

PREDICTING THE FUTURE TO MAKE SENSE OF THE PRESENT: PREDICTIVE BRAIN MECHANISMS FOR SPEECH PERCEPTION

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Background: According to predictive processing theories, the brain is constantly predicting what is going to happen next and uses those predictions to fundamentally shape what is perceived. Despite the popularity of the predictive processing theory, we still do not know how predictive processing is mechanistically realised in the brain. According to the sharpened signal account, brain responses to sensory input are enhanced by predictions. The alternative prediction error account instead proposes that sensory responses are suppressed by predictions, allowing the brain to dedicate its resources to unpredictable (and therefore novel) information.

Aims: In the current study, we aimed to adjudicate between these theories using linear encoding models of EEG data, recorded during perception of a naturalistic speech stimulus (audiobook recording of *The Hound of the Baskervilles*).

Methods: High-density (128 channel) EEG data were collected from 58 participants as they listened to podcast speech against background noise (-3 dB signal-to-noise ratio). We implemented sharpened signal and prediction error accounts as computer models, allowing us to simulate neural responses to each phoneme in the speech stimulus. Simulated sharpened signals and prediction errors were then regressed against the EEG data. We trained and tested the regression models using 12-fold cross-validation. The correlation between the model's predictions and held-out EEG data was used as a measure of model accuracy, quantifying the extent to which neural responses were explained by sharpened signals and prediction errors. Both models included acoustic, phoneme onset and word onset nuisance regressors.

Results: Over participants, the prediction error model was significantly better at explaining EEG responses than the sharpened signal model ($p < .001$). Prediction error model accuracies were distributed most strongly over central and temporal electrodes. Inspection of the model weights linking prediction errors with the EEG data revealed responses at multiple time lags, starting from around 170 ms. This spatiotemporal profile of prediction error responses is consistent with a neural generator in speech-sensitive areas of the temporal lobe (superior temporal gyrus).

Conclusions: Our study provides strong evidence that prediction error computations — which represent the difference between heard and expected speech sounds — play a central role in speech perception.

Keywords: Predictive coding, Speech perception, EEG

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