analysis
- Band filtering around center frequency with half-bandwidths at 24dB roll-off
- Bands (Hz): theta 4-7.9, alpha 8-12.9, beta 13-29.9, gamma 30-90, ALL 4-90
- Power in designated band measured across time interval around stimulus for the high density EEG head coverage (128 electrodes)

First Pilot Study: "Pop-Out Effect"

Comparing electrocortical activity patterns associated with experiencing sine-wave signals as ***nonspeech*** versus ***speech***

Purpose

- The primary goal of this pilot study was to establish procedures to identify and quantify electrocortical differences between identical signals perceived first as nonspeech, then as speech.
- This will establish the framework for our next study, which will include the perception of speech at various levels of degradation, along with concurrent behavioral data collection.

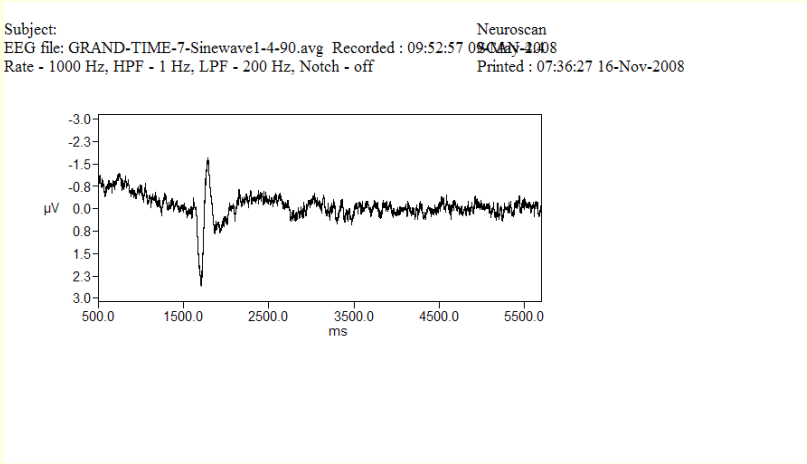
Behavioral Protocol

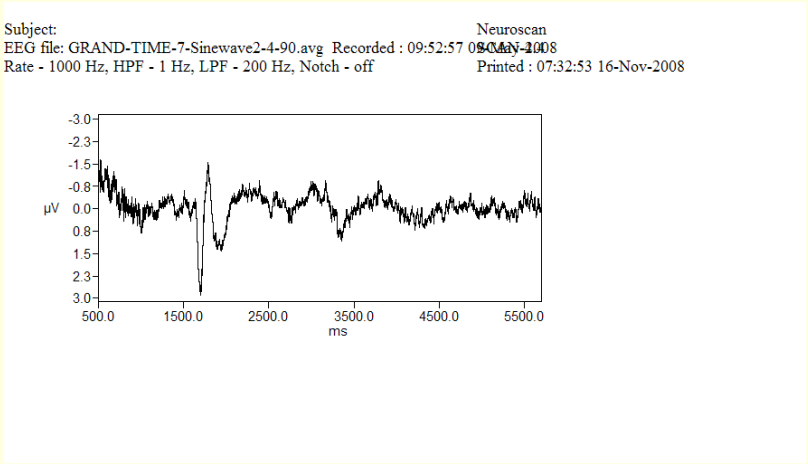
- Sine-wave 1 (SW1): Listen to 180 SW phrases passively
  - “You will hear a series of chirps and whistles”
- Training Set: SW→Clear speech→ SW version of same phrase (same 180 phrases)
- Sine-wave 2 (SW2): Listen to original 180 SW phrases passively
- *Debriefing verified that subjects did not hear speech during SW1 and that they heard speech and believed to have understood some to much of it in SW2.*

