Language-related ERP components: N400

Based on Luck & Kappenmann (2012) and Kutas & Federmeier (2011)

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Kutas & Hillyard (1980)

XXXXX

Kutas & Hillyard (1980)

IT

Kutas & Hillyard (1980)

WAS

Kutas & Hillyard (1980)

HIS

Kutas & Hillyard (1980)

FIRST

Kutas & Hillyard (1980)

DAY

Kutas & Hillyard (1980)

AT

Kutas & Hillyard (1980)

WORK

Kutas & Hillyard (1980)

XXXXX

Kutas & Hillyard (1980)

HE

Kutas & Hillyard (1980)

SPREAD

Kutas & Hillyard (1980)

THE

Kutas & Hillyard (1980)

WARM

Kutas & Hillyard (1980)

BREAD

Kutas & Hillyard (1980)

WITH

Kutas & Hillyard (1980)

SOCKS

Kutas & Hillyard (1980)

XXXXX

Kutas & Hillyard (1980)

SHE

Kutas & Hillyard (1980)

PUT

Kutas & Hillyard (1980)

ON

Kutas & Hillyard (1980)

HER

Kutas & Hillyard (1980)

HIGH

Kutas & Hillyard (1980)

HEELED

Kutas & Hillyard (1980)

SHOES

Kutas & Hillyard (1980)

- Hypothesized **Oddballs of language**, i.e., unpredictable words would elicit P3b
- Recap: P3b reflects (inhibition) processes during memorization
- Recap: P3b is stimulus(category)-independent (letters, words, faces, etc.)
- Does semantic content affect the component?

