VARIABILITY IN FRICATIVE PRODUCTION OF YOUNG PEOPLE WITH DOWN'S SYNDROME: AN EPG ANALYSIS

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ABSTRACT

Speech production in Down's syndrome is highly variable, with particular problems arising from complex articulations such as fricatives. In this paper, EPG analysis is used to study the variation in the production of the fricatives /s/ and /ʃ/ in 6 young people with Down's syndrome. The variability of these productions is compared with information from the Robbins and Klee Oral/Speech Motor Control Protocol.

Keywords: Fricatives, Electropalatography, Down's syndrome, Motor Control, Variability.

1. INTRODUCTION

Fricatives are complex articulations that require a precise and complex motor program [4]. They are characterised phonetically by a narrow constriction (a groove along the centre of the tongue), placed at the alveolar ridge for /s/ and at the post-alveolar area of the palate for /ʃ/. Speech articulation in Down's syndrome is very variable and inconsistent [2] and it has been found that fricative production errors in this population are more frequent than errors with other consonants [1]. There have been many reasons given for speech impairment in people with Down's syndrome: small oral cavity, hypotonicity, macroglossia and, importantly for this study, specific oral-motor dysfunction [13].

This paper looks at the correlation between articulation difficulties with /s/ and /ʃ/ and oral/speech motor control difficulties within a small group drawn from this population.

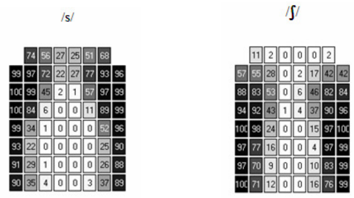
2. EPG AS AN ANALYSIS TOOL

EPG is a computer-based analysis tool that records the timing and location of tongue contact with the hard palate during speech articulation [7]. The lingual-palatal information obtained from EPG is particularly useful for analysing the detailed articulations of /s/ and /ʃ/, specifically the narrow constriction.

This study used the WinEPG system which when used with Articulate Assistant ™ allows synchronisation of acoustic (waveform and spectrographic) and EPG information, from which various annotations and calculations can be made.

Figure 1 shows typical patterns of lingual-palatal contact for /s/ and /ʃ/ (note the narrow groove down the centre of each frame). The 62 electrodes of the EPG palate are shaded depending on the contact with the tongue (darker representing more contact). The numbers also represent contact, with 100 representing constant contact and 0 indicating no contact at all.

Figure 1: Average EPG palatal contact of /s/ and /ʃ/ (typical data), Macleod & Roberts [10:112] (reproduced with permission from Speech Pathology Australia).



2.1. EPG and fricative production

EPG has been used in a small number of studies to analyse fricative production in typical speakers. McLeod et al [11] found wide variation in EPG patterns of /s/ in a group of English speakers, noting that the width of the narrow constriction can range (see also Hoole et al [8] and Tabain [14]).

2.2. EPG and speech disorders

EPG has been used to analyse speech disorders such as cleft palate [3] and lateralisation of /s/ [4]. However, there has been little EPG work on speech articulation in Down's syndrome. The work of Hamilton [6] and Gibbon et al [5] illustrated the speech problems these children have and highlighted the benefits of EPG as an analysis tool.

3. METHOD

3.1. Participants

Six young people with Down's syndrome (DS) aged 10-18 yrs with a cognitive age of 3+yrs were recruited from the first phase of an ongoing project, in which each participant had an EPG palate made specifically for them. Also recruited were 4 typically developing (TD) children, aged 3-7 yrs, also with EPG palates.

3.2. Recording material

The speakers were recorded, using Articulate Assistant ™, reading a list of 10 words, repeated 10 times, which included 'sun' and 'sheep'. The first recording of this list of ten words was a practice recording and removed from subsequent analysis.

3.3. EPG measurements

The duration of all attempted /s/ and /ʃ/ productions were annotated according to the acoustic signal shown on a spectrogram in Articulate Assistant ™. If there was no attempt at the target articulation (e.g. [ip] for 'sheep') then the trial was discarded.

A spatial variability index for /s/ and /ʃ/ for each speaker was calculated from all the frames in the annotated region. The index calculates the frequency of contact of the electrodes of the palate across repetitions. The variability index assigns a variance index of 50 to each contact (with 100% and 0% representing invariance), and divides this by 62. High values of the variability index indicate more variance of the EPG patterns, with a maximum of 50.

