

R34D1NG WoRD5 W1TH NUMB3R5: Is Lexical Activation Triggered by Holistic Processing or Analytical Processing?

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Introduction

SMS text and email messages often use combinations of digits and letters to spell out words, known as LEET words (see example below).

7H15 M3554G3 53RV35 7O PR0V3 H0W 0UR M1ND5 C4N D0
4M4Z1NG 7H1NG5! 1MPR3551V3 7H1NG5! 1N 7H3 B3G1NN1NG
17 WA5 H4RD BU7 N0W, 0N 7H15 LIN3 Y0UR M1ND 1S
R34D1NG 17 4U70M471C4LLY W17H 0U7 3V3N 7H1NK1NG 4B0U7
17, B3 PROUD! ONLY C3R741N P30PL3 C4N R3AD 7H15.

Previous studies have suggested that LEET words can automatically activate lexical information because of their physical similarity to real words (e.g., Perea, Duñabeitia, & Carreiras, 2008). Lien, Allen, and Martin (in press) recently used electrophysiological measures (event-related brain potentials; ERPs) to show similar lexical/semantic activation (based on the N400 effect, described below) for LEET words and regular, consistent uppercase words.

The Present Study

The present study examined whether the lexical activation in LEET words, relative to consistent-uppercase words, is the result of **analytical processing** (using individual letters as the basic encoding unit) or **holistic processing** (using whole-word shape as the basic encoding unit). We measured both the N170 and N400 effects elicited by the target word.

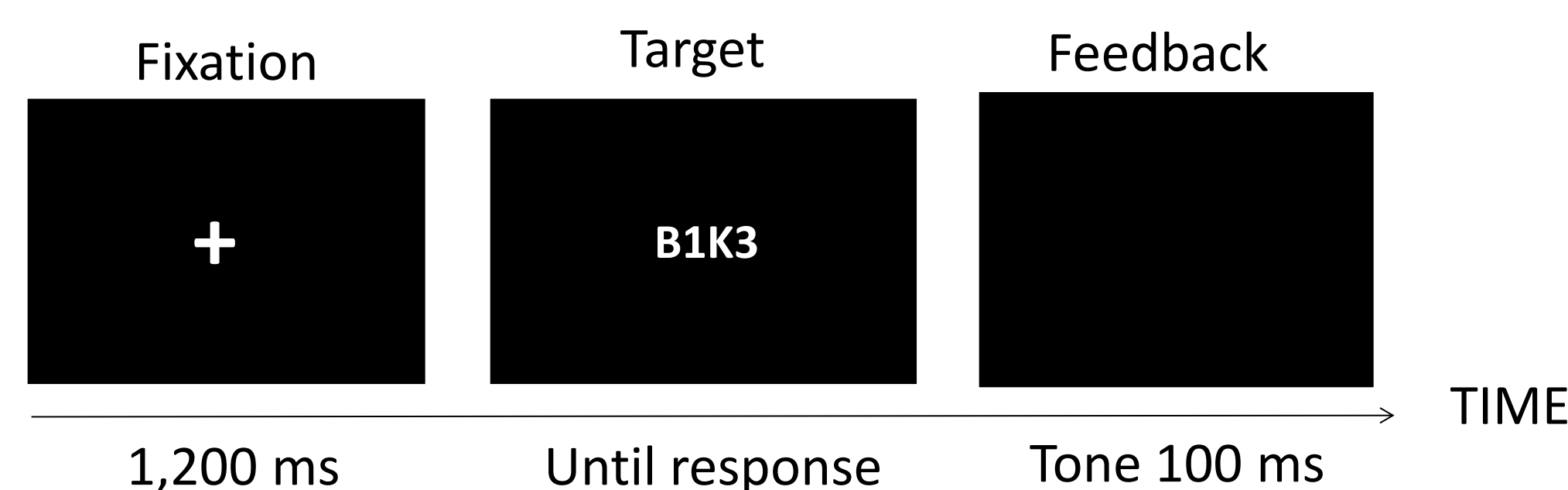
Previous studies have suggested that the lexical activation for consistent-uppercase words (e.g., READING) is triggered primarily by holistic processing and the lexical activation for mixed-case words (e.g., ReAdInG) is triggered by analytical processing (Allen, Wallace, & Weber, 1995). We first supported this conclusion using the N170 as an index of analytic vs. holistic word processing in Experiment 1. We then compared the encoding of consistent-uppercase words and LEET words in Experiment 2.

Experimental Design

We used a category task - determining whether the target word was related or unrelated to a given category prior to each block. Each participant received 21 different categories (e.g., "transportation"). Each block contained 18 related words and 18 unrelated words. Word type (LEET vs. consistent-uppercase vs. mixed-case) was varied within blocks.

