Today

- Reading presentations Monday
- HW3 due Wednesday
- EEG and language: what's the brain doing, when?

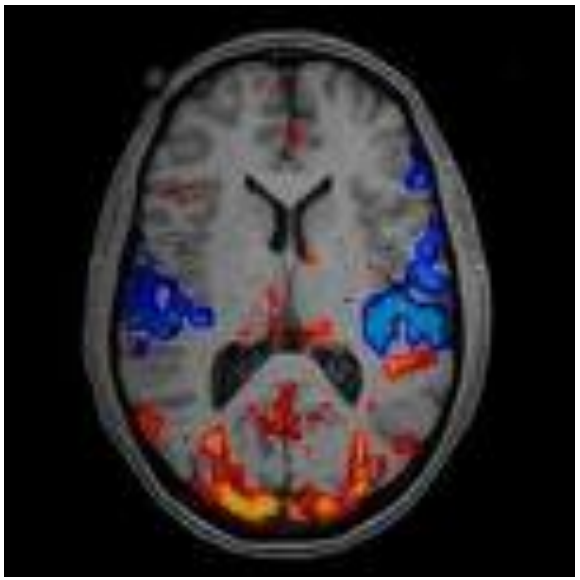
fMRI

- Spatial resolution ≈ 2-3 mm
- Temporal resolution ≈ 2 sec
- Measures: hemodynamics (blood flow) that responds to neuron uptake of oxygen

EEG

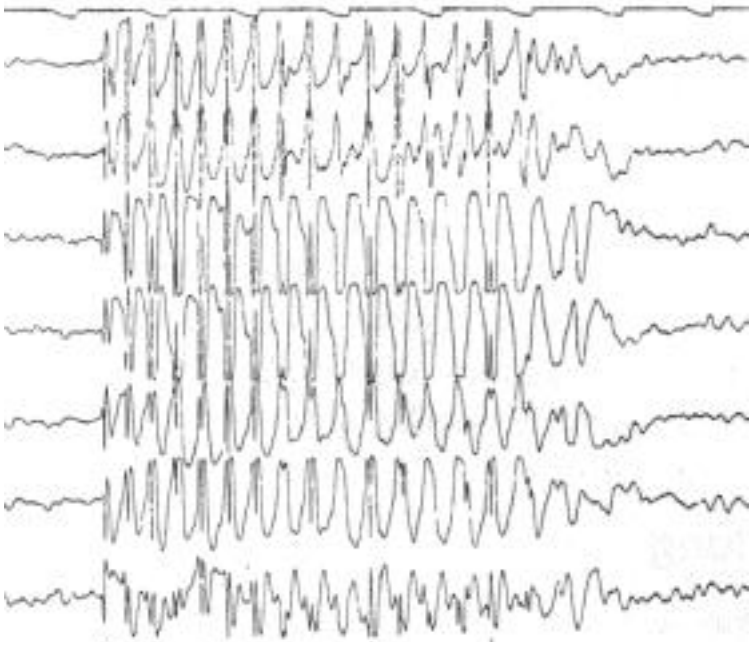
- Spatial resolution not great
- Temporal resolution 1msec
- Measures: electrical field (and changes therein) induced by neuron activity

