UNDIFFERENTIATED GESTURES AND THEIR IMPLICATIONS FOR SPEECH DISORDERS IN CHILDREN

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ABSTRACT
Research using electropalatography (EPG) has shown that a distinctive articulatory characteristic of lingual consonants in the speech of school age children with articulation/phonological disorders (APD) is a high amount of tongue-palate contact. Consonants produced in this way have been referred to as involving undifferentiated lingual gestures (UGs). UGs are characterised by contact that lacks clear differentiation between the tongue apex, tongue body and lateral margins of the tongue. EPG data from 17 children with APD are summarised and examples given. Standard transcriptions do not reliably detect UGs, which are transcribed as speech errors (e.g. phonological substitutions, phonetic distortions) in some instances, but as correct productions in others. UGs are interpreted as reflecting a speech motor constraint involving either delayed or deviant control of functionally independent regions of the tongue. The implications of the phenomenon are discussed in terms of the assessment and diagnosis of speech disorders in children.

1. ARTICULATION/PHONOLOGICAL DISORDERS

1.1. Introduction

It has been estimated that 3-5% of children fail to develop speech in the normal way, and yet have no readily identifiable etiological condition. Attempts over the past four decades to explain idiopathic speech disorders in children have produced divergent accounts. Morley's [1] view that speech disorders of unknown origin were phonetic in nature, due specifically to "persistence of faulty habits of articulation" (p. 232) persisted throughout the 1960s and 1970s. During this period the term functional articulation disorder replaced Morley's term dyslalia, with "articulation" indicating the assumed phonetic origin of the speech difficulty.

Recent accounts, however, view speech disorders of unknown aetiology quite differently. Instead of a phonetic disorder, the origin of this type of speech disorder is now thought to be phonological or cognitive/linguistic [2, 3, 4]. This view has come about largely through the influence of linguistic frameworks for analysing auditory-based transcriptions of child speech. Support for a phonological explanation comes from observations that speech data is systematic or rule governed, and evidence that children often demonstrate accurate articulatory abilities of speech sounds in some contexts.

The shift of emphasis from articulation to phonology has been reflected in a change of diagnostic classification, with phonological disorder becoming the preferred term. Phonological disorder is commonly used as a diagnostic label where the underlying origin of the disorder is considered to be abnormal speech sound organization. Grunwell summarises this latter position, stating that: "phonological disorders … because they occur in the absence of any known physical or physiological deficits, must result from breakdowns at the cognitive level of linguistic knowledge and organisation" (p. 5) [3]. The term articulation/phonological disorder (APD) will be used here to refer to children with speech disorders of unknown origin.

If a cognitive/linguistic explanation of APD is to be upheld, it is of considerable importance to explore constraints at what are regarded as more peripheral levels of speech production. One obvious constraint is immature speech motor control. Electropalatography (EPG) is an instrumental technique able to record actions of one of the major articulators involved in speech production, namely, the tongue. If children with APD have motoric deficits, then the articulatory data from EPG would reveal features known to be typical of impaired speech motor control. Such features might include poor positional accuracy, difficulties with timing or inter-articulator phasing between the tongue apex and tongue body, and variable execution of lingual gestures. At present, relatively few children with either APD or normal speech development have been reported using EPG, and articulatory data from both groups remain sparse [5, 6, 7, 8].

1.2. EPG Studies of Children with Normal Speech

EPG patterns of lingual consonants in typically developing children are summarised in a recent paper [6]. The studies show that school age children with normal speech produce anterior consonants, such as /t/ and /d/, by a combination of lateral bracing and an upward movement of the tongue tip/blade to the alveolar ridge, resulting in a characteristic horseshoe shape EPG configuration. This is illustrated in Figure 1, which shows EPG patterns for a 12-year-old with normal speech producing the /t/ in the word "a tar". The frames are sampled at 100Hz, with the alveolar region at the top and the velar region at the bottom of each palatogram. In certain contexts, such as in /kt/ or /kl/ consonant sequences, the tongue tip/blade and tongue body overlap, producing periods of double articulation. The ability of the different tongue systems (i.e. the tongue tip/blade, tongue body and lateral regions) to function in a quasi-independent manner and to coarticulate provided insights into a distinctive articulatory pattern in APD – namely UGs.