Responses: Press the "1" key for related and the "5" key for unrelated.

Event Sequence: The example below is based on the "transportation" category ("B1K3" is like 'bike' so participants should press the "1" key).



References

Allen, P. A., Wallace, B., & Weber, T. A. (1995). Influence of case type, word frequency, and exposure duration on visual word recognition. *Journal of Experimental Psychology: Human Perception & Performance*, 21, 914-934.
Lien, M.-C., Allen, P. A., & Martin, N. (in press). Processing visual words with numbers: Electrophysiological evidence for semantic activation. *Psychonomic Bulletin & Review*.
Perea, M., Duñabeitia, J. A., & Carreiras, M. (2008). R34D1NG WoRD5 W1TH NUMB3R5. *Journal of Experimental Psychology: Human Perception and Performance*, 34, 237-241.

N400 Effect

The N400 effect is an ERP component known to be elicited when a person notices that a stimulus is incongruent with the current semantic context (see Figure 1 below). The N400 effect is a negative-going wave that peaks about 400 ms after the onset of the incongruous stimulus and is often referred to as *mismatch negativity*. Critically, the **N400 effect can be elicited only when the word is identified and processed up to the semantic level**.

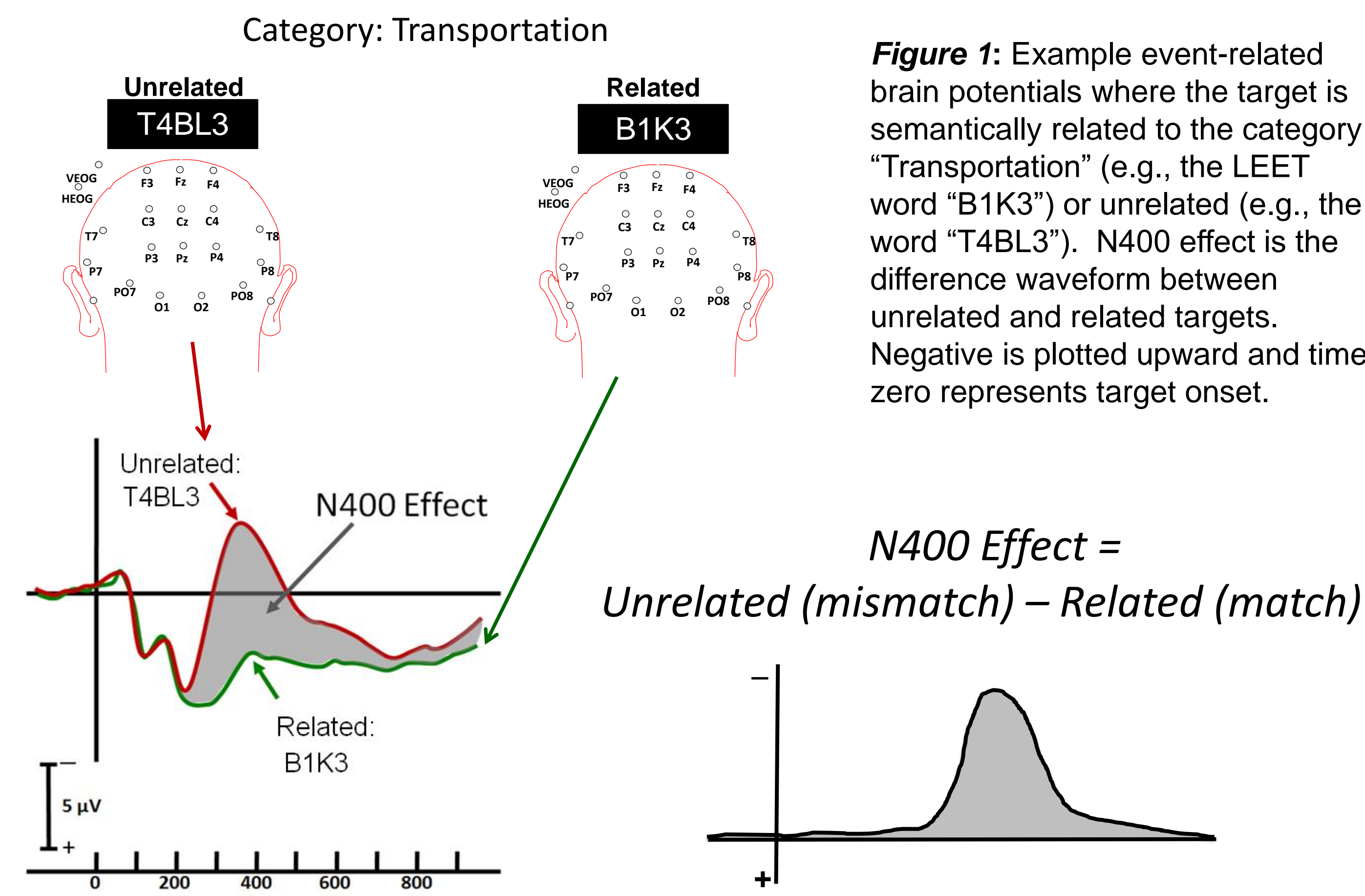


Figure 1: Example event-related brain potentials where the target is semantically related to the category "Transportation" (e.g., the LEET word "B1K3") or unrelated (e.g., the word "T4BL3"). N400 effect is the difference waveform between unrelated and related targets. Negative is plotted upward and time zero represents target onset.

N170 Effect

The N170 effect, occurring 140-240 ms after stimulus onset, is an ERP component known to be related to structural encoding that is specialized for faces and words. It reflects an early process of object recognition based on analytical processing (features/components). The effect occurs most strongly at occipito-temporal sites.

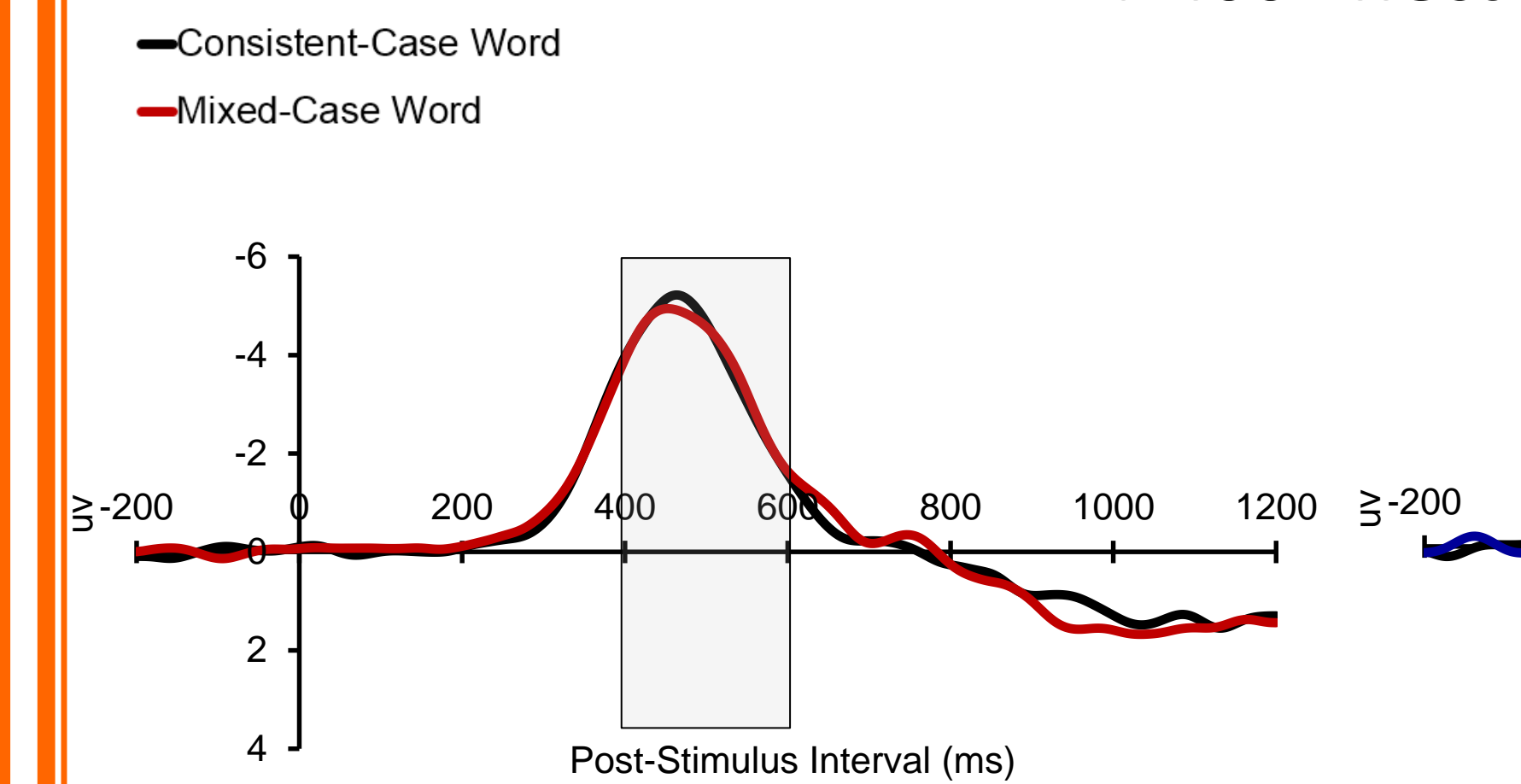
ERP Measures: The N170 effect was measured between 140-240 ms after target onset, relative to a 200-ms baseline period before target onset, averaging across the O1, O2, PO7, PO8 electrode sites and the T7, T8, P7, and P8 electrode sites. The N400 effect (difference in mean amplitude between unrelated and related targets) was measured between 400-600 ms after target onset, averaging across the P3, Pz, and P4 electrode sites.

