ABSTRACT

THE EFFECT OF TASK TYPE ON FUNDAMENTAL FREQUENCY IN CHILDREN AGES 4.0-5.11 YEARS

by Dana Sprouse

The purpose of this study was to determine how task type influences fundamental frequency in children ages 4.0 to 5.11 years. Fundamental frequency is an acoustic measure and is defined as the average rate of vocal fold vibration. Thirty children (16 males; 14 females) without hearing loss or the presence of a voice disorder were included in this study. Each participant completed 3 tasks for the elicitation of fundamental frequency. The tasks included: sustaining a vowel for approximately 5 seconds, counting from 1 to 10, and telling a story from 4 picture cards. A repeated measures analysis of variance indicated that there was no significant difference in fundamental frequency across the task type (p=.101). These findings are clinically useful as speech-language pathologists should be able to use any of the three tasks to assess function and track progress with children ages 4.0 to 5.11 years.
# TABLE OF CONTENTS

## CHAPTER I (INTRODUCTION & REVIEW OF LITERATURE) ................................................. 1
- Dysphonia in the Pediatric Population ........................................................................ 1
- Referral and Case History .......................................................................................... 2
- Physical Examination ............................................................................................... 3
- Voice Evaluation ...................................................................................................... 3
- Perceptual Measurement ........................................................................................... 3
- Aerodynamic Measurements .................................................................................... 4
- Acoustic Measurements ............................................................................................ 5
- Task Elicitation and Cue Type .................................................................................. 6
- Statement of the Problem ......................................................................................... 10
- Statement of Purpose ............................................................................................... 10
- Research Question ................................................................................................. 11
- Research Hypotheses ............................................................................................... 11

## CHAPTER II (METHODS) ................................................................................................. 12
- Participants ............................................................................................................. 12
- Procedures .............................................................................................................. 12
  - Hearing Screening ............................................................................................... 12
  - Voice Screening .................................................................................................. 13
  - Experimental Tasks ............................................................................................. 13
  - Data Measurement and Analysis ........................................................................ 14

## CHAPTER III (RESULTS) .................................................................................................. 14
- Quality of Data ....................................................................................................... 14
- Analysis by Task Type ........................................................................................... 15
- Fundamental Frequency and Age .......................................................................... 16
- Fundamental Frequency and Gender ..................................................................... 18

## CHAPTER IV (DISCUSSION) ............................................................................................ 20
- Critique of Study Design .......................................................................................... 22
- Limitations ............................................................................................................. 21
- Future Research ..................................................................................................... 22
# Conclusion

References

Appendices

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix A</td>
<td>Flyer</td>
<td>27</td>
</tr>
<tr>
<td>Appendix B</td>
<td>Informed Consent Form</td>
<td>28</td>
</tr>
<tr>
<td>Appendix C</td>
<td>Child Assent</td>
<td>31</td>
</tr>
<tr>
<td>Appendix D</td>
<td>CAPE-V</td>
<td>32</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table 1. Mean Fundamental Frequency and Standard Deviation by Task Type for All Participants ...............................................................15

Table 2. Mean Fundamental Frequency and Standard Deviation by Task Type and Age..................................................................................16

Table 3. Mean Fundamental Frequency and Standard Deviation by Task Type and Gender.................................................................18
LIST OF FIGURES

Figure 1. Mean Fundamental Frequency and Standard Deviation by Task Type for All Participants…………………………………………………………………..…15

Figure 2. Mean Fundamental Frequency and Standard Deviation by Task Type and Age………………………………………………………………………………….17

Figure 3. Mean Fundamental Frequency and Standard Deviation by Task Type and Gender……………………………………………………………………….……..19
CHAPTER I
Introduction and Review of the Literature

*Dysphonia in the Pediatric Population*

Various criteria have been used to define dysphonia in children. Children with dysphonia may present with a “chronically hoarse voice,” a voice deviation, disorders of nasal resonance, and combined articulation and/or voice problems (Carding, Roulstone, Northstone, & ALSPAC, 2006). The American Speech-Language-Hearing Association (ASHA) defines dysphonia as an impairment of the speaking or singing voice (ASHA, 2005). Dysphonia may cause pain, a communication disability, and/or an occupational or social handicap. Dysphonia occurs because of an abnormality of the structures of the voice production system and/or the manner in which these structures are used. A voice disorder also can occur rapidly in association with a traumatic event (Stemple, Glaze, & Klaben, 2000).

Previous studies speculate that the prevalence rate of voice disorders in the pediatric population ranges anywhere from 6% to 24% (Wilson, 1983). Stemple et al. (2000) reported that the most common causes (etiologies) of dysphonia in children are subglottic stenosis, vocal nodules, laryngomalacia, dysphonia without known pathology, and vocal fold paralysis. There are several risk factors that put children in danger of developing chronic dysphonia. These include hearing loss, frequent upper respiratory tract problems, and large family dynamics (Carding et al., 2006). It has been reported that children with older siblings are at a significant risk of developing dysphonia (Carding et al.). The assumption is that children with a large number of siblings have to work harder to have their voice heard which may put them at risk for vocally abusive behaviors, such as yelling.

