The final version of this appears in Wood, S., Cleland, J. & Roxburgh, Z. (2015) Powerful tools for motor-based treatment approaches. *Royal College of Speech and Language Therapists Bulletin*, 762, 18-20.

Speech Sound Disorders

Powerful tools for motor-based treatment approaches

Sara Wood, Joanne Cleland and Zoe Roxburgh provide a guide to visual biofeedback techniques in the treatment of speech sound disorders

Since the phonological revolution in the 1970s, SLTs have embraced phonological intervention when dealing with speech sound disorders (SSDs) and largely turned their backs on articulatory approaches.

Joffe and Pring (2008) surveyed 98 clinicians working with children with speech difficulties and found the most common approaches used with this client group were auditory discrimination, minimal pairs and phonological awareness, with articulatory approaches used only 'sometimes' by around half of respondents. While there is good evidence that phonological impairments can be remediated with these types of phonological therapies (Law, Garrett and Nye, 2003), there remains a proportion of children with persistent SSDs for whom traditional phonological approaches do not provide the whole solution. For these children, the likely root of the impairment is motoric (Gibbon et al, 1999).

Motoric speech impairments

Motoric speech impairments need interventions that capitalise on the principals of motor learning (see Maas et al, 2008 for a tutorial on how to use the principles of motor learning in speech therapy). Moreover, children with ingrained incorrect motor programmes (for example, children who persistently misarticulate certain phonemes) are often resistant to traditional speech therapy approaches, with visual biofeedback (VBF) often cited as the missing piece of the puzzle.

Visual biofeedback techniques in this context are instrumental phonetic techniques that allow clients to see their own articulators moving in real-time and use this information to correct erroneous motor programmes. These techniques are especially useful for errors involving lingual articulations and offer clients real-time biofeedback of their own tongue moving *and* a visual model of what their tongue *ought* to be doing – in essence a target motor programme. Visual biofeedback therapies typically start with the clinician demonstrating a target movement to the client before the client sees their own tongue and attempts to reproduce the movement.

There is increasing interest in offering a visual articulatory model (VAM) only, using dynamic models or videos of articulations without the biofeedback. Several apps exist for this purpose, for example 'Speech Trainer 3D'. However, there is limited evidence for the use of VAMs. Only one study, Kroger et al (2005), has tested a VAM in therapy for clients with developmental speech disorders and apraxia of speech. There was a significant increase in visual recognition rate of sounds and syllables within both client groups.

We suspect some clients require the direct biofeedback that some instrumental phonetic techniques offer. Techniques which show the client what their own tongue is doing in real-time provide explicit knowledge of performance that clients and therapists use together to stabilise new motor programmes. Additionally, they are powerful diagnostic tools, enabling clinicians to identify covert contrasts and errors often undetected through auditory analysis, which can be important when planning therapy.

Electropalatography and ultrasound

Electropalatography (EPG) has led the way as a VBF technique in the speech therapy clinic. It requires the client to wear a custom-made artificial palate with 62 silver-electrodes embedded in the surface. Contact with the tongue activates the electrodes, enabling EPG to provide a real-time visual display of tongue-palate contact represented by a standard palate shape (Gibbon and Wood, 2010).

Over the past 30 years, a large number of small-scale studies have shown that EPG has great potential as a VBF device (Gibbon, 2011), although it is often considered relatively expensive due to the manufacture costs of the palate. In a randomised controlled trial (Michi et al, 1993) children receiving EPG intervention required fewer sessions to reach treatment goals compared to those receiving conventional therapy. This suggests EPG is a cost-effective method of intervention.

A less expensive and relatively new technique is ultrasound visual biofeedback (U-VBF). This uses standard medical ultrasound to image the tongue in real-time. Placed under the chin, the probe allows real-time visual feedback of most of the surface of the tongue in either the mid-sagittal or coronal plane. Unlike EPG, the image is an anatomically correct representation of a slice of the speaker's own tongue and the technique is less expensive (after purchasing the equipment).

The evidence for U-VBF therapy is small but promising, with around 20 small case or group studies reported in the literature. Most studies originate from the US and Canada, with therapy mainly addressing the production of the consonant /r/; however, recent work by the Ultrax project shows great potential for other targets such as velars, sibilants and alveolars.

While ultrasound is cheaper to use than EPG, it too has drawbacks. For example, in the mid-sagittal view (most commonly used for therapy) the lateral margins of the tongue are not visible and the relation of the tongue to the hard palate is not imaged. Also, the imageable area is constrained by shadows from bone, with the tongue tip in particular being susceptible to a shadow from the mandible. These difficulties with the clarity of the image may explain why in a study of naïve participants, most found EPG images easier to interpret than ultrasound images (Cleland et al, 2013).

VBF versus VAMs

There therefore exists a hierarchy of costs and logistics associated with VAMs and VBF – with VAMs being easily accessible and cheap, ultrasound being less accessible but still relatively cost effective and EPG being the most expensive. However, it is also clear that the techniques are not equivalent in what they offer. Visual articulatory models offer no direct feedback of the speaker's own articulations and the SLT is unable to use it to demonstrate non-English speech sounds. For example, a client with cleft palate may produce pharyngeal articulations that the SLT would be unable to demonstrate using the VAM because they are typically based on English.