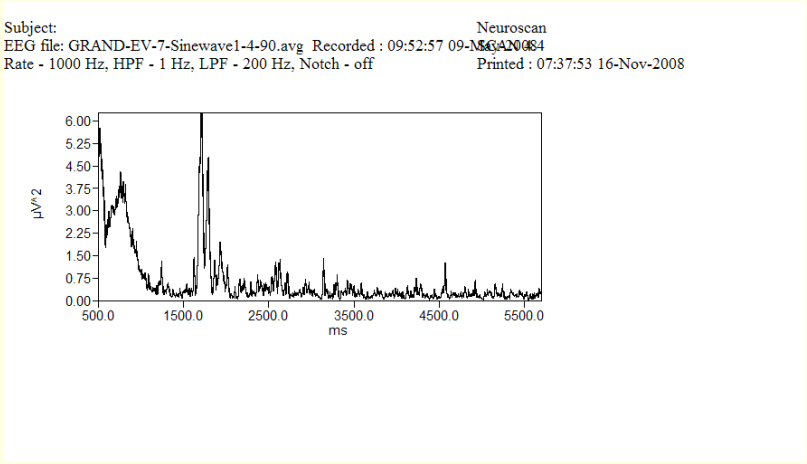
General Observations

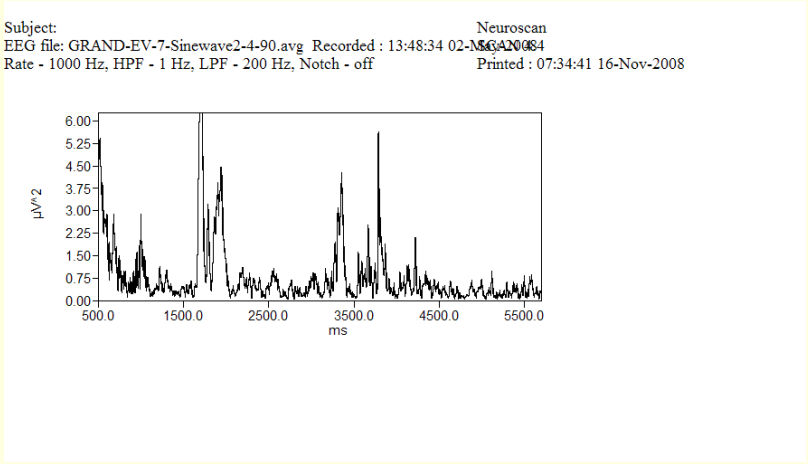
- For all participants, SW1 EEG ERBP were of smaller amplitude than for SW2, but timing and band characteristics vary
- Activity in response to SW2 was time-locked to the stimulus (evoked)
- Activity was localized to temporal, temporoparietal and posterior temporal regions
- Patterns were different across participants (some showed more anterior activity, some more posterior, etc)

Evoked Potential (upper) versus Bandpower Change (4-90Hz) (lower) for SW1 (left) and SW2 (right). Phrase begins at 1550ms and ends at 2750ms