Yelling at increased volumes is, in fact a common occurrence in this age group. In a study by Connor et al. (2006), parents' opinions about their children's voices were examined. Children, ages 2 to 4 years old, as well as their caregivers were interviewed about physical aspects, social/functional aspects, and emotional components of the child's voice. All of these children had a
Diagnosis of dysphonia. Parents reported that the child’s day care providers frequently asked the toddlers to be more quiet in the classroom. Seventy-eight percent of the toddlers indicated that they were frequently told to use a quiet voice. Ten children, ages 5-7 years old, were also interviewed about their voice with their caregivers. These children reported that their most significant problems were running out of air and difficulty initiating voice without increased physical effort. Half of this age group of children reported feeling saddened, angered, or frustrated by their dysphonic voice and 50% of those children who felt saddened, angered, or frustrated also reported that other people asked them about their voices.

**Dysphonia Management: Assessment**

**Referral and Case History**

A child may be referred for voice evaluation by a physician, teacher, school speech-language pathologist, singing teacher, voice coach, or the patient’s parent (Stemple et al., 2000). When a referral is made for a voice evaluation, the speech-language pathologist will attempt to identify the potential causes of the disorder, describe the present vocal components, and develop a management plan unique to the patient (Stemple, 2000). Information pertaining to the chronological history of the problem, etiologic factors associated with the history, and patient motivation should all be included in the case history portion of a voice evaluation (Stemple). It is necessary to receive detailed case history information including a detailed medical and social history. A speech-language pathologist can conduct a voice evaluation in the absence of medical information, however the decision about whether or not to begin voice therapy should be deferred until all medical information is obtained (Boone, McFarlane, Von berg, & Zraick, 2005). Knowledge of a patient’s medical history is pertinent because his/her voice problem could be due to a mass lesion on the vocal folds, which could be malignant, and life threatening (Boone et al., 2005). The medical history portion should include medically related etiologic factors and establish awareness of the patient’s basic personality (Stemple). The patient’s vocational, social, recreational, and psychological history should also all be collected as part
of the case history (Colton, Casper, & Leonard, 2006). The goal of collecting the social history is to know the patient’s home and recreational environments, emotional, social, or family components, and to determine more etiologic factors (Stemple).

**Physical Examination**

It is necessary for a child who presents with symptoms of dysphonia to undergo a complete examination by an otolaryngologist, as well as a detailed medical history. An otoscopic examination of the ears, observation of the oral and nasal cavities, palpation of the salivary glands, lymph nodes, and thyroid gland, and a visual examination of the larynx are imperative to ensure the correct diagnosis of the voice disorder and to rule out any other health condition that may be the cause of a voice problem (Stemple et al., 2000). The use of a fiberoptic or rigid endoscope will aid the otolaryngologist in visualizing the structure and function of the vocal folds. Videostroboscopy allows the examiner to evaluate each vocal fold’s vibration characteristics cycle (e.g. phase closure, symmetry, glottis closure, and mucosal wave) during different phases of the vocal folds’ vibration (Baken & Orlikoff, 2000). Videostroboscopy allows the otolaryngologist and speech-language pathologist to view the vocal folds at a simulated slower rate with the use of a strobe light and microphone. The light from the stroboscope is synchronized to the vocal fold vibration at a slightly slower speed. This allows the examiner to observe vocal fold vibration during vocal production in simulated slow motion (Stemple et al.). After reviewing the results of the videostroboscopy, the otolaryngologist can then make a diagnosis and recommend treatment.

**Voice Evaluation**

**Perceptual Measurement**

Auditory-perceptual measurement is another tool that a clinician can use during a voice evaluation that rates a patient’s pitch, loudness, and vocal quality. Clinicians may use the GRBAS (grade, roughness, breathiness, asthenia, and strain) to perceptually rate a patient’s voice (Hirano, 1981). A scale ranging from 0-3 is used for each parameter: 0=normal, 1=slight disturbance, 2=moderate
disturbance, and 3=severe disturbance. Another scaling tool, the Consensus Auditory Perceptual Evaluation of Voice (CAPE-V; ASHA, 2003), was developed for perceptual assessment of voice. Overall severity, roughness, breathiness, strain, pitch, and loudness are rated using a 100-mm visual analog scale. The patient is asked to sustain vowels, produce multiple sentences, and provide a spontaneous speech sample. The rater then places a vertical marking along each vocal characteristic's horizontal line. The far left portion of the line represents a mild impairment and the far right represents a severely impaired voice.

Aerodynamic Measurements

Aerodynamic measures are also collected during a voice evaluation to determine the valving efficiency of the vocal folds during phonation. Two of the most common aerodynamic measures include: subglottic pressure and airflow rate.

Subglottal pressure is the pressure that builds up below the vocal folds, until the airflow overcomes resistance and sets the closed folds into vibration (Stemple et al., 2000). If insufficient pressure is generated, the vocal folds will not vibrate. Normative range for subglottal pressure in children, ages 8.5-11.5 years, is 3-7 cm H₂O (McAllister, 1998). Normative values for subglottal pressure of children ages, 6 to 10 years range from 5.13 to 10.48 cmH₂O (Baken & Orlikoff, 2000; Weinrich, Salz, & Hughes, 2005).