A temporal variability measurement, COV (coefficient of variance) was also calculated for both /s/ and /ʃ/. This shows the degree to which data vary, a larger coefficient indicating greater variance. Weismer [15] notes that kinematic and acoustic variability across repetitions of an utterance is common in speech motor disorders, therefore the above measures appear to be suitable to assess speech motor control in these speakers.
Along with these two variability measures a qualitative analysis of the EPG patterns from the annotated regions was performed. Motor control measures

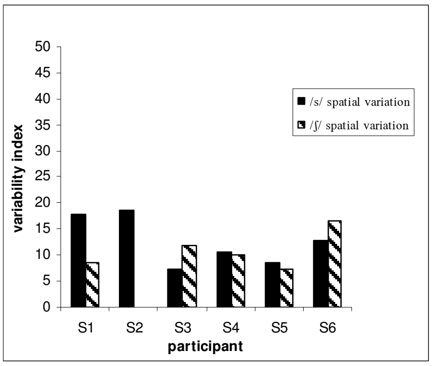
The parent study involves a wide-ranging assessment battery looking at articulation (using EPG and acoustics) in relation to a battery of language measures. One of the assessments in the battery is the Robbins and Klee Oral/Speech Motor Control Protocol [12] which is being used to score oral function and structure in children with DS. The results from the function analysis section of this protocol were used as a measure of oral/speech motor control for participants reported here, with a higher score indicating a more adult-like function.

4. RESULTS

4.1. Variability measurements

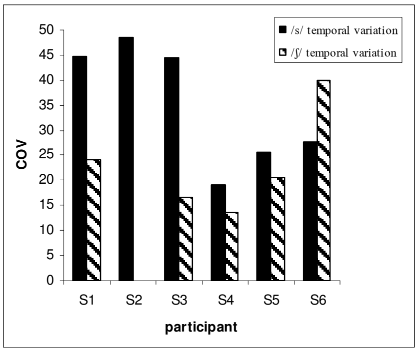
The results of the spatial variability measures (see Figure 2) indicate that these 6 speakers are variable but there is no pattern to indicate that one segment is more variable than the other. Some speakers show high variability for /s/ production and others for /ʃ/ production, indicating a degree of inter- and intra-speaker variability (note: For S2 only one production of /ʃ/ was attempted). When compared with the small set of TD speakers (n=4) it was found that there was a near significant difference in variation for speakers with DS (p=0.0514) for /s/ production. However, there was no significant difference for variation of /ʃ/ between the DS and TD speakers.

Figure 2: Spatial variation of all attempts of /s/ and /ʃ/ for 6 speakers with Down's syndrome.



The temporal variability is shown to be greater for production of /s/ for the majority of the speakers with DS (see Figure 3). Again, there is a degree of inter- and intra-speaker variability for temporal measurements. There was a similar pattern to the spatial variance when these measures were compared with the TD speakers: a significant difference for /s/ (p=0.011), but not for /ʃ/.

Figure 3: Temporal variation of all attempts of /s/ and /ʃ/ for 6 speakers with Down's syndrome.



4.2. Auditory analysis

Auditory analyses were made of all attempted productions of /s/ and /ʃ/. The transcribed errors from these speakers are shown in Table 1 and Table 2. The tables indicate that all speakers produce errors, though some more than others. Both the errors for /s/ and /ʃ/ show variability within speakers but we also can see different productions being used across speakers. S6 seems to show the most variability in the perceptual data, more so than in the spatial variability graph (Figure 2) but this may be due to the use of bilabial sounds which do not register with EPG analysis.

