Brain recordings in people before surgery reveal how minds plan what to say prior to speaking

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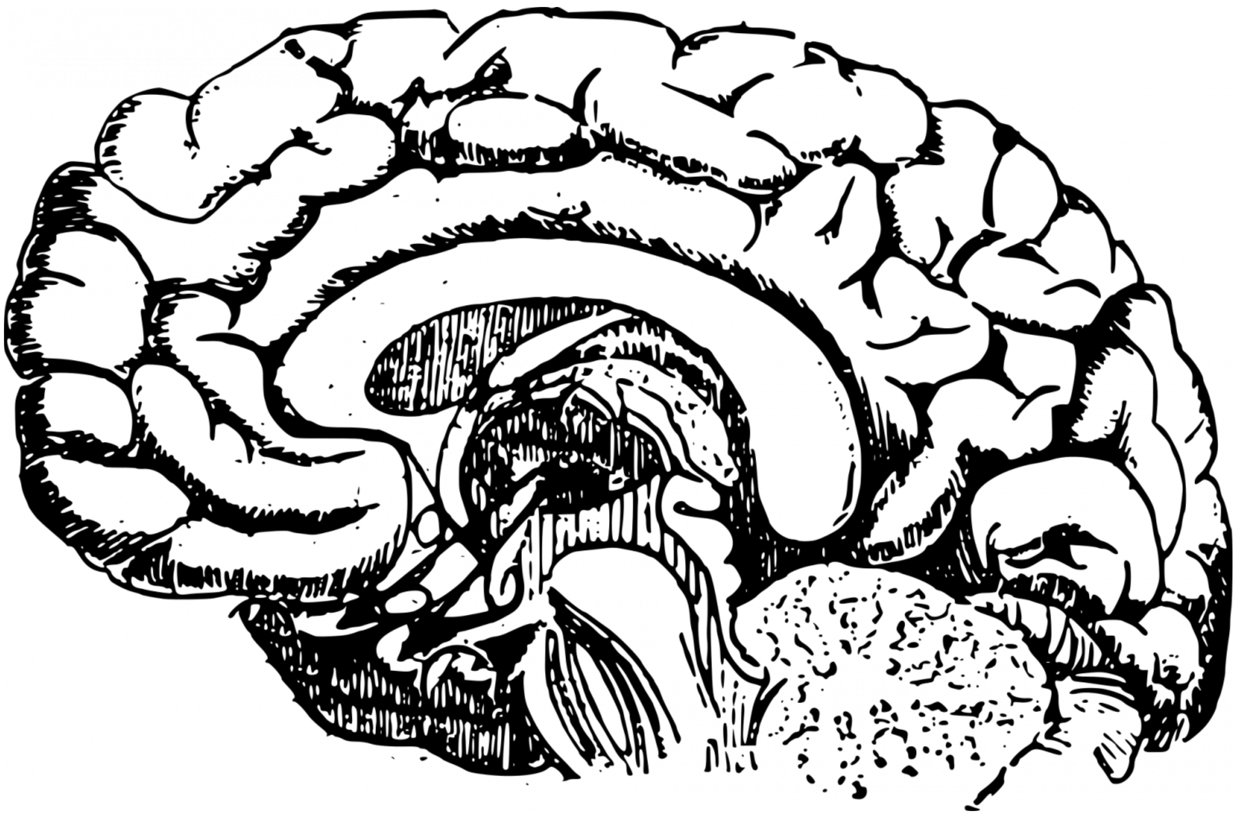

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A new study in people undergoing surgery to treat seizures related to epilepsy shows that pauses in speech reveal information about how people's brains plan and produce speech.

Led by researchers at NYU Grossman School of Medicine, the study results add to evidence that neighboring brain regions, the inferior frontal gyrus and the motor cortex, play an important role in such planning before words are said aloud. Both are part of the folded top layers of the brain, or cerebral cortex, which has long been known to control the muscle (motor) movements in the throat and mouth needed to produce speech. Less clear until now was how closely these regions determine the mix of sounds and words people want to say aloud, the authors report.