Kutas & Hillyard (1980): The results

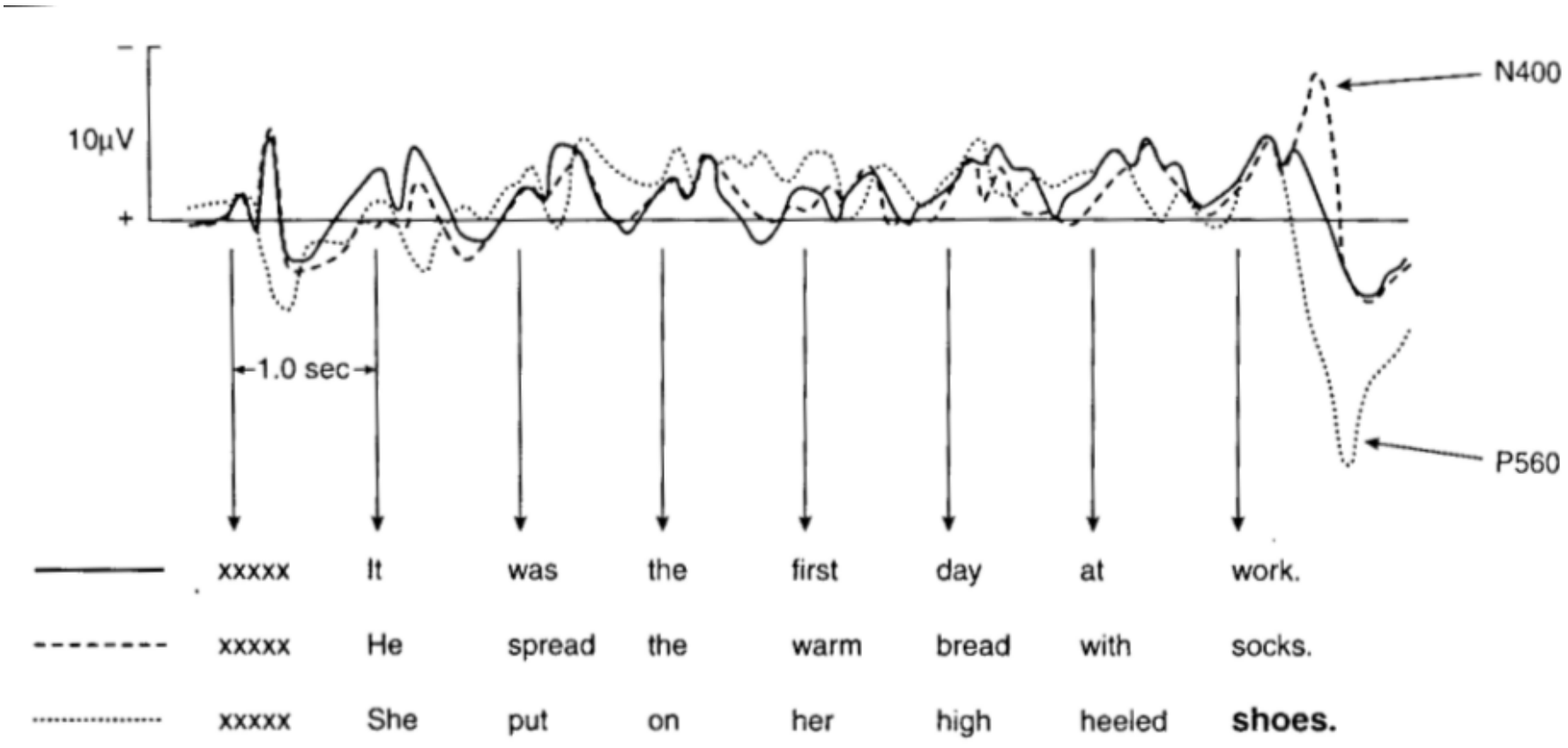


Figure: Kutas & Hillyard (1980)

Properties of the N400

- **Negativity** between 200 and 600 ms (stable latency)
- Maximum amplitude at about 380-440 ms
- Difference in latency for visual and auditory stimulus presentation
- Elicited at each **content word** - semantically anomalous or not
- Linked to a word's semantics, not it's surface (shoes vs. SHOES)
- Decreases incrementally with stimulus (sentence) processing since words become more **predictable**
- Large over **centro-parietal** brain region

N400 reflects meaning...

N400 appears both in reading comprehension and comprehension of spoken language in different contexts:

- Lexical context
- Sentence context
- Discourse context
- Nonliteral language

Lexical context

Reduced N400 effects for:

- **Lexical repetition**
- **Semantic priming**:
  spread of activation within a lexical-semantic network

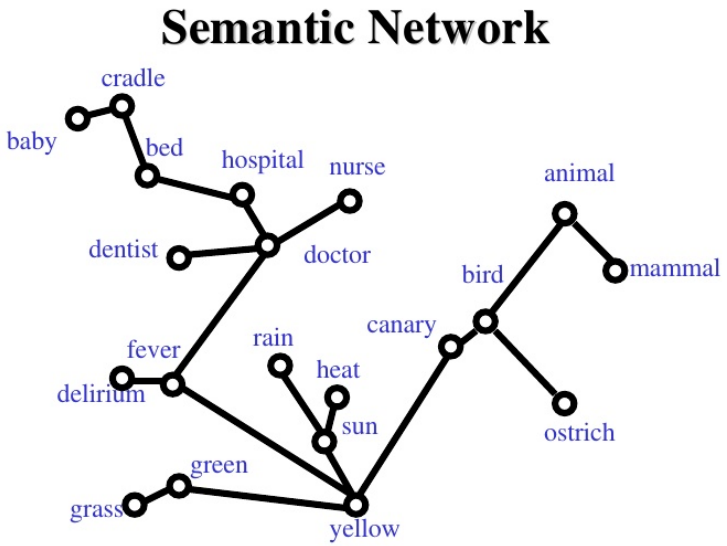


Figure: http://www.slideshare.net/melly91/l2-thinking

Sentence context in reading

Cloze probability and sentence constraint: Do they jointly affect N400?

- The children went out to ..... .

Sentence context in reading

Cloze probability and sentence constraint: Do they jointly affect N400?

- The children went out to play.

Sentence context in reading

Cloze probability and sentence constraint: Do they jointly affect N400?

- The children went out to play.
- She went into her room to look at her ..... .

Sentence context in reading

Cloze probability and sentence constraint: Do they jointly affect N400?

- The children went out to play.
- She went into her room to look at her clothes/gift.

Sentence context in reading

Cloze probability and sentence constraint: Do they jointly affect N400?

- The children went out to play.
  (Strongly constraining)
- She went into her room to look at her clothes/gift.
  (Weakly constraining)

Sentence context in reading

Cloze probability and sentence constraint: Do they jointly affect N400?

