Decoding Semantic Content from EEG

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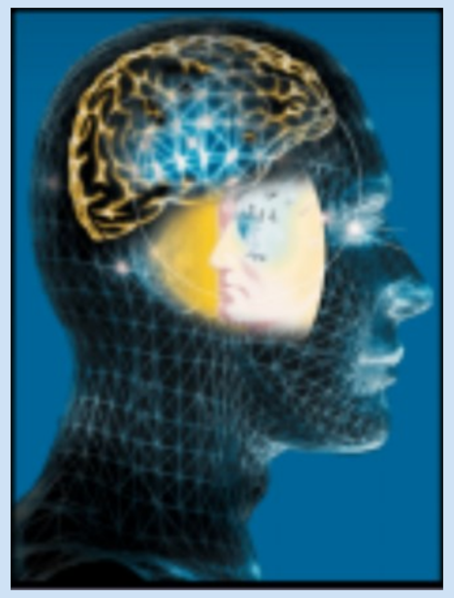
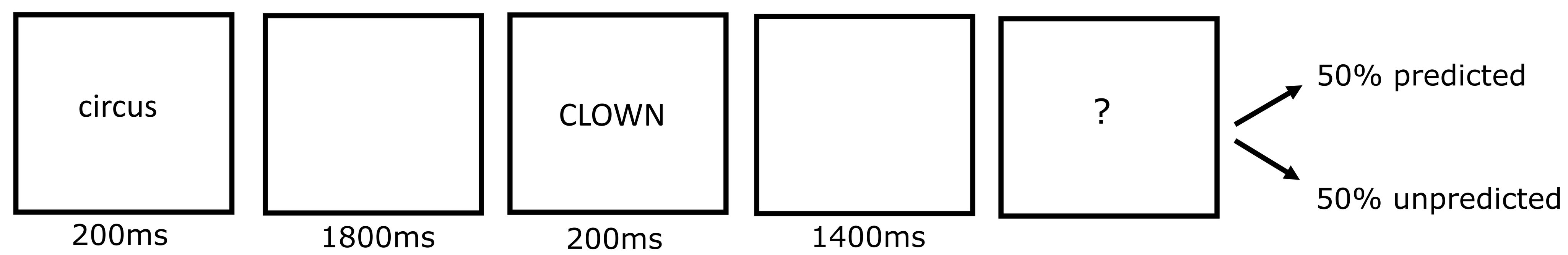