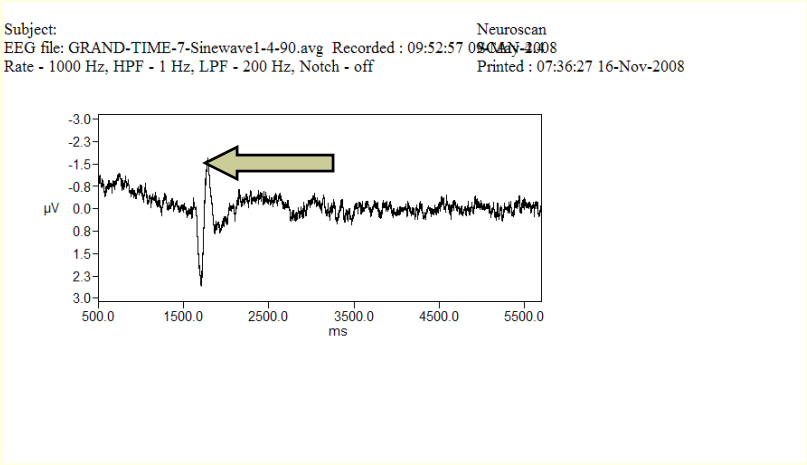


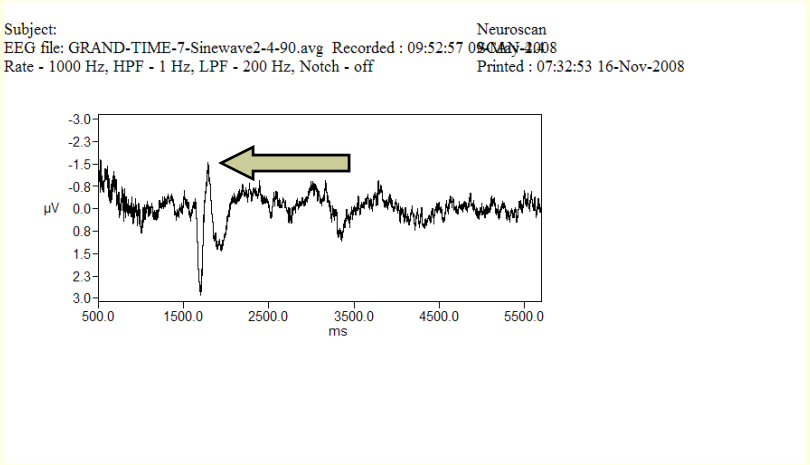


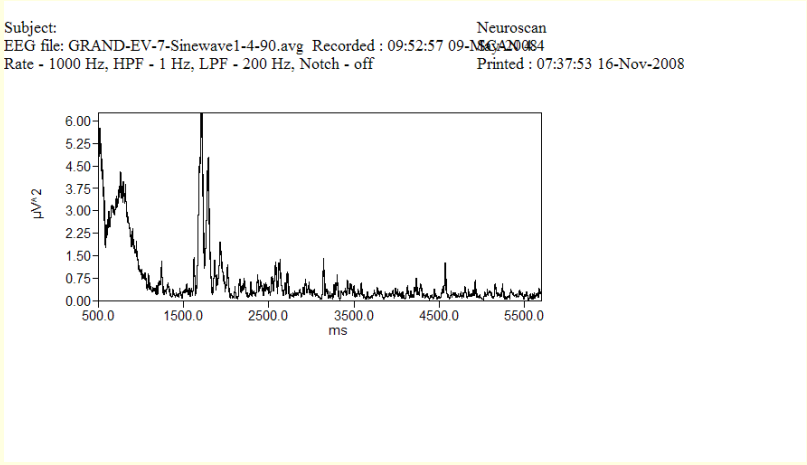


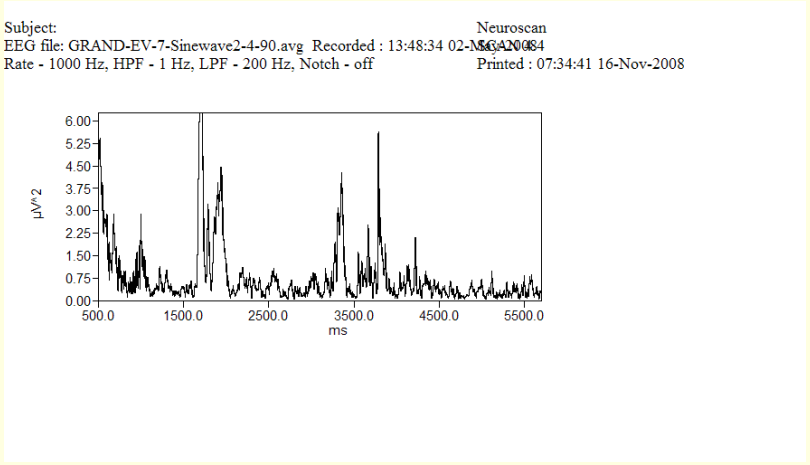


First significant waveform shows P1-N1-P2-N2 complex and may represent obligatory “encoding” of acoustic information. It is almost identical between SW1 and SW2 except possibly for a larger N2 in SW2.