Airflow rate is the measurement of the air flowing through the vocal folds during speech (Boone et al., 2010). The interchange of pressure and flow is essential to vocal fold vibration as well (Colton et al., 2006). Normative values for average airflow rate in the adult population range from 80 to 200 ml/s (Colton et al.). There is sparse data on average airflow rate in the pediatric population. A person with a neurologic disease or patients with a disordered voice may present with abnormal patterns of average airflow rate, as low as 10 to 15 ml/s (Stemple et al., 2000). A person who presents with a vocal fold paralysis, such as unilateral vocal fold paralysis could have abnormally high values, which in one study were reported as a mean of 425.1 ml/s (Kraus, Orlikoff, Rizk, & Rosenberg,
Acoustic Measurements

The voice evaluation also includes the collection of acoustic measurements. Acoustic measurements can be used as objective indicators for the evaluation of the severity of the voice disorder. They could also be used to track progress throughout the patient’s participation in a voice therapy program (Niedzielska, 2000). Fundamental frequency refers to the average number of cycles of vibrations of a speaker’s vocal folds per second (Baken & Orlikoff, 2000). Fundamental frequency can be measured in a variety of ways and can be obtained from a sustained vowel production or connected speech. Previous methods of obtaining this measure included the use of a frequency counter and low-pass filter, as well as a pitch meter (Colton, et al., 2006). Currently, measures of fundamental frequency can be obtained quickly and easily with computer software, such as Visi-Pitch (KayPENTAX, 2006).

Many physical characteristics of the laryngeal source can affect fundamental frequency. The properties of the laryngeal source and vocal tract, which may include mass and stiffness of the vocal folds, can affect the patient’s fundamental frequency values (Niedzielska, 2000). Fundamental frequency is controlled by vocal fold length and tension (Stemple et al., 2000). To achieve higher fundamental frequency, the cricothyroid muscle is contracted which causes the vocal folds to lengthen and the medial edge to thin (Stemple et al.). In contrast, when a lower fundamental frequency is produced, the contraction of the vocalis shortens the vocal fold length, which decreases tension on the cover and rounds the medial edge (Stemple et al.).

A previous study examining normative data for children ages, 5 to 11 years, showed that males had a mean fundamental frequency value of 226 Hz, with an overall range from 179 Hz to 272 Hz (Glaze et al., 1988). Females had a mean fundamental frequency value of 238 Hz, with a range of 193 Hz to 294 Hz. One study demonstrated that fundamental frequency may vary by race (Awan & Mueller, 1996). This study found the mean fundamental frequency for
kindergarten-aged African American children to be 236.40 Hz and 248.71 Hz in Hispanic children.

Another acoustic measurement useful in a voice evaluation is maximum phonation frequency range (MPFR). Maximum phonation frequency range (lowest to highest sustainable note) involves phonating at both the modal and falsetto registers (Reich, Frederickson, Mason, & Schlauch, 1990). Maximum phonation frequency range values may provide knowledge of the operating capability of the human voice and can be obtained in a short time, with minimal instrumentation, and values can be compared to published normative data (Reich et al., 1990). If an individual’s MPFR values are not within normative range, this could be a possible indicator of pathology affecting the voice. Maximum phonation frequency range is a reflection of the physiological limits of a person’s voice and the physical condition of the person’s vocal ability. A person who has MPFR values out of the normative range could have poor vocal health. An adult speaker has a frequency range of approximately two octaves above the lowest sustainable tone (Zemlin, 1998). Studies have reported differing values for MPFR in relation to age, but mean MPFR has been reported as more than thirty semitones, or 740 Hz for typical, healthy young- and middle-aged adults (Baken & Orlikoff, 2000). This type of data is unknown for children. In Reich’s study, all elicitation conditions evoked a significantly higher maximal fundamental frequency and a significantly larger fundamental frequency range (in both hertz and semitones) than did the discrete-steps condition (Reich et al.). The women demonstrated a significantly larger fundamental frequency range (in hertz but not semitones) than did the men (Reich et al.).

Task Elicitation and Cue Type

When using acoustic measures to assess a patient’s voice, it is important that the measures be valid and reliable. Acoustic measurements obtained from young children have the potential to vary depending on the task and types of cues given throughout the task. Previous research indicates several different types of tasks that may be used to gather acoustic measures. These include having a child sustain a vowel, counting, or obtaining a connected speech
Several studies have demonstrated mixed findings in whether or not fundamental frequency values of children significantly change depending on the type of task they complete (Baker, Weinrich, Bevington, Schroth, & Schroeder, 2008; Zraick, Marshall, Smith-Olinde, & Montague, 2004; Zraick, Skaggs, & Montague, 2000).

