Gradient Acquisition of Velars via Ultrasound Visual Biofeedback Therapy for Persistent Velar Fronting.

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BACKGROUND: Velar fronting (substituting /k,g,ŋ/ with [t,d,n] is a well attested phonological process in both the speech of young typically developing children and older children with speech sound disorders, with typically developing children acquiring velars by the time they are three and half years old. This particular speech error is of interest because absence of velars in the phonetic inventory at three years of age is predictive of phonological disorder and children who fail to differentiate coronal (tongue tip) and dorsal (tongue body/back) articulations may present with motoric deficits. When children fail to acquire velars in the process of normal development, speech therapy techniques which draw children's attention to the homophony in their speech sound systems is can be effective. However, a subset of children become persistent velar fronters, still unable to articulate velar consonants well into the school years. Cleland et al. (2015) showed that it is possible to remediate persistent velar fronting using Ultrasound Visual Biofeedback (U-VBF), but like most studies of instrumental articulatory therapies, very little about how the children acquire the new articulation is known, with most studies presenting pre and post therapy assessment data only.

This paper presents data from multiple assessment time-points from the Cleland et al. (2015) study. Given that these children may have a motoric deficit it is important to look at the fine phonetic detail of their articulations in order to identify how they begin to make new articulatory gestures and how these gestures change over time.

METHOD: Data from four children with persistent velar fronting was analysed. Each child received 12 sessions of therapy with U-VBF and five assessment sessions. All ultrasound data was recorded with a high-speed Ultrasonix SonixRP machine running Articulate Assistant Advanced software (Articulate Instruments, 2012) at 121 frames per second. The probe was stabilised with a headset and data was normalised across sessions using hard-palate traces. Attempts at velar and alveolar minimal pairs from pre-therapy, mid-therapy, post-therapy and six weeks post therapy were annotated at the burst. The nearest ultrasound frame to the annotation point was selected and a spline indicating the tongue surface fitted to the image using the automatic function in AAA software. We calculated radially "kmax-t" where "kmax" was the tongue spline point at the burst of /k/ further from the probe and "t" was the tongue spline point along the same fan line. Results were compared to those for 30 typical children. In addition, we used the methodology from Roxburgh et al. (under revision) to perceptually evaluate the children's attempts at words containing velars at four of the time points.

RESULTS: Three of the children achieved a dorsal articulation after only three sessions of U-VBF. One child (05M) achieved no velars after 12 sessions of therapy, but went on to achieve velar stops after a second block of U-VBF. In each child, pre-therapy kmax-t was near zero, indicating no difference in tongue shapes for /t/and /k/ and suggesting no covert contrast. Mid-therapy, two children overshot the optimum kmax-t (heard as uvular) and subsequently moved in a gradient fashion towards kmax-t in the normal range. The other two children had kmax-t small than normal at mid-therapy, but increased this measurement to normal levels six weeks post-therapy. Results of the perceptual experiment show similarly gradient improvement, with listeners rating later attempts at words

containing velars as more like those of adults, even when phonetic transcription rated adjacent session recordings as both 100% on target. This gradual improvement in the articulation if velars suggests a motor-based deficit in these children with persistent velar fronting.

References.

Cleland, J., Scobbie, J. M., & Wrench, A. A. (2015). Using ultrasound visual biofeedback to treat persistent primary speech sound disorders. *Clinical linguistics & phonetics*, (0), 1-23.