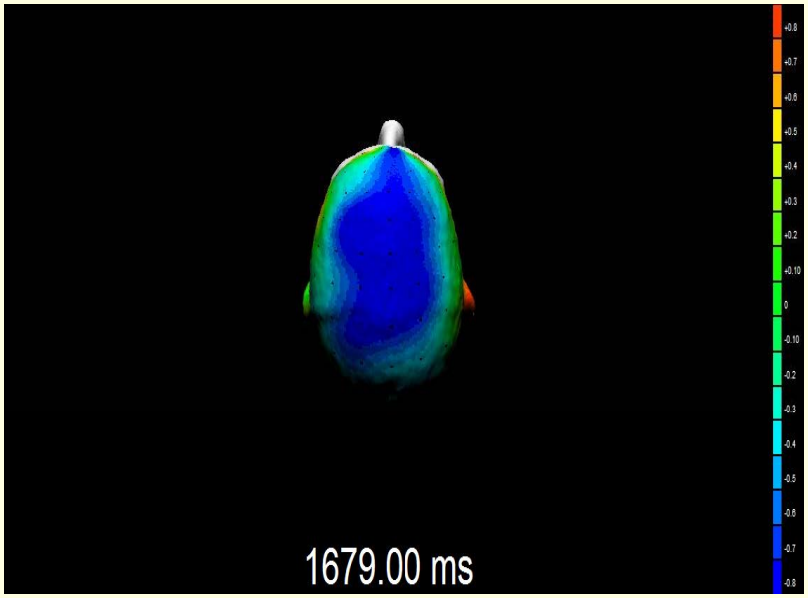


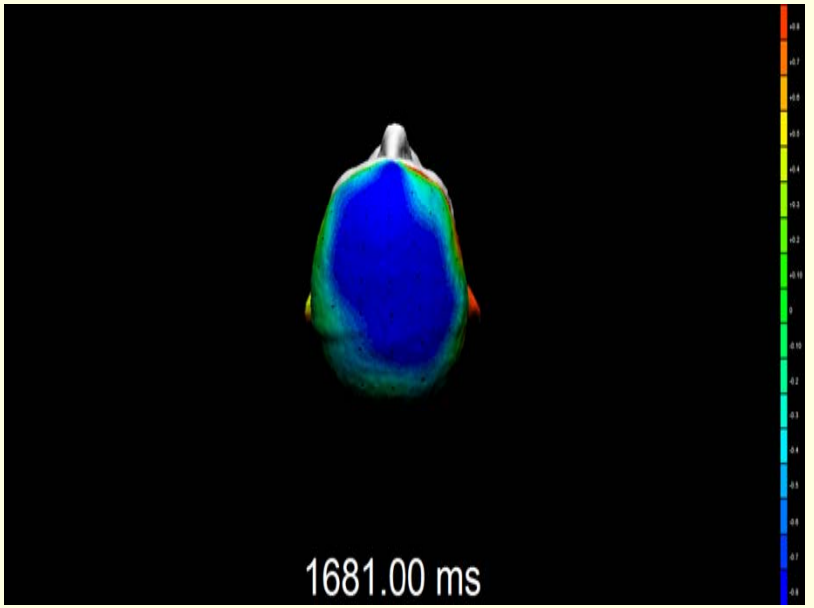




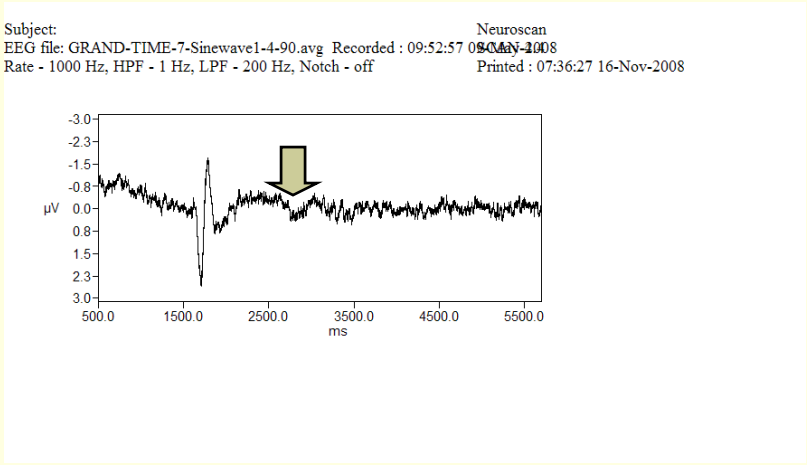


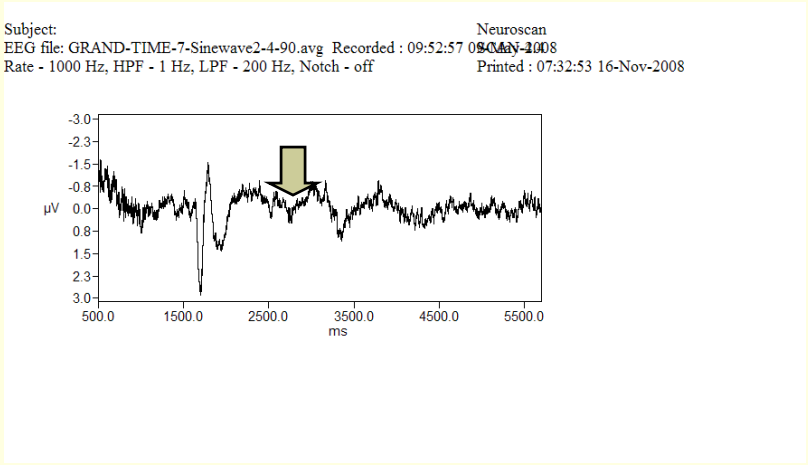
3-D mapping of “N100” for SW1 (left) and SW2 (right). The two voltage maps show very similar activation for the obligatory “encoding” potential