Zraick, Skaggs, and Montague (2000) also completed a study that examined if task type influences fundamental frequency. Thirty-six subjects were examined including, 12 adult males, 12 adult females, and 12 prepubescent children (ages 5 to 10 years). The study used 7 different conditions to elicit fundamental frequency including, counting, sustaining an “ah”, reading from a passage, a spontaneous speech sample, producing an “um-hum”, counting from 1 to 3 with the production of “eeh”, and producing an “uh-huh”. The findings of this study indicated that task type did not affect fundamental frequency in the pediatric population or adult male population. However, the adult women’s fundamental frequency was affected by the type of task completed.

In another study, Baker et al. (2008) examined the relationship between fundamental frequency and task type, using four elicitation tasks (sustained vowel task, phrase task, sentence task, and counting task) in 48 children ranging in ages from 5 to 7 years. None of the children in this study had a voice disorder and were not serviced by an Individualized Education Plan. A sustained vowel task was completed for approximately 5 seconds. A phrase task with a sustained vowel at the end was then completed, followed by a sentence task (“Bob wants a Ball”). Lastly, the participant was asked to count from 1 to 10. All of these tasks were randomized for each participant. This data was analyzed using the Multi-Dimensional Voice Analysis Program to determine mean fundamental frequency. This study concluded that counting elicited significantly higher fundamental frequency values in comparison to phrase and sentence tasks in this group of children. It is important to note the significance of the difference in fundamental frequency produced from different elicitation tasks when fundamental frequency is being used to track progress. The same elicitation task should be used to compare baseline and post-treatment values, otherwise a change in acoustic
values may be observed due to the task performed. These results are comparatively different than those of Zraick’s study. These two studies used some of the same fundamental frequency elicitation tasks which were completed in similar ways in both studies. It is unknown why these two studies had differing results. There were slight differences in these two studies. The Baker et al. study included more participants and used a narrower range than the Zraick et al. study. The Zraick et al. study also integrated more vowel tasks than the Baker et al. study. The Baker et al. study incorporated more functional tasks.

It has been noted that a person’s loudness level may also change depending on the type of speech task they complete (Zraick et al., 2004). Four different task types, including a counting task, elicited task, reading task, and spontaneous task were completed by 30 women (18 to 30 years old). Zraick et al. concluded that there were statistically significant differences in vocal intensity between automatic speech and spontaneous speech, as well as, automatic speech and reading. This study also supports that clinical findings, such as acoustic measurements, can vary depending on task type.

The effect of the administration of cues on frequency measures has also been examined. Cue type can affect measurements of fundamental frequency values. Bohnenkamp, Andrews, Shrivastav, and Summers (2002) confirmed that using cognitive cueing (being told to imagine what is happening) elicits more vocal variability. The study examined 15 children (9 males and 6 females) with a mean age of 10 years. The children participated in 2 different trials, including reading sentences with no cues and then reading sentences with a cognitive cue (participants were asked to think about and “feel” the meaning of the sentence). For example, a child was instructed to say “the submarine sank to the bottom of the sea” and picture this in their mind while saying it. The children’s voices changed significantly in the direction indicated by the meaning of the words. This study also revealed gender differences, revealing that male subjects produced less frequency variability in the reading tasks than the female subjects during the no cue condition. However, the males showed greater frequency variability than the females did in the cognitive cue condition. Providing cues, such as cognitive
cues, could result in differing fundamental frequency values in comparison to not using cues.

In another study examining the effect of cues on fundamental frequency, Andrews, Shrivastav, and Yamaguchi (2000) examined 9 adult females, with a mean age of 25 years, and a minimum of 5 years of singing training, normal hearing, and no history of voice problems. The study also examined 4 subjects with voice disorders. Eight sentences were used in this study and for each sentence two cognitive cues were administered. Each participant read each sentence a total of three times. In trial one, the participant was not given any cue and in trial two the research investigator asked the subject to imagine the situation given in the cue. Instructions to the participant were as follows, “We want to practice how your voice reflects meanings and feelings. Picture it in your mind as you read it and then say it aloud.” They then produced the sentence. One sentence was as follows “The submarine sank to the bottom of the sea.” The research investigator then would reinforce the sentence by saying to the participant “Let me hear how the sailors felt as the submarine sank, think about the surface of the water. Start your voice there and show me how the submarine goes down.” Each participant read the 8 sentences 3 different times, once with no cue and twice with cues. This study concluded that the participant’s voices varied more with cues than with no cues. All subjects showed a significant increase in duration when reading the sentences with the cognitive cue. The 4 voice disordered participants showed a significantly higher frequency variation in the cued trials.

Zraick, Nelson, Montague, and Monoson (2000) examined if task elicitation type alters maximum phonation frequency range (MPFR). Thirty females between the ages of 20 and 31 years participated in this study. Verbal instructions accompanied by “hand-stepping” cues were used during the discrete-step trials and “hand-sweeping” motions were used in the glissando trials. The maximum fundamental frequency and minimum fundamental frequency values were examined. This study concluded no statistically significant differences between the 2 elicitation tasks. Therefore, the question of whether
elicitation type causes changes in MPFR values in adults remains debatable. More research needs to be completed in the future with children regarding MPFR and task elicitation.