Predictions

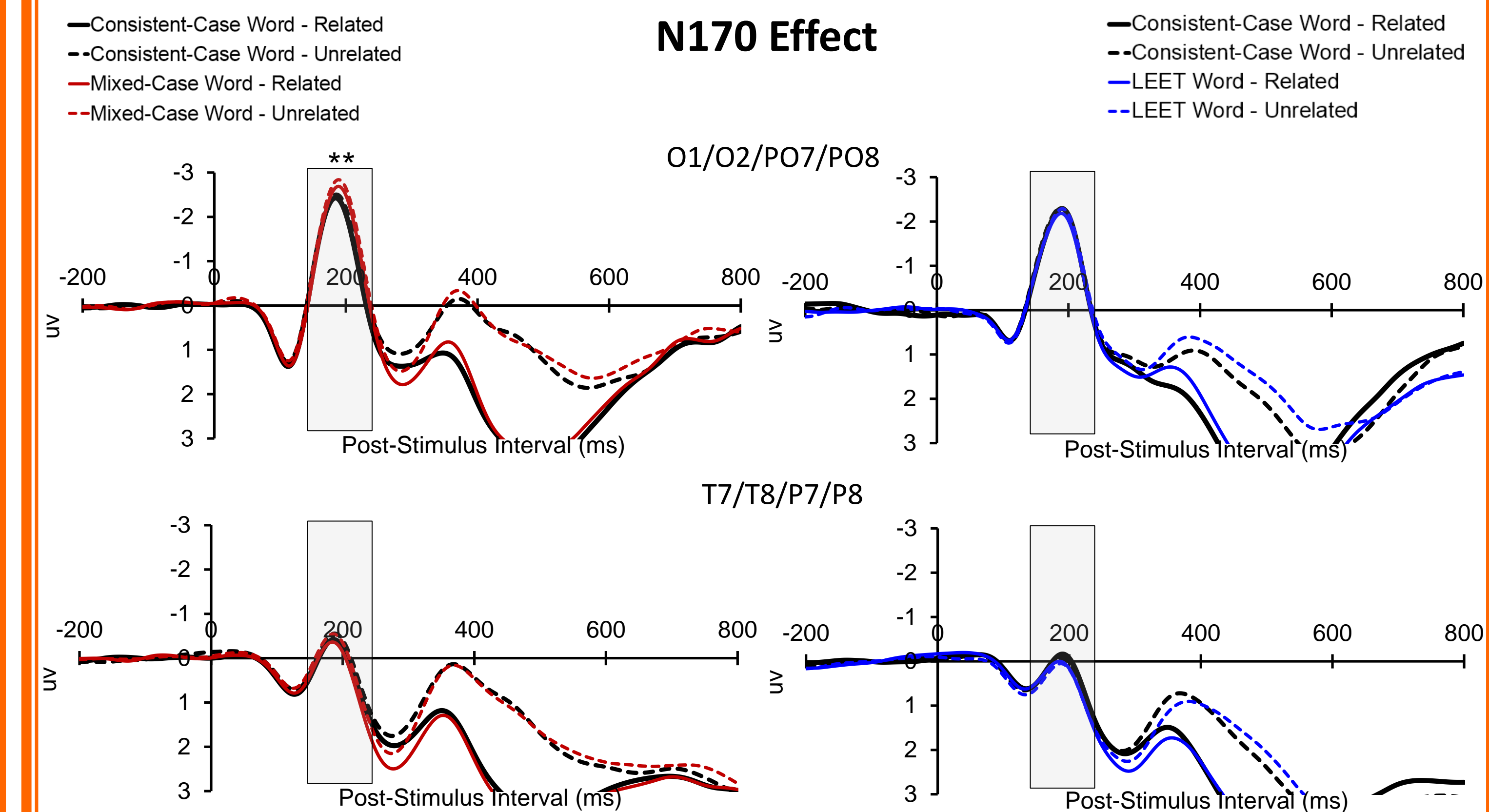
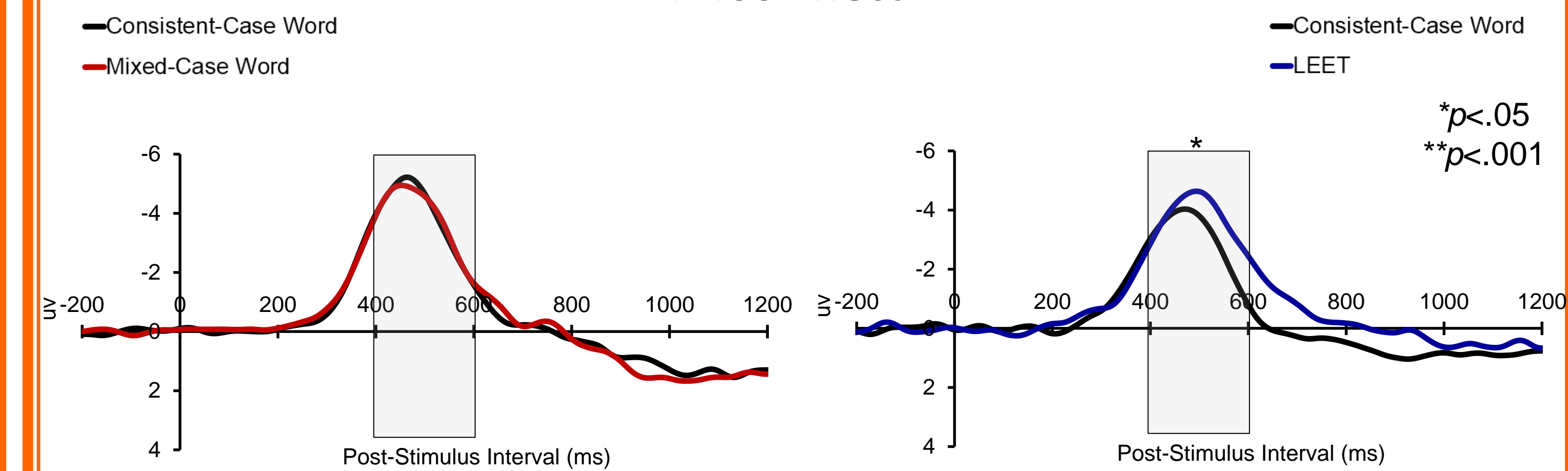
We expect all word types to produce similar N400 effects, replicating Lien et al. (in press). We also expect the N170 effect, an index of structural encoding (letter by letter) to be larger for mixed-case words than consistent-uppercase words in Experiment 1.

