Ultrasound imaging in clinical speech settings

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Background: Real-time imaging of the tongue during speech production can be useful in making specific diagnostic/prognostic decisions, describing the nature of current and target articulatory configurations, and providing qualitative feedback to help shape an individual's tongue to match a visual model (e.g. Sugden et al., 2019; Bernhardt et al., 2005). The primary focus of this class will be on the use of ultrasound biofeedback in children with speech sound disorder (SSD), the efficacy of which has been documented in numerous case studies and single-case experimental studies, including Cleland et al. (2015) and Preston et al. (2019). This class will cover 1) methods used to collect ultrasound images of the tongue, 2) interpretation of ultrasound images of the tongue, and 3) instruction on administration of real-time ultrasound biofeedback. The methods that will be described reflect those utilized in NIH R01DC013668 grant "Improving clinical speech remediation with ultrasound technology" (PIs: Whalen; Boyce) and NIH F31DC018197 grant "Establishing the role of sensorimotor skills in speech development and disorders" (PI: Kabakoff; Sponsor: McAllister; Co-Sponsor: Whalen).

Data collection: While the most widely-used measure of accuracy in a clinical setting is the clinician's perceptual judgment, ultrasound recordings and time-synced audio/video allow for later objective measurement to provide insight into speech development. To track clinician ratings during treatment, we use a custom target elicitation software that applies the principles of motor learning to adaptively increase stimulus difficulty and reduce clinician support in an effort to maximize generalization of treatment gains (McAllister Byun et al., 2014). Ultrasound video is digitally encoded using a video capture card and associated software. Placing the ultrasound probe (e.g., a Siemens C8-5 transducer) in a microphone stand is an adequate way to achieve probe steadiness for treatment purposes. For quantitative progress tracking, improved stabilization via a child-friendly adjustable headset is preferred (e.g., Derrick et al., 2018). To ensure midsagittal alignment, visual facial/probe markers can be tracked and used to calculate by-frame degree of probe displacement from video. Misaligned frames can be identified in the ultrasound video and discarded.

Interpretation of images: During real-time inspection of ultrasound images, the area under the visible bright contour is interpreted as the tongue's surface. Only the region between the anterior mandibular shadow and the posterior hyoid shadow is interpreted. In treatment for /r/ errors, qualitative evaluation of tongue shapes can be made, such as whether an individual utilizes a shape with the tongue blade raised (bunched) or with the tongue tip raised (retroflex). For quantitative evaluation of tongue shape, lingual contours can be traced using specialized software (e.g, GetContours; Tiede, 2016) and degree of lingual complexity can be calculated (Dawson et al., 2016; Preston et al., 2018).

Tutorial for administering ultrasound biofeedback: In a typical therapeutic interaction, the clinician encourages the learner to explore different articulatory strategies that facilitate production of a perceptually accurate target sound, such as /r/. In early stages of treatment, the clinician can display 1-2 ultrasound images from typically developing speakers to serve as a visual model. Custom pointers and contour outlines can be superimposed over the ultrasound screen to signal the articulatory target (see Figure 1). Early phases aim to explore various tongue shapes, with the focus shifting over time to one or more shapes judged most successful in eliciting a perceptually accurate sound. Previous studies incorporating ultrasound into treatment for the /r/ sound have described such clinician cues as raising the tongue tip/blade, retracting the tongue root, and raising the lateral edges of the tongue to form a grooved contour. While 2D ultrasound devices have elucidated how some combination of these three articulatory characteristics is required to yield a perceptually accurate /r/ sound, efforts to describe optimal tongue shapes for /r/ using 3D ultrasound are currently underway.

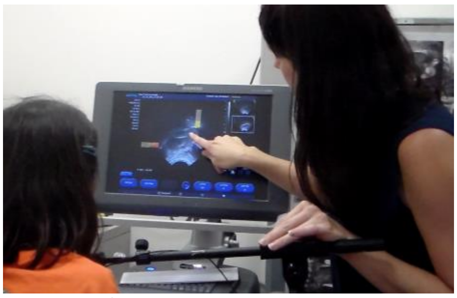

Figure 1. Photo of clinician using visual targets on the screen to facilitate correct production of /r/ from a child speaker.

Conclusion: Many children with SSD who have not responded to prior traditional treatment derive benefit from guided support using ultrasound. Coupled with traditional treatment techniques, ultrasound can provide the child with immediate insight into the extent to which they are meeting articulatory goals, which may in turn help them achieve auditory-perceptual goals. After this class, learners will know how to collect and interpret ultrasound images of the tongue and how to use this info to assess and provide feedback to clients about their tongue shape during speech.

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