Articulation Rate and Vowel Space Characteristics of Young Males With Fragile X Syndrome: Preliminary Acoustic Findings

**Purpose:** Increased speaking rate is a commonly reported perceptual characteristic among males with fragile X syndrome (FXS). The objective of this preliminary study was to determine articulation rate—one component of perceived speaking rate—and vowel space characteristics of young males with FXS.

**Method:** Young males with FXS \( (n = 38) \), developmental age (DA)-matched males \( (n = 21) \), and chronological age (CA)-matched males \( (n = 16) \) were audiotaped while engaged in spontaneous conversation and a picture-naming task. Articulation rate in syllables per second during intelligible utterances and vowel space area/dispersion measures were acoustically determined for each speaker.

**Results:** Males with FXS did not articulate significantly faster than CA-matched males. Area and dispersion of the acoustic vowel space also were similar between the 2 groups. Males with FXS, however, used significantly shorter utterances and had a tendency to pause less often than CA-matched males. In addition, males with FXS exhibited greater intraspeaker variability of formants associated with the vowel /a/.

**Conclusions:** These preliminary findings suggest that articulation rate may not be a primary factor contributing to perceived speaking rate of males with FXS. Limitations of the study relative to speech production tasks and utterance intelligibility are discussed.

**KEY WORDS:** fragile X syndrome, speaking rate, articulation rate, vowel space

Fragile X syndrome (FXS), a recently identified genetic disorder, is the most common inherited cause of mental retardation in males, with an estimated prevalence rate of approximately 1 in 4,000 (Crawford, Acuna, & Sherman, 2001; Turner, Webb, Wake, & Robinson, 1996). In FXS, there is a change in the fragile X mental retardation 1 (FMR-1) gene so that it does not make the normal amount of fragile X mental retardation protein (FMRP), which is believed to be essential for normal brain functioning (Devys, Lutz, Rouyer, Belloqc, & Mandel, 1993; Jin & Warren, 2000). The amount of FMRP affects physical and development aspects of individuals with FXS. The range of functioning in affected males varies from profound retardation to average intelligence (de la Cruz, 1985; Tassone et al., 1999), with the majority showing deficits in the moderate to severe range.

Most males with FXS have moderate to severe delays in speech and language. Delays in vocabulary and syntax, as well as some atypical pragmatic language (e.g., perseveration of words, sentences, and topics; poor topic
Articulation errors are common in males with FXS, including consonant substitutions, omissions, and distortions (Hansen et al., 1986; Madison, George, & Moeschler, 1986; Newell, Sanborn, & Hagerman, 1983; Palmer, Gordon, Coston, & Stevenson, 1988; Prouty et al., 1988). Speech is fairly clear at the single word level, with errors characteristic of developmentally younger children (Hansen et al., 1986; Madison et al., 1986; Newell et al., 1983; Palmer et al., 1988; Paul, Cohen, Breg, Watson, & Herman, 1984; Roberts et al., in press). In contrast, conversational speech is often unintelligible (Paul et al., 1984; Spinelli, Rocha, Giacheti, & Richieri-Costa, 1995). Although poor intelligibility in conversational speech is common among young and adult males with FXS, there is a spectrum of speech involvement among affected individuals.

Based on perceptual judgments, speech and vocal characteristics of males with FXS have often been described as “peculiar,” “distinct,” or “unusual” (Abbeduto & Hagerman, 1997; Hanson et al., 1986; Paul et al., 1987). In addition to speech errors and poor speech intelligibility, dysfluent or perseverative speech has been reported among males with FXS (Borghgraef, Fryns, Dielkens, Pyck, & Van den Bergh, 1987; Palmer et al., 1988; Rhoads, 1984), as well as cluttering (Hanson et al., 1986). Oral motor difficulties, such as deficits in motor planning and sequencing, have also been reported (Abbeduto & Hagerman, 1997; Hagerman, Hills, Scharfenaker, & Lewis, 1999; Paul et al., 1984).

