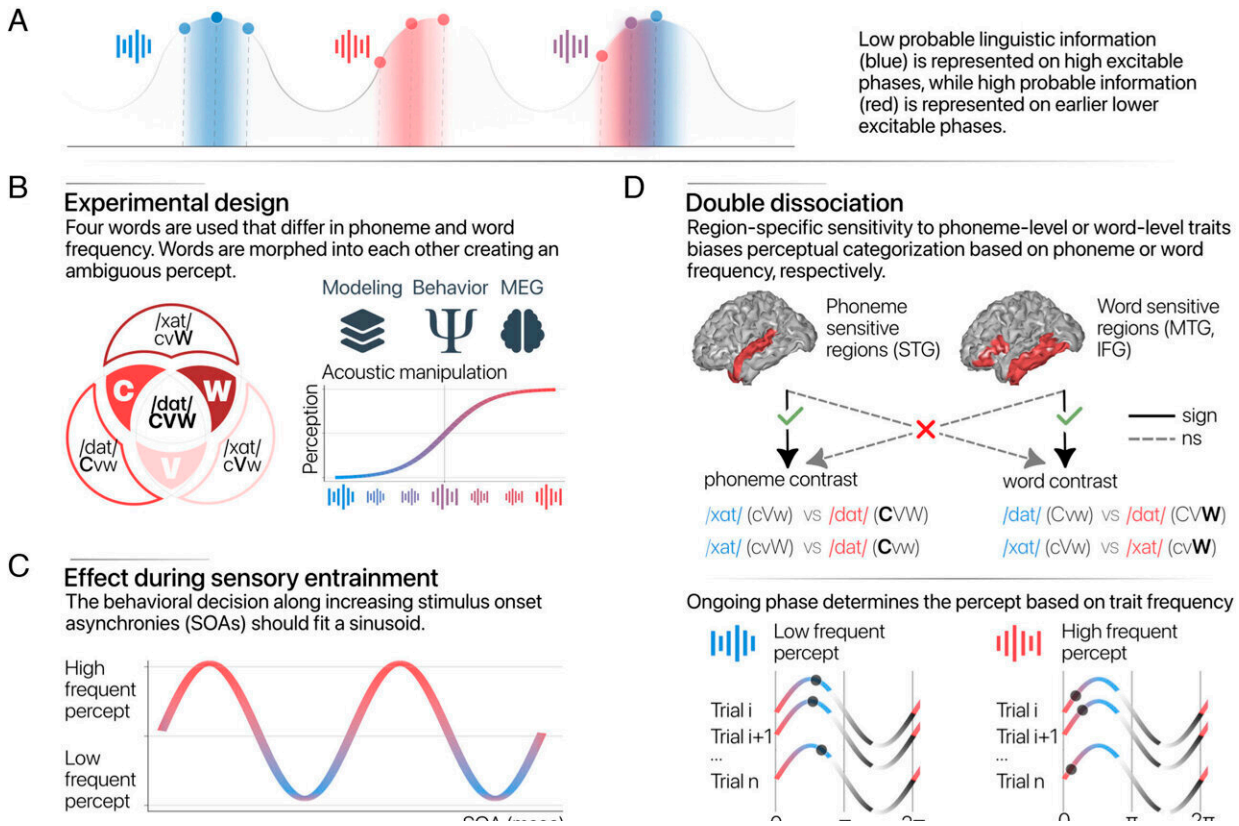
Study finds timing of brain waves shapes the words we hear

June 3 2024



Overview of the current study. Credit: *Proceedings of the National Academy of Sciences* (2024). DOI: 10.1073/pnas.2320489121

The timing of our brain waves shapes how we perceive our environment. We are more likely to perceive events when their timing coincides with

the timing of relevant brain waves. Lead scientist Sanne ten Oever and her co-authors set out to determine whether neural timing also shapes speech perception. Is the probability of speech sounds or words encoded in our brain waves and is this information used to recognize words?

The team first created ambiguous stimuli for both sounds and words. For instance, the initial sounds in da and ga differ in probability: "d" is more common than "g." The Dutch words dat "that" and gat "hole" also differ in word frequency: dat "that" is more common than gat "hole."

For each stimulus pair, the researchers created a spoken stimulus that was in between. Next, participants were exposed to each ambiguous stimulus and asked to select what they thought they heard (for instance, dat or gat). The team used magnetoencephalography (MEG) to record the timing of brain waves.

The findings are published in the journal *Proceedings of the National Academy of Sciences*.

Excitable phases

The researchers found that brain waves bias perception towards more probable sounds or words when stimuli were presented in a less "excitable" brain wave phase. Perception was biased to less probable sounds or words when stimuli were presented in a more "excitable" brain wave phase.

This means that both the probability of an event and its timing influenced what people perceived. Brain regions classically associated with speech sounds vs. word processing were sensitive to the probability of occurrence of sounds vs. words. Computational modeling confirmed the relationship between neural timing and perception.

"We conclude that brain waves provide a temporal structure that enhances the brain's ability to predict and process speech based on the probability of linguistic units," says ten Oever. "Predictable speech sounds and words have a lower threshold for activation, and our brain waves reflect this. Knowledge about how probable something is, and what it is (which phoneme or which word) work hand in hand to create language comprehension."

Predictive coding

"Our study has important consequences for theories of predictive coding," adds senior author Andrea Martin. "We show that the time (or phase) of information processing has direct consequences for whether something is interpreted as a more or less likely event, determining which words or sounds we hear.

"In the fields of speech and language processing, most emphasis has been put on the neural communication role of neural oscillations. However, we show that properties of phase coding are also used for interpreting speech input and recognizing words."

More information: Sanne Ten Oever et al, Phase-dependent word perception emerges from region-specific sensitivity to the statistics of language, *Proceedings of the National Academy of Sciences* (2024). DOI: 10.1073/pnas.2320489121

Provided by Max Planck Society