Proposals

• Due Friday March 17 in Coulson’s mailbox
  – OK to turn in during our last class (3/16)

• Abstract
  – Is there one?
  – Does abstract provide a quick overview of what comes next?

• Introduction
  – Is it clear that the research question is an interesting and important one?
  – Does the text make clear why EEG/ERP is a good technique to use to answer this question?
  – Has previous work on this topic been described where relevant?
    • Do describe previous studies if you will build on them
    • Don’t describe all studies on this topic in great detail
  – Are references cited appropriately?
  – Is text well-organized and coherent?

• Methods
  – Includes discussion of Participants, Materials, Procedure, and EEG Collection
  – Is it clear from the text what you are planning to do in the study?
  – Sometimes a picture is worth a thousand words
  – Give examples of stimuli from each of your experimental categories

• Analysis and Conclusions
  – How will ERPs be measured?
  – If looking at particular ERP component, be clear about how it is measured
  – Describe at least 2 possible outcomes of study, e.g.
    • 1 outcome that would support your hypothesis
    • 1 outcome that would argue against it
  – Explain the theoretical implications of each possible outcome
  – Is text well-organized and coherent?
Metaphor & Discourse
Standard Pragmatic Model

1. Compute Literal Meaning
2. Is meaning contextually appropriate?
   - Yes: Integrate with Contextual Representation
   - No: Compute Figurative Meaning
Space Structuring Model

- Mental Spaces – partitions in working memory
- Representations – spaces contain partial cognitive models (hierarchical attribute-value structures)
- Mappings
  - Identity
  - Similarity
  - Analogy
  - Metonymy
*Titanic* is about the voyage of the Titanic.
Titanic: Unsinkable after all!

Ship

Movie

Blend
Unsinkable Titanic

<table>
<thead>
<tr>
<th>Generic</th>
<th>Input</th>
<th>Input</th>
<th>Blended</th>
</tr>
</thead>
<tbody>
<tr>
<td>object</td>
<td>ship</td>
<td>movie</td>
<td>ship</td>
</tr>
<tr>
<td>course</td>
<td>voyage</td>
<td>run</td>
<td>voyage</td>
</tr>
<tr>
<td>outcome</td>
<td>sinks</td>
<td>wins-oscars</td>
<td>finishes-voyage</td>
</tr>
</tbody>
</table>
Metaphor: The nurses at the hospital say that surgeon is a butcher.

Surgeon

Means: scalpel
Ends: save patient, cut tissue

Butcher

Means: cleaver
Ends: slaughter cows, chop meat

Blend

Means: cleaver
Ends: save patient, cut tissue
Literal Mapping: During the war, that surgeon worked as a butcher.
Blending Processes

• Composition
  – 4 course dinner
  – Irish 4 course dinner

• Completion
  – Went to Baskin Robbins for ice cream

• Elaboration
Since my last report, this employee has reached rock bottom and has started to dig.
Space Structuring Model

- Explicit grammatical cues used to construct blended space
- Emergent structure activated to produce coherent juxtaposition of input concepts
- Emergent structure can be projected back to inputs
- Metaphor comprehension requires:
  - activation of concepts in generic and input spaces
  - establishment of mappings between spaces
  - activation & integration of concepts in blend
Experiment I: Feature Listing

- Null Context: anchor
- Literal: Last time he went sailing he almost forgot about the anchor.
- Metaphor: Amidst all the trappings of success, his wife was his anchor.
- Literal Mapping: We were able to use a barbell for an anchor.
Proportion of Unique Features

![Bar graph showing the proportion of unique features for Literal, Literal Mapping, and Metaphor categories. The graph indicates that the proportion is highest for Metaphor at approximately 40.00%, followed by Literal Mapping at about 30.00%, and the lowest for Literal at 20.00%.]