Table 1: Summary of error productions of /s/

/s/	n	errors	%errors	Error transcriptions
S1	9	5	**56**	**tʃ, ɬ, !, tʃ, ts**
S2	7	7	**100**	**ɬ↓, ɬ↓, ɬ↓, ɬ↓, hɬ↓, cɬ↓, ɬ↓**
S3	9	1	**11**	**θ**
S4	9	3	**33**	**ts, t, t**
S5	9	5	**56**	**x, θ, ls, θ, θ**
S6	9	7	**78**	**xs, ʍ, x, ts, x, tʃ, tʃ**

Table 2: Summary of error productions of /ʃ/

/ʃ/	n	errors	%errors	Error transcriptions
S1	9	6	**67**	**h, ç, tʃ, tʃ, ç, ç**
S2	1	1	**100**	**ʝ**
S3	9	7	**78**	**θr, h, h, h, h, h, h**
S4	9	9	**100**	**ts, s, z, s, s, s, s, s, s**
S5	8	1	**13**	**kʃ**
S6	8	8	**100**	**rk, cʝ, dʒ, kx, phr, fθ, pç, s**

4.3. Articulatory Analysis

Figure 4 shows the average EPG contact of the productions of /s/ and /ʃ/ for all speakers. The average frame consists of five points from the annotated region; start, middle, end and 2 other evenly spaced points (this was found to be more suitable than taking an average over the entire annotated region as productions varied in length).

Figure 4: Average EPG frames of all productions of /s/ and /ʃ/.

4.3.1. /s/ EPG patterns

S1 shows patterns similar to TD patterns (see Figure 1) although there is evidence of complete closure for the /s/ productions (heard as affricate production in the auditory analysis). S2 consistently produces a lateral fricative (complete closure) for /s/, which can also be seen from the EPG patterns above. S3 is very consistent (almost always heard as producing /s/), and this is illustrated with a low score on the spatial variability index. S4 shows presence of a narrow groove with some complete contact. This speaker is not highly perceptually variable (mostly producing /s/ or /t/). S5 almost always produces a wide grooved pattern as does S6 (though more of these are heard as errors). S6 also appears to have more velar contact, heard as /x/.

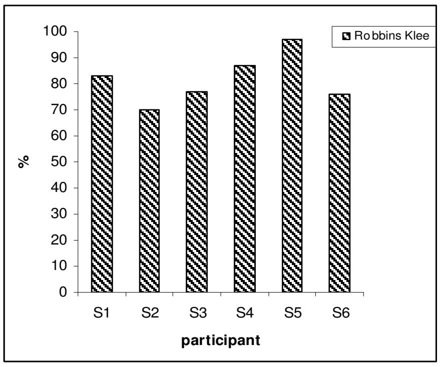
4.3.2. /ʃ/ EPG patterns

The patterns of /ʃ/ production for these speakers are visibly variable. S1 shows an overall /ʃ/-like pattern, but this is heard as a palatal fricative or an affricate. S2 only produces one instance which has little contact. S3 shows a similar pattern for /ʃ/ as for /s/ which is heard mostly as [h]. S4 shows a pattern similar to /s/, and this is heard mostly as /s/. S5 does show a more retracted pattern for /ʃ/ than his /s/ patterns and these are heard mostly as correct productions. The EPG composite frame for S6 shows presence of complete contact at the anterior region, due to a large amount of affricates produced by this speaker (see Table 2).

4.4. Motor control analysis

Correlations of the Robbins and Klee [12] scores with the spatial and temporal variability measures were not significant but a qualitative examination of the scores indicated that the speakers with the higher scores (S4 and S5) are those who show low variability for /s/ and /ʃ/ spatially and temporally (see Figure 5), while those with low Robbins and Klee [12] scores also show high variability in spatial and temporal measures (S2 and S6).

Figure 5: Percentage score of motor control function from Robbins and Klee Protocol [12].



5. DISCUSSION

As seen from the data above, target fricatives in young people with Down's syndrome show a large amount of articulatory and perceptual variation. However, some speakers are more variable than others. The differences in variability can possibly be explained by the levels of oral motor function difficulty. Those with the lower Robbins and Klee [12] function scores show more variation in /s/ and /ʃ/ for both spatial and temporal measures.

Another interesting finding is the differences between the variability measures in /s/ and /ʃ/. No significant difference in the variation of the TD and DS groups for /ʃ/ production is possibly due to the younger aged TD speakers who are still in the process of developing the articulation of /ʃ/.

6. CONCLUSION

There seems to be some indication of a possible correlation between speech motor control as measured by articulation variability and oral/speech motor control as measured by the Robbins and Klee protocol [12]. If this correlation proves robust when analysing more data, this would suggest a need for therapy treatment of motor control and articulation as highlighted in Kumin [9].

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