WHAT IS DOWN SYNDROME?
Down syndrome (DS), the most common genetic disorder, is caused by the presence of an extra copy of chromosome 21. About 1 in 700 infants are born with Down syndrome or trisomy 21. For common characteristics and co-occurring conditions see http://www.ncbi.nih.gov/pubmedhealth/PM0031992/
Speech difficulties, that affect speech intelligibility or speech clarity, are common in individuals with DS.

ABSTRACT/ SUMMARY:
Vowel acoustic space, the area bounded by corner vowels /i/, /æ/, /u/, and /a/, has been documented to reflect speech intelligibility such that the smaller the area, the less distinct the vowels. The purpose of this study is to examine developmental changes in vowel acoustic space in typically developing (TD) individuals and individuals with Down syndrome (DS). Word repetitions were collected from participants (40 DS, 75 TD). Three analyses (vowel planar area, formant centralization ratio, and F2 ratio for /i/ and /u/) were used to assess differences. Results show atypical vowel production by individuals with DS. Such differences may be of clinical significance, and likely to be due to both craniofacial anomalies as well as disrupted motor control.

INTRODUCTION:
Speech and language difficulties often occur in individuals with DS. The focus of this study is to examine vowel production in individuals with DS. Previous acoustic studies of speech in individuals with DS have yielded inconsistent results.

The primary purpose of this study is to examine the vowel acoustic space in children and adults with DS compared to a typically developing (TD) sample. The acoustic vowel quadrilateral, the area bounded by the corner vowels, /i/ as in “bed,” /æ/ as in “bat,” /u/ as in “boot,” and /a/ as in “pot,” has been related to speech intelligibility such that the smaller the area, the less distinct the vowels.

METHODS:
Participants
40 individuals with Down syndrome, 24 males and 16 females, ages 5.3 to 36.9 years, mean age of 19.0 years
75 typically developing individuals, 34 males and 41 females, ages 4.4 to 66.4 years, mean age of 14.0 years.

The primary purpose of this study is to examine the vowel acoustic space in children and adults with DS compared to a typically developing (TD) sample. The acoustic vowel quadrilateral, the area bounded by the corner vowels, /i/ as in “bed,” /æ/ as in “bat,” /u/ as in “boot,” and /a/ as in “pot,” has been related to speech intelligibility such that the smaller the area, the less distinct the vowels.

Three different measures were obtained to assess differences in the size and configuration of the vowel quadrilateral.
1. Vowel Planar Area:
   0.5(+/F2*//F2 + /F2*//F1 + /F2*//F1 + /F2*/(F1 - /F2*/F1) - /F2*/F1)
   Formant Centralization Ratio (FCR):
   F2/F2
   Vowel Functional Ratio:
   F2/F2

DATA ANALYSES:
I. Graphical Display of Vowel Acoustic Space:
   • Graphical displays of the vowel quadrilaterals were judged qualitatively to assess the geometry of the vowel quadrilaterals in comparison to developmental data reported by Vorperian and Kent (2007). Data was grouped into developmental age groups: pre-pubescent (ages 4-10), pubescent (ages 10-15), post-pubescent (ages 15-20) and adult (ages 20+).

II. Formant Values Calculations:
   • Three different measures were obtained to assess differences in the size and configuration of the vowel quadrilaterals.

   1. Vowel Planar Area:
   0.5(+/F2*//F2 + /F2*//F1 + /F2*//F1 + /F2*/(F1 - /F2*/F1))
   2. Formant Centralization Ratio (FCR):
   F2/F2
   3. Vowel Functional Ratio:
   F2/F2

RESULTS:
Vowel Acoustic Space
As seen in Figure 5, the vowel quadrilaterals in individuals with DS are different from those of TD participants. A frequently occurring feature is the poor distinction between vowels /a/ and /æ/, sometimes resulting in a collapse of the low vowel portion of the vowel quadrilateral.

CONCLUSIONS/ IMPLICATIONS:
1. Our findings confirm that vowel production is atypical in individuals with DS, particularly the back vowels /æ/ and /a/ and the high vowels /i/ and /u/.
2. Such findings may be relevant to the reduced speech intelligibility that individuals with DS typically experience.
3. The deficiencies in vowel production could be related to craniofacial anomalies, disrupted motor control, faulty phonological representation, or some combination of these.
4. Acoustic measures of vowels are an objective measure of articulatory ability in individuals with DS and could be used to assess the outcome of interventions.

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SELECT REFERENCES:

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