fMRI

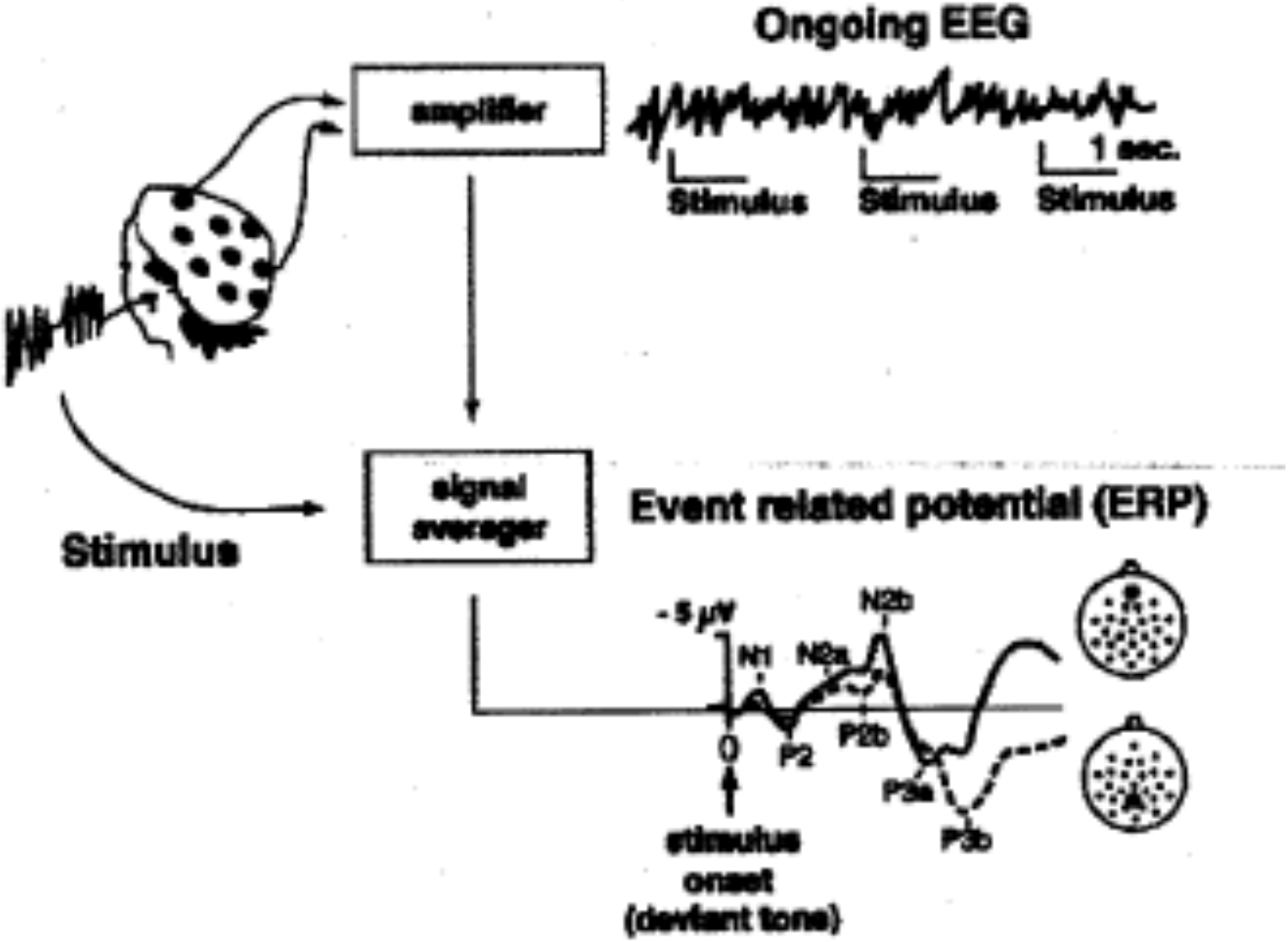


- Output: Maps of difference in hemodynamics across conditions

EEG



- Output: Electrical signal over time. Can be linked to events in the form of Event-Related Potentials (ERPs)


Ongoing EEG
amplifier
1 sec.
Stimulus
Stimulus
Stimulus
signal averager
Event related potential (ERP)
Stimulus
- 5 μV
N1
N2a
N2b
P2
P2b
P3a
P3b
0
stimulus onset (deviant tone)

Why use EEG

- Measures electrical activity of neurons (so more direct than hemodynmics, eye-movements, or reaction times)
- Has good temporal resolution, so allows measures of exactly when processing is happening
- Recording from many sites allows some indication of localization

Phonological processing

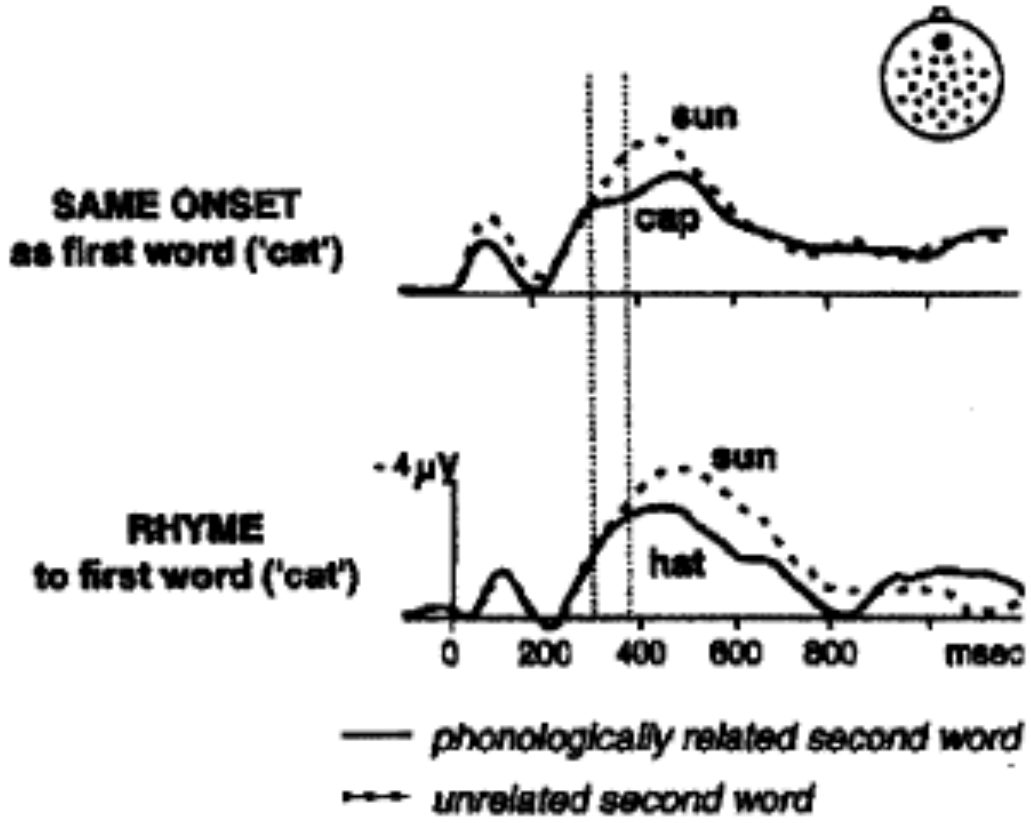


FIG. 7.2. Comparison of the grand average ERPs elicited by a second word of a phonologically related and unrelated spoken word-pair (the same 24 participants in all conditions; 40 trials per condition). The top panel shows an early phonological effect when the second word shares the same onset phonemes with the first word. The bottom panel shows a later phonological effect when the second word rhymed with the first, that is, shared final phonemes. (Adapted from Praamstra et al., 1994, with permission).

