SPATIAL & TEMPORAL VARIABILITY OF SIBILANTS IN CHILDREN WITH DOWN'S SYNDROME

Claire Timmins[1,2] & Sara Wood[2]
1. Speech and Language Therapy, School of Psychological Sciences and Health, University of Strathclyde
2. Clinical Audiology, Speech and Language Research Centre, Queen Margaret University
claire.timmins@strath.ac.uk; swood@qmu.ac.uk

ABSTRACT

This paper presents findings from EPG analysis of word initial /s/ and /ʃ/ in twenty five children with Down's syndrome (DS) and ten cognitively age-matched typically developing children (TD).

Spatial and temporal variability measures show evidence of increased variability in all attempts of target /s/ and /ʃ/ for the speakers with DS. The findings also show evidence of high levels of spatial variability in children with DS and typically developing children in perceptually acceptable productions of the target sounds.

These findings support previous research that links speech production difficulties in children with DS to impaired speech motor ability.

Keywords: Down's syndrome, sibilant fricatives, EPG, variability

1. INTRODUCTION

Speech disorders are common in DS, with phonetic variability increasingly identified through both perceptual [3] and instrumental analysis [9]. Fricative sounds have been identified as particularly problematic for this population and variability in the production of these speech sounds has been identified in a small group of speakers [9]. Timmins et al. [9] analysed the variability of sibilant production in a small group of speakers with DS, alongside a group of cognitively-aged matched typical-developing (TD) children and found that children with DS presented with higher spatial variability than the TD group. Research suggests that there is a link between speech motor control ability and variability in articulation (duration, amplitude, spectral measures) [8], with increased articulatory variability reflecting reduced coordination skills [6].

Alongside oral cavity size differences, macroglossia, and hypotonia, it has been suggested that oral-motor difficulties play an important part in the speech problems in DS [2, 3]. Evidence of increased variability in these speakers has so far been presented for a small group of speakers. This paper presents an investigation into both spatial and temporal articulatory variability in a group of 25 children with DS in compared to cognitively age-matched controls, hypothesising that the speakers with DS would show higher levels of variability reflecting a high occurrence of motor speech difficulties.

2. METHOD

2.1 Participants

25 children with DS aged 8;3-18;9 years (mean 13;5, SD 3.11) were recruited from the central belt of Scotland. A control group of 10 cognitively age-matched TD children aged 3;8–7;1 years (mean 5;7, SD 1.28) and a second control group of 8 adult (AD) speakers (ranging from 30-60 years) were also recruited.

All children had previously completed the DEAP phonology assessment [4] and scores for the DS group ranged from 19-87% (mean 61%, SD 18.6) for PCC, reflecting the typical heterogeneity of this population.

2.2. Recording material

Each group of speakers were recorded, wearing an EPG palate, producing the words 'a sun' and 'a sheep'. These were repeated 10 times as part of a larger wordlist. The data recorded was annotated and analysed via the Articulate Assistant ™ software.

Attempted productions of the target sibilants were subject to a narrow transcription. Perceptually acceptable tokens were established following Dodd et al. [4].

2.4. EPG Measures

All attempted productions of target /s/ and /ʃ/ were annotated (according to the acoustic and EPG information). The AA software provides a spatial variability index to calculate the stability of articulatory gestures [4]. A score between 0-50 is calculated based on percent frequency of activation of EPG contacts [12]

Intra-speaker spatial variability was calculated from the frame of maximum EPG contact within the annotated region of all attempted productions of WI

/s/ and /ʃ/. The index measures variability of the target sound whether produced correctly or not. A high variability index in this context would likely be indicative of a participant whose attempts were noticeably perceptually different and also phonemically different [7]. This will be referred to as the Overall Spatial Variability Score (OSVar).

A further measure was calculated from only the perceptually correct tokens of the target sounds (PSVar) to reflect the variability in articulation of productions deemed to be phonemically similar (perceptually). It was hypothesised that the PSVar would reveal articulation difficulties for children with DS even when target sounds are considered to be perceptually acceptable. OSVar and PSVar was calculated for the TD and AD groups for the target sounds to investigate whether the children with DS presented with higher levels of variability compared with typical children (the TD group presented with errors in both target sibilants but the AD group produced no errors).

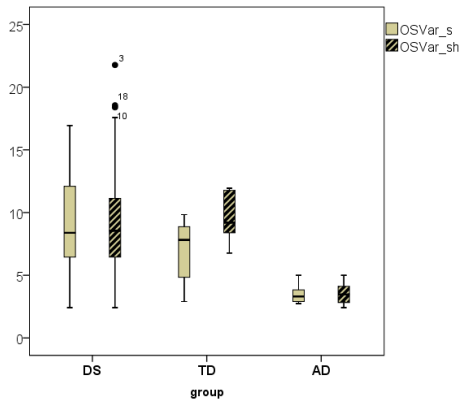
2.2. Temporal variability

Duration was calculated from the annotated regions of the target sounds. The duration of the annotated sounds considered perceptually acceptable for each target sound was measured and the variability was calculated by using a coefficient of variation (COV = standard deviation/mean) measure. Perceptually acceptable tokens were chosen in order to compare the results with previous studies on sibilant length [1, 8]. It was hypothesised the children with DS would show higher levels of temporal variability to the TD group.