- The children went out to play (expected) / look (unexpected).
  (Strongly constraining)
- She went into her room to look at her clothes (expected) / gift (unexpected).
  (Weakly constraining)

Sentence context in reading

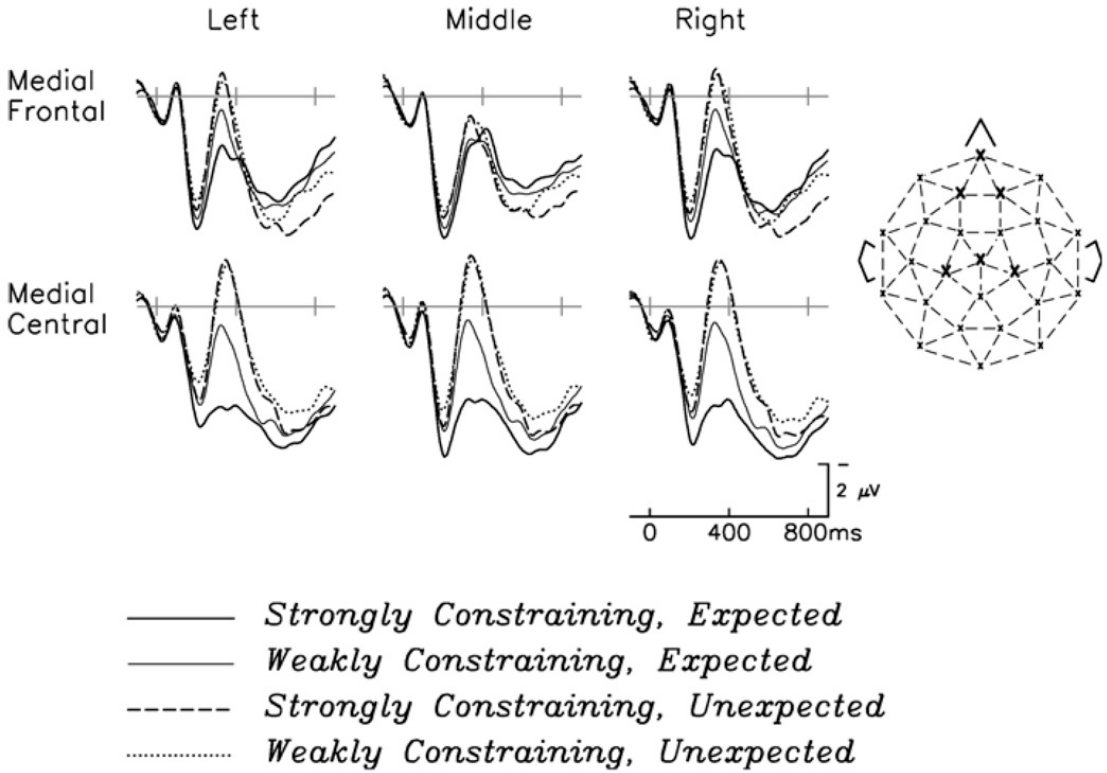


Figure: Close-up of the effects at six electrode sites, 3 over the central part of the head (showing the N400 effect pattern) and 3 over the front of the head (showing the frontal positivity to unexpected items in strongly constraining contexts)

(Federmeier et al., 2007)

Sentence context in reading

- Sentence context provides a processing benefit.
- The effects of sentential constraint are delayed relative to the effects of cloze probability.
- Frontal positivity may be associated with processes involved in inhibiting and/or revising a strong prediction when unexpected input is encountered.

Discourse context

N400 amplitudes are sensitive to discourse

- Lower N400 for words of a semantic category that is biased by the discourse context

They wanted to make the hotel look like a tropical resort. So along the driveway they planted *palms/pines/tulips*.

(Fedemeier & Kutas, 1999)

Discourse context

N400 amplitudes are sensitive to discourse

- Animacy violations show a reduced N400 with context appropriate words, even if they are noncanonical

The peanut was *salted/in love*.

(Nieuwland and van Berkum, 2006)