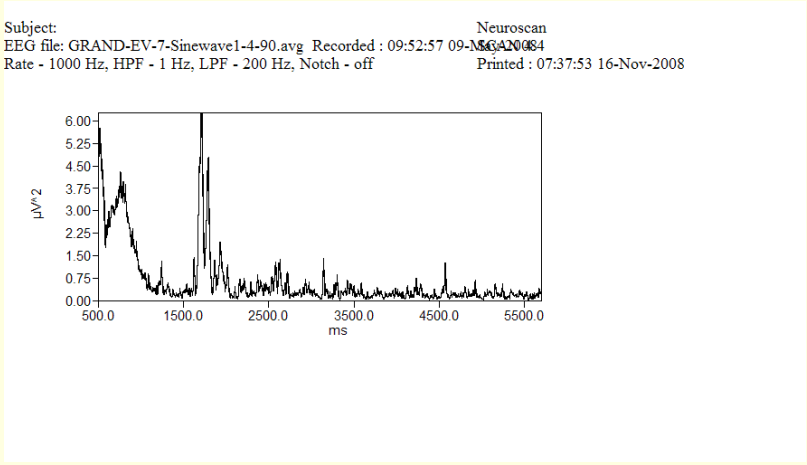


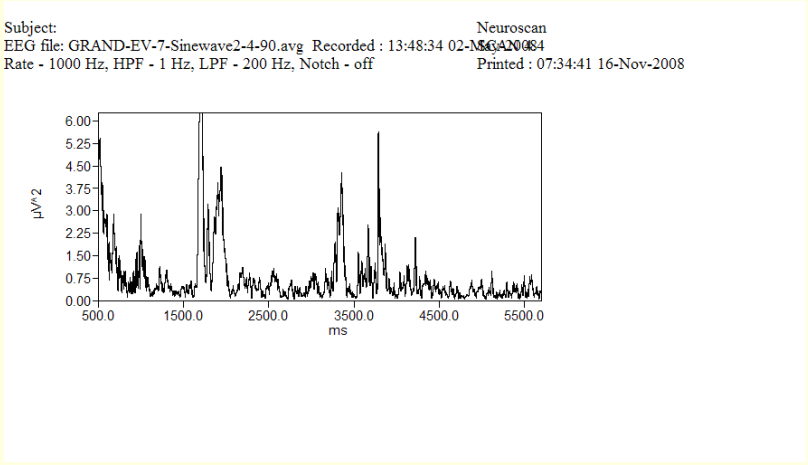


Second observation: Smaller nonspecific auditory evoked potential at about 2750ms for both SW1 and SW2, coinciding with signal offset (silence onset).