Published in the journal *Brain*, the findings come from an analysis of hundreds of brain-mapping recordings made on 16 patients between the ages of 14 and 43 preparing for surgery to treat epilepsy at NYU Langone Health between 2018 and 2021.

As a routine part of their procedures, surgeons electrically (and painlessly) stimulate specific parts of the brain while asking patients to perform standardized speaking tasks. Patients are asked, for example, to recite numbers or days of the week, or even the Pledge of Allegiance.

The goal before surgery, researchers say, is to isolate and spare the parts of the brain nearby needed for speech, as marked by increased slurring or total loss of speech following electrical stimulation. This enables surgeons to remove only the brain tissue responsible for the errant electrical signals that cause seizures.

What makes the new study unique, the researchers say, was their measurement and analysis of the time intervals, lasting less than two seconds, during which brain stimulation starts and speech becomes slurred and eventually stops. Previous research, they note, did not directly measure such latencies, but instead relied on behavioral observations to inform which brain regions were involved in whether a patient could continue to speak or not after stimulation of the cortex.

Measuring the latencies, they say, provides new insight into the parts of the cortex involved in planning speech, even if not responsible for actually voicing and mouthing the words. Among the new study findings was that latencies between electrical stimulation and eventual loss of the ability to speak were different among brain regions.

Latencies were longest in the inferior or lower regions of the motor cortex as well as another surface layer, the inferior frontal gyrus, at 1.0 seconds and 0.75 seconds, respectively. Because patients were able to keep speaking so long after stimulation, investigators say this suggests that these regions are more likely than other regions to be involved in planning what people want to say.

Smaller latencies, lasting on average 0.5 seconds, were found in other parts of the motor cortex. Researchers say these shorter interruptions of speech indicate that these regions play a more crucial role in the physical mechanics of speaking.

Based on these observations, researchers determined that a pattern of longer latencies corresponded to speech planning in different regions of the brain cortex more likely than shorter latencies, which corresponded to parts of the brain cortex involved in speech production.

"Our study adds evidence for the role of the brain's motor cortex and inferior frontal gyrus in planning speech and determining what people are preparing to say, not just voicing words using the vocal cords or mouthing the words by moving the tongue and lips," said study lead investigator Heather Kabakoff, Ph.D., a speech pathologist at NYU Langone.

"Our results show that mapping out the millisecond time intervals, or latencies, between electrical stimulation in parts of the brain to the disruption or slurring of words and eventual inability to speak can be used to better understand how the human brain works and the roles played by different brain regions in human speech," said study senior investigator and neuroscientist Adeen Flinker, Ph.D. "When it comes to mapping out functions of the brain cortex involved in speech, timing is key."

Flinker, an associate professor in the Department of Neurology at NYU Langone, says the team's overall findings also confirm that motor execution and speech planning occur in distinctly different areas of the brain.

Clinically, Flinker says the team findings, if further research confirms their work, could help surgeons better refine their brain mapping to protect patients' speech.

Researchers say their next steps are to evaluate latency patterns in other parts of the brain to determine if they too play a role in the finer functions of planning speech or physically making sounds and words. Tasks include the naming of pictures aloud to determine if poststimulation latencies help distinguish parts of the brain needed to interpret visual inputs and process them into actual words.

They also want to investigate whether latency patterns can expose real-time speech feedback mechanisms by measuring how long it takes patients to correct forced errors. This, they say, could provide insight into how people use the sound of their own voice to control the way they sound.

Besides Flinker and Kabakoff, other NYU Langone researchers involved in the study are co-investigators Leyao Yu, BA; Daniel Friedman, MD;

Patricia Dugan, MD; Werner Doyle, MD; and Orrin Devinsky, MD.

More information: Heather Kabakoff et al, Timing and location of speech errors induced by direct cortical stimulation, *Brain* (2024). DOI: 10.1093/braincomms/fcae053

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