Speech Intelligibility in Down Syndrome: A Developmental Perspective

Alyssa Wild, Houri K. Vorperian, Ray D. Kent, Diane Austin, and Emily Reinicke

Vocal Tract Development Lab, Waisman Center, University of Wisconsin - Madison

**Objective:** To identify phonetic properties that contribute to speech intelligibility in speakers with DS across the lifespan ages 4 to 40 years. Intelligibility is defined as percentage of words identified correctly by listeners.

**Introduction:**

1. Developmental trend: Age and sex were used as fixed effects, with individual differences considered random effects. Results showed significantly reduced intelligibility, even in adulthood.

2. Phonetic properties: Separate models were fit for each vowel and consonant. Contributions of vowel errors were more significant than final consonants.

3. Implications: Reduced speech intelligibility in DS is likely due to multiple factors, including: (a) craniofacial dysmorphology; (b) motor impairment or immaturity; and (c) hearing loss and/or auditory processing disorders.

4. Future research: Further longitudinal data would allow for a more complete understanding of how the various factors contribute to reduced intelligibility. Collecting sex and age variables would likely help the identification of the ontological and/or developmental processes that are involved in the reduction of speech intelligibility in DS.

**Methods:**

1. Part I: Speech sample production - (a) 64 speakers with DS (30 female, 34 males) ages 4 to 40 years; (b) 38 TD speakers (11 female, 14 male) ages 4 to 7 years.

2. Part II: Intelligibility - (a) 40 TD listeners (18 male, 22 female) ages 18 years and older. Listeners were instructed to type what they heard, not what the speaker was trying to say.

**Data Analysis:**

1. Mixed effects with a random intercept for each participant.

2. Polynomial polytomous were used to fit models and select the best fitting transformation.

3. Developmental trend: Age and sex were used as predictors (see Fig. B).

4. Phonetic properties: Separate models were fit for each phonetic property to examine the strength of the relationship to words correct.

**Results:**

1. Table 1 shows that all phonetic properties significantly contributed to reduced intelligibility in speakers with DS, with some contributing more than others.

2. In descending order, variance most correlated with words correct were: total vowels, initial consonants, final consonants (see Fig. 7c).

3. All of the phonetic properties were squared due to a curvilinear relationship with words correct. Each result above represents a different model.

4. Table 1 shows significance of phonetic properties as predictors for words correct in intelligence, including age, sex, and TD speaker. Each of the four sets of data were derived from the same words.

**Discussion:**

1. As an overall trend, intelligibility improved significantly with age. However, individual variability was marked and the results showed severely reduced intelligibility, even in adulthood.

2. Both consonants and vowels contributed to reduced word intelligibility. Consonants contributed more to final consonants, perhaps because there were twice as many consonants as vowels in the 150-word initial and final consonants contributed more than final consonants.

3. Low vowels /a/ and /æ/ contributed more than high vowels /i/ and /u/ because this could be due to production features of the low vowels.

4. Tongue-jaw coordination needed for precise production. Little-tongue feedback between the tongue and the maxilla. More restricted tongue movement between the low vowels than between the high vowels.

5. Results of this perceptual study combined with acoustic analyses derived from the same words (see Fig. 7) provide insights into the specific reduced speech intelligibility, and are in line with documented anatomical dysmorphology.

**Implications for research and clinical intervention:**

1. Reduced speech intelligibility in DS is likely due to multiple factors, including: (a) craniofacial dysmorphology; (b) motor impairment or immaturity; and (c) hearing loss and/or auditory processing disorders.

2. Future research that collects longitudinal data would allow for a more complete understanding of how the various factors contribute to reduced intelligibility. Collecting sex and age variables would likely help the identification of the ontological and/or developmental processes that are involved in the reduction of speech intelligibility in DS.

3. An assessment should be developed that includes all of the phonetic properties, taking into account the specific contribution of each factor to reduced speech intelligibility.

4. These treatments could be included in a general intervention plan, such as that described by Swift & Rossen.

5. Because reduced intelligibility in DS could be due to both articulatory and perceptual factors, interventions that directly address the anatomy of the oral complex, such as a stimulating palatal plate, may be particularly warranted. Considering age-specific longitudinal and articulatory patterns might further clarify such interventions on speech intelligibility in DS.