**Statement of the Problem**

Acoustic measurements of voice are an essential component of a voice evaluation and can be used to differentiate a disordered voice from a normal voice. Acoustic measurements are also a means of tracking progress throughout the course of voice therapy. Fundamental frequency is an acoustic measurement that is often obtained during a voice evaluation. Fundamental frequency can be measured by completing different tasks including sustaining vowels, counting, and producing connected speech (e.g., repeating sentences). There is limited research regarding task types and their effects on fundamental frequency, particularly in children. In fact, only two such studies were found in this literature review. These studies were also completed using older children and not with preschool aged children. In general, previous research tends to demonstrate the acoustic measures do vary by task type (Baker et al., 2008; Zraick et al., 2000; Zraick et al., 2004).

**Statement of Purpose**

The purpose of this study was to determine how task type affects fundamental frequency in preschool and kindergarten aged children. This information is potentially useful to clinicians when using these measures to determine differences between normal versus abnormal voices, as well as to track progress over time with these measurements. In previous studies mentioned above, researchers have concluded that providing children with different types of tasks may significantly influence their fundamental frequency values. The outcome of this study will provide information about how differing task types including sustaining a vowel, counting, and informal speech sample affect fundamental frequency measurements in children ages 4.0-5.11 years.
Research Question
1. Does task type (sustained vowel task, counting task, structured speech sample) significantly alter fundamental frequency measurements in children ages 4.0-5.11 years?

Research Hypothesis
1. It is hypothesized that fundamental frequency will be significantly different when elicited by a sustained vowel task, counting task, and structured speech task in children ages 4.0-5.11 years.
CHAPTER II

Methods

Participants

Thirty children, ages 4.0-5.11 years, were recruited from the southwestern Ohio area for participation in this study using flyers (Appendix A). Sixteen 4-year old children (8 males and 8 females) and fourteen 5-year children (8 males and 6 females) participated in this study. Flyers were placed at local early childhood care centers, Miami University’s Speech and Hearing Clinic, academic buildings located in Oxford, Ohio, as well as local preschools in order to recruit participants. Parental/guardian consent (Appendix B) was obtained for each participant before beginning the testing session, which was completed in the Clinical Voice Lab at Miami University. The informed consent and child assent forms (Appendix C) included a description of the study; all participation in this study was voluntary. This study was approved by Miami University’s Institutional Review Board.

Procedures

All participants were required to pass a perceptual voice examination and a hearing screening in order to participate in this study. One participant did not pass the hearing screening and was therefore excluded from the study. Any participant diagnosed with a voice disorder was excluded from this study (screening described below). Each participant was briefed on the nature of the study and agreed to participate (child assent). The parent read an informed consent form, explaining the study’s purpose and procedures. After the consent forms were signed data collection began. Each testing session lasted approximately 30 minutes. All data collection took place in the Clinical Voice Lab, which constituted a quiet environment with minimal background noise. This was important to the study’s reliability because the microphone could have picked up excess noise, which could have impaired the fundamental frequency values.

Hearing Screening

Prior to collecting acoustic measurements, a bilateral pure-tone hearing screening was administered. A child with a hearing loss could have varying vocal
characteristics that could alter the study’s overall results. Any child who failed the hearing screening was not included in the study. A portable pure-tone audiometer (MAICO MA 25) was used to screen each child. Each participant was instructed to raise his or her hand upon hearing the tone. Pure tones were presented at 25 dB HL at 500, 1000, and 2000 Hz.

**Voice Screening**

After passing the hearing screening, a perceptual voice screening was completed. Each child was instructed to count from 1 to 10 and then repeat three short sentences from the Consensus Auditory Perceptual Evaluation-Voice (CAPE-V) (Appendix D). Two 2nd year master’s students in the field of speech-language pathology conducted each screening. While all children passed the voice screening, if a child had exhibited signs of dysphonia, the child would not have been included in the study and would have been referred to a speech-language pathologist for further screening.

**Experimental Tasks**

The participant was asked to complete 3 tasks. The tasks included: sustaining the vowel /a/ for approximately 5 seconds (3 consecutive times), counting from 1 to 10 (3 consecutive times), and talking about 4 picture cards (representing a structured story). The research investigator modeled each task one time. Tasks were randomized by having the participant choose a card from a stack of cards. Each card had a specific task for the child to complete (vowel task, counting task, and picture card task). Cues were administered to each participant who appeared to be having difficulties with sustaining the vowel for 5 seconds. Verbal, visual, and tactile cues were used. Visual cues, such as counting to five on the research investigator’s hand were used. Tactile cues, such as running a finger down the participant’s arm for them to visualize the length of time to say the vowel were also used.

A microphone (Shure Dynamic SM48) was used to record speech productions. This microphone was connected to a desktop computer containing the Real-time Pitch Program (KayPENTAX, 2006). A 2-inch mouth-to-microphone distance was maintained at all times for all tasks.
Data Measurement and Analysis

The middle 3-second portion of the sustained vowel was used for analysis. The average fundamental frequency of the 3 trials of sustained /a/ was recorded. The onset and offset of the counting task was used for analysis. The average fundamental frequency of the 3 trials of counting from 1 to 10 was used for analysis. The average fundamental frequency of three 5-syllable phrases were used from the story telling task for analysis.