3. RESULTS

3.1. Spatial variability

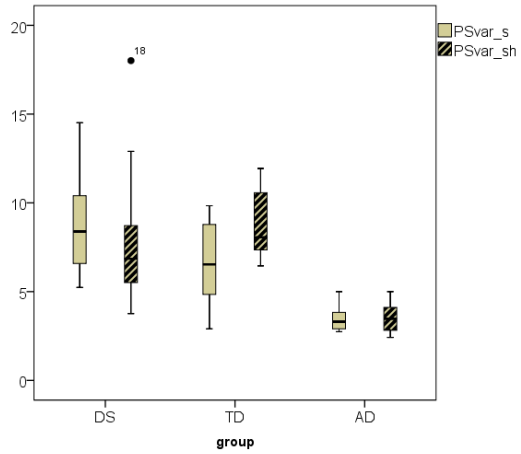
Figure 1: Boxplot showing median and IQR values of individual spatial variability (OSVar) for all attempted productions of target /s/ and /ʃ/ for DS, TD, AD groups.



The DS group have higher mean scores for target /s/ than the TD and AD groups (DS =8.84; TD =6.97; AD =3.48). Target /ʃ/ shows a closer relationship between the DS and TD scores than /s/. The DS group show a slightly higher OSVar mean than the TD group and the AD group show a low OSVar mean score (DS = 9.74; TD = 9.47; AD = 3.53). There was a significant difference in the OSVar between the groups with ANOVA ($F(2,40) = 11.6$, $p < 0.001$). A Tukey post hoc test found significant differences between all three groups ($p<0.001$). Pearson's correlations were run to check for the effect of age, as in typical children articulation variability is found to decrease as the child matures. There were no correlations for either the DS or TD groups for age and OSVar scores for /s/ and /ʃ/.

The AD and TD mean OSVar scores for /s/ and /ʃ/ do not correlate (AD: N=8, r = .238, p=.57; TD: N=10, r = -.13, p=.97) though this is possibly a result of the small Ns. The OSVar scores for /s/ and /ʃ/ correlate significantly for the DS group (N=25, r=0.466, p=0.017) suggesting that both sibilants behave similarly in this group (though not in the control groups).

Figure 2: Boxplot showing median and IQR values of individual spatial variability (PSVar) of only perceptually acceptable productions of target /s/ and /ʃ/ for DS, TD, AD groups.

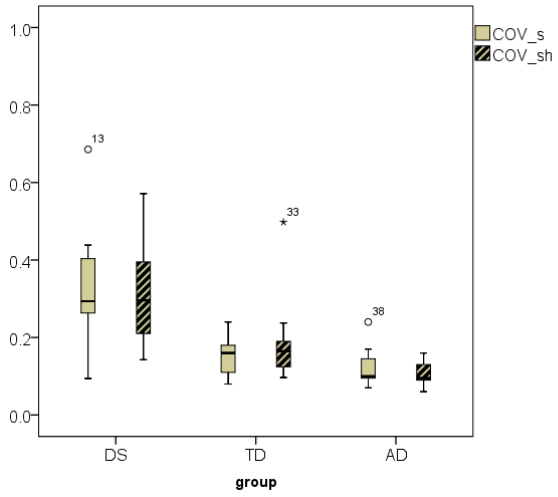


After removing the perceptually inacceptable productions, the data shows a similar pattern to the mean OSVar measures for /s/ but not /ʃ/. The DS group still show higher scores than the TD and AD groups for target /s/ with mean PSVar scores: DS =8.05; TD =6.63; AD =3.48. Target /ʃ/ shows a different relationship between the DS and TD scores than the previous target sounds: DS = 7.86; TD = 8.73; AD = 3.53. There was a significant difference

in the PSVar scores between the groups with ANOVA ($F(2,31) = 42.308$, $p<0.001$). A Tukey post hoc test found a significant difference between the PSVar scores for the DS and AD group ($p<0.001$), the TD and AD group ($p<0.001$) but not between the DS and TD groups ($p=.242$). The interaction between group and sound was not statistically significant. The AD variability scores were the same for both measures so no correlations were performed on the PSVar measure. The mean PSVar scores for /s/ and /ʃ/ for the TD group did not correlate ($N=10$, $r=-.405$, $p=.246$), neither did the DS group mean PSVar scores ($N=26$, $r=.249$, $p=.336$).

3.2. Temporal variability

Figure 3: Boxplot showing median and IQR values of COV of duration for target /s/ and /ʃ/, presented for DS, TD and AD groups.



The COV scores for the three speaker groups show that the DS group are more variable in the duration of the target sibilants. Mean COV scores for /s/ were: DS=0.38, TD=0.15, AD=0.12). Mean COV scores for /ʃ/ were: DS=0.36, TD=0.17, AD=0.11). The TD group show lower COV scores than the DS group and the AD group are lower than both the DS and TD groups. There was a significant difference between groups (ANOVA ($F(2,40)=15.21$, $p <0.001$). A Tukey Post-Hoc test found that the significant differences were between the DS and TD groups ($p=0.006$), and DS and AD groups ($p<0.001$) but not between the TD and AD groups.