2. UNDIFFERENTIATED LINGUAL GESTURES

In a review of the EPG literature on APD, Gibbon [6] found that, compared with children with typical development, a distinctive articulatory characteristic of lingual consonants in school age children was a high amount of tongue palate contact. Gibbon refers to this type of pattern as involving undifferentiated lingual gestures or UGs. In terms of EPG patterns, UGs manifest as either simultaneous tongue palate contact in both anterior and posterior regions of the palate, or contact that extends across the entire surface of the palate (see Figure 2). Out of the 17 children with APD reported in the EPG literature, 12 presented with EPG patterns that involved UGs. One important finding was that standard transcriptions do not reliably detect UGs, which are transcribed as speech errors (e.g. phonological substitutions, phonetic distortions) in some contexts, but are transcribed as correct productions in others. In other words, abnormal articulatory gestures underlie a range of targets with different perceptual consequences.

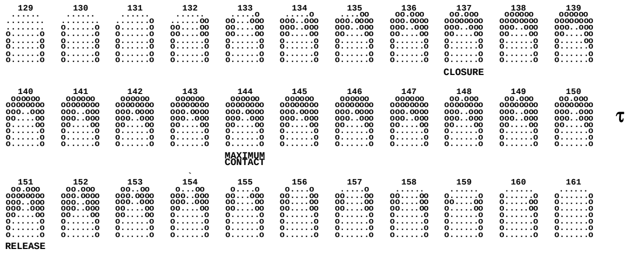

Figure 1. EPG printouts for a normal /t/ target. Closure, maximum contact and release frames are identified.

2.1. UGs and Perceptually Correct Productions

UGs transcribed as correct productions of alveolar stops are reported frequently in the EPG literature on APD. Hardcastle et al. [9] describe a child (Beryl) whose alveolar stops were judged by listeners as correct, but whose EPG patterns "involved closures in the alveolar, palatal, and velar zones of the palate" (p. 179). Two children with lateral lisps who both "produced perceptually correct alveolar stops by contacting far more sensors than did normal speakers" (pp. 68-69) are reported in [10]. An example of a UG judged by listeners as a correct alveolar stop is shown in Figure 2 (a). Compared with a normal speaker's production of an alveolar stop (Figure 1), the EPG patterns show increased contact across the palate with the result that at maximum contact there is almost complete contact between the tongue and the hard palate. This EPG configuration suggests not only an abnormally high tongue body position but also an abnormally convex tongue body surface shape for an alveolar target.

2.2. UGs and Phonological Substitutions

The EPG literature contains examples of UGs transcribed as phonological substitutions. Beryl (reported in [9]) produced UGs for /s/ targets which, depending on the vowel context, were transcribed as a substituted velar stop /k/. Gibbon [11] reports EPG data from a child, MB, who was using the phonological process of alveolar backing. EPG printouts of a target /d/ produced in word-initial position in "a dart", transcribed as backed to [γ] are shown in Figure 2 (b). The location of the closure and release phases of MB's alveolar targets in the velar region of the palate would have contributed to perceptual cues that led listeners to judge these targets as velar substitutions. The EPG contact that moved into the alveolar region took place during the silent closure phase of the stop, and would not have been detected easily by the human ear. Another example is in Figure 2 (c), which shows EPG printouts of a /k/ produced in word-initial position in "a cap", transcribed as fronted to alveolar place of articulation [t].

