Predicting behavioral preferences in language use from electrophysiological activity

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Introduction

Traditional ERP research has often divided components into "stimulus-locked" and "response-locked". Yet, when we consider that ERP components index evoked electrical activity within the perception-action loop, it becomes clear that a component is not "response-locked" but rather "response-locking". Why then do we analyse our data as response-locked and not response-locking?

Neural correlates of behavioral responses

Response-related ERPs have been observed in a range of response settings. In studies on language, this has been extensively studied with a late positivity for ill-formed sentences, which seems to be strongly dependent on the task [1]. Additionally, neural correlates for behavioral preferences without a canonical intersubject answer have been observed in other domains (e.g. beverages [2], car manufacturers [3]), suggesting that it may be possible to measure preferences in language.

To-may-to, To-mah-to — Acceptability is not absolute

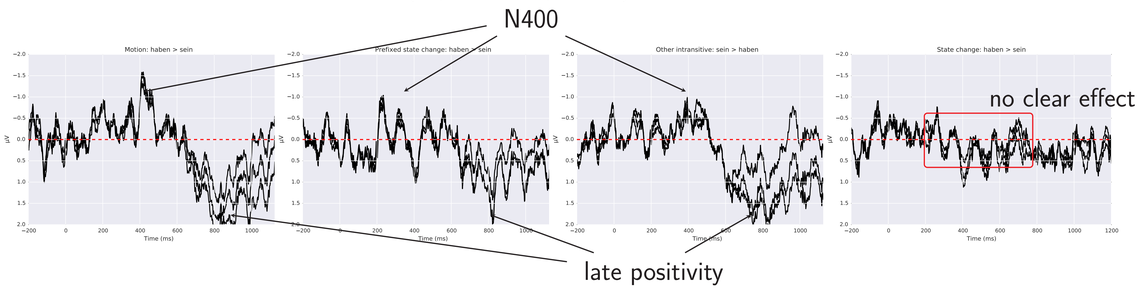
Variation within a given language permeates all levels – pronunciation, lexical choice (*biscuit*/*cookie*), choice of bigram (*different than/from/to*) or even verb agreement (*NASA is/are*). Such differences may be perceived as anywhere from "neutral" to "dispreferred" or even "incorrect" by other speakers. The data presented here are reanalyzed from [4] and focus on the selection of the auxiliary verb for different verb classes.

From behavioral preferences . . .

While subjects were strongly in agreement about the "correct" auxiliary in three of the four conditions, the fourth lacked a canonical auxiliary and and the subjects were greatly divided on the acceptability of the two possibilities.

. . . to EEG . . .

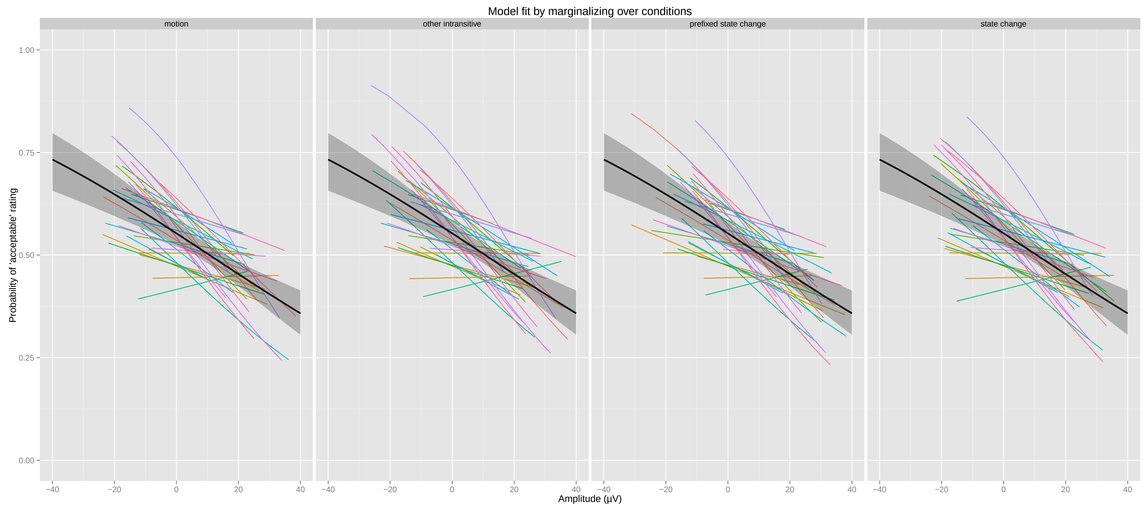
Differences waves (dispreferred > preferred) for electrodes Cz, CPz, and Pz



Conditions with a canonical auxiliary show a clear N400-late positivity effect across centro-parietal sites for the non-canonical auxiliary. No difference is visible across subjects in the condition without a canonical answer, reflecting a lack of "consensus" in the electrophysiology in line with the lack of consensus in the behavioral data.

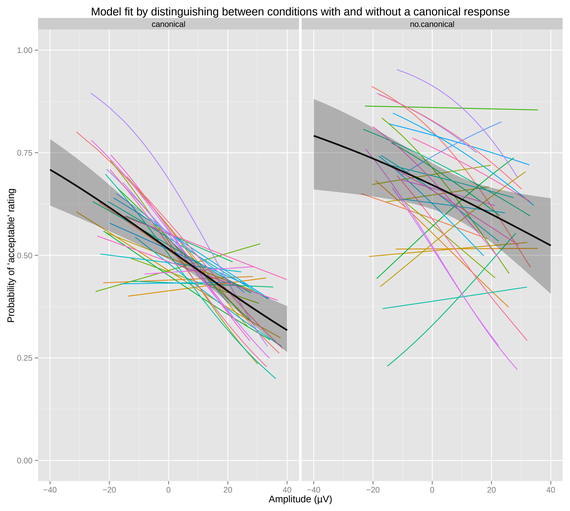
. . . and back again

Using generalized linear mixed-effects models (GLMM, [5]), we find that single-trial mean amplitude in the time window 600-800ms post stimulus is a significant predictor of behavioral judgements across conditions. Interindividual variance was captured by a random intercept (behavioral biases) and a random slope for amplitude (differences in strength of EEG response).



The colored lines represent per-subject fits, while the black line represents the fixed-effect estimate and its confidence interval for amplitude.

Preferences are weak judgements



Adding a predictor for "canonicity" of expected answer drastically improves model fit. We see that the strength of the response is much stronger for conditions with a canonical answer, but the average dynamics (slope) of the response do not differ strongly between canonical and non-canonical conditions (no significant interaction). There is also far less coherence between subjects for the non-canonical condition and a broadening of the confidence interval. This reflects a lack of a broad, inter-subject consensus on the correct answer.

Conclusion

Perception precedes action in the perception-action loop, and so electrophysiology precedes behavioral response. Predicting behavioral responses from electrophysiology places action in its correct place in the perception-action loop. Here, we have demonstrated that the feasibility of using electrophysiological activity to predict even subtle behavioral preferences. The difference between "preferred" and "required" response is a quantitative and not a qualitative one.

Literature

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