Data was analyzed using SPSS 16.0 for Windows. A repeated measures analysis of variance (ANOVA) was used to examine the mean differences in fundamental frequency values across task types.

Chapter III

Results

Quality of Data

The data obtained was examined by a 2nd year master’s student researcher in the field of speech-language pathology to assess the quality of the data. The researcher listened to the recorded samples twice to ensure that the length of the sustained vowel was at least 3 seconds and that there were at least 3 5-syllable phrases in the structured story task. Out of 30 participants, seven children completed the sustained vowel for less than 3 seconds for each of the three trials (six 4-year olds and one 5-year old could not produce the sustained vowel for 3 seconds). Two participants did not provide a sufficient structured story sample (one 4-year old and one 5-year old could not provide a long enough speech sample to use for the data analysis). The two participants who did not provide a sufficient story sample were amongst the seven participants who did not sustain the vowel for at least 3 seconds. Therefore a total of seven participants were not included in the data analysis.

Analysis by Task Type

A repeated measures ANOVA was used to analyze the data using SPSS 17.0 for Windows. The results of the analysis revealed that there was no significant difference between the task types \( F(2,44) = 2.42, p = .101 \). The means and standard deviations for task types are shown in Table 1 and Figure 1.
Table 1

*Mean Fundamental Frequency and Standard Deviation by Task Type for All Participants*

<table>
<thead>
<tr>
<th>Task Type</th>
<th>Sustained /a/</th>
<th>counting</th>
<th>storytelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>263.21 Hz</td>
<td>255.31 Hz</td>
<td>267.84 Hz</td>
</tr>
<tr>
<td>SD</td>
<td>5.21</td>
<td>22.49</td>
<td>25.05</td>
</tr>
</tbody>
</table>

Figure 1

*Mean fundamental frequency by task type for all participants*
*Fundamental Frequency and Age*

For all three tasks, the mean fundamental frequency values were higher for the 4-year old participants than for the 5-year old participants. These values are illustrated in Table 2 and Figure 2.

Table 2

*Mean Fundamental Frequency and Standard Deviation by Task Type and Age*

<table>
<thead>
<tr>
<th>Task Type</th>
<th>Sustained /a/</th>
<th>counting</th>
<th>storytelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 year olds</td>
<td>Mean 266.04 Hz 256.56 Hz 272.79 Hz</td>
<td>SD 7.05 26.48 28.54</td>
<td></td>
</tr>
<tr>
<td>5 year olds</td>
<td>Mean 261.04 Hz 254.34 Hz 264.04 Hz</td>
<td>SD 3.79 19.43 22.37</td>
<td></td>
</tr>
</tbody>
</table>
Figure 2

Mean fundamental frequency by task type and age
**Fundamental Frequency and Gender**

For all three tasks, the mean fundamental frequency values for the male participants were lower than for the female participants. These values are illustrated in Table 3 and Figure 3.

**Table 3**

*Mean Fundamental Frequency and Standard Deviation by Task Type and Gender*

<table>
<thead>
<tr>
<th>Task Type</th>
<th>Sustained /a/</th>
<th>counting</th>
<th>storytelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>260.43 Hz</td>
<td>251.36 Hz</td>
<td>263.5 Hz</td>
</tr>
<tr>
<td>SD</td>
<td>6.33</td>
<td>22.15</td>
<td>25.43</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>266.25 Hz</td>
<td>259.61 Hz</td>
<td>272.59 Hz</td>
</tr>
<tr>
<td>SD</td>
<td>3.99</td>
<td>22.87</td>
<td>24.6</td>
</tr>
</tbody>
</table>
Figure 3

*Mean fundamental frequency by task and gender*
Chapter IV

Discussion

The present study determined whether task type (sustained vowel, counting, or structured speech task) influenced fundamental frequency values in children ages 4.0 to 5.11 years. This study examined the mean fundamental frequency of 23 children. Results indicated that there was no significant difference for fundamental frequency between any of the task types. The present study demonstrates similar results to the Zraick, Skagg, and Montague (2000) regarding the influence of task type on fundamental frequency in children. Although the Zraick et al. study examined older children, the results of their study were similar to the findings of the current study in that task type did not affect fundamental frequency values. However, the results of the present study were not in agreement with the findings of the Baker et al. (2008) study regarding task type and fundamental frequency. This study collected data from 5- to 7-year old children. Four similar task types were used to elicit fundamental frequency (sustaining a vowel, counting, phrase task, and sentence task) in these children. This study reported that counting task elicited a statistically significant higher fundamental frequency value than all other tasks. Both the Zraick et al. (2000) and Baker et al. (2008) studies used the same types of task to elicit fundamental frequency. However, there were slight differences in the tasks used in these two studies. The Zraick et al. study used more vowels in their task production in comparison to Baker et al. study. The Baker et al. study also used a narrower age range than the Zraick et al. study, which could account for the result differences.