Another speech characteristic frequently reported based on perceptual judgments in children with FXS is a rapid and fluctuating rate of speech. Reiss and Freund (1992) used parental reports to compare the rate of speech of 34 boys who had FXS (age 3–18 years) with the rate of speech of 32 boys who were developmentally delayed and found that significantly more boys with FXS used an unusual rate of speech. The term unusual was not defined. Hanson and colleagues (1986) evaluated the speech characteristics of 10 boys with FXS (ages 3 to 8 years). They reported that 9 of the 10 boys used a fast and fluctuating rate of speech with rapid bursts, which they described as characteristic of cluttering. Borghgraef et al. (1987) surveyed the parents, speech–language pathologists, and teachers of 23 boys with FXS (age 2–12 years) on various speech characteristics and found that 85% of the boys were reported to use rapid speech rhythm. Spinelli et al. (1995), however, reported that 3 of 8 (38%) Portuguese-speaking males with FXS (age 7–26 years) “did not present variable speed of speech.” It must be emphasized that all of these studies assessed speaking rate by perceptual judgments and/or ratings, not by objective methods.

The purpose of the present investigation was twofold. First, we wished to determine by acoustic methods if young boys with FXS differed from typically developing boys in their rate of articulation. This objective was motivated by perceptual reports suggesting that excessive speaking rate is a common characteristic of males with FXS. Although the perception of speaking rate may be influenced by several factors, including articulation rate, the number and length of pauses (Goldman-Eisler, 1968; Miller, 1981; Miller, Grosjean, & Lomanto, 1984), and prosodic characteristics (den Os, 1985), we chose to focus on articulation rate as a preliminary goal. Second, we wished to determine if acoustic vowel space differed between young boys with FXS and typically developing boys. This objective was motivated by (a) recent findings that have shown relationships between speech intelligibility and acoustic vowel space in speakers with dysarthria (Higgins & Hodge, 2002; Turner & Tjaden, 2000; Turner, Tjaden, & Weismer, 1999; Weismer, Jeng, Laurens, Kent, & Kent, 2001) and in speakers with normal speech (Bradlow, Torretta, & Pisoni, 1996), and (b) the possibility that the perception of increased speaking rate might be related to articulatory undershoot rather than rate per se (Kent & Rosenbek, 1982). Because of the preliminary nature of the study, we did not attempt to relate perceptual measures of speaking rate to either articulation rate or vowel space characteristics.

### Method

#### Participants

Participants were 38 young males with FXS, 21 typically developing young males matched on nonverbal developmental age (DA), and 16 typically developing young males matched on chronological age (CA). Table 1 describes the three groups of study participants relative to nonverbal developmental and chronological ages.

<table>
<thead>
<tr>
<th>Table 1. Developmental age (DA) and chronological age (CA) levels for males with fragile X syndrome (FXS), DA-matched males, and CA-matched males.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chronological age (months)</strong></td>
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<tr>
<td><strong>M</strong></td>
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<tr>
<td><strong>SD</strong></td>
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<tr>
<td><strong>Range</strong></td>
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<td><strong>Leiter developmental age (months)</strong></td>
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<td><strong>M</strong></td>
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<tr>
<td><strong>SD</strong></td>
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<td><strong>Range</strong></td>
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*Abbeduto & Hagerman (1997).*
boys with FXS were between 95.1 and 167.5 months of age, the DA-matched boys were between 39.2 and 79.3 months of age, and the CA-matched boys were between 97.1 and 163.1 months of age. More details about study recruitment and procedures have been previously reported (see Roberts et al., in press). The School of Medicine Institutional Review Board at the University of North Carolina at Chapel Hill annually reviewed and approved the study protocols. The child’s parent or guardian provided informed consent at entry into the study.

All of the boys with FXS had been diagnosed with full mutation, confirmed by DNA analyses and noted in their medical reports. The boys were recruited from an ongoing longitudinal study of FXS at Frank Porter Graham Child Development Institute or referred from pediatricians’ offices, genetic clinics, or developmental clinics in North Carolina, South Carolina, Virginia, Maryland, Florida, Delaware, New Jersey, Pennsylvania, and Georgia. The typically developing DA- and CA-matched boys were recruited from physicians’ offices, child care centers, and schools in North Carolina.

### Speech Sample

A conversational speech sample was elicited from all children. For boys with FXS and DA-matched boys, conversation was obtained during administration of the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 2002). The ADOS is a semi-structured play session consisting of developmentally appropriate social and toy-based interactions designed to elicit language and social behaviors from children. The administration of the ADOS generally takes about 45 min. CA-matched children talked with an examiner for 10 to 15 min on a topic of their choice.