- **Literal**: 20.00%
- **Literal Mapping**: 30.00%
- **Metaphor**: 40.00%
Semantic Similarity

- Potentially misleading to focus on unique features
- Semantic similarity assessed using latent semantic analysis (Landauer & Dumais)
- Transform feature set into vector in high dimensional semantic space (300-d)
- Measured cosine of angle between each sentence condition and the null context
Similarity Scores

- (1 is most similar, 0 is least similar)
- Null Context and Literal Sentences = .84
- Null Context and Literal Mapping = .81
- Null Context and Metaphors = .78
backbone

• The coach said he’d miss his seniors because they were the backbone.
  – RELIABLE, SECURE, RIGID, BEST, FASTEST

• The paleontologist quickly discovered that the foot bones were actually fragments of backbone.
  – BREAK, DELICATE, INJURY
backbone

- At the academy, young FBI officers are taught to target the backbone.
  - VULNERABLE,
    IRREPARABLE,
    DAMAGING
Experiment I

- 60% of features in generated for words in sentence contexts were also generated for words in the null context
- Overall proportion of unique features was high (>40%) in all 3 sentence types
- Metaphors < Literal Mapping and Literal Mapping < Literal in terms of semantic similarity to the null context
- Completion versus Elaboration

- Constancy in conceptual structure available for meaning construction across different sentence contexts
- Context-specific activation of conceptual structure
- Systematic difference in types of features related to differences in blending operations
Event-Related Brain Potentials

I take my coffee with cream and ...

sugar  nutrasweet
Materials

Literal: He knows that whiskey is a strong *intoxicant*.
Litmap: He has used cough syrup as an *intoxicant*.
Metaphor: He knows that power is a strong *intoxicant*.

Literal: The secret ingredient in her stew is *cayenne*.
Litmap: The chef apparently uses salt instead of *cayenne*.
Metaphor: My crazy uncle says jokes are conversation’s *cayenne*.

Literal: They had a few chickens in the yard, and in the barn was a *goat*.
Litmap: On our trip to the mountains, Dad thought a bighorn sheep was a *goat*.
Metaphor: Someone had to take the fall, and unfortunately your husband was the sacrificial *goat*.
Predictions

• Literal stimuli will elicit smallest N4, Metaphors largest N4, with Literal Mappings in between.
metaphor
literal mapping
literal

Pz

2 μV

0 400 800 ms
ERPs and Metaphor Processing

• Metaphoric language is harder to understand
• Graded N400 difference argues against literal/figurative dichotomy
Discourse Processing

• N400 amplitude indexes congruity with sentence context
• Does it also index congruity with larger discourse context?
St. George et al. (1994)

The procedure is actually quite simple. First you arrange things into different groups depending on their makeup. Of course, one pile may be sufficient depending on how much there is to do. If you have to go somewhere due to lack of facilities that is the next step, otherwise you are pretty well set. It is important not to overdo any particular endeavor. That is, it is better to do too few things at once than too many. In the shorter run this may not seem important, but complications from doing too many can easily arise. A mistake can be expensive as well. The manipulation of the appropriate mechanism should be self-explanatory, and we need not dwell on it here. At first the whole procedure will seem complicated. Soon, however, it will become just another facet of life. It is difficult to foresee any end to the necessity of this task in the immediate future, but then one can never tell.

• TITLE: Procedure for washing clothes
• ERPs formed for all content words in titled paragraphs vs. untitled paragraphs
  – N400 larger for words in untitled paragraphs
  – N400 sensitive to discourse-level coherence
St. George fMRI study
St. George, et al.
Issues with St. George

• Kind of weird to collapse across all content words in paragraph (less temporal resolution that way)

• Written language might be processed differently than spoken

• Enter: Van Berkum
  – Short stories (3 sentences), timelock to a word at or near the end of the stories
  – Visual & Auditory Presentation
As agreed upon, Jane was to wake her sister and her brother at five o’clock in the morning. But the sister had already washed herself, and the brother had even got dressed. Jane told the brother that he was exceptionally

A: discourse-semantic anomaly effect

Van Berkum, et al. (1999)