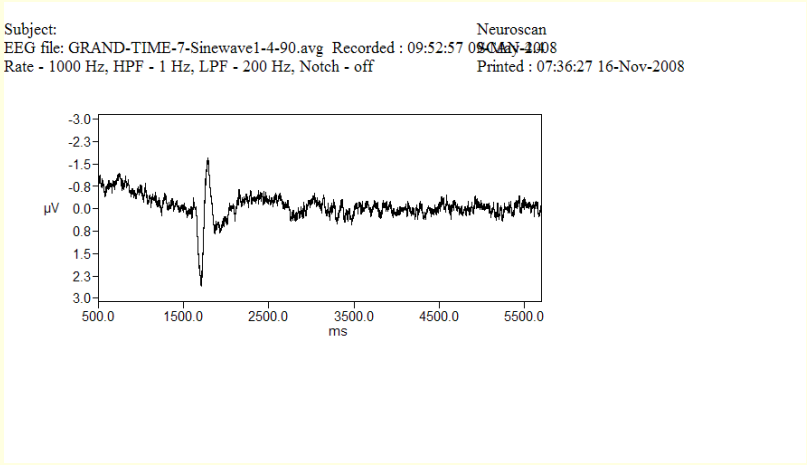


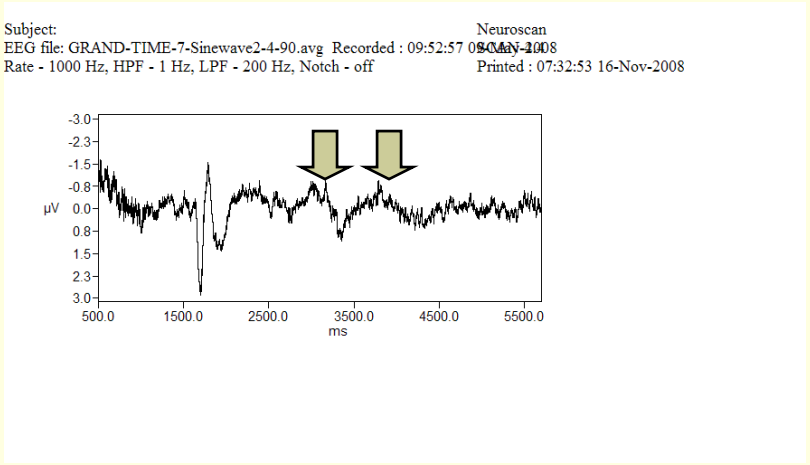


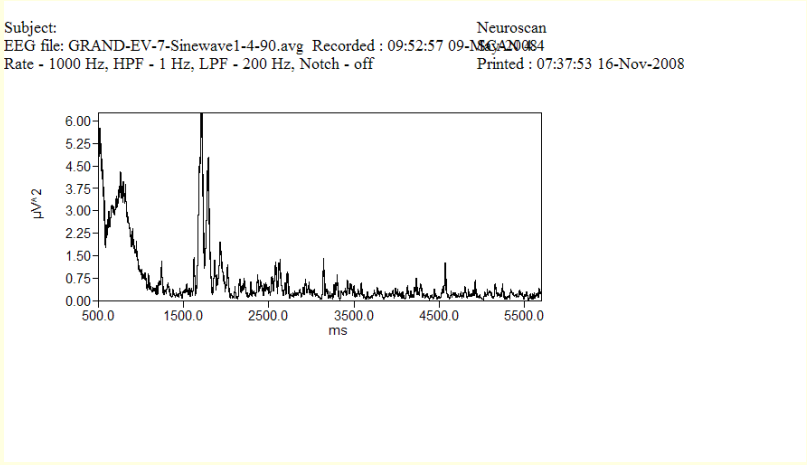


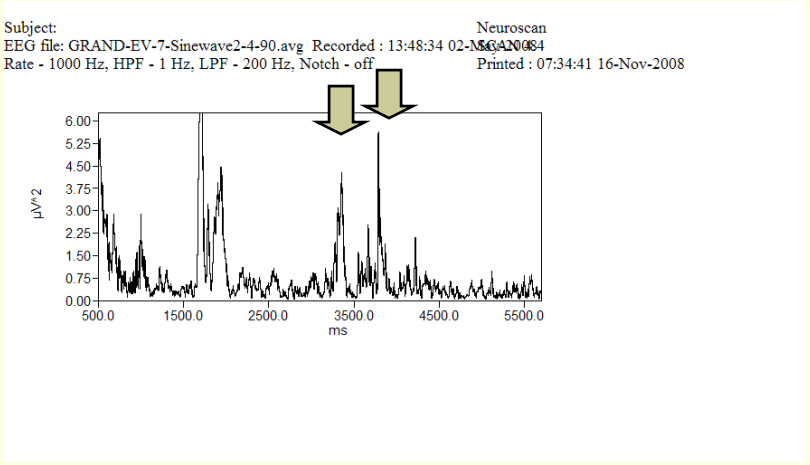


Third observation: Robust activity about 400-1200msec AFTER signal offset in SW2 that is not present in the SW1 trace, localizing at lateral temporal lobes.



