ABSTRACT

VOICE CHARACTERISTICS OF PRESCHOOL AGE CHILDREN

By Melanie Schuckman

Limited data exists in the literature that describes typical voice production for preschool-aged children. The purpose of this study was to collect normative data for voice production and calculate the prevalence of dysphonia in 3- to 5-year-olds. Twenty-seven children were recruited from the greater Cincinnati, Ohio area. Several acoustic and aerodynamic measures of voice were obtained, including (a) sustained vowel fundamental frequency ($F_0$), (b) speaking $F_0$, (c) maximum phonatory frequency range (MPFR), (d) and maximum phonation time (MPT). Findings for $F_0$ and MPT corroborate data in existing literature. Data for MPFR was not able to be reported due to lack of accurate measurement methods. The prevalence figure for dysphonia was not valid due to small sample size. Continuation of this study is necessary to further validate results.
VOICE CHARACTERISTICS OF PRESCHOOL AGE CHILDREN

A Thesis

Submitted to the

Faculty of Miami University

in partial fulfillment of

the requirements for the degree of

Master of Arts

Department of Speech Pathology and Audiology

by

Melanie Schuckman

Miami University

Oxford, Ohio

2008

Advisor__________________________________________

Susan Baker, Ph.D.

Reader___________________________________________

Barbara Weinrich, Ph.D.

Reader___________________________________________

Wendy LeBorgne, Ph.D.
# TABLE OF CONTENTS

## CHAPTER I (Introduction and Review of the Literature)

What is Dysphonia? ........................................................................................................ 1
Prevalence of Dysphonia in Children ............................................................................. 1
Dysphonia Management: Evaluation ............................................................................. 3
  Significance and Validity of Referral Source ......................................................... 3
  Visualization of the Vocal Mechanism .................................................................... 5
  Perceptual Measurements ......................................................................................... 5
  Aerodynamic Measurements ..................................................................................... 6
  Acoustic Measurements ............................................................................................ 7
    Fundamental frequency .......................................................................................... 7
    Frequency range .................................................................................................... 7
Normative Measures .................................................................................................... 8
Statement of the Problem ............................................................................................ 12
Statement of Purpose .................................................................................................. 12
Research Questions .................................................................................................... 13

## CHAPTER II (Methods)

Participants .................................................................................................................. 14
Procedures .................................................................................................................... 14

  Hearing Screening ..................................................................................................... 14

  Voice Screening ......................................................................................................... 14
    Fundamental frequency .......................................................................................... 15
    Frequency range measurement ............................................................................. 15
    Maximum phonation time measurement ............................................................... 16

Analysis of Data .......................................................................................................... 16

## CHAPTER III (Results)

Methodology ................................................................................................................ 17
Compliance ..................................................................................................................... 18
Analysis of Data by Research Question ........................................................................ 18

  Research Question 1 .................................................................................................. 18
    Sustained vowel $F_0$ ............................................................................................ 18
LIST OF TABLES

Table 1—Sustained Vowel $F_0$ of Children by Gender .......................................................... 19
Table 2—Sustained Vowel $F_0$ of Children Aged Three to Five Years by Age Group ............. 19
Table 3—Speaking $F_0$ During Counting Task of Children by Gender ..................................... 20
Table 4—Speaking $F_0$ During Counting Task of Children Aged Three to Five Years by Age
   Group ........................................................................................................................................ 20
Table 5—Speaking $F_0$ During Sentence Repetition Task of Children by Gender ..................... 22
Table 6—Speaking $F_0$ During Sentence Repetition Task of Children Aged Three to Five Years
   by Age Group .............................................................................................................................. 22
Table 7—Maximum Phonation Time (MPT) of Children by Gender .......................................... 24
Table 8—Maximum Phonation Time (MPT) of Children Aged Three to Five Years by Age
   Group ........................................................................................................................................ 24
LIST OF FIGURES

Figure 1. Sustained vowel F0 of children by gender ................................................................. 19

Figure 2. Sustained vowel F0 of children aged three to five years by age group .................. 20

Figure 3. Speaking F0 during counting task of children by gender ........................................ 21

Figure 4. Speaking F0 during counting task of children aged three to five years by age group... 21

Figure 5. Speaking F0 during sentence repetition task of children by gender ....................... 22

Figure 6. Speaking F0 during sentence repetition task of children aged three to five years by age group ........................................................................................................... 23

Figure 7. Maximum phonation time (MPT) of children by gender ........................................ 24

Figure 8. Maximum phonation time (MPT) of children aged three to five years by age group ... 25
CHAPTER I
Introduction and Review of the Literature

What is Dysphonia?

From the time we are born, our voices are used as a means to communicate with those around us to convey information about our physical health, our emotions, and our personality. When there is a problem with any one of the subsystems of voice production (respiration, phonation, or articulation), we perceive a notable difference in vocal quality (Andrews & Summers, 2002). Dysphonia is present when a person’s quality, pitch, or loudness differs significantly from others of similar age, gender, and cultural background. Speech-language pathologists (SLPs) are often involved in the identification and management of dysphonia in children. It is estimated that 6% to 38% of school-aged children have a voice disorder (Carding, Roulstone, Northstone, & ALSPAC, 2006). Lee, Stemple, and Glaze (2003) compiled a list of functional indicators of dysphonia in children and adolescents, which include, but are not limited to, frequent coughing or throat clearing; rough, hoarse, breathy, weak, or strained vocal quality; higher than average vocal loudness; frequent yelling, screaming, or crying; frequent laryngitis due to colds; and chronic illness or disease.

Alterations in laryngeal function as the result of dysphonia can be quantified with a variety of instrumental tools, including aerodynamic and acoustic measures. Acoustic and aerodynamic data is used as a noninvasive, indirect measurement of laryngeal function in patients who have dysphonia (Stemple, Glaze, & Klaben, 2000). There is a wealth of information available on the acoustic and aerodynamic parameters of the typical adult voice (e.g., Awan, 2006; Dogan, Eryuksel, Kocak, Celikel, & Sehitolu, 2007; Gamboa et al., 1997; Klein, Piccirillo, & Painter, 2000; Lim, Choi, Kim, & Choi, 2006; Robinson, Mandel, & Sataloff, 2005; Tavares & Martins, 2007); however, research and literature focusing on pediatric acoustic and aerodynamic data is sparse. Those studies that do exist, specifically for acoustic data, are limited in age representation.

Prevalence of Dysphonia in Children

Reported values for the prevalence of dysphonia in children are estimated to be between 6% and 9% (Andrews & Summers, 2002). However, studies have reported prevalence figures as low as 0.12% (McKinnon, McLeod, & Reilly, 2007) and as high as 38% (Carding et al., 2006). Completed studies vary greatly in their methods and have primarily focused on school-age
In one such study of school-age children, Carding and colleagues (2006) examined a group (n=7389) of 8-year old children for voice disturbances. Participants were recruited from a large-scale epidemiological study, the Avon Longitudinal Study of Parents and Children (ALSPAC; n=13,971). In this study, 5 research SLPs, with 5 to 17 years clinical experience, completed voice screenings, consisting of a binary assessment instrument (a simple yes/no value for atypical voice). At the time of the evaluation, parents were asked to respond to a questionnaire regarding risk factors for dysphonia (i.e., number and age of siblings, asthma, surgeries, noise level in the home) and were asked to state whether their child “never, sometimes, or often” experienced a husky or absent voice. Prevalence of dysphonia in this cohort was found to be 6% using the binary voice screening. Parental reports revealed that 11.6% of the sample had either an intermittent or a permanent voice problem. The study was conducted in the United Kingdom, and the sample was determined to be slightly lacking in proportion of less affluent and ethnic minority families. This study employed a large sample and two different methods of dysphonia identification; however, it did not: (a) sample from a variety of ages, (b) use assessment instruments that have been established as reliable or valid, or (c) obtain detailed acoustic data.