If LEET words are read primarily holistically, then the N170 should resemble that for consistent-uppercase words in Experiment 2. However, if they are read analytically, then the N170 should resemble that for mixed-case words.

Experiment 1 (N=20)



Experiment 2 (N=22)



As expected, a large N400 effect was observed for all 3 word types in both experiments, $|t_s| \geq 7.69$, $ps < .0001$. In Exp1, N400 effects were not significantly different between consistent-case words and mixed-case words, $F < 1.0$. In Exp2, the LEET words produced a larger N400 effect than the consistent-case words, $F(1,21) = 5.20$, $p < .05$, suggesting that LEET words were processed up to a semantic level at least similar to that of consistent-case words.

In Experiment 1, the N170 effect was larger for mixed-case words than consistent-case words for the O1/O2/PO7/PO8 than the T7/T8/PT7/PT8 electrode sites, $F(1,19) = 26.56$, $p < .0001$. In Experiment 2, although the N170 effect for LEET words was slightly smaller than that for consistent-case words for the T7/T8/PT7/PT8 but not the O1/O2/PO7/PO8 electrode sites, $F(1,21) = 6.59$, $p < .05$, the difference in the N170 effect for both electrode sites was not significant, $F_s < 1.66$, $ps \geq .21$.

Conclusions

We used electrophysiological measures (i.e., the N400 effect and the N170) to determine whether the lexical activation in LEET words is the result of **analytical processing** or **holistic processing**. We found that LEET stimuli showed similar N400 effects as consistent-case and mixed-case words, suggesting that LEET words can be used to access meaning, just like regular non-distorted words. Most importantly, while the mixed-case words produced a larger N170 effect than the consistent-case words, the LEET stimuli produced similar N170 effect as the consistent-case words. Supporting previous studies, we conclude that the mixed-case words are processed in an analytical manner whereas the LEET words are primarily processed in a holistic manner.