Evaluating the Clinical Effectiveness of EPG in the Assessment and Diagnosis of Children with Intractable Speech Disorders

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Introduction

In every clinic there are a group of children who present with speech sound production errors which persist well beyond the stage of normal childhood development. Some may have an identifiable aetiology, for example cleft palate. Many others, estimated at 3-5% of the school-aged population (Enderby and Philipp, 1986), have disorders with no known cause. In both groups, some of these children receive many years of speech therapy and are either very slow to resolve or are eventually discharged with residual errors. Systematic speech production errors that are judged not to have responded to conventional clinical intervention, or those in children who are 10 years or older but who have not been referred to speech therapy until very late are defined here as “intractable”. Such cases are problematic since they are expensive for service providers in terms of time and resources, and they increase waiting times for others. From the perspective of the child, persistent difficulties can have a detrimental effect on their educational and social development.

A fundamental requirement for clinically-effective treatment is an accurate diagnosis of the speech problem. Yet, despite well-documented limitations, “auditory-articulatory descriptions remain the lingua franca of the speech and language therapy profession” (Grunwell, 1993: p.2). The problem is that these procedures are subjective, and so transcription is replete with errors and intra- and inter-transcriber variability. A study by Amorosa, von Benda, Wagner and Keck (1985) highlighted how “agreement [between transcribers] often did not reflect the child’s production but rather the transcribers’ ‘normalisation’ of what they had heard” (p.281). This is not a failing of particular transcribers but a flaw in the methodological assumptions underpinning the field. The human perceptual system is simply inca-2003 for CPLOL – draft, please do not circulate further, this paper is subject to redrafting.
pable of detecting some of the extremely subtle distinctions found in disordered child speech (Scobbie, Gibbon, Hardcastle & Fletcher, 2000).

**Method and Procedures**

Twelve children aged between 7 and 10, with a variety of speech sound errors described by the referring therapist as intractable, were referred for Electropalatographic (EPG) investigation. The EPG system we used, Articulate Assistant 1.3, is based on the Reading EPG system (Articulate Instruments, [http://www.articulateinstruments.com](http://www.articulateinstruments.com)). It requires the client to have a custom-made artificial palate housing 62 electrodes. The palate records the timing and location of tongue contact against the hard palate during connected speech. See Hardcastle, Gibbon and Jones (1991) and Gibbon (2003) for more details.

Audio recordings of each child during administration of the Goldman-Fristoe Test of Articulation (GFTA) were made on three separate occasions prior to EPG involvement to ensure stability. A speech and language therapist (SLT) who did not know the children transcribed the audiotapes and made a summary of the child’s difficulties to supplement the clinician’s report. Targeted probe lists were then made of the sounds and/or sound processes that were identified as problematic, and EPG and acoustic recordings were made. The results from these were analysed to provide an objective articulatory basis for assessment, and to inform the subsequent EPG-based therapy.

Once palates are available for a client, EPG is immediately revealing. The additional qualitative information that EPG typically provides will be illustrated from two cases, and we will also describe the clinical progress that has been made. Both cases involve the production of velars, so canonical lingual-palatal EPG contact patterns for target velar and alveolar stop plosives produced by a normal speaker are shown in Figure 1.

![Figure 1. Typical EPG contact patterns for /t/ (left) and /k/ (right)](image-url)
Case Study 1: AC

AC is a 10-year-old girl with a repaired cleft of the soft palate. She has received 6 years of regular speech therapy targeting the production of a range of speech sounds. She was referred for EPG investigation because, although able to articulate velars at word level, as reported by her speech and language therapist, she was unable to transfer this to other levels. Analysis of recorded items using EPG and acoustic measures revealed the inaccuracy of this long-standing diagnosis. Our conclusions are based on the following evidence:

1. There is often abnormal anterior contact during the production of velars (Figure 2). This may due to fronting, and/or a post-velar/alveolar double articulation. (The post-velar portion may be articulated too far back for EPG to detect and display.)

2. There is abnormally high inter-token variability, e.g. in velar target words (Figure 2).

   Figure 2. EPG frames of maximum tongue-palate contact during stop closure for target velar /k/ from 8 repetitions of “a cap”

3. Alveolar targets are also variable in articulation and in how they sound.

4. Similar EPG patterns can be perceived as velar or alveolar (e.g. the /t/ targets in Figure 3). The velar percept is likely to be due to a double articulation.