In another study, McKinnon and colleagues (2007) reported prevalence figures that were much lower than Carding et al. (2006). Within an Australian Catholic diocese, 10,425 children from middle- to upper-class families, in kindergarten through Grade 6, were recruited. For this study, children were identified primarily by classroom teachers to be evaluated for speech, voice, and stuttering disorders. Utilizing collaboration from certified SLPs, the researchers reported prevalence of voice disorders among this sample as 0.12%. This study also reported that the prevalence of speech disorders decreases in the upper grade levels, and it corroborated the report that speech disorders in general occur more frequently in male children than female children. The results of this study are difficult to generalize due to the absence of data to establish interrater reliability among teachers, who served as the primary referral source for intervention.

Prevalence of dysphonia has been well-documented in school-age children; however, only one study has been dedicated to the study of the prevalence of dysphonia in preschool age children (Duff, Proctor, & Yairi, 2003). This study examined the prevalence of dysphonia in
African-American and European-American preschoolers. A total of 2445 children, aged 2 to 6 years old, were screened for dysphonia using three referral methods: teacher identification, investigators’ screening, and parent identification. Teachers and parents were asked to identify any child suspected of having a speech, language, stuttering, voice, or hearing disorder. The investigators of this study screened every child in the study, and each child identified by a teacher or parent was more closely observed by the investigators during the screening process. Corroboration of two certified SLPs was necessary for identification of dysphonia. The researchers found a prevalence figure of 3.9% in their large sample of American preschoolers; however, no significant difference was identified between the two races. The authors concluded, based on their research, that there is a slightly lower prevalence of dysphonia among preschool children than among older school-age children. Although the researchers sought to find a difference in the prevalence between male and female groups, no significant difference was found between the groups.

**Dysphonia Management: Evaluation**

In the management of dysphonia, a complete voice evaluation is necessary before a remediation program can be initiated. In children, deviant vocal quality must first be identified and then brought to the attention of the child’s pediatrician or an otolaryngologist. Following identification, a diagnostic evaluation and complete voice analysis may be completed. When the appropriate steps have been completed, an individualized management plan can be developed (Stemple et al., 2000).

Identification of deviant voice quality is the initial step. Ideally, an individual will independently determine that his own voice is insufficient for his functional voice demands and seek the help of a medical professional. Additionally, family, friends and colleagues may initiate informal, subjective identification of deviant voice quality for adults (Stemple et al., 2000). For children, self-identification is unlikely. A referral for pediatric vocal disturbances can come from many sources, including classroom teachers, pediatricians, and parents (Andrews & Summers, 2002).

**Significance and Validity of Referral Source**

Children with dysphonia may be identified through routine speech and language screenings in schools (Stemple et al., 2000). However, rising demands are being placed on school-based SLPs. The average caseload for SLPs has increased to as many as 80 students in
some states (ASHA, 2004). With larger numbers of children who have multiple handicaps or are medically fragile in mainstream classrooms, SLPs are beginning to manage their time according to the size of caseload, and to a lesser extent, the individual needs of the students (Dowden et al., 2006). There is a growing incidence of complex cases on the typical SLP’s caseload, and assessment and treatment of medically fragile children has become more complicated (Ruddy & Sapienza, 2004; Woodnorth, 2004). As a result of advances in neonatology, average caseload size and complexity is continually increasing. Many studies warn readers of the risk of under-identification of children in need of services (McKinnon et al., 2007; Ruddy & Sapienza, 2004; Woodnorth, 2004). Because of these demands, it is often physically impossible for the school-based SLP to screen all children.

The adults in a child’s life must be aware of the signs and symptoms of pediatric dysphonia and should be the first to identify a voice quality concern (Carding et al., 2006; McKinnon et al., 2007). Despite this need, little research has been done regarding the validity of referrals for voice evaluations made by teachers, pediatricians, and parents. While calculating a prevalence figure of voice disorders in a large group (n=7389) of 8-year old children, Carding et al., in a study previously described in this Review of the Literature, found that parents reported far more cases of dysphonia (11%) than were discovered by the researchers (6%). Also, 5% of parents of children found to have dysphonia reported that their children had never had a problem. It should be noted that the parent questionnaire asked whether the child had ever had difficulty with his or her voice, whereas the identification process occurred at a single point in time. The investigators reported that parent report of dysphonia does not necessarily correspond with clinician findings in calculation of prevalence. Consequently, in order to improve the validity of referrals made for pediatric dysphonia, adults must be educated further in this area.

A pattern of under-identification has begun to emerge as research studies are conducted which compare findings of clinicians to those of untrained individuals. In the Australian research study previously described in detail (McKinnon et al., 2007), teachers were utilized as the primary identifiers of students with speech disorders, including disorders of fluency, voice, and speech sounds. Prevalence of voice disorders was found to be 0.12% among students in the private schools of one Catholic diocese in New South Wales. This figure is the lowest prevalence figure reported for voice disorders in children. This low prevalence figure may be due to under-identification by teachers. This may indicate a faulty referral source for the study.
In another study previously described in this Review, Duff et al. (2004) examined the prevalence of preschoolers with vocal hoarseness utilizing teacher referral and parent/guardian questionnaire for identification of children with dysphonia. Teachers concurred with 26.3% of the investigators’ positive cases of dysphonia. Parents concurred with 25.7% of the investigators’ positive cases of dysphonia. This implies an under-identification pattern of dysphonia in children by both parents and teachers. This study emphasizes the finding that disagreement between clinicians and untrained individuals can cause a pattern of under-identification of pediatric dysphonia. It has also underscored the need for appropriate staffing of SLPs in the school system to offset this pattern, identifying students requiring services of any kind so that appropriate remediation programs may be set in place.

**Visualization of the Vocal Mechanism**

Once the appropriate referral to a medical professional occurs, the child undergoes a diagnostic evaluation. During the diagnostic evaluation, visual analysis of the laryngeal mechanism is carried out by an otolaryngologist or SLP. Instrumental analysis is used to view the anatomy of the larynx and to determine presence of vocal fold lesions or abnormal vocal behavior (Stemple et al., 2000). For visualization of the vocal mechanism, one of several methods may be utilized. Laryngeal mirrors have been used by otolaryngologists for indirect laryngeal examination, however, this method does not allow the vibratory characteristics of the vocal folds to be observed. The same is true of endoscopes, rigid and flexible, which have been used to directly view the vocal mechanism. Such approaches to laryngeal examination yield information regarding the presence of lesions, anatomical structures, and vocal fold function (Stemple et al., 2000). Videostroboscopy utilizes strobe lighting to create the illusion of slow motion vocal fold vibration, and has become the standard in evaluation of laryngeal function (Andrews & Summers, 2002). Videostroboscopic evaluation allows the examiner to assess the vibratory characteristics of the vocal folds, such as phase closure, symmetry, glottic closure, and mucosal wave (Baken & Orlikoff, 2000). These methods are used by otolaryngologists as a means for identifying and diagnosing laryngeal pathology and by SLPs for the evaluation of laryngeal function.