Predicting the next word (and semantic relatedness)

The N400

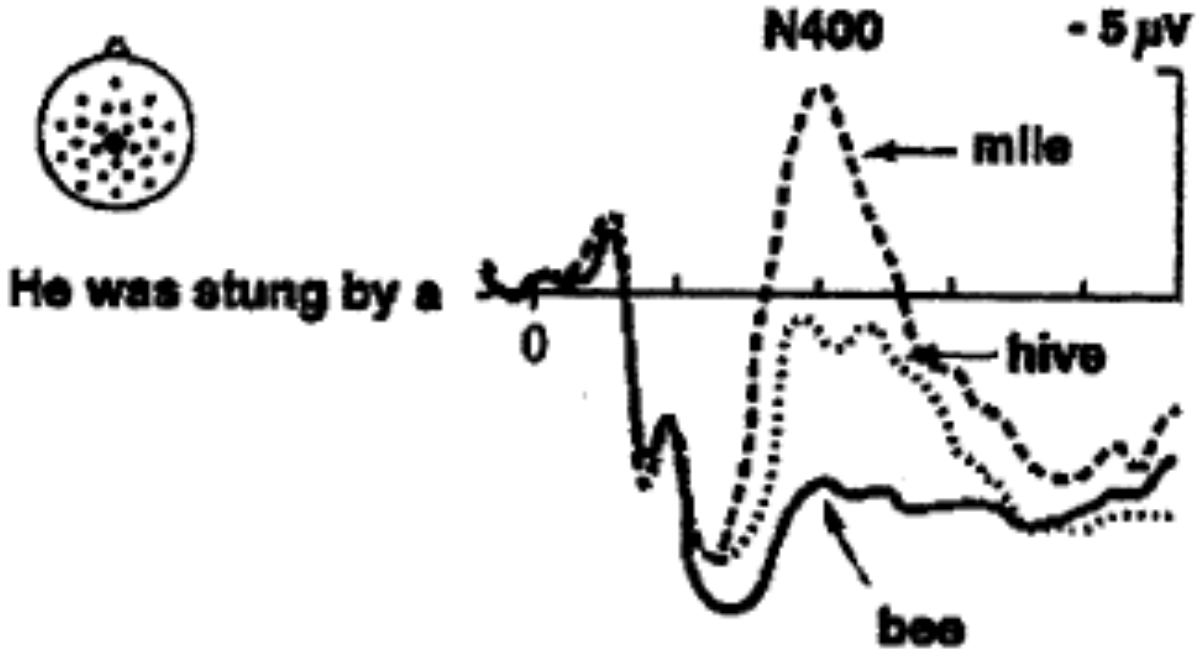


FIG. 7.3. Grand average ERPs elicited by visually presented sentence–final words, showing a positivity between 250 and 500 msec (solid line) for a predictable word, and an N400 between 200 and 500 msec for a semantically anomalous word (thick dashed line). When the final word is semantically incongruent but semantically related to the expected final word (dotted line), it elicits an N400 of intermediate amplitude (After Kutas and Hillyard 1984), with permission.

Is the N400 sensitive to discourse context?