In addition, all children were engaged in a picture-naming task. The task consisted of 12 pictures that contained the four corner vowels. The target words were sheep, Pete, beet, bat, fat, vat, hoop, suit, boot, shop, tot, and dot. Several practice items were first administered to familiarize the children with the task. If a child did not spontaneously name a picture, then the examiner provided a model.

### Audio Recording Procedures

All sessions were recorded using a portable digital audiotape (DAT) recorder (TASCAM, DA-P1) at a sampling rate of 44.1 kHz. A Shure WBH headset microphone was positioned approximately 3 in. from the child’s mouth. Location of the recording sessions varied among the children. All CA-matched children were recorded in a quiet room at the laboratory of the second author. Children with FXS and DA-matched children were recorded in quiet rooms at the laboratory, in their school, or in their home.

### Data Analysis

All conversational speech samples were orthographically transcribed as part of a larger study. To determine articulation rate, five utterances were selected from a portion of the recorded speech samples of all children. A trained research assistant selected utterances that (a) were mostly intelligible and (b) consisted of at least three to four syllables. A “mostly intelligible” utterance was defined as having no more than one unintelligible word. It was necessary to select utterances that were mostly intelligible because the calculation of the articulation rate—the primary objective of the study—required a determination of the number of syllables. Because of the selection criteria, the five utterances chosen for each speaker typically were noncontiguous from the conversational sample.

The utterances were digitally transferred to Computerized Speech Lab (CSL; Model 4400, Kay Elemetrics), low-pass filtered, and downsampled to 11.025 kHz. Because we used the orthographic transcription as a guide during utterance selection, some utterances contained pauses. After extracting pauses that exceeded 200 ms, a research assistant determined the duration of the utterance in seconds and counted the number of syllables. A second research assistant recounted the number of syllables for all utterances. Discrepancies in the counts of the two research assistants were resolved by having the first author count the number of syllables. The final syllable count for an utterance was then based on agreement with the first author. For all children, mean articulation rate expressed in syllables per second (sps) was calculated based on the five utterances. The mean number and duration of pauses extracted from all five utterances per child were also calculated.

To estimate intrascorer reliability of the measurements of utterance duration, the first research assistant randomly selected 6 participants and repeated the duration measurements. To estimate interscorer reliability, the second research assistant randomly selected 5 participants and repeated the duration measurements made by the first research assistant.

To determine acoustic vowel space, the utterances from the picture-naming task of all children were digitally transferred to CSL, low-pass filtered, and downsampled to 11.025 kHz. A trained research assistant determined the first (F1) and second (F2) formants of the vowels from each target word, using a combination of linear predictive coding (LPC) and wide-band spectrographic procedures. Settings for the LPC analysis included a preemphasis factor of 0.95, a 20-ms frame length,
a Blackman window, and a filter order of 12; settings for the wide-band spectrogram included a preemphasis factor of 0.95, a bandwidth of 323 Hz, and a Blackman window. If the LPC analysis failed to indicate a formant, the wide-band spectrogram was used to manually estimate the formant. All formant frequencies were determined at the temporal midpoint of the vowels as estimated visually from the waveform and/or spectrogram. A second trained research assistant reanalyzed all vowels. F1 and/or F2 discrepancies greater than 100 Hz (greater than 500 Hz for F2 of /i/) were resolved by the first author and used for data analysis. Average F1 and F2 values were then calculated for each child and each of the four vowels. Vowel quadrilaterals were plotted for each child, and vowel space area in Hz squared was determined by using the formula for an irregular quadrilateral (Johnson, Flemming, & Wright, 2004):

\[
\text{Area} = 0.5 \times \left| (i/F2 \times /ae/F1 + /ae/F2 \times /a/F1 + /a/F2 \times /u/F1 + /u/F2 \times /i/F1 - (i/F1 \times /ae/F2 + /ae/F1 \times /a/F2 + /a/F1 \times /u/F2 + /u/F1 \times /i/F2)) \right|
\]

According to Bradlow and colleagues (1996), the usefulness of calculating vowel space area may be limited by the fact that the averaging of vowel categories may obscure patterns of individual vowel articulation. To safeguard against this possibility, Bradlow and colleagues (1996) also calculated vowel space dispersion, a unitless measure. Vowel space dispersion was defined as the mean distance of each individual vowel token (i.e., F1 × F2 location) from a central point in the speaker’s vowel space. Accordingly, we also calculated mean vowel dispersion for each speaker in the present study. Finally, ellipses were drawn in the acoustic vowel space to represent the 95% probability distribution for each vowel (R Software ver. 2.0.1; R Foundation, 2004).