B: control study without the discourse

C: effect for low-constraint stories only

D: effect for sentence-medial words only

E: effect for long (>550 ms) words only
Discourse-level Anomaly Effects

- Locally congruent sentences elicit similar N400 presented in isolation.
- Larger N400 for sentence completions not congruent with information set up in the discourse context.
- Also true for words in the middle of sentences.
  - Need not be at end of sentence.
- N400 enhancement happened even for low constraint (open-ended) contexts that did not suggest a particular word.
- Suggests words are integrated with the discourse context as soon as they are processed for meaning.
  - Argues against model of word processing followed by sentence processing followed by discourse processing.
Written Materials: Discourse- versus Sentence-Level Anomalies

A: Discourse-semantic anomaly effect while reading

B: Sentence-semantic anomaly effect while reading

distribution of effect in 300-500 ms
Spoken Materials: Discourse- versus Sentence- Level Anomalies

A: Discourse-semantic anomaly effect while listening

B: Sentence-semantic anomaly effect while listening

distribution of effect in 300-500 ms
Discourse- versus Sentence-Levels

• Similarity of N400 context effects with sentence- and discourse- level anomalies suggests the brain treats these two levels similarly

• Perhaps there is only context…
Anticipation

(1) The burglar had no trouble whatsoever locating the secret family safe. Of course, it was situated behind a

(2) een groot schilderij  a big\textsubscript{NEU} painting\textsubscript{NEU}  neuter gender  “zero” suffix
een grote boekenkast  a big\textsubscript{COM} bookcase\textsubscript{COM}  common gender  -e suffix
ERP effect at adjective suggests people anticipate particular words.

*Figure 13.2* ERPs elicited by spoken adjectives whose suffixes are congruent or incongruent with the gender of a predictable noun. Results are shown for a right-temporal site (RT), and for stories with at least 75% cloze probability. Apart from the critical inflection-elicited early positivity, one can also see a discourse-induced N400 effect, elicited if a subsequently presented noun was not the predictable one. Estimated onset of the inflectional suffix is at 0 ms. Negative voltage is up. Data from J. J. A. Van Berkum et al., 2004.
Vertex ERPs by median split on cloze probability,

\[ e.g., \text{The day was breezy so the boy went outside to fly ...} \]

\begin{align*}
\text{Articles} & \quad \text{Nouns} \\
\text{\lq an\rq} & \quad \text{\lq airplane\rq} \\
\text{\lq a\rq} & \quad \text{\lq kite\rq}
\end{align*}

\begin{align*}
\lt 50\% & \quad \geq 50\% \\
\lt 50\% & \quad \geq 50\% \\
\gt 50\% & \quad \geq 50\% \\
\lt 50\% & \quad \geq 50\%
\end{align*}

\begin{align*}
\text{N400 x cloze probability correlations at vertex}
\end{align*}

\begin{align*}
\text{Mean amplitude} & \quad \text{Mean amplitude} \\
200-300 \text{ ms (µV)} & \quad 200-500 \text{ ms (µV)} \\
r = -0.68 & \quad r = -0.79
\end{align*}

\begin{align*}
\text{r-values at all recording sites}
\end{align*}
Discourse Context can Overrule Local Anomalies

Example story:
1. Once upon a time a psychotherapist was consulted in her home office by a **yacht/sailor** with emotional problems.
2. The yacht/sailor confided her that everything in life had gone wrong and started crying.
3. The psychotherapist **consoled** the **yacht/sailor** by stating that everybody experiences these kinds of trouble every now and then.
4. But the yacht/sailor doubted whether to continue outlining his problems to her.
5. The psychotherapist **advised** the **yacht/sailor** to be honest not only with her, but especially with himself.
6. At that moment the yacht/sailor cried out that he was absolutely terrified of water.