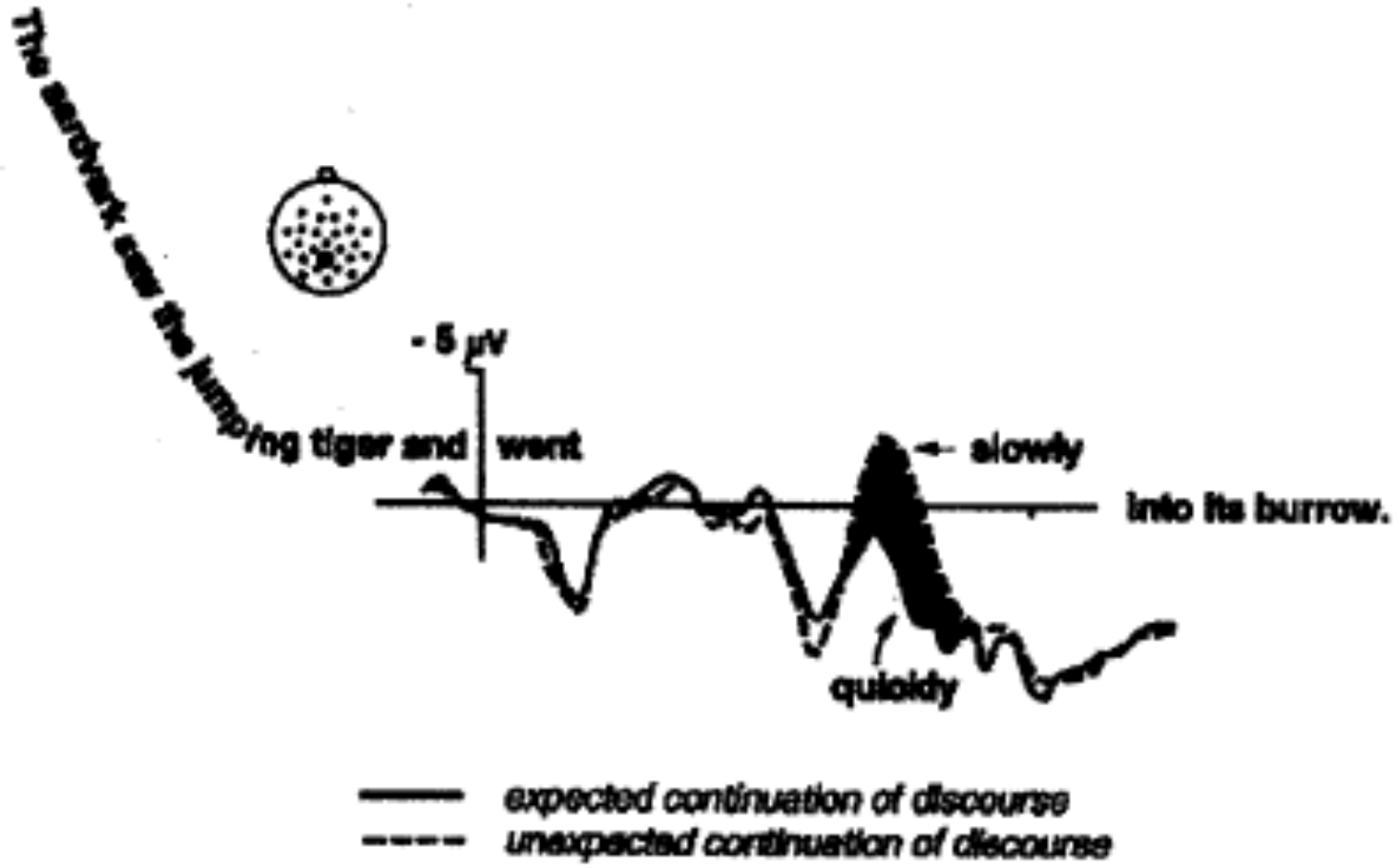


FIG. 7.4. Grand average ERPs (24 participants, 40 trials per participant) elicited by three words in a sentence; the second word is either an expected or an unexpected adverb, where the expectancy is based on discourse level information. The solid line shows the ERP to an expected continuation of a sentence in the discourse. The dashed line represents an unexpected continuation. The shaded area depicts the discourse level effect on N400 elicited by the unexpected adverb. After Van Berkum, Brown, and Hagoort, (1999), with permission.

Words that are easier or harder to process

The lexical processing negativity (LPN) or frequency sensitive negativity (FSN)