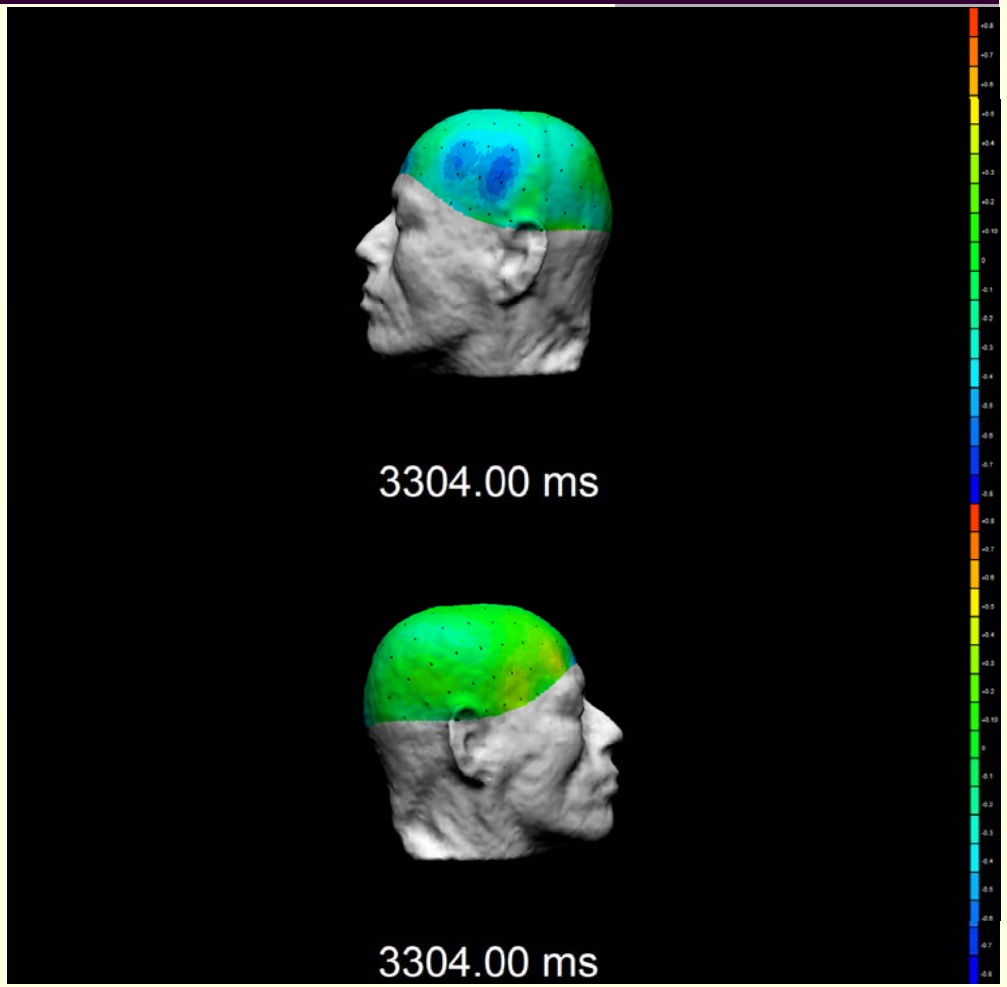






3-D mapping of post-phrase potential at 550 msec after the phrase ends (3304 msec). SW2 minus SW1

- Left hemisphere shows localized negative potential (blue) over lateral temporal lobe.
- Right hemisphere shows near zero activity (green)



Next Steps

- What is the average and range of the spatio-temporal activation pattern across large number of subjects?
- What are the individual differences in time and frequency domains?
- Do the frequency and time bands provide us any hypotheses? (e.g., is this a mandatory echoic memory buffer)
- Can we find statistically significant differences in power between SW2 and SW1 for individual subjects treating trial as the random variable?
  - Power calculated during sentence
  - Power calculated after sentence
  - How many sentences required to find significant effects?