**Perceptual Measurements**

Perceptual analysis provides another important component of a voice evaluation. Clinicians perceptually evaluate a voice by listening to pitch, loudness, and vocal quality.
Clinical judgment gained through experience allows clinicians to integrate perceptual voice qualities with information regarding case history and behavioral observation. Areas of voice typically assessed during perceptual evaluation include: general quality, respiration, phonation, resonance, pitch, and loudness (Stemple et al., 2000). A common tool for perceptual evaluation of voice quality is the Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V; ASHA, 2002). However, diagnostic information gained through perceptual analysis alone is limited due to variability between listeners (Krieman, Gerratt, Precoda, & Berke, 1992).

**Aerodynamic Measurements**

Instrumental measurement has made significant contributions to the assessment process, and it augments clinical findings. Aerodynamic measurements provide objective non-invasive measurements of vocal quality and laryngeal function. The interactions of pressure and airflow within the vocal tract lead to conclusions about the valving capabilities of the vocal folds (Baken & Orlikoff, 2000). Subglottic pressure, average airflow, and maximum phonation time are commonly used aerodynamic measures (Stemple et al., 2000).

Because it is simple to obtain, maximum phonation time (MPT) is a common aerodynamic measure of voice. The equipment used to obtain some aerodynamic measures of voice can be expensive, but measurement of MPT requires only a stopwatch. As the name suggests, MPT refers to the length of time a speaker is capable of producing continuous voicing (Stemple et al., 2000). Maximum phonation time is influenced by several of factors, including the amount of air available for phonation, glottal airway resistance, and ability to maintain consistent driving pressure (Baken & Orlikoff, 2000). It also demonstrates the speaker’s physiologic capacity for speech production (Andrews, 2006). Maximum phonation time can be estimated when a speaker inhales to the maximum capacity and produces a comfortable voice on a sustained vowel until breath support is diminished and the tone can no longer be produced. Typically, several trials are necessary to determine a true value for this measurement (Baken & Orlikoff).

Because of its contributing factors, MPT taken in isolation is not an accurate depiction of laryngeal function (Finnegan, 1984; Stemple et al., 2000). A number of variables may contribute to a decreased MPT value. Disordered glottal valving, reduced volume availability, and loss of subglottal pressure each may cause a lower MPT (Baken & Orlikoff). In a complete clinical
voice evaluation, several aerodynamic and acoustic measures must be taken in conjunction with the visual examination to determine pathological bases for dysphonia.

**Acoustic Measurements**

Acoustic measures of voice are also objective, non-invasive methods to gain indirect measures of vocal function (Stemple et al., 2000). Of all of the components of a voice evaluation, acoustic measures are generally the most simple to obtain and require the least amount of instrumentation. Software programs for acoustic analysis of the voice are widely available at this time, which makes these measures highly accessible to clinicians. Information gained from acoustic analysis of a voice can be used in the voice evaluation process as an indirect measurement of laryngeal function (Baken & Orlikoff, 2000). While a large number of acoustic measures can be extracted from a recorded voice signal, two of the more common measures include fundamental frequency ($F_0$) and maximum phonatory frequency range (MPFR).

**Fundamental frequency.** Fundamental frequency ($F_0$) refers to the average number of cycles of vibrations of a speaker’s vocal folds per second (Baken & Orlikoff, 2000). In order for $F_0$ to be measurable for a sample, the waveform produced must be nearly periodic, meaning the waveform repeats itself at a near constant rate (Baken & Orlikoff). Vocal production of a sustained vowel emits such an acoustic signal. The acoustic signal produced from a voice is shaped by the resonating cavities in the vocal tract. When connected speech is produced, a range of frequencies is present. Because the average frequency of a sustained vowel is more consistent, specialized software can be used to analyze the sample and produce an average measurement of frequency (Baken & Orlikoff). When connected speech is produced, a Speaking $F_0$ can be measured as the average of the varying frequencies present in the speech sample (Stemple et al., 2000).

**Frequency range.** Maximum Phonatory Frequency Range (MPFR) is the range of frequencies that a speaker is able to produce, which may be measured in semitones or hertz. This value provides information about the vocal abilities of the speaker, as well as the physical condition of the vocal mechanism (Baken & Orlikoff, 2000). Measurement of frequency range requires a higher level of cooperation on the part of the speaker. A recording must be made of a speaker’s highest and lowest frequency. A maximum frequency is usually obtained through a gliding exercise, where the speaker voices a glide from a mid-range frequency to the highest frequency he is capable of producing. Conversely, a similar gliding exercise can be used to
obtain a minimum frequency, where the speaker voices a glide from a mid-range frequency to
the lowest frequency he is capable of producing (Stemple et al., 2000). Measurement of MPFR
includes both modal and falsetto registers; however, glottal fry is not included in the
measurement because it is not typically used continuously in connected speech (Baken &
Orlikoff). Once a sample has been collected and defined, specialized computer software is used
to determine the range of frequencies produced by a single subject. Reports of MPFR vary with
age and representative sample, but mean MPFR has been reported as more than thirty semitones,
or 740Hz for typical, healthy young- and middle-aged adults (Baken & Orlikoff).

**Normative Measures**

Interpretation of instrumental measures of voice requires a standard against which one
can compare obtained values. Without normative values, it would be impossible to competently
assess an individual’s vocal performance based on measures obtained during a diagnostic
evaluation. However, normative values reported through research studies vary according to the
demographic being analyzed, elicitation techniques, equipment, and analysis method. Using
these measurements, individual measures can be compared to normal and pathological groups
(Stemple et al., 2000). Normative measures for F₀ in female adults range from 151.2-256.6 Hz
and from 118.4-152.7 Hz in adult males (e.g., Altenberg & Ferrand, 2006; Gamboa et al. 1996;
Oguz, Demirci, Safak, Arslan, Islam, & Kargin, 2007). Normative measures for MPFR in female
adults range from 19.9-35 semitones and from 20.9-36 semitones in adult males (e.g., Gamboa et
al., 1996; Robinson et al., 2005; Robert, Pouget, Giovanni, Azulay, & Triglia, 1999). Normative
measures for MPT in female adults range from 10.5-26.0 seconds and 12.1-35.6 seconds in adult
males (e.g., Awan, 2006; Fishman & Shipp, 1970; Kim et al., 2006).

Normative measures for F₀, MPFR, and MPT for children are of limited availability in
the literature. Anatomical and perceptual differences between children and adults justify the
need for normative data specific to pediatric populations. The most obvious difference between
an adult and a pediatric larynx is the size of the vocal mechanism. The structure of the pediatric
larynx is much smaller than the typical adult larynx. In newborns, typical vocal fold length
ranges from 2.5 to 3.0 mm (Hirano, Kurita, & Nakashima, 1983). The pediatric larynx grows
continually as a function of age, with vocal cord length ranging from 11 to 15 mm in typical
adult females and 17 to 21 mm in typical adult males (Hirano et al., 1983). Position,
composition, and configuration of the pediatric larynx also differ from those of adults. A child’s
larynx is positioned higher in the pharynx than an adult’s larynx (Fried, 1983). In children, the cartilages of the larynx are softer than those in adults, making it less susceptible to trauma but more susceptible to collapse. Also, the vocal folds in children have a much higher proportion of membranous tissue and lower proportion of ligamentous tissue than the vocal folds in adults (Hirano et al.). Another major difference is the configuration of cartilages. In children the epiglottis is typically omega-shaped and pliable, and the configuration places the epiglottis in more direct contact with the tongue and sometimes the soft palate (Fried, 1983).

