ARTICULATORY/ACOUSTIC RELATIONSHIPS IN LATERALISED PRODUCTIONS OF SIBILANT FRICATIVES

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INTRODUCTION

Clients presenting with abnormal productions of the lingual fricatives /s/ and /ʃ/ (the "sibilants") are common in the speech and language disordered population. One form of sibilant misarticulation is the "lateral lisp", (Dagenais, Critz-Crosby and Adams, 1994), which may be encountered not only in individuals who have structural abnormalities such as malocclusion and cleft palate, and those who have a history of delayed or disordered acquisition of speech and language, but also in children with otherwise normal articulatory skill development. It has been suggested that in such cases the speech production difficulty may be due to oral sensory feedback or neuromuscular deficits, or speech discrimination problems, (Wilcox, Daniloff and Ali, 1984). Regardless of aetiological factors, it is generally acknowledged clinically that lateral misarticulations are notoriously resistant to therapeutic intervention employing conventional techniques.

Neither the frequent occurrence, nor the resistance to treatment, of the lateral lisp is particularly controversial given the precise lingual neuromuscular control and the fine co-ordination of the lingual and respiratory systems which are necessary for accurate sibilant production. Furthermore, the visual inaccessibility of sibilants with placement posterior to the alveolar ridge not only means that description of the precise articulatory characteristics of abnormal productions has proved difficult, but also reduces the amount of information available to the clinician and client attempting to modify lingual configuration.

Electropalatography (EPG) is a computer-based technique which records, stores and displays information concerning the timing and location of lingual contact with the hard palate. The sibilants /s/ and /ʃ/ involve a relatively narrow oral constriction, resulting in an identifiable area of lingual-palatal contact, and EPG can therefore be employed to derive objective details regarding articulatory placement during their production. This information can be used in both the assessment and the remediation of atypical speech patterns and the application of EPG to these aspects of intervention has been widely reported, (see Nicolaidis, Hardcastle and Gibbon, 1994).

This paper will illustrate the articulatory patterns seen in lateral lisps produced by five English speaking children and adolescents. These will be related to acoustic characteristics of the noise spectra in an attempt to identify the salient articulatory and acoustic features of this type of distortion. Observations before and subsequent to EPG-based intervention will be compared and discussed with a view to providing some insight into why this type of disorder commonly arises and why it is so resistant to therapeutic intervention.

Table 1. Subject Details

	AGE	SEX	LATERALISED SOUNDS	ASSOCIATED FACTORS
D1	16;03	F	/ʃ/	family history of speech problems; orthodontic abnormalities
D2	11;07	F	/ʃ/	open-bite
D3	12;03	F	/s/ and /ʃ/	early history of conductive hearing loss; orthodontic abnormalities
D4	10;05	M	/s/ and /ʃ/	delayed speech and language development; attended primary language unit
D5	18;06	M	/s/	delayed speech and language development; ongoing disfluency

METHOD

Subjects

The five subjects formed part of a larger group which participated in a research project, described in Dent, Gibbon and Hardcastle (in press). Each had failed for some time to respond to conventional therapy. Auditory judgements of each of the subjects' productions of the sibilants were made (by the authors) at the time of their referral to the project. For each of the five subjects, the lateral lisp was the only presenting speech problem. All had histories of possible associated factors although only for D4 and D5 were these considered to be potentially significant. Table 1 summarises the details of the five subjects.

Instrumentation

The Reading EPG system is based on an artificial palate which contains 62 electrodes arranged in eight horizontal rows and exposed to the lingual surface. When the tongue touches the electrodes, a signal is conducted to an external processing unit and the pattern of lingual-palatal contact displayed on a VDU. Patterns can be stored on computer or printed out for subsequent analysis. (For more details see Hardcastle, Gibbon and Jones, 1991.) A multichannel system for simultaneous acquisition and processing of EPG and acoustic data was used for assessment of the subjects' speech, with sampling rates of 200 Hz for the EPG and 20,000 Hz for the acoustic signal. The system has been described elsewhere, (Hardcastle, Jones, Knight, Trudgeon and Calder, 1989). In addition, DAT recordings were made of each assessment session, using a Sony DAT (DTC-100ES).

Test material

The recordings made were of a word list containing all the consonants of English in single words and short sentences. Also recorded in each case was an additional list which contained further examples of sibilant targets, in items which were potential homonyms in the speech of the subject concerned.

Data analysis

In order to extract the salient articulatory features of the subjects' lateral lisp productions, specific EPG frames were selected at a number of points during each abnormal fricative segment. These points were identified according to criteria relating, for example, to the initiation and cessation of friction, and the frame of maximum

lingual-palatal contact. (The criteria are defined in Dent, Gibbon and Hardcastle, in press.) EPG frames from the annotation points for each production could then be presented in a single sequence. (See Figure 1.)

