Frontal Mechanisms in Language Pragmatics: Evidence from Event-Related Potentials

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ABSTRACT

Although studies of patients with frontal lobe damage implicate a link between language pragmatics and executive function (Ferst et al., 2005; Channon & Watts, 2003), evidence from ERPs predominantly reports changes in the amplitude of the N400 component in response to pragmatic manipulations (Coulson & Van Petten, 2002; Noveck & Posada, 2003). Two studies were conducted to explore ERP responses to standardized pragmatic inferences called 'implicitures' (Bach, 1994) with preferred interpretations (for example 'It's raining' usually referring to weather in the speaker's location rather then somewhere else). Implicitures were presented context-free (Experiment 1) and embedded in short contexts (Experiment 2). ERP responses to impliciture final words were recorded. The N400 was observed to free-standing implicitures, but implicitures in context elicited a negative component in the later 400 ms window with mostly anterior distribution. In addition, a later positive component about 700 ms post stimulus onset with more posterior distribution was observed. These results provide ERP evidence consistent with the tenet that frontal lobes are important for pragmatic processing requiring integration of linguistic context with an utterance for the correct interpretation.

BACKGROUND

Patients with traumatic brain injury (TBI) and localized lesions to the frontal lobes display deficits in:

- Implicit inferencing in text-comprehension (Ferstl et al., 2005; Channon & Watts, 2003)
- Comprehension of irony (Dennis et al., 2001)
- Interpretation of sarcasm (McDonald & Pearce, 1996)
- Understanding of humor (Docking, Murdoch, & Jordan, 2000)
- Production of nonconventional indirect speech (McDonald & Pearce, 1998)
- Different aspects of conversational exchange (Bernicot & Dardier, 2001)

Previous ERP studies of pragmatic phenomena:

- N400 to final words in metaphor sentences (Coulson & VanPetten, 2002)
- Anterior N400 to anomaly in non-verbal discourse (West & Holcomb, 2002)
- N400 to anomaly in verbal discourse (van Berkum et al., 2003)
- N400 to implicature sentences (Noveck & Posada, 2003)
- P600 to demanding inference making in discourse (Burkhardt, 2007)

Implicitures

- Generalized conversational implicature (Grice, 1975)
- Explicature (Sperber and Wilson, 1986)
- 'Default heuristics' (Levinson, 1995)

PURPOSE AND HYPOTHESIS

The purpose of this study was to investigate ERP responses to implicitures presented context-free and in two context conditions, either supporting the context-free preferred meaning (enabling contexts) or cancelling it (canceling contexts).

Following results of previous studies on metaphor and jokes, an N400 was predicted to free-standing implicitures.

For implicitures embedded in contexts, a modification of the N400 reflecting discourse integration processes was expected, especially for implictures presented in canceling contexts. This prediction was based on a previous neuropsychological study with the same materials that found a positive relationship between frontal lobe functioning and correct interpretation of implicitures embedded in canceling contexts (Dorjee Khenchen, Garrett, & Glisky, submitted).

MATERIALS AND METHODS

Participants:

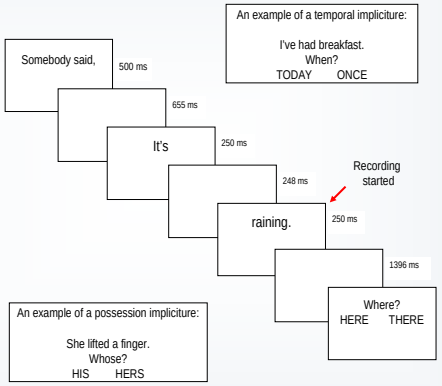
- 20 young adults, native speakers of English (average age 21, range 18-37; 6 male, 14 female)
  - right handed, no immediate family members left-handed, no history of brain injury or neurological condition, no medication

General procedure and electrophysiological recording:

- Testing was conducted in a sound attenuated room with a computer display
- Data were recorded from 64 channels following the extended 10-20 system, referenced to the left mastoid and off-line re-referenced to the average voltage of both mastoids; additional four electrodes were placed below and above the left eye and horizontally to monitor eye blinks
- Impedances of the electrodes were reduced below 5 kΩ
- Sampling rate of 500 Hz with a low pass filter of 70 Hz was used
- Stimuli were presented using the DMDX software, EEG signal was recorded and analyzed using the Neuroscan software
- ERP responses were time-locked to the final words in impliciture sentences

Experiment 1: Free-standing implicitures (30-35 min)