Differences between the voices of adults and children can be attributed to the smaller structure of the pediatric larynx and vocal folds, as well as the more membranous, less ligamentous composition of vocal structures. For example, average speaking F0 is higher for children than adults. Because of these differences in anatomy and voice production between adults and children, normative data for the adult population should not be used as evaluative measurement standards for the pediatric population (Sapienza, Ruddy, & Baker, 2004). Although limited in number and scope, several studies have been published which report normative acoustic and aerodynamic parameters in children. The majority of research in this area has focused on the F0 of children’s voices. Mean values reported for F0 in typical male children can be found in Appendix A, and for typical female children in Appendix B. These tables include comprehensive lists of available research studies and data resulting from each study. This data makes it clear that F0 is a common measure obtained in research studies seeking normative data. The studies present a range of mean F0 in their outcome data. Although the data in these tables is extensive, only six of these studies present data on the preschool-age population (Hall & Yairi, 1992; Perry, Ohde, & Ashmead, 2001; Wertzner, Schreiber, & Amaro, 2005; Awan & Mueller, 1996; Weinberg & Zlatin, 1970; McGlone & McGlone, 1972). Several studies found an inverse relationship between F0 and age. No major gender differences were observed from the data in the table prior to the age of 13 years, where the average for males continues to be lower than for females in each successive age group (Linders, Massa, Boersma, & Dejonckere, 1995; Morris, 1997; Weinberg & Zlatin, 1970; Wertzner et al., 2005; Whiteside & Hodgson, 2000).

Far fewer studies report normative values for maximum phonation time (MPT). A table representing research studies that report MPT in children and the findings from their research can be found in Appendices C and D. Appendix C represents values for typical male children, while
Appendix D represents values for typical female children. A single study by Finnegan (1984) presents data for the preschool-age population. In this study, a clear relationship can be seen between MPT and age. As age increases, MPT does as well. This points to the need for complete normative data for all age groups. There is no marked gender difference in the data portrayed in Appendix D; however, average MPT in females appears to be slightly lower than the average for males after the age of 10 years. Although MPT is a very common measure to include in a voice evaluation because of ease of collection of data, several studies that report MPT also point to limitations of this measure in the assessment process.

In Finnegan (1984)—referred to above, several problems with obtaining MPT in children are described. Finnegan examined 286 male and female children with normal voices aged 3.6 to 17.11 years. The investigator, an SLP with 9 years experience, elicited 14 trials for MPT from each participant to analyze the effect of age, sex, and multiple trials on performance. This study reported findings for each age group, consisting of 1-year ranges. (Reported MPT values for this study can be found in Appendices C and D.) This study reported that a mere 16.2% of male and 23% of female children produce their actual MPT within the first three trials, making MPT a somewhat inaccurate measurement, depending on the elicitation method used. Finnegan also reported several drawbacks to using MPT as a diagnostic indicator of voice: differences in body height and weight within age groups contribute to MPT ability, competitiveness and motivation are subjective contributors among individuals, and consistency of maximum effort exerted differs among individuals within age groups. Finnegan also reported several factors that may enhance individual performance on MPT tasks, as a result of his analysis of multiple trials. These include visual feedback, self-monitoring, encouragement, verbal instructions, and multiple trials. The author suggested that in order for MPT to be considered an accurate diagnostic measure, procedures for elicitation must be standardized across clinicians.

Maximum phonatory frequency range (MPFR) has received little attention in reports of normative data in children. Three studies were found that address MPFR in outcome data for the pediatric population. In the most recent study available, Reich, Mason, Frederickson, and Schlauch (1989) examined 40 children in the third, fourth, fifth, and sixth grades with normal vocal quality to determine which elicitation method was most effective for measuring MPFR. The task was presented as a discrete steps (slow and fast) and glissando task (slow and fast). Measured in Hertz (Hz) and Semitones (ST), Reich and colleagues found a mean MPFR of 735.9
Hz (27.9 ST) for the males, and 959.6 Hz (31.8 ST) for the females. The study reported that all MPFR values were unrelated to participants’ height, weight, age, and gender; however, a small range of ages, third- to sixth-grade, were employed for the study.

Van Oordt and Drost (1963) studied MPFR in a group of children from a larger age range. MPFR was recorded in children aged birth to 16 years (n=126). For children aged birth to 5 years (Group A, n=45), cries were recorded during medical visits. For children aged 6 to 16 years (Group B, n=81), speaking and singing tasks were utilized to obtain measures of highest and lowest frequencies for both singing and speaking. Results indicated that a slight increase in vocal range occurs as age increases; however, the increase found was minimal. Ranges were similar for both groups, each with no child producing less than a 1-octave range, and several children demonstrating ranges greater than 3 octaves. The authors noted similarity between their findings and the range of the typical adult singer, implying a minimal increase in MPFR over time. The authors defined musical range as the tones that a child is able to sing, and physiologic range was defined as the total function of the larynx, including all tones within speaking range. Comparison of physiological and musical ranges of Group B showed a smaller musical range than physiologic range. The lower limit of the musical range was often observed as a frequency higher than the child’s habitual pitch during reading tasks. The elicitation method for Group A was noted to be somewhat inferior. The method was utilized due to inability of the younger children to sufficiently follow directions. Samples of cries for Group A were not expected to elicit maximum and minimum frequencies, rather an estimate of these values, as well as a habitual pitch. Although the authors compared their results to the ideologies of the time period, it is difficult to generalize these results, as values were reported in octaves without mention of which octaves were present. Also, results were presented as individual values, with no mean values presented.

In a third study containing MPFR outcome data, Coleman and Mott (1978) examined voice profiles of 9 female singers (ages 10.10 years to 13.3 years; mean=11.11 years) including frequency and intensity ranges. In agreement with results from van Oordt and Drost (1963), singers in this study produced smaller musical ranges, or total sung tones (mean=19.78 ST), than physiological ranges, or total spoken tones (30.09 ST). However, MPFR for this group of adolescent females (mean=30.09 ST) was nearly comparable to typical adult female measures reported by Coleman and Mott (mean=37.4 ST). MPFR findings in the above studies are
consistent; however, the low number of studies dedicated to measures of pediatric MPFR makes standardization of data difficult.

Statement of the Problem

Few studies exist which examine the prevalence of dysphonia in children, and of these studies, the vast majority are dedicated to the school-age population. Few existing prevalence studies have been conducted that focus on finding the prevalence of dysphonia among children younger than kindergarten age. One study (Duff et al., 2004) suggests that preschool-age children have a lower prevalence of dysphonia than school-age children; however, there has been limited evidence to support or oppose this hypothesis.

Acoustic and aerodynamic parameters of “typical” voices have been well-documented for adults, and the few studies that report on pediatric vocal characteristics have primarily focused on school-age children. Few studies exist that present data with which a preschool-age child’s voice can be compared. Normative acoustic and aerodynamic data is essential for the evaluation of voice for any age group. In the current literature search, only 9 studies were found that examined F0 in preschool-age children. A single study was found which examined MPT, and a single study was found which examined MPFR in children aged three to five years. Without a database of values considered to be “typical,” professionals would not be able to determine when a measure obtained from a particular patient is deviant.

Statement of Purpose

One projected outcome of this study is a contribution of additional data to the literature regarding the number of preschool age children who have dysphonia. As there is no current widely accepted figure for prevalence of dysphonia in preschool-age children, this information will contribute to the academic community by increasing awareness of dysphonia among preschool students. Heightened awareness of dysphonia may lead to an increase of early intervention services, and services needed for dysphonia in elementary school may be avoided if such issues are addressed and resolved in preschool.