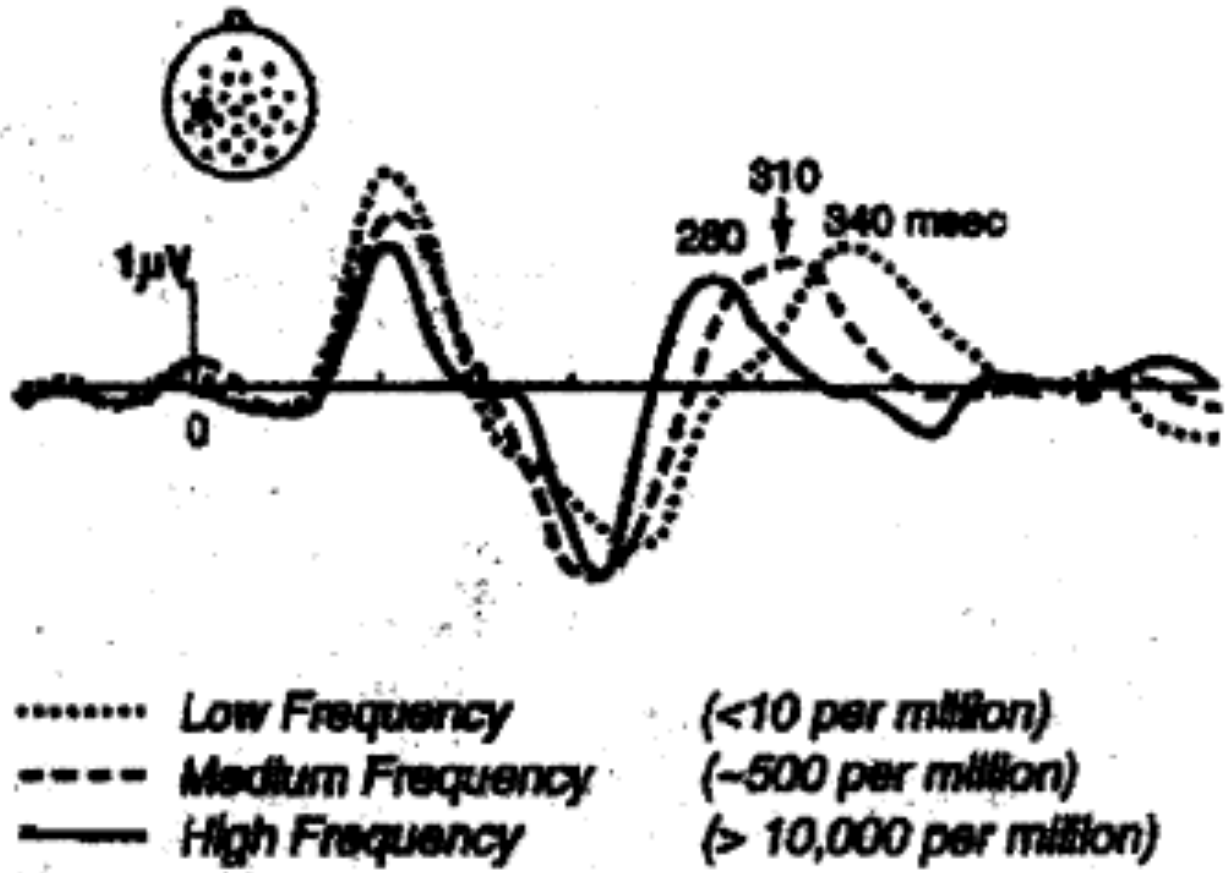


FIG. 7.5. Grand average ERPs elicited by words of different frequency of usage (bandpass–filtered, 4–20 Hz). High frequency words (solid line) elicit a negativity peaking at about 280 ms after word onset. This peak latency is earlier than for medium frequency words (dashed line, 310 msec) and low frequency words (dotted line, 340 msec). The negativity is called the lexical processing negativity or LPN, or even more generally the frequency sensitive negativity or FSN. (After King and Kutas, 1998), with permission.

When do you detect agreement errors?