A further correlation was run to investigate whether speakers showed high variability of spatial measures alongside temporal variability. There were no significant results.

4. DISCUSSION

Spatial and temporal variability measures of sibilant fricatives identified higher levels of variability in attempted productions of target word initial /s/ and /ʃ/ in children with DS in comparison to a cognitively age-matched group of TD children and a group of adult speakers.

Measures of variability of perceptually acceptable tokens found unexpected higher levels of spatial variability of /ʃ/ in the TD group. TD children have been noted to show decreasing levels of both spatial and temporal variability until mid-adolescence [8]. Walsh et al. [10] note that high levels of articulation variability may reflect the acquisition of a novel articulation (which may be seen in /ʃ/ for some of these speakers).

The spatial variability identified in the children with DS in this study showed no relationship with age. It is suggested that the higher levels of spatial variability in the DS group are related to a combination of the speech motor difficulties and possibly the structural differences in this speaker group.

It was hypothesised that the children with DS would also present with higher levels of temporal variability than the TD group. As expected, the COV of duration measure found that, overall, children with DS were significantly more variable than the TD and AD groups. Temporal variability has also been noted in Brown-Sweeney and Smith [1] for word initial consonant closure in 16 children with DS aged 7-12 (which were significantly different to their chronological age-matched control group). Temporal variability is considered an indication of speech motor difficulties [11] and this group of children with DS clearly show signs of increased temporal variability when compared with cognitively age-matched typical controls.

5. CONCLUSION

Analysis of spatial and temporal articulation variability of sibilants found significantly higher levels in children with DS which could not be explained by age. These findings provide evidence of articulation instability that may be a result of speech motor difficulties in this population.

High levels of spatial variability in young TD speakers for perceptually acceptable later developing sibilants support findings that note articulation variability as children stabilise a novel phonetic structure.

6. REFERENCES

[1] Brown-Sweeney, S. G., Smith, B. L. 1997. The development of speech production abilities in children with Down syndrome. Clinical Linguistics and Phonetics. 11, 5, 345-362.

[2] Bunton, K., Leddy, M. & Miller, J. 2007. Phonetic Intelligibility Testing in Adults with Down syndrome. Down Syndrome Research and Practice, 12 (1), 1-4.

[3] Bunton, K. & Leddy, M. 2011. An evaluation of articulatory working space are in vowel production of adults with Down syndrome. Clinical Linguistics and Phonetics, 25 (4), 321-334.

[4] Cheng, H. Y., Murdoch, B. E., Goozee, J. V., Scott, D. 2007. Electropalatographic assessment of tongue-to-palate contact patterns and variability in children, adolescents, and adults. Journal of Speech, Language and Hearing Research. 50, 2, 375-392.

[3] Dodd, B., Thompson, L. 2001. Speech disorder in children with Down's syndrome. Journal of Intellectual Disability Research. 45, (4), 308-316.

[4] Dodd, B., Zhu H., Crosbie, S., Holm, A. Ozanne, A., 2002. Diagnostic Evaluation of Articulation and Phonology. London: The Psychological Corporation.

[5] Farnetani, E., Provaglio, A. 1991. Assessing variability of lingual consonants in Italian. Quaderni del Cantro di Studio per le Ricerche di Fonetica del C.N.R., X, 117-145.

[6] Goffman, L. 2010. Dynamic Interaction of motor and language factors in normal and disordered development. In B. Maassen and P. Van Lieshout (eds.), Speech Motor Control: New developments in basic and applied research. Oxford: Oxford University Press. 137-153.

[7] Holm, A., Crosbie, S., Dodd, B. 2003. Differentiating normal variability from inconsistency in children's speech: normative data. International Journal of Language and Communication Disorder, 42, 4, 467-486.

[8] Lee, S., Potamianos, A., Narayanan, S. 1999. Acoustics of children's speech: Developmental changes of temporal and spectral parameters. J. Acoust. Soc. Am. 105, 1455-1468.

[9] Timmins, C., Hardcastle, W., Wood, S. E., McCann, J., Wishart, J. 2007. Variability in fricative production of young people with Down's syndrome: an EPG analysis. Proc16th ICPhS. Saarbrucken, 1981-1984.

[10] Walsh, B., Smith, A., Weber-Fox, C. 2006. Short term plasticity in children's speech motor systems. Developmental Psychobiology, 48, 660-674.

[11] Weismar, G., Elbert, M. 1982. Temporal characteristics of "functionally" misarticulated /s/ in 4- to 6-year old children. Journal of Speech, Language and Hearing Research, 25, 275-289.

[12] Wrench, A. A. (2008). Assessing changes in speech production using the whole EPG pattern. Presented at The 12th Meeting of the International Clinical Phonetics and Linguistics Association, Istanbul, Turkey, June 25th-28th.