Assessments are extremely important to clinicians and need to be valid and reliable as these are the tools that clinicians rely on to diagnose and track progress in patients with voice disorders. The present study’s results are clinically applicable, stating that there is evidence provided by this study that a clinician could use any of the three task types (sustained vowel, counting, structured speech sample) to evaluate and track progress throughout therapy in
children, ages 4-5.11 years. It can be difficult to collect acoustic measurements, such as fundamental frequency, in this age group. Some children may be shy, nervous, or uncooperative, which is why it is important to have a variety of tasks that are known to produce accurate results when collecting fundamental frequency. The type of task the clinician chooses should not influence fundamental frequency values.

Children may also react differently to the manner that a task is presented to them. For example, a person who appears to be speaking with excitement might influence their own speech production to have a higher amount of vocal variability or an increase in their fundamental frequency. This could cause the child’s fundamental frequency values to be inconsistent compared to other tasks. The person who is demonstrating the fundamental frequency task could also influence a child’s fundamental frequency values. A child may produce a varied level of fundamental frequency values when speaking with a family member of friend than a clinician that they are unfamiliar with.

The present study also illustrates fundamental frequency differences in gender and age. This study provides evidence of the physiologic changes that occur with age of the vocal folds. This study demonstrated that the younger aged participants (4-year olds), produced slightly higher fundamental frequency values than the older participants (5-year olds). This can be verified in Table 2 and Figure 2. As children mature, the vocal folds lengthen which, in turn, causes fundamental frequency to decrease (Stemple, 2000). This study also demonstrated that the female participants produced slightly higher fundamental frequency values than male participants. This can be verified in Table 3 and Figure 3. However, it should be noted that the greatest difference in fundamental frequency between males and females was 9 Hz on the storytelling task. This is a barely perceivable difference in frequency. This minor difference in gender is not surprising as significant differences in fundamental frequency in gender do not appear until the age of 10 years.

**Limitations**

This study examined an age group that is not frequently studied. There were
some challenges in using this young age group. Cooperation and behavior were problematic at times and some participants appeared shy, or could not follow multiple directions. The majority of the data that had to be removed from the formal data analysis was from the 4-year old participants. Six 4-year olds in comparison to one 5-year old had to be removed from the formal data analysis. This could be due to their young age and difficulty following directions. It should also be noted that multiple models were used with each participant to ensure that each participant knew how to complete the tasks.

Even though cues (tactile, verbal, and visual) were added in an attempt to have the participant sustain a long enough vowel, there was no standardized, consistent hierarchy of cueing that was used in this study. A consistent standardization of cues could be added into the sustained vowel task in order to achieve the full five seconds. Different methods should be used to achieve a longer structured speech sample. Different methods could include, looking through a picture book and describing the pictures or recording the child during play. These would be less structured tasks that would elicit longer speech samples. It also would be helpful to give the participant more time to become more comfortable with the research investigator. Due to the children’s young age, the child’s comfort level may play a large role in the reliability of an assessment.

**Future Research**

There are many aspects of the current study that could be replicated and expanded upon such as, measurements of intensity and MPFR. Zraick et al. (2004) previous study concluded that different task types elicit different intensity levels. This loudness measurement could be examined in preschool aged children to determine if loudness measures are affected by task type. This would be clinically useful when tracking the progress of children with voice disorders. Maximum phonation frequency range (MPFR) is another acoustic measurement that clinicians use to evaluate children with voice disorders and track progress patients with voice disorders make throughout treatment. Zraick et al. previous study (2000) examined if task elicitation type alters maximum phonation frequency range (MPFR) in the adult population, but task type differences for this
measure have not been evaluated in the preschool population. Future research also needs to address fundamental frequency values in children with voice disorders. Fundamental frequency values need to be examined in this atypical population to determine if task type influences fundamental frequency values. This is important so that clinicians can be ensured that the types of tasks used will not significantly affect fundamental frequency measurements in children with voice disorders.

Conclusion

The results of this study have concluded that within the 4-5.11 year old age group, task type did not impact fundamental frequency results. Three tasks were examined, including counting, sustained vowel, and a structured story task. The results of this study will be valuable to speech-language pathologists when evaluating and tracking progress in children with voice disorders.
References


Attention Parents!

Children ages 4 and 5 years old needed at Miami University’s Speech and Hearing Clinic for a research study
Your child will…
• receive a hearing and voice screening.
• be asked to complete several speech tasks such as counting and telling a story.
• receive a small toy for their time and travel.

This study will take approximately 30 minutes and parents will receive a Kroger gift card in the amount of $15.
If interested, please contact Dana Sprouse or Shelley May at 513-529-7181 or email at sprousdc@muohio.edu or maysk2@muohio.edu

This study has been approved by the Miami University Institutional Review Board, protocol number 09-187.
Appendix B

Informed Consent

The effect of task type on acoustic measures and repeatability of aerodynamic measures in children ages 4.0-5.11 years

Description of the Research

A primary component of a voice disorder evaluation is to collect measures of voice production, and measures related to the respiration required to support speech. Average airflow is one measurement that will be collected from your child. Average airflow is the rate of airflow through the vocal folds during speech. The purpose of this study is to investigate how repeatable average airflow is. In addition, fundamental pitch, which is an acoustic measurement, will be collected using various task types. Your child is being asked to participate in this study because he/she does not have any problems with his/her voice, but the results of this study will be beneficial in developing assessment protocols to use with children who have voice disorders.