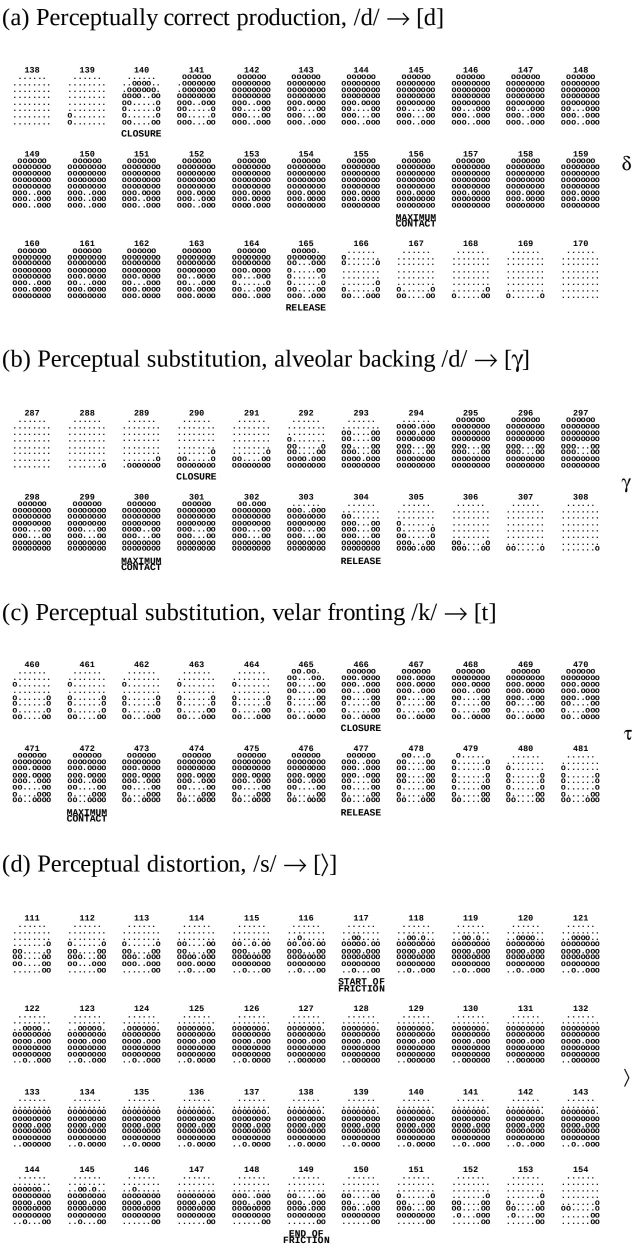

Figure 2. Examples of UGs.

2.3. UGs and Phonetic Distortions

UGs occur during gestures transcribed as phonetic distortions, especially lateral and palatal/velar fricatives produced for sibilant targets [9, 12, 13]. Figure 2 (d) shows EPG patterns during a production of a lateralized fricative [〉] in word-initial /s/ in "a saw" [13]. Increased tongue-palate contact occurring during two children's productions of sibilant targets transcribed as distortions (lateral lisps) are reported in [10]. UGs have been found to occur during sibilant targets transcribed as palatal or velar fricatives. For example, Beryl (reported in [8]) produced UGs for /s/, /z/ targets, which were transcribed in some contexts as velar fricatives [ξ], and D2 (reported in [13]) who produced UGs for sibilant targets, which were transcribed as palatal fricatives [ ].

2.4. UGs and Perceptual Variability

There is ample evidence in the literature of perceptually based variability in the speech of children with APD [2, 4]. EPG patterns of a child (E) whose alveolar targets were perceptually variable were investigated by [7]. Despite perceptual variability, abnormal EPG contact was observed during all alveolar stop targets. This abnormality was manifest in the production of UGs, the closure phase of which was always located in the velar region but with a variable location of the release. Where the release occurred at a relatively anterior location, listeners judged targets as correctly produced. Conversely, where the location of the release was further back on the palate, alveolar targets were more likely to be judged as velar substitutions. Further examples of UGs with variable closure/release phases are given in [6], where the different location of closure and release phases of stops is considered a major contributor to perceptual variability.

3. UGS AND SPEECH MOTOR CONTROL

Three pieces of evidence are interpreted as supporting the claim that UGs reflect motor-level (phonetic) difficulties.

3.1. Immature Lingual Control

During UGs, anterior tongue-palate contact occurs simultaneously with posterior contact. That is, tongue tip/blade movement does not occur independently of tongue body movement. One characteristic of mature lingual control is that the tongue tip/blade and the tongue body articulators do not always move together, but demonstrate the ability to occur relatively independently of each other, and to coarticulate. The finding that some children do not raise the tongue tip/blade without simultaneously raising the tongue body suggests immature lingual control, insofar as the basic control mechanism that allows the tongue apex and tongue body systems to operate independently has not yet developed. In the early stages of speech development, articulators are thought to operate according to the "everything moves at once principle" (p. 70) [14], whereby sets of articulatory gestures are produced in a largely synchronous manner. The phenomenon of UGs is a good example of this type of immature speech motor control.

3.2. Abnormal Closure/Release Phases of Stops

UGs that involve complete contact between the tongue and the hard palate (e.g. Figure 2 (d)) have an articulatory configuration that precludes the possibility of lateral bracing. In addition, as has been shown earlier, UGs are frequently coupled with variable articulatory placement at closure and release phases of stops. Variable execution of gestures and poor spatial (positional or articulatory) accuracy have been viewed as features of disrupted speech motor control [14]. Further, control of the lateral margins of the tongue is essential for normal speech, since lateral anchorage gives stability to the whole of the tongue [15]. The implication is that children with UGs lack control of the lateral margins of the tongue, and this will have an adverse effect on the development of normal speech production.