Another purpose of this study is to obtain normative data for commonly used acoustic and aerodynamic parameters of voice in children age 3 to 5 years. These parameters include F0, MPT, and MPFR. The current literature is lacking in the number of studies that report these acoustic and aerodynamic measures. This study will provide the research community with objective values to describe the voice of typical preschoolers. With the data collected in this
study, clinicians will have normative data for these parameters of voice, with which preschool children’s voices can be evaluated.

*Research Questions*

1. What was the mean fundamental frequency ($F_0$) for children aged three to five years?
2. What was the mean maximum phonation time (MPT) for children aged three to five years?
3. What was the mean maximum phonatory frequency range (MPFR) for children aged three to five years?

The current thesis project was the initiation of a multi-year study. Only 27 subjects were tested in this pilot project. A projected outcome of the long-term study will be a figure of the prevalence of dysphonia among preschool children aged three to five years.
CHAPTER II
Methods

Participants

Twenty-seven children, aged 3.0 to 5.11 years, were recruited from preschools in Oxford, Ohio and the greater Cincinnati, Ohio area for completion of this study. Parent/guardian consent for each child participating in the study was obtained prior to data collection via informed consent forms (Appendix E), which were sent home with all children at each school. Classroom teachers provided each participant with two copies of this form, accompanied by an announcement regarding the research study (Appendix F). The included cover letter (Appendix G) briefly described the study for parents. Signed informed consent forms were collected by the teacher and provided to the principle investigator prior to initiation of screening. Those children who returned completed informed consent forms were entered as participants in the study.

Procedure

Participants were released from their preschool classroom for a single session lasting 10 to 15 minutes. Data collection took place in a quiet room at each school.

Hearing Screening

Prior to collection of the acoustic and aerodynamic parameters, each participant enrolled in the study was required to pass a bilateral pure-tone hearing screening. A hearing loss may cause differences in voice productions, including higher habitual pitch and/or loudness, as well as more nasal or strained vocal quality (Higgins, 1994). A portable pure-tone audiometer was used to screen each child (Maico, MA-19). Each participant was instructed to raise his or her hand whenever a tone was audible. Pure tones were presented at 25 dB HL at 500 Hz, 1000 Hz, and 2000 Hz.

Voice Screening

A screening tool based on the Quick Screen for Voice (Lee, Stemple, Glaze, & Kelchner, 2004) was utilized for voice screenings (Appendix H). One of two certified SLPs, with experience in the area of voice evaluation and treatment, administered each screening. All screenings administered were listened to by a second SLP to establish validity in determining whether dysphonia was present. The screening tool included several vocal tasks and a checklist-style assessment. The checklist consisted of a list of perceptual characteristics associated with different types of dysphonia, divided into four areas: respiration, phonation, resonance, and vocal
flexibility. Within these lists, examiners could find appropriate terms for identification of deviant vocal quality, which they may not have utilized with a more open-ended screening tool.

The Quick Screen for Voice has been validated on both school-age (n=3000) and preschool students (n=47, ages 3-6 years). Revisions were made, based on these field tests, to improve ease of administration and clarity of instructions, and the instrument was determined to be valid and reliable by the researchers (Lee et al., 2004). Any child who was identified as having dysphonia was referred by a certified SLP for a follow-up professional voice evaluation. In addition to the checklist completed by the clinician, each child completed the speaking tasks described below.

Each participant in the current study was instructed to follow directions provided by a certified SLP for the completion of the F₀, MPFR, and MPT measurement tasks described below. A headset microphone (MicroMic Series, C420 PP) was worn by each participant and connected to a digital audio tape recorder (Tascam Sony DAPI) to obtain and record productions. A 6-inch mouth-to-microphone distance was maintained at all times.

Fundamental frequency. Fundamental frequency (F₀) measurements were obtained from each participant utilizing the following tasks to elicit measurements of sustained vowel F₀ and speaking F₀. Three samples of each task were obtained. The first task required the participant to sustain the target vowel, /a/. Each child was instructed to inhale normally and sustain the vowel /a/ for at least 5 seconds using a comfortable pitch and loudness level, as used during daily speech. The participant was provided with two examples by the examiner, and provided with one practice trial. The second task required the participant to inhale comfortably and count from 1-10 using a comfortable pitch and loudness, as used during daily speech. The third task required the participant to repeat six sentences (Appendix I) after they were produced by the investigator, again using a “habitual” pitch and loudness, as used during typical conversation on a day-to-day basis. Sentences utilized for this study were derived from the Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V) as these sentences elicit various laryngeal behaviors, including varied vowel production, easy onset, voiced consonants, nasal consonants, hard glottal attack, and voiceless plosives (ASHA, 2002).

Frequency range measurement. Following the F₀ assessment the participants’ frequency range was measured with the presentation of a verbal cue. The following instructions were given to the participants: “I want you to make your voice go up—up to your very highest note, like a fire engine does when the siren is on. Listen.” A clinician model was given for how to glide up
on “whoop.” One practice was provided, and then three trials were obtained. The average value of the highest note for the three trials was analyzed. The participants were then directed to glide down in pitch with the following instructions; “Now I want you to make your voice go down—down to your very lowest note, like a robot sounds when he turns off. Listen.” Again, a clinician model was given for how to glide down on “boom.” One practice was provided, and then three trials were obtained. The average value of the lowest note for the three trials was analyzed.

Maximum phonation time measurement. To elicit a maximum phonation time measurement, each child was given the following instructions: “Take your biggest breath and say /a/ for as long as you can.” The clinician provided a model and a visual cue, dragging a finger along a table to represent continuous voicing. One practice was provided, and then three productions were obtained. The average value of the duration for the three trials was analyzed. Time was measured with a stop-watch.

Analysis of Data

The recorded acoustic samples from the DAT recorder were digitized and analyzed utilizing the Multi-Dimensional Voice Analysis Program (MDVP; Kay Pentax, Model 5105). Measures were obtained for sustained vowel F0, speaking F0, maximum phonation time, and vocal range and flexibility. The middle one-second of the sustained vowel samples was used for the analysis. When the selected sample contained glottal fry, another portion of the sample was used for analysis at the discretion of the investigators. Measures were taken from the onset and offset of voicing for the speaking/connected speech samples (Sentences/Counting). The maximum and minimum musical notes were noted from the gliding tasks using a Seiko Chromatic Tuner (Model ST-909).
CHAPTER III

Results

Methodology

The purpose of this study was to collect normative data measurements from the voice production of preschool-age children. Immediately following initiation of screening procedures of four subjects, several issues arose regarding the methodology which were not anticipated prior to collection of data. As these issues came to the attention of the examiners, modifications were made to data collection procedures to ensure a standardized collection method. First, it was determined that the children required a cueing method for sustaining the vowel /a/ for 5 seconds. The clinician implemented a cueing method of holding up her five fingers and asking the child to sustain the vowel until all five fingers were “down.” Also, the six sentences included in the CAPE-V assessment tool (ASHA, 2003) proved to be too long for immediate repetition for three- to five-year-olds. As a result, the sentences were shortened (Appendix I). It was also determined that a visual cueing method obtained the best results for the MPT measurement, as several children paused phonation in order to take a breath during the MPT task. Therefore, an imaginary line drawn across a surface was added to the list of standardized cues provided to each participant. Fourth, the chosen method for measurement of MPFR proved to be insufficient for use in this study. The Seiko Chromatic Tuner (Model ST-909) does not measure the octave of the tone produced, nor does it register the sung note quickly enough to capture the highest or lowest tone of a glide. For these reasons, data from the gliding tasks for measurement of MPFR were not included in this study. The MPFR task was still completed during the testing to allow the clinician to make a perceptual assessment of appropriate pitch range.

