Combining computational language models and neuroimaging to understand prediction during language comprehension

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Prediction during language comprehension has been studied extensively in psycholinguistics. Prediction is typically studied within the context of psycholinguistic models which include prediction among other cognitive constructs such as retrieval and integration. In neatly controlled experiments there are conditions which contain sentences with varying degrees of predictability. Our approach to studying prediction (and integration) during language comprehension has been different. In recent studies we have combined computational language models with rich neuroimaging data sets to study prediction during contextualized language comprehension. I will give examples in my talk. The approach crucially rests on two ingredients that I will now briefly describe in turn.

First, we use computational language models to get to a computationally explicit implementation of prediction and integration. Computational language models have seen a recent and spectacular increase in their ability to perform a range of language tasks. Since most of their usage is application-based, the majority of models were not designed to be psychologically realistic. Still it has been found that the characterization from such models fits human language use data (e.g. reading times or eye movement durations during reading) reasonably well. The main reason to use computational language models in our line of work is that they make notions such as 'integration' and 'prediction' computationally explicit.

Second, we use rich, contextualized language stimuli. In most of our experiments, participants read or listen to narratives of a few thousand words long. The words within those narratives differ naturally in how predictable they are. We exploit this natural variation by regressing the prediction values as given by the computational language models onto the neural time series. Since we model prediction / integration for each word in the narrative, we end up with a statistically very powerful analysis. Not only is this approach statistically powerful, it is also efficient in the sense that every time point in the neuroimaging time series is used in the analysis. Finally, it scores high on ecological validity given that the language that our participants listen to is contextualized. One of the shortcomings of this approach is that it is essentially quasi-experimental. After all, as experimenters we do not manipulate our factors of interest.

In my talk I will present what we have learned so far about (the neural basis of) prediction during language comprehension from taking this approach. I consider my presentation a success if we engage in fruitful discussion about the advantages and disadvantages of studying prediction during language comprehension in this manner.