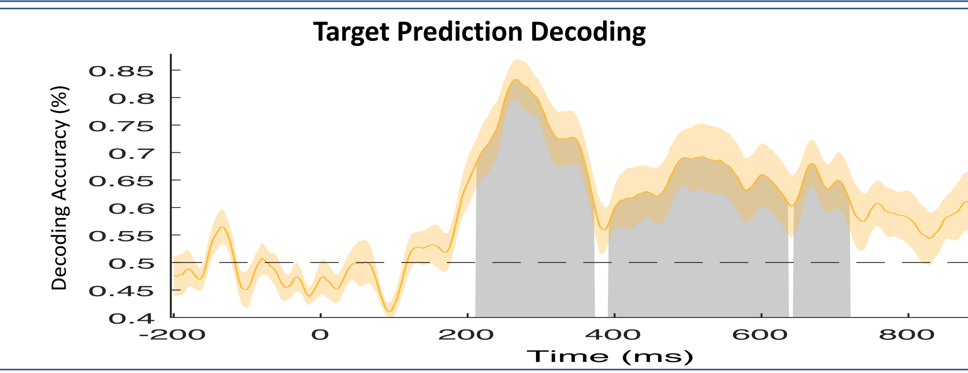
Introduction

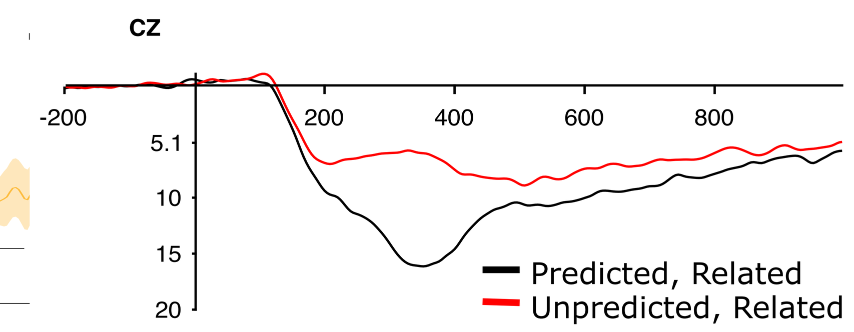
Traditional univariate analysis of EEG and ERP data have provided many insights in the dynamic neural computations that underlie visual word recognition (Grainger & Holcomb, 2009). But it is difficult to infer the linguistic content of these computations using traditional analysis methods. Recent developments in machine-learning classification have provided a promising tool to provide insight into the content of computations in memory and attention paradigms (Bae & Luck, 2018, 2019; Hong et al., 2020), but little is known about their application to studies of word recognition. In the present study, EEG data from a visual ERP priming paradigm (Brothers et al, 2016) were used to examine if an adaptation of a Support Vector Machine (SVM)-based classification analysis method (Bae & Luck 2018) could reliable categorize the EEG signal according to the animacy of the prime and target words. The SVM method classified 500 time points across the -200 to 1600 ms stimulus-locked interval. Decoding accuracy was calculated for each subject and then averaged across subject. We found grand-average decoding accuracy was greater than chance (50%) in multiple clusters during the time interval. Several of these decodable clusters are within typical windows of interest in semantic processing. These results indicate the SVM-based method was able to reliably classify EEG data according to the animacy of words.

Methods

- We presented 480 related (happy – SAD) and 480 unrelated word pairs (table – CLOWN) to 13 participants. Related word pairs had a forward association strength of 0.5 (range = 0.4-0.6).
- Participants were asked to actively predict the target word following presentation of a prime word and to report their prediction accuracy after query presentation.
- We used an adapted version of a support vector machine (SVM)-based classification algorithm (Bae & Luck, 2018) to decode animacy across prime/target, predicted/unpredicted, and related/unrelated word-pair conditions, respectively.
- The SVM method classified 500 time points across the -200 to 1800 ms stimulus-locked interval on single trials. Decoding accuracy was calculated for each subject and then averaged across subject.







Not Significant Decoding: Prime Predicted: Target Animacy

Results

- We found grand-average decoding accuracy was significantly greater than chance (50%) in multiple clusters during the time interval across multiple conditions (all stimuli, prime/targets separated, predicted/unpredicted, and prime words mapped to target labels).
- Critically, most conditions present decodable clusters within 250 – 500 ms; a typical window of interest in semantic processing (N400).
- When decoding all words, significant decoding accuracy was detected at earlier time points between 200-350ms.
- In prime animacy words mapped to target labels, we found decodable clusters around 1200-1400ms. This period was prior to the typical time window associated with anticipatory responses.
- Prime-predicted words mapped to target labels were not significant, most-likely due to our small sample size (9 trials/condition)

Discussion

- These results indicate the SVM-based method was able to reliably classify EEG data according to the animacy of words, consistent with prior EEG animacy studies (REF).
- A small portion of the N400 was consistently decoded across most decodable conditions. This may suggest that an early segment of the N400 component may be critical to processing semantic content.
- Our significant early (200-350ms) and late(1200-1400ms) decoding results suggest that semantic content may be processed across multiple time points during language processing.
- This was an exploratory analysis from a paradigm not designed to compare across animacy conditions. However, our promising results demonstrate the potential power of applying decoding techniques in language research. We are developing an animacy decoding experiment designed to isolate specific semantic content.

Acknowledgements

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