Visual biofeedback therefore holds a major advantage over VAMs since it not only gives direct knowledge of performance of the speaker's own articulations, but is also a powerful diagnostic tool. Still, the two VBF techniques we review here are not equivalent; while they both offer information about lingual targets they do so in quite different ways, making the choice of which technique to use difficult. Table one offers a recommendation as to which techniques suits which types of errors best.

The final version of this appears in Wood, S., Cleland, J. & Roxburgh, Z. (2015) Powerful tools for motor-based treatment approaches. *Royal College of Speech and Language Therapists Bulletin*, 762, 18-20.

Summary

Visual biofeedback techniques and VAMs show great potential for the treatment of SSDs, particularly those that have been unresponsive to more conventional therapy approaches. While more research is needed to prove effectiveness as a intervention approach and to tease apart which techniques work best for which clients, it is clear these techniques are potentially a powerful tool for motor-based treatment approaches.

Dr Sara Wood and Zoe Roxburgh, Clinical Audiology, Speech and Language Research Centre, Queen Margaret University; Dr Joanne Cleland School of Psychological Science and Health, University of Strathclyde. Email: SWood@qmu.ac.uk

References

Cleland J, McCron C, Scobbie JM. Tongue reading: Comparing the interpretation of visual information from inside the mouth, from electropalatographic and ultrasound displays of speech sounds. *Clinical Linguistics and Phonetics* 2013; 27:4, 299-311.

Gibbon FE, Wood SE. Visual feedback therapy with electropalatography (EPG) for speech sound disorders in children. In Williams, L, McLeod S, McCauley R. (Eds.) *Interventions in Speech Sound Disorders*. Baltimore: Brookes, 2010, 509-536.

Gibbon F, et al. Widening access to electropalatography for children with persistent sound system disorders. *American Journal of Speech-Language Pathology* 1999; *8*, 319-334.

Joffe V, Pring T. Children with phonological problems: A survey of clinical practice. International *Journal of Language and Communication Disorders* 2008; 43:2, 154–164.

Kroger BJ, et al. A visual articulatory model and its application to therapy of speech disorders: a pilot study. *ZAS Papers in Linguistics* 2005; 40, 79-94.

Law J, Garrett Z, Nye C. *Speech and language therapy interventions for children with primary speech and language delay or disorder*. Cochrane Database of Systematic Reviews, Issue 3. 2003. *Art. No.: CD004110. DOI*, *10*, 14651858.

Maas E, et al. Principles of motor learning in treatment of motor speech disorders. *American Journal of Speech-Language Pathology* 2008; 17: 3, 277-298.

Michi KI, et al. Role of visual feedback treatment for defective/s/sounds in patients with cleft palate. *Journal of Speech, Language, and Hearing Research* 1993; 36:2, 277-285.

The final version of this appears in Wood, S., Cleland, J. & Roxburgh, Z. (2015) Powerful tools for motor-based treatment approaches. *Royal College of Speech and Language Therapists Bulletin*, 762, 18-20.

Links to Further Information:

Clinical Audiology, Speech and Language Research Centre: www.qmu.ac.uk/casl

The UltraPhonix Project: http://www.qmu.ac.uk/casl/ultraphonix/default.htm

The Ultrax Project: www.ultrax-speech.org

EPG and Down's Syndrome Project: www.qmu.ac.uk/nuffield-epg-down-syndrome

Seeing Speech Website (Ultrasound and MRI examples of speech): www.seeingspeech.arts.gla.ac.uk/uti/

The final version of this appears in Wood, S., Cleland, J. & Roxburgh, Z. (2015) Powerful tools for motor-based treatment approaches. *Royal College of Speech and Language Therapists Bulletin*, 762, 18-20.

Table one: Comparison of EPG and U-VBF (ultrasound) techniques for treating various types of SSD.

Error type/	**EPG**	**U-VBF**	**Recommended technique**
Velar fronting/alveolar backing/ double articulations /k,g,ng,t,d,n/	✓ Back of hard palate visible, but /k/ in back vowels contexts is not imageable	✓✓	U-VBF
Post alveolar fronting of /ʃ/ & affricates	✓✓ Wider grooving visible	✓✓ Tongue retraction and 'bunching visible'	Either
Lateral sibilants or other errors with lateral escape	✓✓	✓ Some information in coronal view	EPG
Stopping of fricatives/ affricates	✓✓ Complete closure vs grooved sibilant visible	✓Some information in coronal view	EPG
Vowel errors	✓ Some information for high vowels	✓✓ All vowels imageable	U-VBF
/r/ errors	✓ Some information	✓✓ Full information on bunched and retroflex varieties	U-VBF
/l/ errors	✓ Light /l/ visible	✓ Dark /l/ visible but no simultaneous lateral info	Dependent on exact error
Dyspraxia/sequencing errors	✓	✓	Dependent on segmental errors

✓**:** Technique potentially useful

✓✓: technique likely to beneficial