For this pilot study, procedures for data collection were standardized following completion of four voice screenings. As a result, the data collected from the first four subjects tested was not included in the outcome data for this study. However, these four subjects were judged by the examiner to have no signs of dysphonia, and so their data will be included in the findings for prevalence of dysphonia in this pilot, and in future studies of this nature by the primary investigator.

It should be noted that some participants in this study required additional cueing beyond that which was previously described in the methods section of this paper. Sixteen children paused to breathe during sustained vowel F0 tasks, requiring 1 to 6 additional trials, as well as
additional cueing to “keep saying /a/ until all of my fingers are down.” Six children required 1 to 2 additional practice trials to complete the sentence repetition task; 5 children required 1 to 2 additional models to complete sustained vowel production tasks for measurement of MPT; and 14 children required 1 to 2 additional practice trials and visual cues (holding up fingers) to complete the counting task. Also, when offered additional practice trials and visual cues, 7 children did not count directly to 10 on one or more trials.

Compliance

A total of 27 children age 3 to 5 years were entered as participants in the study. One participant verbalized refusal to complete the vocal tasks for collection of normative data. Because this participant provided a spontaneous speech sample, this data was included in the figure of prevalence of dysphonia; however, values were not obtained for the normative data portion of this thesis. All 27 participants complied with the hearing screening and passed the screening at all frequencies presented.

Analysis of Data by Research Question

Mean values were obtained for each vocal task. Additional analyses were done to determine whether differences existed among age groups and gender. However, these analyses were secondary to the primary research questions.

Research Question 1

What was the mean fundamental frequency (F₀) for children aged three to five years?

Three tasks were utilized to determine the F₀ of children aged three to five years. For sustained vowel F₀, a single sustained /a/ task was utilized. For speaking F₀, two tasks were utilized: counting to ten, and repeating sentences. Each task is reported separately below.

Sustained vowel F₀. The mean F₀ values for the sustained vowel task for male and female children who were examined are displayed in Table 1 and Figure 1. The mean F₀ values by age for the sustained vowel task are displayed in Table 2 and Figure 2. An independent t-test was used to determine if differences existed between gender groups. The results revealed that there was no significant difference in F₀ values between males and females, t(24) = 1.585, p = .126. A one-way analysis of variance (ANOVA) was used to determine if differences existed among age groups for Sustained Vowel F₀ measures. The results revealed that there was no significant difference in F₀ values among age groups, F(2, 23) = .602, p = .556.
### Table 1

**Sustained Vowel F₀ of Children by Gender**

<table>
<thead>
<tr>
<th>Gender</th>
<th>n</th>
<th>Mean F₀ (Hz)</th>
<th>Range (Hz)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>10</td>
<td>261.14</td>
<td>218.69—332.74</td>
<td>37.26</td>
</tr>
<tr>
<td>Female</td>
<td>16</td>
<td>241.49</td>
<td>206.67—293.68</td>
<td>26.08</td>
</tr>
</tbody>
</table>

### Table 2

**Sustained Vowel F₀ of Children Aged Three to Five Years by Age Group**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>n</th>
<th>Mean F₀ (Hz)</th>
<th>Range (Hz)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0 to 3.11</td>
<td>10</td>
<td>245.67</td>
<td>213.25—293.68</td>
<td>31.68</td>
</tr>
<tr>
<td>4.0 to 4.11</td>
<td>12</td>
<td>255.86</td>
<td>206.67—332.74</td>
<td>36.07</td>
</tr>
<tr>
<td>5.0 to 5.11</td>
<td>4</td>
<td>237.05</td>
<td>224.53—254.30</td>
<td>12.59</td>
</tr>
</tbody>
</table>

*Figure 1. Sustained vowel F₀ of children by gender.*
Figure 2. Sustained vowel F₀ of children aged three to five years by age group.

Speaking F₀. The mean F₀ values for the counting task for male and female children are displayed in Table 3 and Figure 3. The mean F₀ values by age for the counting task are displayed in Table 4 and Figure 4. An independent t-test was used to determine if differences exist between gender groups. The results revealed that there was a significant difference in F₀ values between males and females, t(24) = 2.099, p = .047. A one-way ANOVA was used to determine if differences exist among age groups for speaking F₀ measures. The results revealed that there was no significant difference in F₀ values among age groups, F(2, 23) = .551, p = .584.

Table 3  
**Speaking F₀ During Counting Task of Children by Gender**

<table>
<thead>
<tr>
<th>Gender</th>
<th>n</th>
<th>Mean F₀ (Hz)</th>
<th>Range (Hz)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>10</td>
<td>278.32</td>
<td>244.67—319.98</td>
<td>24.83</td>
</tr>
<tr>
<td>Female</td>
<td>12</td>
<td>256.72</td>
<td>211.74—302.20</td>
<td>25.94</td>
</tr>
</tbody>
</table>

Table 4  
**Speaking F₀ During Counting Task of Children Aged Three to Five Years by Age Group**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>n</th>
<th>Mean F₀ (Hz)</th>
<th>Range (Hz)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0 to 3.11</td>
<td>10</td>
<td>269.65</td>
<td>233.07—310.31</td>
<td>23.71</td>
</tr>
<tr>
<td>4.0 to 4.11</td>
<td>12</td>
<td>265.36</td>
<td>218.75—319.98</td>
<td>29.08</td>
</tr>
<tr>
<td>5.0 to 5.11</td>
<td>4</td>
<td>252.46</td>
<td>211.74—283.09</td>
<td>33.20</td>
</tr>
</tbody>
</table>
The mean $F_0$ values for the sentence repetition task for male and female children who were examined are displayed in Table 5 and Figure 5. The mean $F_0$ values by age for the sentence repetition task are displayed in Table 6 and Figure 6. An independent t-test was used to determine if differences exist between gender groups. The results revealed that there was no significant difference in $F_0$ values between males and females, $t(24) = 1.260, p = .220$. A one-way ANOVA was used to determine if differences exist among age groups for the sentence repetition task. The results revealed that there was no significant difference in $F_0$ values among age groups, $F(2, 23) = .206, p = .815$. 

Figure 3. Speaking $F_0$ during counting task of children by gender.

Figure 4. Speaking $F_0$ during counting task of children aged three to five years by age group.
Table 5
*Speaking F₀ During Sentence Repetition Task of Children by Gender*

<table>
<thead>
<tr>
<th>Gender</th>
<th>n</th>
<th>Mean F₀ (Hz)</th>
<th>Range (Hz)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>10</td>
<td>278.81</td>
<td>248.56—327.80</td>
<td>28.29</td>
</tr>
<tr>
<td>Female</td>
<td>16</td>
<td>265.06</td>
<td>218.42—316.18</td>
<td>26.32</td>
</tr>
</tbody>
</table>

Table 6
*Speaking F₀ During Sentence Repetition Task of Children Aged Three to Five Years by Age Group*

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>n</th>
<th>Mean F₀ (Hz)</th>
<th>Range (Hz)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0 to 3.11</td>
<td>10</td>
<td>273.27</td>
<td>218.42—318.59</td>
<td>28.48</td>
</tr>
<tr>
<td>4.0 to 4.11</td>
<td>12</td>
<td>270.52</td>
<td>225.76—327.80</td>
<td>28.23</td>
</tr>
<tr>
<td>5.0 to 5.11</td>
<td>5</td>
<td>262.53</td>
<td>225.05—285.25</td>
<td>28.07</td>
</tr>
</tbody>
</table>

*Figure 5.* Speaking F₀ during sentence repetition task of children by gender.
Research Question 2

What was the mean maximum phonation time (MPT) for children aged three to five years?

