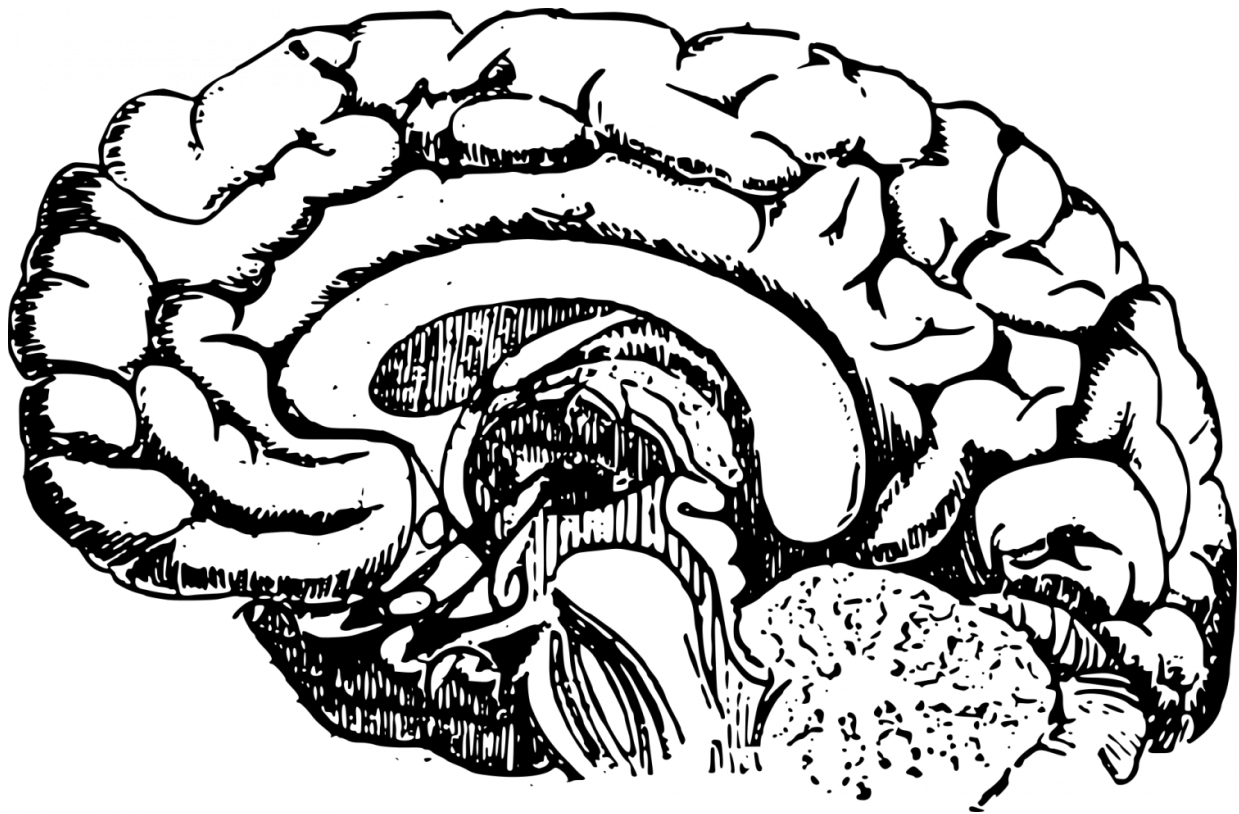


# Large-scale replication study challenges key evidence for the pro-active reading brain

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When people read or listen to a conversation, their pro-active brains sometimes predict which word comes next. But a scientific team led by the MPI for Psycholinguistics now demonstrates that the predictive function of the human language system may operate differently than the

field has come to believe in the last decade. Their study is the first large-scale, multi-laboratory replication effort for the field of cognitive neuroscience.

When listening to a speaker, we often feel that we know what they will say next. How is this possible? It is assumed that the [brain](#) routinely uses clues within a sentence to estimate the probability of upcoming words. Activating information about a word before it appears helps to rapidly integrate its meaning, once it appears, with the meaning of the sentence.