The P600

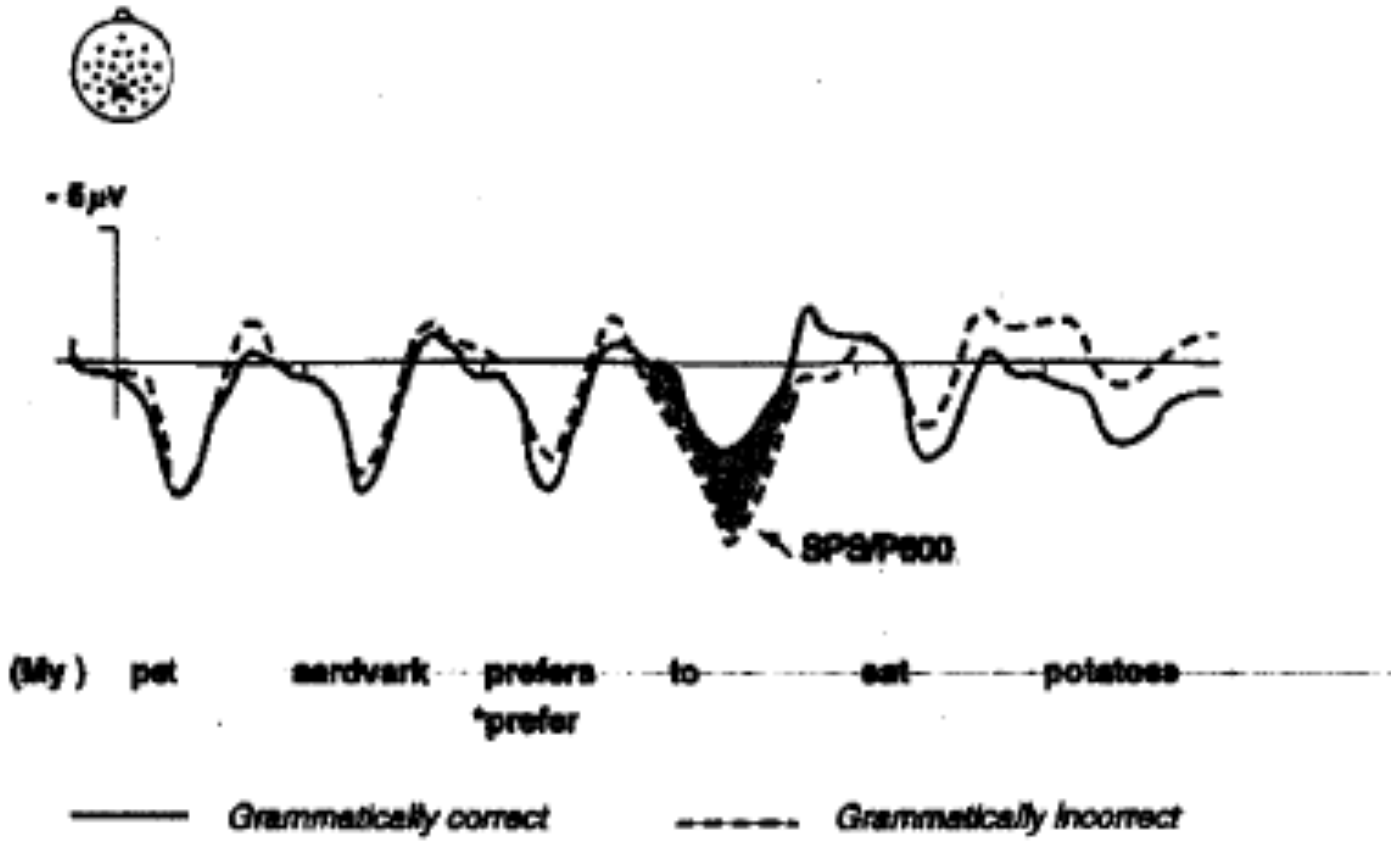


FIG. 7.6. Grand average ERPs elicited by a syntactic violation of subject–verb–number agreement. The solid line shows the ERP to syntactically correct sentences, the dashed line to syntactically incorrect sentences. The shaded area indicates the effect of this violation, known as the syntactic positive shift (SPS), or P600. After Hagoort, Brown, and Groothusen (1993), with permission.

The P600 is also sensitive to syntactic ambiguity resoltion

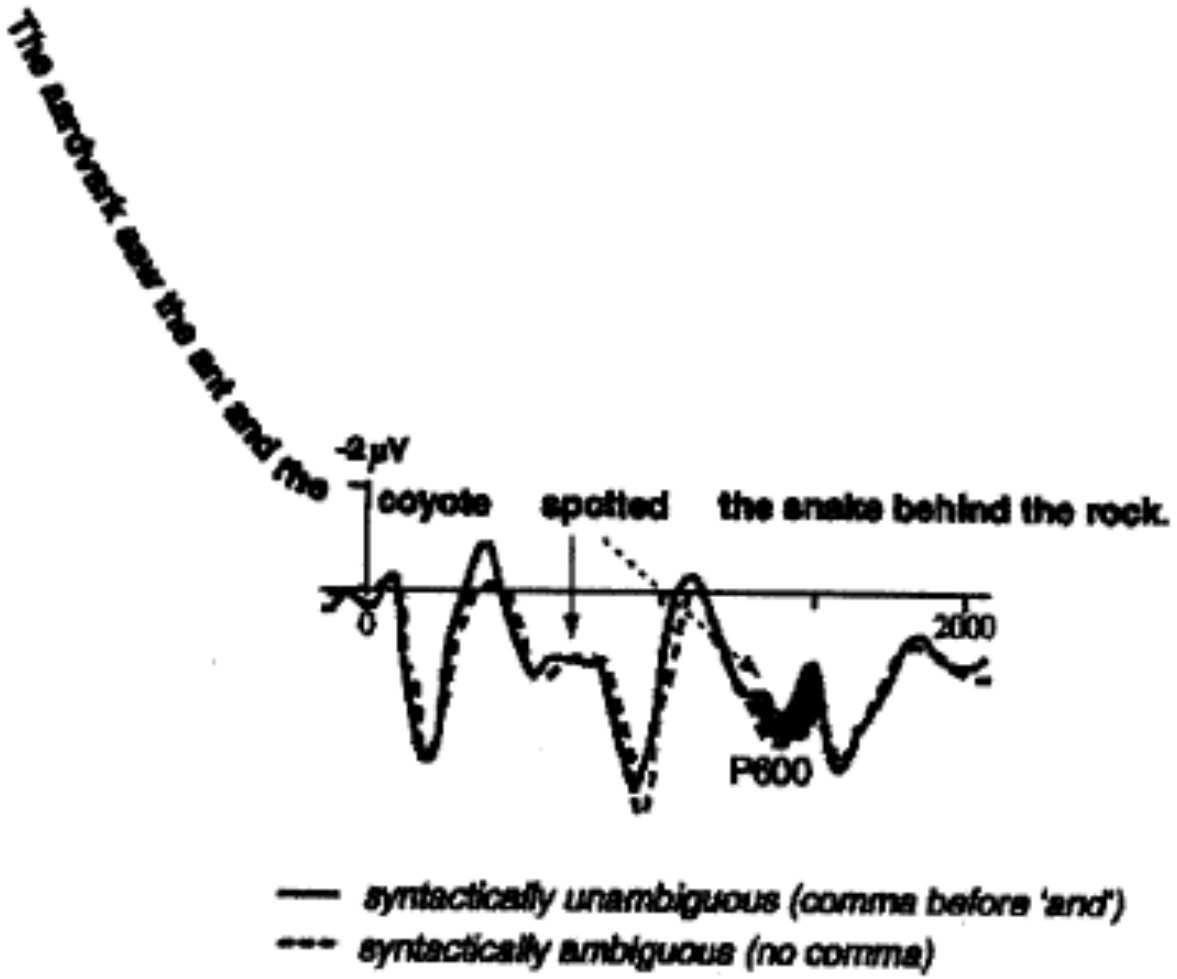


FIG. 7.7. Grand average ERPs to three words within syntactically ambiguous (dashed line) versus syntactically unambiguous (solid line) sentences: the syntactically ambiguous word, the disambiguating word, and the word following. Note the greater P600 or SPS to the disambiguating word ("spotted") relative to the same word, when a comma before "and" prevented an ambiguity. After Brown, Hagoort, and Kutas, (2000), with permission.