**Figure 1.** Means and standard deviations (error bars) of articulation rate in syllables per second (sp) for CA-matched males, DA-matched males, and males with FXS.

**Articulation Rate**

Figure 1 illustrates the means and standard deviations of articulation rates in sps for CA-matched males, DA-matched males, and males with FXS. Because of recording problems, rate data were not available for 3 males with FXS and 2 DA-matched males. A one-way analysis of variance (ANOVA) indicated a significant group effect for articulation rate, F(2, 69) = 11.86, p < .0001. Post hoc comparisons indicated significant differences (p < .05) between DA-matched males (M = 3.5 sps, SD = 0.6) and CA-matched males (M = 4.6 sps, SD = 0.6) and between DA-matched males and males with FXS (M = 4.3 sps, SD = 0.8). There was no significant difference between males with FXS and CA-matched males.

**Number of Pauses and Duration of Utterances**

Table 2 lists the total number of pauses extracted across all utterances and the mean duration of utterances for the three groups of males. The pause data were analyzed using a one-way analysis of covariance (ANCOVA) with mean duration of utterances (with pauses included) as the covariate. This was done to control for the effects of utterance length as shorter utterances might be associated with fewer pauses. The ANCOVA was not significant, F(2, 67) = 3.03, p > .05, indicating that when utterance length was controlled, the number of pauses did not differ significantly among groups. Relative to duration of utterances, an ANOVA indicated a significant group effect, F(2, 67) = 3.419, p < .0001. Post hoc comparisons indicated significant differences (p < .05) between...
males with FXS ($M = 1.3 \text{ s}$) and both DA-matched males ($M = 1.9 \text{ s}$) and CA-matched males ($M = 2.3 \text{ s}$). This analysis indicates that males with FXS produced significantly shorter utterances than DA- and CA-matched males.

**Acoustic Vowel Space**

Figures 2–4 illustrate acoustic vowel space for CA-matched males, DA-matched males, and males with FXS, respectively. Because of recording problems, vowel space data were not available for the same 3 males with FXS who had missing articulation rate data. In each figure, the superimposed quadrilateral represents mean $F1/F2$ data for children (ages unspecified) as reported by Peterson and Barney (1952). Quadrilaterals are not shown for the

**Table 2.** Total number of pauses exceeding 200 ms across all utterances and duration of utterances (in seconds) during conversation for males with FXS, DA-matched males, and CA-matched males.

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of pauses</th>
<th>Duration of utterances</th>
</tr>
</thead>
<tbody>
<tr>
<td>FXS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>3.8</td>
<td>1.3</td>
</tr>
<tr>
<td>$SD$</td>
<td>2.6</td>
<td>0.4</td>
</tr>
<tr>
<td>DA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>6.7</td>
<td>1.9</td>
</tr>
<tr>
<td>$SD$</td>
<td>2.9</td>
<td>0.4</td>
</tr>
<tr>
<td>CA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>5.3</td>
<td>2.2</td>
</tr>
<tr>
<td>$SD$</td>
<td>2.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

**Figure 2.** Acoustic vowel space for CA-matched males. $F1$ and $F2$ values are illustrated for the four corner vowels. The quadrilateral drawn in the figure represents data for children reported by Peterson and Barney (1952).

**Figure 3.** Acoustic vowel space for DA-matched males. $F1$ and $F2$ values are illustrated for the four corner vowels. The quadrilateral drawn in the figure represents data for children reported by Peterson and Barney (1952).

