Evaluation of prototype MagTrack articulograph and its effects on speech production

Christopher Geissler and Maura Jaye (Boston College)

Rationale/Purpose: MagTrack is a prototype flashpoint-tracking system for speech research, and a possible alternative to electromagnetic articulography (EMA). However, current MagTrack tracers are larger than those of EMA systems. In this study, we establish the reliability of a MagTrack system with mechanical testing, then compare its effects on speech articulation and acoustics with those of EMA.

Methods: For mechanical tests, two MagTrack tracers were affixed to a static wooden rod, a plastic pendulum, and a 3D-printed plastic turntable. For *in vivo* tests, three MagTrack tracers were affixed to one English speaker in the midsagittal plane: one each on the vermillion border of the upper lip, the gingival margin of the lower incisors, and ~1cm behind the tongue tip. Measurements were compared to EMA recordings taken of the same speaker producing the same stimuli with an NDI WAVE system as part of the Haskins-IEEE Rate Comparison Database (Tiede et al. 2017). Following acoustic analysis, we found the recorded position of the tongue tip at the acoustic midpoint of /s/, /θ/, and the closure of /t/.

Results: In static tests, the distance between two sensors placed 30 mm apart were recorded accurately (mean 29.83 mm, SD 0.079). In the moving pendulum test, results were less accurate and more variable (mean 43.5 mm, SD 10.8), especially at the edges of the tracking area and very high velocities. Later mechanical tests conducted after prolonged, accidental exposure to weak magnetic fields resulted in recordings that were inaccurate but consistent within each trial.

With MagTrack, articulation differed in the early and late portions of the recordings. In the early blocks, the articulatory steady-state for /s/ and /t/ was ~3 mm behind that of /θ/. In the late blocks, /s θ t/ were retracted to ~4mm behind the previous position of /s/ and /t/. In the EMA data, /s/ was likewise ~3 mm behind /θ/, but /t/ was recorded ~4 mm behind /s/; these did not change over the course of the recording session.

Vowel acoustics were minimally impacted by MagTrack, but coronal obstruents were substantially affected. Some /t/s lacked a complete closure, with audible turbulent airflow throughout. As compared to the no-sensor condition, /s/ in EMA and MagTrack conditions had a lower spectral center of gravity (CoG) and higher (positive) skewness; kurtosis, though, was highest for EMA. With both EMA and MagTrack, /θ/ had a higher CoG and SD.

Discussion: The effects of wearing tracers was most pronounced for close constructions at the location of the tracer. Both EMA and MagTrack tracers had quantifiable acoustic effects, particularly on /s/, where they disrupt the precise formation of a narrow channel. The larger tracers of MagTrack caused the speaker to change the location of coronal constrictions over time. Overall, we find MagTrack to be a promising tool, but caution that large tracers can induce changes in articulation.