But is the P600 a purely syntactic component?

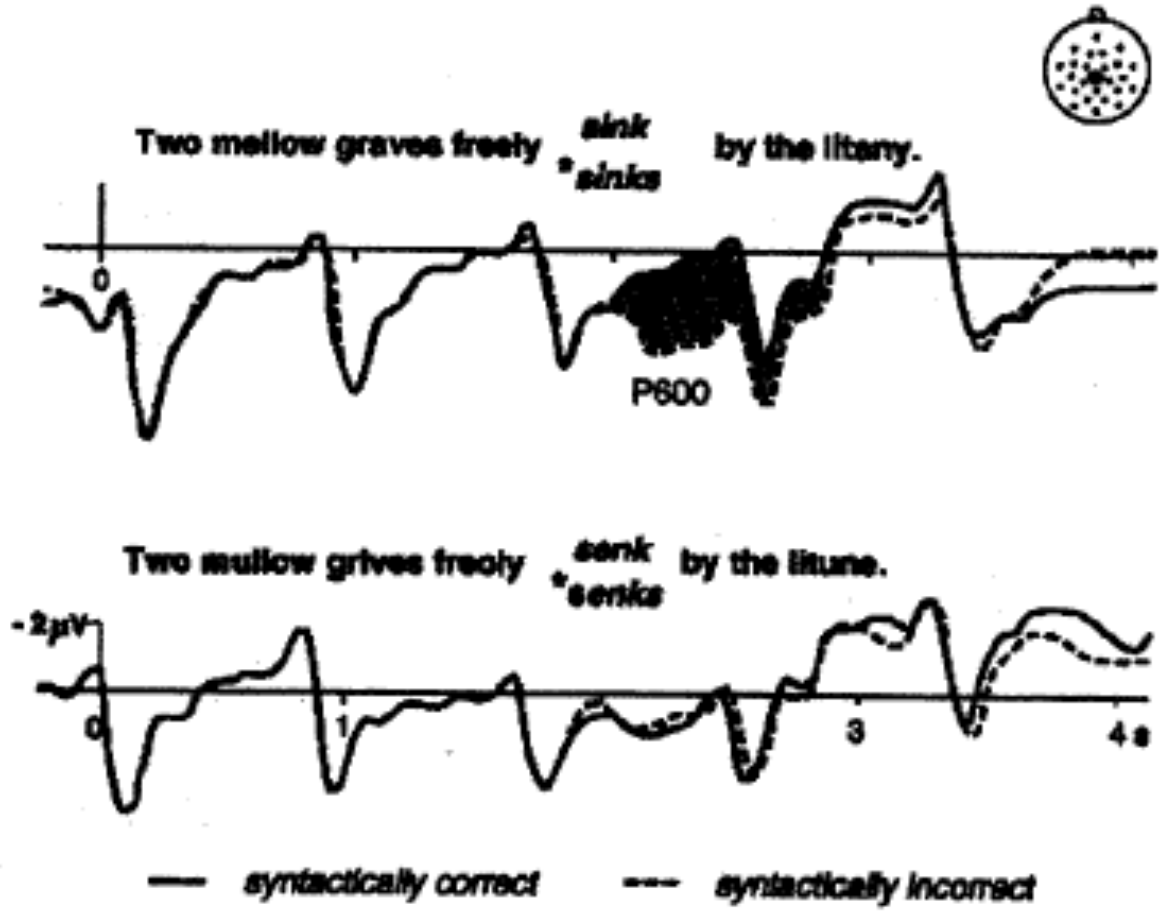


FIG. 7.8. Grand average ERPs elicited by morphosyntactic (subject–verb–number agreement) violations in meaningless sentences (prose). The solid lines show ERPs to syntactically correct sentences, and the dashed lines to incorrect sentences, wherein the verbs do not agree in number with their subject. At the top panel, the sentences are so-called syntactic prose. A syntactic violation in this case elicits a P600 effect (shaded area). In contrast, in the bottom panel, syntactic prose made of pseudowords is shown. Syntactic violations in pseudoword prose do not elicit a P600 effect. After Münte, Matzke, and Johannes (1997), with permission.