**Figure 4.** Acoustic vowel space for males with FXS. $F1$ and $F2$ values are illustrated for the four corner vowels. The quadrilateral drawn in the figure represents data for children reported by Peterson and Barney (1952).
participants of the current study in order to permit a clearer comparison to the Peterson and Barney (1952) data. Ellipses also show the 95% probability distribution for each vowel. As illustrated in Figure 2, the F1/F2 values and relative positions of the vowels for CA-matched males are generally similar to data reported by Peterson and Barney (1952). A notable discrepancy, however, occurs for F2 values of /u/. CA-matched males in the present study tended to exhibit relatively high F2 for /u/. This pattern is also evident for the males with FXS (see Figure 4). A combination of factors may account for these formant differences: (a) excessive allophonic variation that is characteristic of /u/ (Bradlow et al., 1996; Kent & Read, 2001), (b) contextual influence of alveolar consonants on /u/ (Stevens & House, 1963), or (c) dialect differences (Hillenbrand, Getty, Clark, & Wheeler, 1995).

Regarding dialect, the children in the present study were from a relatively large geographic region that included the mid-Atlantic and southern states. As indicated by Hillenbrand and colleagues (1995), Peterson and Barney (1952) provided little information regarding dialect, especially relative to the child speakers.

Mean quadrilateral areas for CA-matched males, DA-matched males, and males with FXS were 350, 645 Hz^2; 742, 763 Hz^2; and 389, 369 Hz^2, respectively. Mean vowel space dispersions were 550, 780, and 587, respectively. DA-matched males exhibited the largest vowel space area and greatest dispersion, consistent with a slower rate of speaking or reduced effects of coarticulation. ANOVAs indicated significant group effects for acoustic vowel space area, F(2, 70) = 27.40, p < .0001, and vowel space dispersion, F(2, 68) = 23.17, p < .0001. Post hoc comparisons indicated a significant difference (p < .05) between males with FXS, DA-matched males, and CA-matched males for both vowel space area and dispersion. There was no significant difference between males with FXS and CA-matched males for either measure.

As shown in Figure 4, the generally wider or longer ellipses of the vowels that cover a greater extent of the superimposed quadrilateral suggests excessive scatter of F1/F2 data points of males with FXS. Because of this large group variability, we speculated that intraspeaker variability might also be high. To determine this, we performed a post hoc analysis by computing vowel-specific dispersion measures for each speaker across all groups. The vowel-specific dispersion was calculated by averaging the F1/F2 distance of the three productions of each vowel from a central point for the respective vowel. The vowel /u/ was omitted from this analysis because of the F2 differences for CA males and males with FXS that were noted previously. Table 3 lists the means and standard deviations of the vowel-specific dispersions for the three groups of males and the three vowels /i/, /æ/, and /a/. A multivariate ANOVA indicated a significant group effect, F(6, 120) = 2.81, p < .05. Post hoc ANOVAs were then performed for each vowel. The ANOVA for /a/ indicated a significant group effect, F(2, 64) = 4.15, p < .05. Post hoc comparisons indicated a significant difference (p < .05) between males with FXS (M = 256) and CA-matched males (M = 160).

**Table 3.** Means and standard deviations of vowel-specific dispersions for males with FXS, DA-matched males, and CA-matched males.

<table>
<thead>
<tr>
<th>Group</th>
<th>/i/</th>
<th>/æ/</th>
<th>/a/</th>
</tr>
</thead>
<tbody>
<tr>
<td>FXS</td>
<td>220</td>
<td>122</td>
<td>256</td>
</tr>
<tr>
<td>SD</td>
<td>28</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>DA</td>
<td>200</td>
<td>136</td>
<td>184</td>
</tr>
<tr>
<td>SD</td>
<td>32</td>
<td>18</td>
<td>26</td>
</tr>
<tr>
<td>CA</td>
<td>138</td>
<td>71</td>
<td>160</td>
</tr>
<tr>
<td>SD</td>
<td>36</td>
<td>21</td>
<td>29</td>
</tr>
</tbody>
</table>

**Discussion**

The results of the current study showed that acoustically determined articulation rate and vowel space area for a relatively large group of males with FXS were similar to those for a group of CA-matched males. Although males with FXS exhibited significantly faster articulation rates than DA-matched males, this was expected, given the older chronological age of males with FXS. As indicated by previous research, a positive relationship exists between age and speaking rate. Typically, this relationship is attributed to the fact that younger children use longer sound segment or syllable durations than older children and/or adults (e.g., Hillenbrand et al., 1995; Kent & Forner, 1980; Smith, Kenney, & Hussain, 1996).

