Characterizing neural speech preparation of fluent and stuttered utterances in adults who stutter

Background: Brain imaging research using speech and non-speech tasks has revealed that adults who stutter (AWS) show structural anomalies and atypical activation patterns across sensory and motor regions in the speech-motor network (1-2). However, little is known of the neural processes immediately prior to speech onset and whether this activity can differentiate between stuttered and fluent utterances. In part this is because previous studies have not used imaging methods with sufficient temporal resolution. Speech preparation in non-stuttering speakers induces changes in neural oscillations in motor and auditory regions that are initiated as early as 500 milliseconds preceding speech onset (3-4). Such oscillatory changes are strong indicators of sensory-motor recruitment in coordinating the speech network (5). In the current study we used magnetoencephalography (MEG) to characterize the millisecond-scale processes that precede speech onset of fluent and dysfluent utterances in AWS.

Methods: Twelve AWS rated each of 410 words on the likelihood that they would trigger stuttering. These ratings were used to create participant-specific lists of 220 stimuli each that represented either high or low stuttering anticipation words. Matched control participants were also exposed to the 410 word list (without rating them for stuttering). Two weeks later, participants were cued to overtly read their individual word lists, each word embedded in a carrier phrase, while their brain activity was continuously recorded using a 151-channel MEG scanner. Control participants were presented with the word lists of their matched AWS. Bipolar EMG electrodes were used to detect speech onset from the orbicularis oris. Fluent and dysfluent trials were separated out for independent analysis. After localizing the target MEG signal, activation magnitude was quantified by integrating the time course of the signal in predefined regions of speech preparation (prior to speech onset) and execution (following speech onset).

Results: 314 stuttered utterances were generated across nine participants and compared to fluently produced tokens. In the fluent utterances, speech preparation induced cortical oscillatory modulation bilaterally in the visual, mouth, and auditory cortices. Compared to controls, AWS showed stronger mouth motor cortex engagement bilaterally already in the speech preparation phase, and continued to do so during execution. AWS recruited the right mouth motor cortex significantly earlier in the preparation phase, while controls engaged it closer to speech onset. The analysis of the stuttered utterances and their comparison with fluent speech is currently under way and will be reported at the meeting.

Conclusions: Exaggerated motor response in preparation for speech execution in AWS is proposed to reflect facilitative mechanisms adopted in a limited motor speech network where articulatory-motor representations required for speech coordination have not developed optimally. Enhanced motor activity could further alter proper communication with auditory-sensory regions critical for monitoring speech outcomes. It is expected that the comparison of fluent and stuttered utterances will yield significant insights into the brain processes that precede the observable disruption of fluent speech. As this study involved a large group of AWS, it will be the first to characterize general and individual neural processes leading up to fluent versus stuttered utterances.

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