   Figure 3. EPG frames of maximum tongue-palate contact during stop closure for target alveolar /t/ from tokens of “a tap” [kʰap] (left) and “a top” [tʰap] (right)

This additional information, only available following instrumental analysis, has informed diagnosis as follows. AC is clearly not able to articulate and distinguish velars and alveolars accurately at word level. This is probably why treatment to date to transfer the velar 2003 for CPLOL – draft, please do not circulate further, this paper is subject to redrafting.
lar/alveolar contrast has been clinically ineffective. Therapy is currently using visual feedback (EPG) to modify articulation at word level before moving on to higher levels.

**Case Study 2: KG**

KG, a 10-year-old boy, had referred himself to speech and language therapy reporting difficulties with the production of velars. Initial assessment by the local SLT concluded that he was fronting velars in all word positions. Weekly sessions over eight months were showing very limited progress in reducing his neutralisation of /t, d/ and /k, g/. His SLT reported that he was able to produce velars in isolation and at word level but that he was unable to transfer to connected speech. He was classified as having an intractable speech disorder due to his age and minimal response in therapy.

First, KG was screened to assess whether he would be a suitable candidate for EPG investigation. We undertook qualitative acoustic analysis which revealed that:

1. Alveolars appeared to be generally well-articulated.
2. Velars, on the other hand, were very variable. Some sounded velar, some alveolar, and some pharyngeal. Importantly, some were indeterminate in place while others had alveolar-like formant transitions into the closure but velar-like release (or the opposite) suggestive of abnormal constrictions.

Although some tokens of velars did sound identical to alveolars, a fact which is often supposed to be due to linguistic processes, these acoustic results were highly suggestive that KG did not have a phonological neutralisation of alveolar and velar place. It was felt that the use of EPG was motivated, since it could confirm the nature of the underlying articulatory problem, and provide a basis for therapy. An EPG palate was made for KG and the same velar-alveolar probe list as AC was recorded.

EPG analysis revealed that some velars were fronted, but that also:

1. Some /k/ and /g/ judged as acceptable were actually abnormally retracted.
2. Others judged as acceptable showed both velar and alveolar contacts (double articulations). The anterior constrictions in these cases were not audible because the 2003 for CPLOL – draft, please do not circulate further, this paper is subject to redrafting.
acoustic cues in the transitions into and out of the closure were generated by the velar constriction (Figure 4). The alveolar constriction (148-159) was “masked”.

3. Some /k/ and /g/ judged as unacceptable (i.e. as alveolar) did not arise from a normal [t] articulation. Figure 5 shows a slightly retracted release at frames 107-108, but the constriction is anterior enough at release (frames 107-108) to cue a [t] percept. The more posterior onset to the closure is not so perceptually salient.

4. Alveolar target stops were also revealed to be sometimes articulatory abnormal, a fact which had not been apparent even from our own acoustic analysis. Some /t/ displayed additional velar articulation (double articulation) (Figure 6) while others had abnormally high amounts of palate contact (not shown). In Figure 6, the release (frames 198-199) generates highly salient cues for /t/.

Following this assessment, KG underwent therapy using EPG as a visual feedback device. He modified his velar articulations and transferred this skill into his speech within 4 weeks.

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Summary

AC and KG, both aged 10, presented with intractable speech disorders affecting the production of velars. In both cases, EPG revealed intermediate, gradient and acoustically masked articulations, information essential for refuting previous diagnoses of categorical phonological neutralisation based on auditory-perceptual analysis (i.e. transcription). In the case of KG, an acoustic investigation had also strongly suggested that EPG therapy would be appropriate. We feel that the misdiagnoses of AC’s and KG’s speech errors had prevented intervention from being clinically effective. This is an unavoidable side-effect of a reliance on transcription in diagnosis. As listeners, we are not able to detect articulations which generate imperceptible acoustic effects, nor are tiny differences between subtly different abnormal productions salient even to trained ears. Consequently, the listener-transcriber tends to categorise productions into a small number of classes, which leads to ineffective feedback to the client.

EPG therapy can directly address the actual abnormal production patterns of alveolar and velar stops by being used as a visual feedback tool in clinic and at home. In the case of AC, therapy is ongoing at the time of writing. In the case of KG, now discharged, it is possible that some remediation may have eventually occurred without EPG therapy, but the rapid improvement during the visual feedback stage of EPG therapy is typical of many cases, and we doubt it would have occurred otherwise. For a review of the literature on the use of EPG in a variety of different types of speech disorder, see Gibbon (2003).

The cases presented here add to the body of work which shows how instrumental techniques can provide essential information to supplement more traditional methods of analysis and diagnosis, and thereby increase clinical effectiveness.
References