Neural speech motor control: Speech kinematics and coordination measured with a neuroimaging-compatible speech tracking system

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1. Introduction

Articulography and functional neuroimaging are two major tools for studying the neurobiology of speech production. Until now, however, it has generally not been feasible to use both in the same experimental setup because of technical incompatibilities between the two methodologies. Here we describe results from a novel articulography system dubbed Magneto-articulography for the Assessment of Speech Kinematics (MASK; [1]) used to obtain kinematic profiles of oro-facial movements during speech, together with concurrent magnetoencephalographic (MEG) measurements of neuromotor brain activity [2, in press].

2. Methodology

MASK was used to characterise speech kinematics in ten healthy adults. The results were compared to measurements from an adult participant with a conventional Electromagnetic Articulography (EMA) system. Analyses targeted the gestural landmarks of reiterated utterances /ipa/ and /api/ and /pataka/, produced at normal and faster rates, and inter- gestural and intra- gestural coordination, indexed by relative phase [3].

3. Results

Results showed that movement peak velocity increased as an overall linear function of movement amplitude. Opening and closing movements showed comparable amplitude/velocity relationships indicating that these parameters are controlled in a similar manner regardless of movement direction (Fig.1, left panel). Kinematic stiffness covaried with movement duration; stiffness systematically decreased as a curvilinear function of durations less than about 200 ms while the relationship plateaus into a relatively flat line at greater durations (Fig.1, right panel). Regarding the relative phase, results showed that the gestural movements of /ipa/ and /api/ can be seen as mirror images, where the relative motions of tongue body (TB) and bilabial closure (BC) gestures are reversed. This reversal is readily apparent in the inter-gestural timing plots of Fig. 2 (right side). These results demonstrate that MASK reliably characterises key kinematic and movement coordination parameters of speech motor control.

4. Conclusions

The orderly patterns of speech behaviors that emerge in the present results are suggestive of parameters that play key roles in the motor control of human speech.

This new capability for measuring and characterising speech movement parameters, and the brain activities that control them, within the same experimental setup, paves the way for innovative cross-disciplinary studies of neuromotor control of human speech production, speech development, and speech motor disorders.

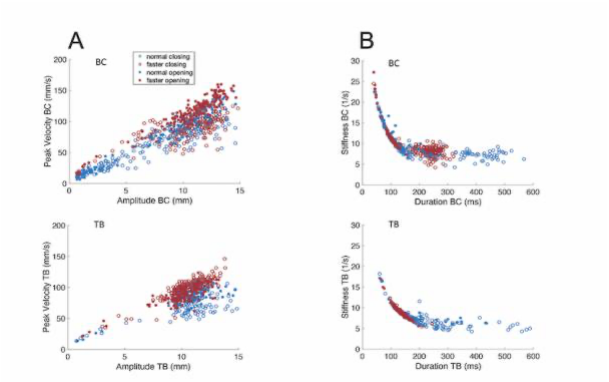

Figure 1. Covariation of kinematic parameters of BC and TB gestures for participant MASK2, for productions of /ipa/.

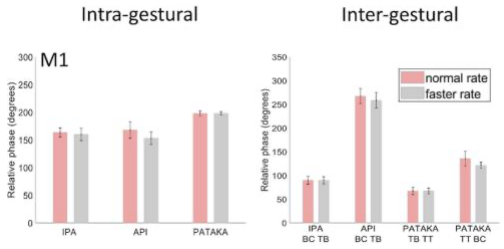

Figure 2. Mean and SD of relative phase for intra- and inter-gestural coordination for participant MASK 1 at normal and faster rates for productions of /ipa/, /api/ and /pataka/.

5. References

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