The mean MPT values for male and female children are displayed in Table 7 and Figure 7. The mean MPT values by age are displayed in Table 8 and Figure 8. An independent t-test was used to determine if differences existed between gender groups. The results revealed that there was no significant difference in MPT values between males and females, \( t(23) = -.827, p = .417 \). A one-way ANOVA was used to determine if differences exist among age groups for MPT measures. The results revealed that there was a significant difference in MPT among age groups, \( F(2, 22) = 3.585, p = .045 \). Because overall significance was achieved, post hoc comparisons using independent t-tests between age groups were completed. There was a significant difference in MPT values between ages 4.0-4.11 years and 5.0-5.11 years, \( t(13) = -2.396, p = .032 \). No significant difference was observed between ages 3.0-3.11 years and 4.0-4.11 years, \( t(19) = .547, p = .591 \), or between ages 3.0-3.11 years and 5.0-5.11 years, \( t(12) = -2.047, p = .063 \).
Table 7

*Maximum Phonation Time (MPT) of Children by Gender*

<table>
<thead>
<tr>
<th>Gender</th>
<th>n</th>
<th>Mean MPT (sec)</th>
<th>Range (sec)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>10</td>
<td>5.15</td>
<td>3.33—7.72</td>
<td>1.45</td>
</tr>
<tr>
<td>Female</td>
<td>15</td>
<td>5.77</td>
<td>2.94—11.33</td>
<td>2.01</td>
</tr>
</tbody>
</table>

Table 8

*Maximum Phonation Time (MPT) of Children Aged Three to Five Years by Age Group*

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>n</th>
<th>Mean MPT (sec)</th>
<th>Range (sec)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0 to 3.11</td>
<td>10</td>
<td>5.50</td>
<td>3.76—7.72</td>
<td>1.37</td>
</tr>
<tr>
<td>4.0 to 4.11</td>
<td>11</td>
<td>4.99</td>
<td>2.94—6.87</td>
<td>1.41</td>
</tr>
<tr>
<td>5.0 to 5.11</td>
<td>4</td>
<td>7.50</td>
<td>5.35—11.33</td>
<td>2.70</td>
</tr>
</tbody>
</table>

Figure 7. Maximum phonation time (MPT) of children by gender.
**Figure 8.** Maximum phonation time (MPT) of children aged three to five years by age group.

For this pilot study, all 27 children enrolled in the study were screened for presence of dysphonia. Two of 27 children exhibited signs of dysphonia, characterized by rough or hoarse vocal quality. This data represents a figure of 7.41% prevalence of dysphonia among the sample tested. However, the number of participants in this study is too small for this figure of prevalence to be considered valid or generalizable. When a child was identified as exhibiting signs of dysphonia, the clinician who completed the testing conferred with the child’s parent. In one instance, the child’s parent was unaware of the problem. The clinician followed-up with this child one month following the testing time. In the other instance, the child’s parent was aware of the problem and reported that she planned to follow-up with the child’s pediatrician.
Chapter IV
Discussion

Background

The purpose of this study was to determine normative values for \( F_0 \), MPT, and MPFR in children age three to five years. As was noted in the Introduction section of this thesis, there has been little research dedicated to typical voice production in this age range. Another projected outcome of this study was a figure of prevalence of dysphonia in the preschool-aged population. Because the current thesis project was the pilot study for a multi-year study, there should be limits to the generalization of the current data. Specifically the prevalence of dysphonia found in the current study is not a valid representation of the general population due to the limited number of subjects recruited. However, this study provided valuable information regarding task selection, required cueing techniques, and measurement methods for the continuation of this project. In forthcoming research, data collection methods will be refined, and more subjects will be tested, making prevalence figures and normative values more valid.

Interpretation of Results by Research Question

Research Question 1

What was the mean fundamental frequency (\( F_0 \)) for children aged three to five years? Three tasks were utilized to measure \( F_0 \) in children aged three to five years. When comparing the \( F_0 \) values obtained from these tasks to the published \( F_0 \) values for preschool aged children, the values are somewhat lower. For example, Perry and colleagues (2001) found the mean \( F_0 \) value was 234 Hz for a sustained vowel task in ten 4-year-olds. In another study, McGlone and McGlone (1972) found \( F_0 \) for ten 5 to 7-year-olds was 275Hz. Values obtained in the current study fall just below these reported data ranges. Specifically, children in the current study aged 4.0 to 4.11 years produced an average \( F_0 \) of 255.86Hz (range 206.67—332.74Hz), and children aged 5.0 to 5.11 years produced an average \( F_0 \) of 237.05Hz (range 224.53—254.30Hz) for a sustained vowel task. Slight differences in values obtained during the current study may be due to the low number of participants. As more children are recruited in the continuation of the current study, mean values may more closely corroborate existing published data for \( F_0 \). However, one notable difference exists between data obtained in the current study and data available in the literature. Hall and Yairi (1992) conducted the single study available in the literature for 3 year-old children, and found a mean \( F_0 \) during sustained vowel tasks for 3 and
4 year-olds of 309Hz. The mean obtained in the Hall and Yairi study is significantly higher than the mean F₀ obtained in the current study (mean F₀ for 3.0 to 3.11 years = 245.67Hz (range 213.25—293.68Hz); mean F₀ for 4.0 to 4.11 years = 255.86Hz (range 206.67—332.74Hz)).

Analysis of F₀ produced for the three tasks demonstrated that there was not a significant difference in the F₀ values between the age groups for each task. Additionally, gender differences were not observed for the sustained vowel or sentence repetition tasks. However, when comparing F₀ of males to females for the counting task, males produced significantly greater F₀ than females. This finding should be considered with caution. Differences in F₀ should not exist at this age level, as pubertal changes in voice have not yet occurred. Factors that may have contributed to this difference include the small number of participants in the study, as well as a lower proportion of males (10 males, 16 females) examined thus far than would be found in the general population. A large sample size should be evaluated before considering this gender difference as reliable.

**Research Question 2**

What was the mean maximum phonation time (MPT) for children aged three to five years? When comparing MPT values obtained in the current study to the published data in the area of MPT of preschool-aged children, the values are somewhat similar. Available research that examines MPT in the preschool age group includes a single study by Finnegan (1984). Finnegan found MPT values for 3, 4, and 5-year-old males and females, ranging from 6.3 seconds to 10.5 seconds, increasing with age. The current study found slightly smaller values, ranging from 4.99 seconds to 7.5 seconds. A possible explanation for this difference is that in Finnegan’s study, participants were provided with 14 trials to reach their true MPT value, as opposed to the 3 trials provided in the current study. Perhaps in the future of the current study, additional instruction and a greater number of trials for MPT should be considered in order for participants to reach their true potential for MPT.

The analysis showed no significant difference between males and females for the MPT task. However, a significant difference was found in MPT values among age groups. Five-year-olds produced longer MPT than four-year-olds. And, while it did not achieve statistical significance, mean MPT for 5-year-olds was also notably higher than that of 3-year-olds. This difference may have been due to the small number of participants in the 5.0 to 5.11 year age
group, or an advanced understanding of the task required for elicitation of MPT among the participants in this age group.