Acoustic analysis was undertaken using the CSL-4300 system (Kay Elemetrics, USA). A 50 millisecond Hanning window was placed at a point during the period of frication which corresponded to the frame of maximum contact in the EPG data. A spectral envelope was then extracted from the FFT and used to obtain a measure of Consonant Peak Energy Frequency (CPF, Wakumoto 1989).

Therapeutic procedure

The therapy mode of the EPG system was used to provide the subjects with visual feedback of target lingual configurations for the sibilants they were misarticulating, and feedback of their own attempts to approach these. General principles and stages of treatment using EPG are outlined in detail in Hardcastle et al (1991).

RESULTS

Sequences of EPG frames from the annotation points of selected items are presented in Figure 1 to illustrate each of the five subjects' production of target sibilants prior and subsequent to EPG intervention.

Figure 2 shows the change seen in CPF prior and subsequent to EPG intervention, for target /ʃ/ in the case of D2 and for target /s/ in the case of D5.

DISCUSSION

The EPG data reported here reveal a tendency for lateral lisps to involve complete closure between the tongue and the hard palate in the anterior region. The exception to this, D1, has increased contact approaching complete closure in the palatal region. The presence of such (near) closure, together with the lack of bilateral posterior contact seen in each of the patterns here, suggests that the friction for these sounds is produced by directing the airstream laterally behind the dental arch into the buccal cavity. Previous EPG studies have also reported increased tongue-palate contact in lateral

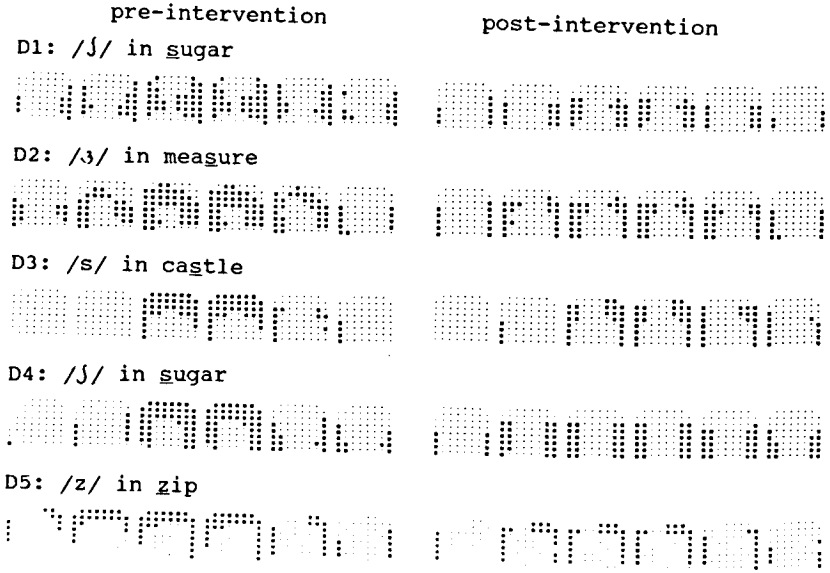

Figure 1. Series of EPG frames representing each subject's production pre- and post-intervention

		castle	saw	search	sue	sip	said	circus1	circus2	average
D5	Session1	4521	3869	3953	4470	4297	4403	3991	4299	4228
	Session2	3804	4810	8943	4503	6380	6362	9453	7543	6475

		wash	fishing	shore	shed	ship	shop	shoe	average
D2	Pretherapy	5183	5553	5237	5476	5357	5171	5271	5321
	Posttherapy	1601	2081	1793	3534	2099	1742	1777	2089

Figure 2. CPF change pre- vs post-intervention

lisp productions, (eg: Dagenais et al, 1994). This may reflect a lack of the fine neuromuscular control necessary to produce accurate sibilants: in the absence of this control, these subjects have adopted the broader, less precise tongue-palate contact typical of plosive articulation and allowed air to escape laterally in order to produce friction.

Following EPG therapy, all the subjects were able to produce sibilants which were perceptually more normal, with minimal lateralisation. The articulatory changes which they made, (see Figure 1), were reflected to some extent in the acoustic results. Figure 2 gives two examples: D5 has, for /s/, CPFs of approximately 4000Hz prior to therapy, and clearly higher peaks, (approximating the more normal 7000Hz, Suzuki et al (in press)), for over half of the items after therapy. The trend for D2's /ʃ/ is clearly towards a lower CPF following intervention, perhaps reflecting the more posterior (and therefore more normal) tongue placement. The results for the other subjects reported here showed similar patterns of CPF values for /s/ and /ʃ/.

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