These findings suggest that articulation rate may not be a primary factor contributing to perceptual impressions of increased speaking rate in males with FXS. Factors such as utterance duration, number and duration of pauses, and prosodic characteristics may be more important to the perceived speaking rate in males with FXS. Indeed, males with FXS in the present study used significantly shorter utterances and tended to pause less often than CA-matched males. The use of relatively short utterances, combined with few pauses, may give rise to the perception of a rapid speaking rate. Similarly, Campbell and Dollaghan (1995) suggested that the perception of a slowed speaking rate in individuals with traumatic brain injury (TBI) may have its origins in either “articulation speed” or pause time within utterances. They reported, for
example, that an adolescent with TBI and a perceptually slow speaking rate exhibited normal articulation speed (i.e., average syllable duration with pauses excluded), but elevated pause time within utterances. Other evidence suggests that prosodic characteristics may also play a role in perceived speaking rate. It has been reported, for example, that utterances with relatively unchanged fundamental frequency contours are perceived as spoken faster than utterances with normal contours (den Os, 1985; Lehiste, 1976). Fluctuations in articulation rate may also influence perception (Hanson et al., 1986). Although we did not systematically evaluate rate fluctuations in the present study, males with FXS exhibited slightly higher group variability in articulation rate ($SD = 0.8$ sps) as compared with CA-matched males ($SD = 0.6$ sps).

Males with FXS and CA-matched males also exhibited similar acoustic vowel space areas. This finding suggests that articulatory undershoot may not contribute to perceived speaking rate in males with FXS. Although similar vowel space areas may be expected, based on similar articulation rates, vowel space areas were determined from a separate speaking task. Thus, articulation rates may not have been similar across tasks. In addition, Kent and Rosenbek (1982) suggested that at least for speakers with parkinsonian dysarthria, articulatory undershoot may occur independently of changes in articulation rate and may contribute to perceived speaking rate.

Finally, males with FXS exhibited significantly greater intraspeaker variability during the production of /a/ than CA-matched males, as indicated by the vowel-specific dispersion measures (see Table 3). Although the significance of this finding is not clear, some investigators have identified a relatively large jaw as a distinctive characteristic of males with FXS (e.g., Paul et al., 1984). Perhaps males with FXS have difficulty controlling the relatively extensive jaw movements associated with the vowel /a/. Jaw movement control may be especially variable during the developmental period of rapid physical growth associated with the prepubescent years. Increased intraspeaker variability was not observed for the low vowel /ae/, however. Obviously, additional research is required to confirm this speculation and determine its impact, if any, on speech intelligibility.

**Limitations of the Present Study**

There are several limitations to this preliminary study. First, as noted earlier, the articulation rate and vowel space data were determined from different speaking tasks. Conclusions regarding vowel space area based on articulation rate, therefore, may not be possible. DA-matched males exhibited the largest vowel space area and slowest articulation rate, a finding that is consistent with previous research (e.g., Turner et al., 1995) and provides some evidence that speakers in the present study, at least the DA-matched males, may have used similar articulation rates during both tasks.

A second limitation involves the utterance selection criterion. Because of the need to reliably count syllables to calculate articulation rate, we selected utterances from males with FXS that were mostly intelligible. It is possible that this approach may have masked differences in articulation rate. To shed some light on this possibility, we conducted another analysis. Using the orthographic transcripts, we identified 10 utterances that were 100% intelligible and 10 utterances that were 50% or less intelligible from the first 5 males with FXS. We then determined the duration of each utterance. For the 5 males selected, the mean duration of 100% intelligible utterances was 1.2 s ($SD = 0.2$), while the mean duration of the unintelligible utterances was 1.4 s ($SD = 0.2$). Although this analysis provides some evidence that unintelligible utterances were not shorter in duration than intelligible utterances, the possibility remains that the unintelligible utterances were produced with a greater number of syllables.

**Summary**

The results of this preliminary study indicate that an increased articulation rate does not appear to be a pervasive characteristic of males with FXS. Findings from the word-naming task also suggest that articulatory undershoot, independent of rate, may not be a characteristic of males with FXS. Obviously, additional research is needed; it should include perceptual ratings of speaking rate in males with FXS, along with simultaneous measures of articulation rate, utterance length, pausing duration, and prosodic features to determine the influence on speaking rate and overall intelligibility.

**Acknowledgments**

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