- **Items:**
  - 60 impliciture sentences
  - 60 fillers of comparable length and structure
  - 24 additional filler items
  - 3 blocks of items with pseudorandom presentation
- **Procedure**
  - word by word with pre-programmed durations (250 ms per word followed by a blank display for 100 ms plus 37 ms times the number of characters in a preceding word)
  - All items preceded by the phrase 'Somebody said,'
  - Responses by pressing mouse buttons marked 'LEFT' and 'RIGHT' with the index finger and the middle finger of the right hand



Experiment 2: Implicitures in contexts (35-40 min)

- Items:
  - 60 implicitures from Experiment 1 embedded as final sentences in pairs of enabling and canceling contexts counterbalanced across two files
  - 3 blocks of items with pseudorandom presentation of contexts
  - 11 practice items
- Procedure:
  - Self-paced reading of contexts presented line by line with lines remaining on the screen
  - Impliciture presentation, decision display and response mode same as in Experiment 1

Example of an enabling context:
Holiday travel: You are Eve
Eve and her sister Ashley have boarded their airplane to Chicago and are waiting for departure. They are chatting about their flying experience. Eve says that she developed a mild flying phobia after a very bumpy flight to Las Vegas. Looking at the sky through the airplane window she adds that she is little anxious about the departure today because it is very cloudy.

Where?
HERE THERE

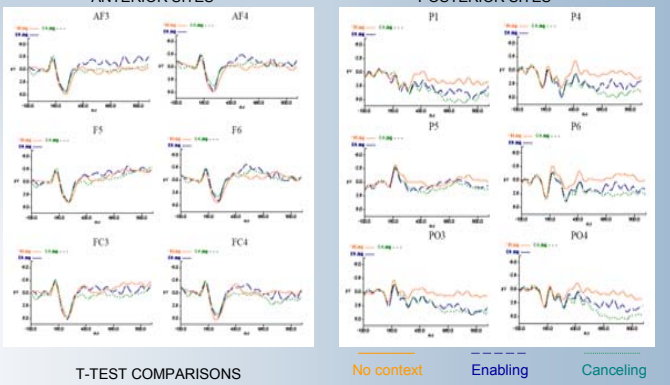
Example of a canceling context:
Holiday travel: You are Eve
Eve and her sister Ashley have boarded their airplane to Chicago and are waiting for the departure. They are chatting about their flying experience. Eve says that she developed a mild flying phobia after a very bumpy flight to Las Vegas. She adds that she is little anxious about the landing today because according to the forecast for Chicago it is very cloudy.

Where?
THERE HERE

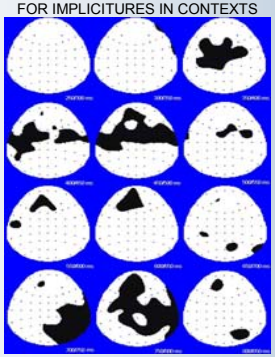
Data analysis:

- In Neuroscan software the EEG data were scanned for eye movements and other artifacts
- Algorithm by Anderer et al. (1987) was used to remove eye artifacts from the data
- Trials containing additional artifacts were rejected
- A low pass filter of 15 Hz was applied on the data
- Mean amplitude values were calculated relative to a 100-ms pre-stimulus baseline
- Averaged ERPs were computed for each rerecording site and each condition

RESULTS



T-TEST COMPARISONS FOR IMPLICITURES IN CONTEXTS



Experiment 1:

- The average bias for impliciture probes in response to impliciture sentences was 91%
- An N400 over central and posterior sites was observed to free-standing implicitures

Experiment 2:

- Average context compliance rate for implicitures embedded in contexts was 93%, with error rates of 6% and 9% for enabling and canceling contexts, respectively
- An N400 component over central and anterior sites was more pronounced for the enabling condition in the 350-500 ms time window
- Positivities in the 700-800 ms time window, mostly over the right hemisphere sites, were significantly larger for the canceling condition

CONCLUSIONS

The results suggest that neural mechanisms involved in processing of impliciture sentences presented context-free and in context are, at least to some extend, different. While traditional N400 was observed to solitary implicitures, the same sentences embedded in short contexts elicited a negative component in the N400 range with more anterior distribution. In addition, a late positive shift was documented for the context conditions. The differences in activations between enabling and canceling contexts might be due to earlier integration of an impliciture with context when contexts matched the preferred impliciture meanings and later integration when cancelation of the standardized meaning was necessary for correct interpretation. Overall, these results contradict accounts that equalize mechanisms involved in integration of sentence meaning with those involved in integration of discourse meaning.

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