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# The Neural Basis of Linguistic Prediction: Introduction to the Special Issue

Theories of language comprehension assume that people routinely predict upcoming linguistic material during sentence comprehension (e.g., Altmann and Mirkovic, 2009; Dell and Chang, 2014; Kutas et al., 2011; Pickering and Gambi, 2018). For example, the meaning of an upcoming word may be activated before it appears as input, which involves activation of relevant semantic knowledge in long-term memory in an anticipatory manner. How does the brain achieve this feat? Contributions to this special issue are dedicated to the neural basis of linguistic prediction; they either elucidate the neural processes and mechanisms by which the human brain generates and evaluates linguistic predictions, or offer new theoretical insights on the cognitive processes involved in linguistic prediction and their relationship to brain function.

Several contributions investigated effects of sentential or extra-sentential context on word predictions, focusing on modulation of the well-known N400 ERP response by word predictability. Brothers, Dave, Hoversten, Traxler and Swaab (2019) report a larger N400 predictability effect for reliable speakers who mostly produced predictable sentences compared to unreliable speakers who mostly produced unpredictable sentences, suggesting that listeners implicitly track the reliability of predictive cues in their environment. Zhang, Chow, Liang and Wang (2019) report a similar N400 effect of predictability in a high and low predictive validity context (containing 50% filler sentences that were predictable or incongruous, respectively), suggesting that participants were sensitive to predictability regardless of the extra-sentential context. Bulkes, Christianson and Tanner (2020) failed to find previously reported effects of predictability on the early stages of visual word recognition, but did find such effects when participants self-paced through the stimuli using button-press; they conclude that visual processing is more fine-grained with increased stimulus-control. Hintz, Meyer and Huettig (2020) report reduced N400s for words that finish a constraining discourse context in an unexpected way but that are related to the event described in the context, which they take as evidence for event-based predictions. Mantegna, Hintz, Ostarek, Alday and Huettig (2019) approach the long-standing question on whether a predictability N400 effect indeed results from prediction rather than integration by using rhyming vs. non-rhyming target words to manipulate their phonological predictability while keeping all targets equally plausible, i.e. equally easy to integrate within the context of the sentence. They attribute the obtained N400 effect to prediction.

Several other contributions throw light on the prediction versus integration debate via 'pre-nominal prediction effects' that are measured at a region preceding a predicted noun (usually an article or an adjective). ERP effects in this earlier region that depend on whether it matches or mismatches the yet-to-be seen noun are considered strong evidence for lexical prediction. Investigating the role of information structure in predictive processing, Bañón and Martin (2019) find a pre-nominal prediction effect on English indefinite (*a/an*) articles but only when the noun was rendered predictable by an it-cleft construction ('It is ..'). In a large scale ERP study on German sentence comprehension, Nicenboim et al. (2020) fail to find a clear pre-nominal prediction effect involving gender, but demonstrate a small prediction effect by combining their data with other recent datasets in a Bayesian meta-analysis. Based on simulations with a neural network model of sentence comprehension, Rabovsky (2020) argues that the English pre-nominal *a/an* effect may be diminished when the articles are only weak cues to the noun due to intervening adjectives, e.g. *an old kite*.

Two studies investigate the timing of morpho-syntactic prediction during sentence processing. Using adjectival modification in Standard Arabic, Matar et al. (2019) investigate the timing or syntactic category prediction and conclude that its effects can be found as early as in the visual M100 component. In a study on Italian sentence comprehension, Ito et al. (2020) compare the timing of pre-nominal prediction effects associated with the upcoming word's phonological features (whether its initial phoneme is a consonant or a vowel) vs. its morphological information (gender). They demonstrate that morphological information is preactivated more quickly than the word's phonology and interpret this finding within the production-based prediction accounts.

Yet other contributions combined computational modelling and/or information-theoretic approaches to investigate the neural basis of semantic or syntactic prediction. Michalon and Baggio (2019) present a new theoretical perspective on the 'semantic P600' as arising from a thematic conflict between a semantic prediction and a syntactic interpretation, and they develop an explicit algorithmic implementation of a parallel processing architecture that captures this conflict. Aurnhammer and Frank (2019) study the correlation between the N400 and well-known information-theoretic measures (surprisal and next word entropy) and a novel measure (lookahead information gain) as the amount of training data increases, and find that the cost of predicting may outweigh its gains thus casting doubt on the ubiquity of predictive processing. Shain, Blank, van Schijndel, Schuler and Fedorenko (2020) investigate which anatomical areas respond to modulation of the statistics of the local lexical and structural linguistic context during sentence processing. They find that the effects of lexical and structural prediction were separable and found within the language network, rather than in the domain-general multiple-demand network. Brennan, Dyer, Kuncoro and Hale (2020) evaluated linguistic complexity metrics from Recurrent Neural Network Grammars against fMRI data from participants listening to an audiobook, thereby dissociating perisylvian language regions wherein activity correlated with word surprisal from

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regions whose activity correlated with hierarchical structure (left posterior temporal lobe) and derivational complexity (left temporal lobe and inferior frontal gyrus).

Finally, two contributions focused on individual differences in predictive processing. Federmeier and Kutas (2019) find that older adults did not show reduced N400s for words that are semantically related to likely upcoming words during reading, and also did not show the hemispheric asymmetry in neural responses associated with prediction, suggesting diminished engagement of left hemisphere mechanisms for linguistic prediction compared to younger adults. In a review and position article, Ryskin et al. (2020) argue that children, older adults, and L2 learners engage less in prediction not due to an often deficit in executive resources, but either because they have less language experience or because prediction effects in these populations are hard to detect in paradigms designed for young adult native speakers.

In sum, the contributions in this special issue address various questions about the cognitive and neural basis of linguistic prediction, and reflect the diverse paradigms and approaches employed in contemporary psycholinguistic research on the issue.

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Mante S. Nieuwland*
*Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands*
*Donders Institute for Brain, Cognition and Behaviour, Nijmegen, the Netherlands*
*Heinrich-Heine-University, Düsseldorf, Germany*

Nina Kazanina
*School of Psychological Science, University of Bristol, Bristol, United Kingdom*
*Institute of Cognitive Neuroscience, National Research University Higher School of Economics, Moscow, Russian Federation*

* Corresponding author. Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands.
*E-mail address:* mante.nieuwland@mpi.nl (M.S. Nieuwland).