Discourse context

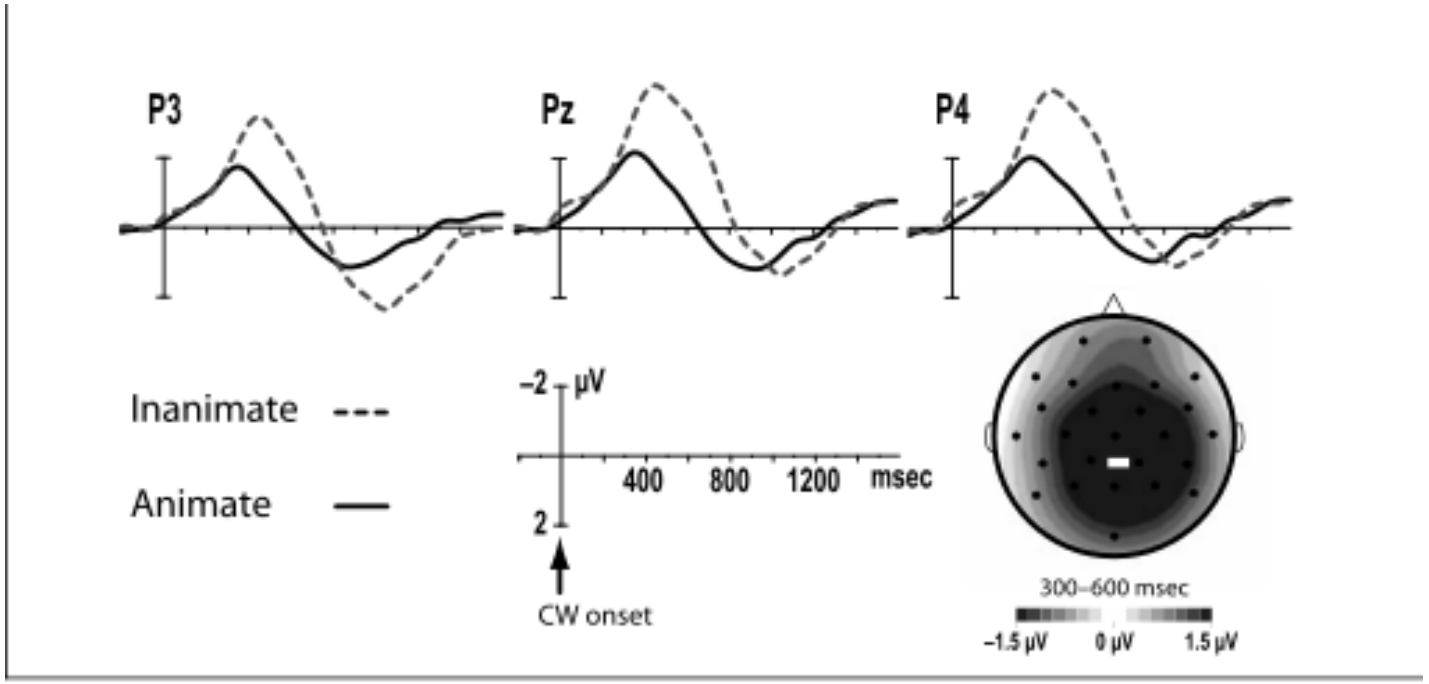


Figure: N400 results in sentences that violating animacy (The peanut was *in love*) or not violating animacy (The peanut was *salted*).

Nieuwland and van Berkum (2006)

Nonliteral language

Metaphors

- Non-metaphorical sense < familiar metaphor < unfamiliar metaphor

Joke comprehension

- Larger N400 effects for joke endings in the left hemisphere
- **However**, similar N400 amplitude for joke and non-joke endings in the right hemisphere (Coulson & Williams, 2005)

Is the N400 always reflecting meaning?

The case of negation: Fischler et al. (1983)

- Assumption 1: Sentences are propositions (are true or false)
- Assumption 2: False propositions elicit N400 (see Kutas & Hillyard, 1980)