"For over 10 years, language scientists and neuroscientists have been guided by a high impact study published in *Nature Neuroscience* showing that these predictions by the brain are very detailed and can even include the first sound of an upcoming word," explains Mante Nieuwland, cognitive neuroscientist at the Max Planck Institute for Psycholinguistics (MPI) and the University of Edinburgh. These findings had, however, not yet been explicitly replicated since 2005, when the study came out.

Today, a new paper published in *eLife* by a scientific team led by Nieuwland of the MPI in the Netherlands questions the replicability of those results. The study is the first large-scale, multi-laboratory replication effort for the field of [cognitive neuroscience](#) and shows that the predictive function of the [human language](#) system may operate differently than the field has come to believe.

## **Same question, state-of-the-art approach**

"Inspired by recent demonstrations for the need for large subject-samples and more robust analyses in psychology and neuroscience research, we re-examined the research question of the original study. We did so by following the original methods and applying improved and current analysis methods," says Guillaume Rousselet from the University of Glasgow, co-author of the study. Furthermore, the researchers pre-

registered their analyses, providing a time-stamped proof that their analysis was not tailored to achieve the reported results.

The team embarked on a massive brain imaging study: Across 9 UK laboratories (University of Birmingham, University of Bristol, University of Edinburgh University of Glasgow, University of Kent, University College London, University of Oxford, University of Stirling, and University of York), 334 participants - 10 times the original amount - read sentences that were presented one word at a time, while [electrical brain activity](#) was recorded at the scalp. Each sentence contained an expected or unexpected combination of an [article](#) and a [noun](#) (e.g., "The day was breezy so the boy went outside to fly a kite/an airplane").

## Surprising nouns and articles

"We saw that unexpected nouns generated an increased brain response compared to expected nouns. Just like the original study," Nieuwland says. Nevertheless, this reaction, also called an enhanced N400 response, is not the core argument that the participants' brains actually anticipated the nouns. After all, it was generated after the nouns were read, and could mean that nouns like 'kite' are merely easier to process than nouns like 'airplane'.

The key evidence for prediction of a yet unseen noun was originally obtained on the preceding articles. In English, the correct use of the article 'a' or 'an' depends on the first sound of the next word. Even though 'a' and 'an' do not differ in their meaning, the 2005 study showed that unexpected articles also elicited an enhanced N400 response compared to expected articles. Presumably 'an' tells the readers that the next word cannot be 'kite'. This supported the claim that has stood since 2005 - that readers can make such precise predictions as the first sound of upcoming words.

"Crucially, our findings now show that there is no convincing evidence for this claim. With the original analysis, we did not replicate this pattern for the articles. With our improved analysis, we also did not find an effect that was statistically reliable, although the observed pattern did go in the expected direction," according to Nieuwland.

"Of course, it may be that people do predict the sound of upcoming words, but that they do not reliably use the articles to change their prediction. This could be because an unexpected article does not rule out that the expected noun will eventually appear ('a' can precede 'kite' if they are separated by another word, like in 'an old kite'). Also, we have to consider this study only investigates the English language. Other research has shown very different findings in languages such as Spanish, Dutch and French, for which articles correspond to nouns in grammatical gender regardless of intervening words. "

## **Less straightforward than assumed**

The authors caution that these new findings should not be interpreted as being against prediction more generally. "There is a larger body of behavioural and neuroscience work that supports a role of prediction in language processing, for example of the meaning of an upcoming word, although many of those other results in the existing literature, especially in neuroscience, still need to be replicated." However, these new findings show that the reading brain is perhaps not as pro-active as is often assumed, by demonstrating a potential limit to the detail in which it predicts.

**More information:** Mante S Nieuwland et al, Large-scale replication study reveals a limit on probabilistic prediction in language comprehension, *eLife* (2018). [DOI: 10.7554/eLife.33468](https://doi.org/10.7554/eLife.33468)

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