Nieuwland & Van Berkum, 2005
Happy Peanuts

- “A woman saw a dancing peanut who had a big smile on his face. The peanut was singing about a girl he had just met. And judging from the song, the peanut was totally crazy about her. The woman thought it was really cute to see the peanut singing and dancing like that. The peanut was…” (from Van Berkum & Niewland, in press)

- “salted” elicits larger N400 than “in love”
  - Study done in Dutch where (I believe) in-love is one word
Referential Ambiguity

• Another semantic process in discourse is keeping track of the different referents.
• If there are 2 men in a scene, a vague word such as “he” or “the man” could refer to either one, imposing additional cognitive demands over the case where there is only a single referent.
• ERP indices of this process was examined by Van Berkum, Brown, & Hagoort (1999).
Just as the elderly hippie had lit up a joint, he got a visit from a friend and a nephew (two friends). Even though his friend (one of his friends) had had quite a few drinks already, and the nephew (the other one) had just smoked quite a lot of pot already, they insisted on smoking along. The hippie warned the friend that there would be some problems/fascists soon.

**Figure 13.8** From left to right: A sustained frontal negative shift to a discourse-induced referential problem ("friend" is referentially ambiguous in the 2-referent context), a P600/SPS effect to a discourse-induced syntactic problem ("there" rules out the provisional relative-clause analysis pursued at "that" in the 2-referent context), and an N400 effect to a discourse-induced semantic problem ("fascists" does not fit the wider story context); see text for explanation. The example item is shown here in several variants (1- and 2-referent contexts, coherent/anomalous ending), but any one subject saw only a single variant. Data from “Early referential context effects in sentence processing: Evidence from event-related brain potentials.” by J. J. A. Van Berkum, C. M. Brown, & P. Hagoort, 1999a, *Journal of Memory and Language*, 41, 147–182, and from “Semantic integration in sentences and discourse: Evidence from the N400.” by J. J. A. Van Berkum, P. Hagoort, & C. M. Brown (1999a). *Journal of Cognitive Neuroscience*, 11(6), 657–671.
A: discourse-referential ambiguity effect

B: discourse-semantic anomaly effect

Fz
sustained frontal negative shift

Cz

Pz

\( \mu V \)

-4 --- referentially ambiguous
---- referentially unique

0

4

0 400 800 1200 ms

Fz

Cz

Pz

N400 effect

\( \mu V \)

-4 --- semantically anomalous
---- semantically coherent

0

4

0 400 800 1200 ms
Referential Difficulty versus Integration Difficulty

• Effect of referential ambiguity on ERPs differed from effect of discourse anomaly
  – Different morphology (wave shape)
  – Different topography (scalp distribution)
• Different brain processes involved in each sort of processing
• Relating words to referents occurs very rapidly
A-t-il donné une bague ou un bracelet à sa fiancée? (Did he give his fiancée a ring or a bracelet?)
Il a donné une bague à sa fiancée. (He gave a ring to his fiancée.)

A-t-il donné une bague à sa fiancée ou à sa soeur? (Did he give a ring to his fiancée or his sister?)
Il a donné une bague à sa fiancée. (He gave a ring to his fiancée.)

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Il a donné une bague à sa fiancée. (He gave a ring to his fiancée.)
Words w/inappropriate prosody elicit N400

A

Sentence-final words

Cz

Pz

-3.5 μV

150 0 300 1050 msec

--- Pragmatically congruous
(M_F + M_{F_a})

--- Pragmatically incongruous
(*M_{F_a} + *M_{F_d})

B

Pragmatic congruity effect

[(*M_{F_a} + *M_{F_d}) - (M_F + M_{F_a})]

50–150 msec 150–300 msec 300–1050 msec

-3.5 μV 0 + 3.5 μV
Prosody & Referential Ambiguity

• Listeners sensitive to use of prosodic cues to disambiguate potentially confusing language
• If prosodic information is present when there is no ambiguity, it causes contextual integration difficulty indexed by N400
• If prosodic information is absent when there is ambiguity, that also causes contextual integration difficulty indexed by N400
  – Interestingly, not frontal negativity previously seen by Van Berkum…
• Flaw in study: participants explicitly asked about prosodic appropriateness of sentences
What kind of a system is this?

- Rapid incremental processing at all levels
- Discourse supports predictions about upcoming material
- Discourse can overrule local constraints
- Understanding does not proceed by first computing meaning in a context-free way, and then incorporating contextual information