3.3. Widespread Occurrence of UGs

Children who produce UGs tend to do so for a wide range of targets [6], a finding that lends further support for the claim that these abnormal gestures reflect an underlying, pervasive speech motor control difficulty.

4. IMPLICATIONS OF UGS

4.1. Diagnosis of APD

On the basis of the available literature, UGs are evident in the speech of a high percentage of school age children with APD, and they do not appear to be characteristic of the speech of adults or typically developing school age children. UGs are interpreted as reflecting immature speech motor involving functionally independent regions of the tongue. Given the unique anatomical properties of the tongue and the complexities involved in controlling temporal and spatial aspects of its behaviour, it is not surprising to find evidence of immature tongue control in children with APD.

The emphasis on the role of phonetic factors in APD is not a wholesale return to earlier conceptions of dyslalia and functional articulation disorders, where the difficulty was considered to be with the articulation of individual speech sounds. Children with widespread occurrence of UGs are interpreted as having a motor control difficulty affecting lingual movements for a wide range of targets, resulting in perceptually complex and highly individual speech output characteristics.

4.2. Assessment of Speech in APD

Previous sections have shown how UGs occur during productions judged by listeners as phonetic distortions, phonological substitutions and correct productions, and that it is not possible to detect UGs from perceptual judgements alone. The occurrence of UGs can potentially account for many of the diverse perceptually based linguistic symtomatology described frequently in the literature on APD. For example, a number of phonological processes that affect lingual targets (such as velar fronting, assimilation to alveolar or velar place of articulation, alveolar backing, fricative stopping and gliding) could be explained by the presence of such a motor control constraint. Timing difficulties in closure and release phases and UGs offer a possible articulatory explanation of the variable speech errors frequently reported in the child phonology and APD literature.

4.3. Order of Mastery

The occurrence of UGs, and the difficulty in detecting their presence, leads us to question the order of acquisition of speech sounds. For example, the occurrence of UGs during perceptually "correct" alveolar stops suggests that adult-like articulation for these sounds may not be acquired, in articulatory terms, as early as is often assumed from transcription based studies. The EPG data show that alveolar stop targets can be produced with relatively gross, immature articulatory gestures, and yet still be judged by listeners as acceptable productions. While mastery of alveolar place of articulation is often considered to be “achieved” at an early stage in children with APD, basic lingual control of the tongue for production of these gestures may occur at a much later stage than transcription based analysis would suggest.

4.4. An Articulatory Mechanism for Smith’s “Puzzles”

Samples of child speech often display variability of articulatory production, revealing that sounds or sound classes are often produced correctly in some contexts, but not in others. The example often given is from the speech of Smith’s son, Amahl, who produced “puddle” as [π↵γ↔λ], and “puzzle” as [π↵δ↔λ] [16]. In other words, Amahl was “unable to produce a particular sound or sound sequence in the correct place, but [was] perfectly capable of producing it as his interpretation of something else” (p. 4, [16]). Smith interprets this as evidence that articulatory difficulty alone is insufficient to account for puzzles, which have been noted to occur extensively in the speech of children with typical development and those with APD.

However, the possibility that UGs might occur in the speech of young children is not generally recognised by those who rely entirely on standard transcription for data analysis. It could be that Amahl, produced UGs for both /d/ and /z/ targets - the gesture for /d/ (heard as [γ]) involving velar contact at closure and release and the gesture for /z/ (heard as [d]) involving contact in the alveolar region during these phases. Perhaps Amahl was not “perfectly capable”, in motoric terms, of producing a normal articulation for /d/ in any context.

According to Smith [16], Amahl produced puzzles with “completely regular rules” (p. 4), which begs the question “why should closure and/or release phases be different for /d/ and /z/ targets?”. It is speculation, but it could be that Amahl produced alveolar stops in a similar way to E [7]. If /z/ targets had a longer duration than /d/ targets, this could increase the likelihood of an alveolar release, and hence increase the chance of an alveolar percept for these targets. Whilst Amahl’s actual articulation during “puzzle” and “puddle” will never be known, the EPG evidence suggests an articulatory mechanism that could be responsible, in principle, for the puzzle phenomenon.

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