Fischler et al. (1983): Stimuli

True sentence

- Affirmative: *A sparrow is a bird.*
- Negative: *A sparrow is not a vehicle.*

False sentence

- Affirmative: *A sparrow is a vehicle.*
- Negative: *A sparrow is not a bird.*

Fischler et al. (1983): Stimuli

True sentence

- Affirmative: *A sparrow is a bird.*
- Negative: *A sparrow is not a vehicle.*

False sentence

- Affirmative: *A sparrow is a vehicle.*
- Negative: *A sparrow is not a bird.*

Fischler et al. (1983): Behavioral Results

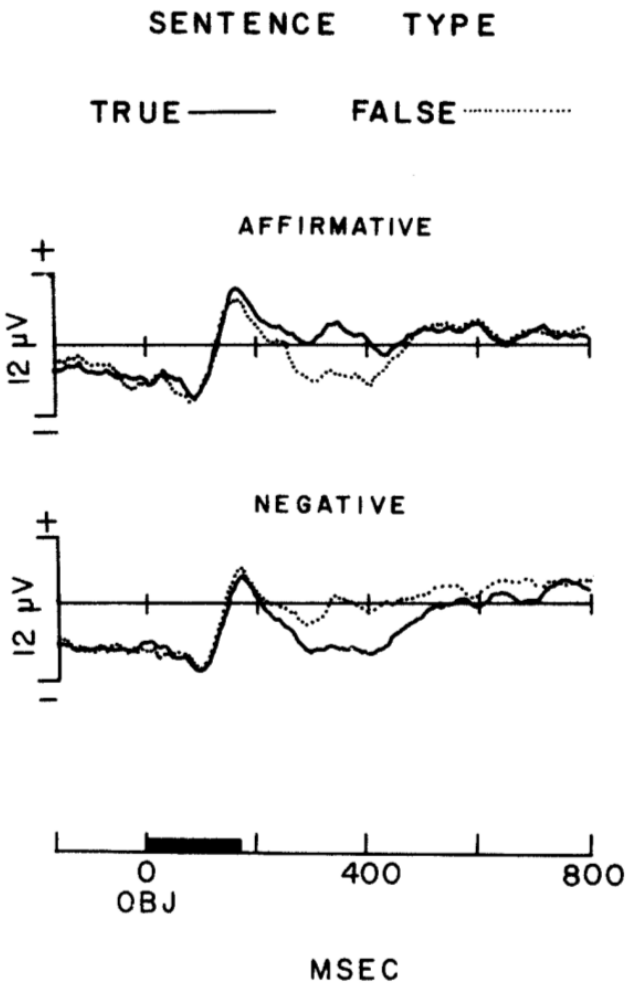
General gradient in processing difficulty based on RT results

True Affirmative<False Affirmative<False Negative<True Negative

A sparrow is a bird<A sparrow is a vehicle< A sparrow is not a bird<A sparrow is not a vehicle

- Processing ease for affirmatives
- Remaining gradient explainable by semantic relatedness

Fischler et al. (1983): ERP Results



True sentence

- Affirmative: *A sparrow is a bird.* (semantically related)
- Negative: *A sparrow is not a vehicle.*

False sentence

- Affirmative: *A sparrow is a vehicle.*
- Negative: *A sparrow is not a bird.* (semantically related)

Fischler et al. (1983): Conclusions

- No difference between affirmative and negative sentences: ERP does not reflect behavioral results (difficulty with negatives)
- Effect for sentences with semantically related words (true affirmatives and false negatives): **N400 reflects semantic unrelatedness rather than meaning since truth value is not vital?**

Fischler et al. (1983): Claim

Other N400 effects (e.g. Kutas & Hillyard) may also be due to semantic unrelatedness (*socks vs. spread the bread*) rather than truth value

However, can we represent meaning simply as a truth value?

Methodological issues

- **Large** number of stimuli and trials
- **Repetition** of stimuli is not possible
- Critical word should always be in the same **position**
- Rapid serial visual representation (RSVP) differs from **natural reading conditions**
- **Alternative**: Self-paced reading is more natural but can cause motor artifacts

Conclusions

- N400 as a measure of processing difficulty on a semantic level
- N400 as a measure of semantic fit of word into its context
- Context in this sense is not strictly defined
- Higher-level context effects tend to override lower-level ones

Questions?

Your turn

Das Frauchen füttert ihren Hund.

Das Frauchen füttert ihren Silberfuchs.

Your turn

$N(Hund) = 17378, N(Silberfuchs) = 16$

Significant co-occurrences of Hund: Frauchen(1097.42)

Significant co-occurrences of Silberfuchs: -

(http://wortschatz.uni-leipzig.de/)

Your turn

Jonas war auf dem Weg zum Flughafen. Statt den Bus zu nehmen, nahm er ein Taxi um dort schneller hinzukommen. Der Taxifahrer war höflich, schaltete den Taxameter an und beachtete durchweg die Straßenregeln. Als Jonas am Flughafen ankam, sagte er zu seinem Kumpel, der im selben Taxi mit ihm war: “Der Taxifahrer war eine Schnecke; er fuhr so langsam, dass er jede rote Ampel erwischte.”

Your turn

Jonas war auf dem Weg zum Flughafen. Statt den Bus zu nehmen, nahm er ein Taxi um dort schneller hinzukommen. Der Taxifahrer war ein älterer Herr, der sehr langsam fuhr und es schaffte, jede rote Ampel zu erwischen. Als Jonas am Flughafen ankam, sagte er zu seinem Kumpel, der im selben Taxi mit ihm war: “Der Taxifahrer war eine Schnecke; er fuhr so langsam, dass er jede rote Ampel erwischte.”

Your turn

Nachdem er zum Arzt gegangen war, deckte Peter den Tisch.

- Der Löffel, den er für die Suppe benutzte, war sehr groß. (B)
- Der Oberarm, den er sich beim Sport gebrochen hatte, war vergipst worden. (B-)
- Der Gastvortrag, den er in England halten sollte, war schon lange vorbereitet. (N)

Thank you!