Research Procedures

Testing Session

Prior to collecting the measurements of your child’s voice, your child will be required to pass a basic hearing and voice screening. The hearing screening will involve listening to a tone presented at four pitches in each ear. Your child will have to raise his/her hand to indicate hearing each tone. The voice screening will involve the examiners listening to your child’s voice while repeating short sentences. If your child does not pass the voice and hearing screenings, he/she will be referred to the Miami University Speech and Hearing Clinic for further evaluation. You will be responsible for any fees associated with a visit to the Speech and Hearing Clinic outside of this study. Your child will be seated in a quiet room (Room 49 Bachelor Hall) and instructed to follow directions provided by the investigators.

Your child will wear a face mask that goes over his/her nose and mouth. This mask will not obstruct breathing. First, your child will be asked to sustain “ah” at a comfortable pitch and volume for 3 trials. Then your child will be asked to choose a card from a stack of cards sitting on the table. Each card represents a specific task that your child will complete. The tasks include sustaining a vowel, counting from 1 to 10, and telling a story using 4 picture cards. Your child will speak into a microphone for these three tasks. The microphone will be connected to a computer that will record all of your child’s speech productions.

The first set of tasks, during which your child wore the face mask and spoke several “ahs,” will be repeated again to examine the consistency of the
measurements for this age group. The entire testing session will take approximately 30 minutes.

When these tasks are completed your child will be given a small toy. You will be given a $15 Kroger card for your time and travel.

**Time Required for Participation**

Your child’s participation will take approximately 30 minutes.

**Risks**

There are no known risks associated with this study and we do not predict any potential for discomfort. If your child does not want to complete a certain task, the study will stop.

**Benefits**

This study has the potential to improve testing procedures for patients with voice disorders.

**Alternative Treatments**

There are no alternative treatments in this study.

**Confidentiality**

The information obtained about your child in this study will be kept confidential. This information will be kept in a locked file cabinet in the primary investigator’s office. Information saved electronically will be on a password protected computer that does not have public access. Your child’s information will be assigned a code number, and the key for this code will be stored separately from your information. Once your child’s participation in this study is completed, all identifying information that could link your child’s information will be destroyed and your child’s data will be kept in a locked file cabinet as anonymous data.

**Voluntary Participation**

Your child’s participation in this study is voluntary. Your child has the right to refuse to participate or discontinue his/her participation in this study at any time. If your child does refuse to participate, he/she will still receive a small toy and you will receive a Kroger gift card for your time and travel. Withdrawing from the study will not affect your relationship with Miami University now or in the future.

**Questions About the Study**
You may ask questions regarding the study and the study procedure at any time. You can reach the primary investigator for this study, Susan Brehm, Ph.D. at (513) 529-2553 or bakerse1@muohio.edu. You may also contact Barbara Weinrich, Ph.D. at (513) 529-2548 or weinribd@muohio.edu with any questions regarding your rights as a participant in this study.

**Questions About Rights of Participants**

You may contact the Office for the Advancement of Research and Scholarship at (513) 529-3734 or at humansubjects@muohio.edu with any questions regarding your rights as a participant in this study.

**In signing this document I acknowledge that I am the legal guardian of this participant and I am at least 18 years of age.** I have been informed about this study’s purpose, procedures, possible benefits, risks, and how my privacy will be protected. I will receive a copy of this form. I have been given the opportunity to ask questions and told that I can ask questions at any time. I voluntarily agree to allow my child to participate in this study. By signing this form, I am not waiving any legal rights.

_______________________________________ __________
Signature of Person Consenting Date

_______________________________________ __________
Witness Date
Appendix C

Child Assent
The effect of task type on acoustic measures and repeatability of aerodynamic measures in children ages 4.0-5.11 years

Hello! Our names are Dana and Shelley, what is your name? We are going to play some games and we would like you to play with us. At any time you can choose not to do something. The first thing we will do is see how your ears are hearing. Let’s see those ears of yours! We are going to pretend that you are an airplane pilot and put these earphones over your ears. We will have you listen closely for beeps and tell us when you hear them. The next thing we will do is have you repeat some sentences. Then we will have you put on this mask (show mask). This mask will not hurt you at all. You will be able to breathe just as you are right now. When you are wearing the mask we will ask you to say some funny sounds. After that, we will start a different game. We have cards on the table, and you can pick whatever card you want. This will tell us what game we are going to play! We will play each game three times. You will get to say “ah”, count from 1 to 10, and make up a story from pictures! After all those games, you will get to put the mask back on and say some more sounds before you leave. Do you have any questions about the games we are going to play? Remember, if you do not want to play a game, it is OK to tell us! Let’s start!
Appendix D

**Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V)**

1. The blue spot is on the key again.
2. We eat eggs every Easter.
3. How hard did he hit him?
4. My mama makes lemon muffins.
5. We were away a year ago.
6. Peter will keep at the peak.