Using ERPs to measure how memory gets taxed

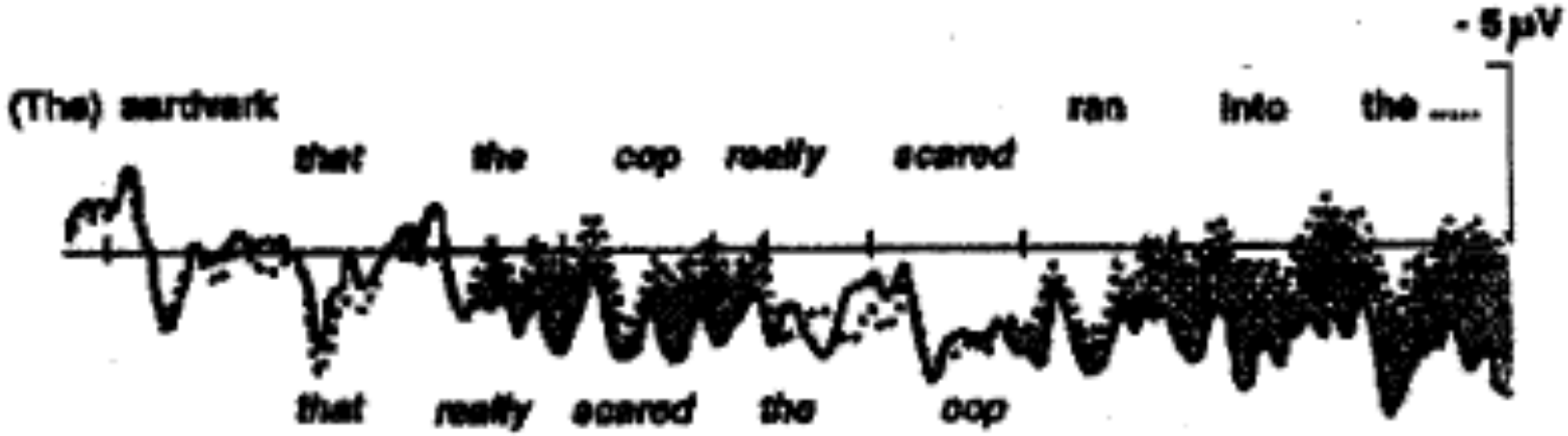


FIG. 7.9. Comparison of the grand-average cross-sentence ERPs elicited by subject relative (solid line) and object relative (dotted line) sentences recorded over a left frontal location. Words were visually presented one at a time every 500 ms for 200 ms each. The shading represents areas of where object relative sentences are reliably more negative than subject relative sentences (after King & Kutas, 1995b).

Not everyone processes language in the same way

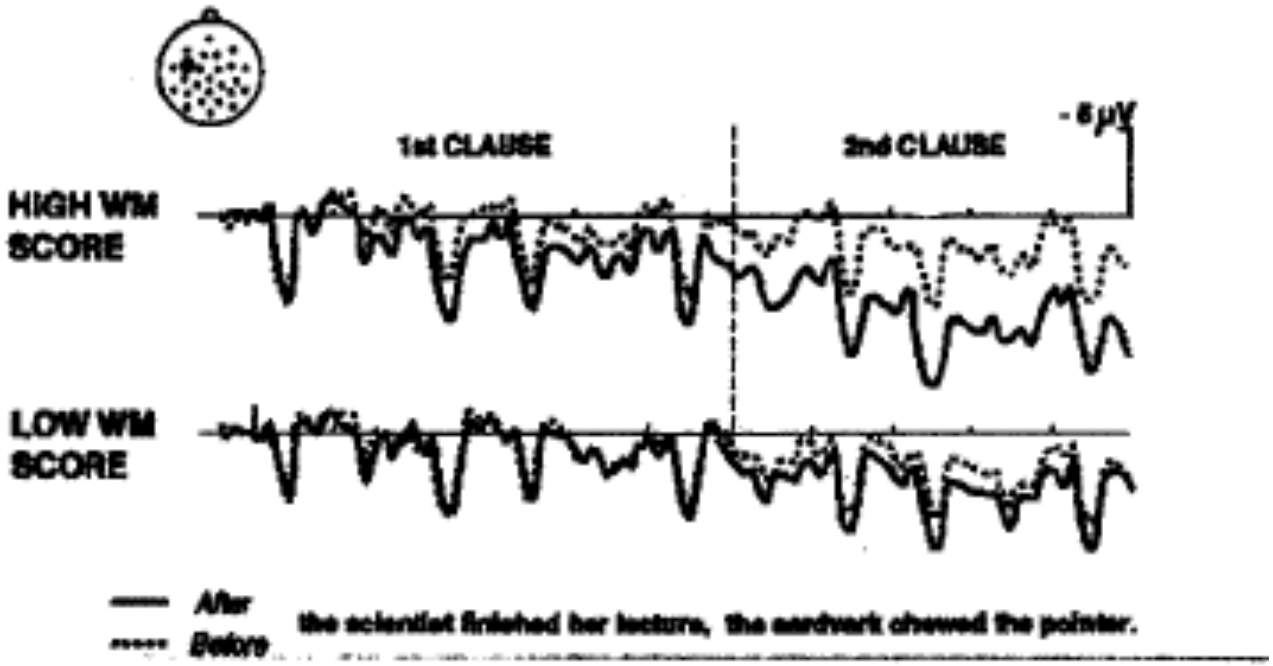


FIG. 7.10. Over-sentence ERPs from the left frontal recording site elicited by visually presented sentences that are equivalent in all respects except their initial word, either 'after' (solid lines) or 'before' (dotted lines). The top trace represents the responses of individuals with high working memory score (based on Daneman & Carpenter, 1980); while the bottom trace comes from individuals with low working memory scores. Individuals with higher working memory span show a more pronounced difference between 'before' and 'after' sentences than those with lower working memory span. These differences are seen within 300 ms of the response to the initial word (after Münte, Schiltz, & Kutas, 1998). Verbal working memory span is an estimate of an individual's temporary buffer for holding and processing of verbal information, presumably used during sentence processing. Loosely, it can be considered the number of language-like items that an individual can maintain for a few seconds without rehearsal.