Research Question 3

What was the mean maximum phonatory frequency range (MPFR) for children aged three to five years? In the current study, an acceptable method for measurement of MPFR was not found. The selected method (Seiko Chromatic Tuner, Model ST-909) for measuring maximum and minimum frequencies was not able to process the acoustic signal quickly enough to accurately measure highest and lowest pitch during a gliding exercise. In order for this instrument or a software analysis system to accurately measure maximum and minimum frequencies, the speaker would have to sustain the highest or lowest note of a glide for at least one second.

Based upon clinician experience in the current study, the reasons that MPFR is poorly documented in the literature are evident. First, it is difficult to provide clear instructions for children aged three to five years, to elicit a maximum or minimum frequency. Also, the task proved to be quite difficult for many participants in the current study. Many children required multiple models and practice trials before the task could be completed. Third, the instructions for a gliding task would be further complicated by the goal of sustaining the highest or lowest pitch for a length of time. Children in this age group may not be able to comprehend the concept, as the simple gliding concept was often too complex for the younger participants.

Although the concept was difficult to understand and an accurate measurement method was not utilized, participants in the current study were asked to complete the gliding exercise as a component of the perceptual screening process for dysphonia. One characteristic of a typical voice is the ability to produce a range of frequencies during speech. The gliding task provided clinicians with information regarding frequency range and vocal flexibility during the voice screening process.

Prevalence of Dysphonia

Within the sample evaluated for presence of dysphonia, a 7.41% prevalence of dysphonia was found. This figure is similar to reports of prevalence for voice disorders in children found in previous studies. For example, published figures of the prevalence of voice disorders range from 0.12% (McKinnon et al., 2007) to 38% (Carding et al., 2006). Andrews and Summers estimate prevalence of dysphonia in children between 6% and 9%. Prevalence of dysphonia found in the
current study fits easily within this range. However, a single study in the literature has evaluated preschool-age children for dysphonia. Duff and colleagues (2003) found the prevalence in preschool-aged children at 3.9%. This figure is far lower than the prevalence of dysphonia found in the current study. However, due to the limited number of children evaluated in this study, this prevalence figure cannot be considered representative of the general population.

**Limitations**

Several limitations exist within the current study at this time. One such limitation was the small number of participants. When calculating normative measures or prevalence figures, a large sample size of at least 200 subjects is desirable. As stated previously, the preliminary nature of this study will be important for improving data collection methods in the continuation of this study. The small sample size helped to establish standard protocols.

Another limitation of this study was the demographic being studied. Participants were recruited from the greater Cincinnati, OH area—a relatively small section of the United States. Across the country, there are different concentrations of cultures in specific geographic areas, as well as individual dialects used in different regions of the country. Many of these dialectal differences are represented within any large metropolitan area in the United States. In order for results to be applied to the general population, participants would need to be recruited with a range of dialects represented in a metropolis or from various regions of the United States. For the current study, a small-scale investigation of the immediate area was necessary to establish standard testing procedures.

A further limitation of this study, which limits generalization, is the lack of testing of conversational speech. The current study elicited several specific vocal tasks in isolation, but did not evaluate the children’s voices in the way that they are typically used. Connected speech is the most common use of an individual’s voice, however the current study opted not to evaluate this aspect of speech. A contributor to this decision was compliance for preschool-age children. A study conducted with children in this age group faces a number of compliance issues: participant willingness to complete tasks, clear directions for elicitation of accurate measures, and sufficient practice trials, among others. Such a complex task as conversational speech would require a high level of compliance on the part of the child in order to elicit a uniform sample from each participant. Therefore, the task was considered too complex for inclusion in this protocol.
**Future Directions**

It would be beneficial to conduct further studies using the testing protocols described in the current thesis. The first obvious next step of this research is to recruit a larger sample size. A greater number of subjects would give resulting measures for $F_0$ and MPT greater validity. Also, if subject groups are equal in size, comparisons between genders and among age groups would be more valid. Furthermore, with a larger sample size, a figure of prevalence of dysphonia in the preschool-aged population will be not only calculable but also valid. A large sample size is desirable for prevalence studies. Implementing this change in the continuation of this study will enable investigators to add a reasonable estimate of prevalence of dysphonia to the literature.

Second, in the continuation of this study, it may be necessary to exclude the measurement of MPFR from the normative study. Few studies exist in the literature which examine MPFR in children. An accurate method must be established for measuring the highest and lowest note of a glide in order for a figure of typical MPFR to be added to the literature. Perhaps a separate study would be necessary, in which the vocal task can be completed in a more controlled setting, and an appropriate amount of time could be available for instruction and task completion. An acceptable method for measuring maximum and minimum frequencies is to have the individual sustain the highest or lowest frequency for at least one second to capture a stable signal for measurement. In order for a stable signal to be captured, extensive training time would be required for very young children to practice the task and to learn to sustain the note at the end of a glide.

Third, a specific and uniform set of protocols should be created regarding elicitation of MPT from children aged 3 to 5 years. It has been suggested that few children produce their true MPT in the first trials (Finnegan, 1984). It would be interesting to attempt to duplicate Finnegan’s findings, which suggest that higher MPT values are obtained when participants are offered a greater number of trials. This could be accomplished with a separate study, in which participants are provided with multiple trials to reach their true MPT. A study of this nature would yield more accurate results if it were completed in a more controlled laboratory setting and if the appropriate amount of time were available for training and task completion. Also, this type of study would need to carefully consider the issue of fatigue. The more trials a participant
is offered during a single session, the faster the participant will fatigue. In this case, a decrease in MPT measures may be noted in subsequent trials.

A final potential continuation of this study could be the evaluation of conversational speech. Evaluation of conversational speech would make results easily generalizable to the preschool-aged population, as many vocal tasks used for evaluation in the current study are not present in a child’s daily speech. As examining conversational speech would not be practical for completion during a voice screening, perhaps a separate study would be needed to complete evaluations of this type.

The current study will benefit the research and clinical community of SLPs by providing additional data regarding normative measures for preschool-aged children. However, as data collection continues in the future of this study, a larger sample size and several modifications to the data collection techniques will strengthen the validity of the results obtained.
References


### APPENDICES

#### Appendix A

*Speaking Fundamental Frequency (F₀) of Normal Male Children*

<table>
<thead>
<tr>
<th>Subjects</th>
<th>F₀</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>N</td>
<td>Mean (Hz)</td>
</tr>
<tr>
<td>3-4</td>
<td>10</td>
<td>309</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>234</td>
</tr>
<tr>
<td>4-10</td>
<td>20†</td>
<td>243</td>
</tr>
<tr>
<td>5</td>
<td>35</td>
<td>236**</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>247</td>
</tr>
<tr>
<td>5-6</td>
<td>10</td>
<td>256</td>
</tr>
<tr>
<td>5-11</td>
<td>60</td>
<td>226</td>
</tr>
<tr>
<td>6</td>
<td>15</td>
<td>262</td>
</tr>
<tr>
<td>6</td>
<td>14</td>
<td>247</td>
</tr>
<tr>
<td>6</td>
<td>50</td>
<td>219**</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>248</td>
</tr>
<tr>
<td>7</td>
<td>15</td>
<td>256</td>
</tr>
<tr>
<td>7-8</td>
<td>10</td>
<td>234</td>
</tr>
<tr>
<td>7-15</td>
<td>29</td>
<td>250</td>
</tr>
<tr>
<td>8</td>
<td>15</td>
<td>235</td>
</tr>
<tr>
<td>8</td>
<td>25</td>
<td>255</td>
</tr>
<tr>
<td>8</td>
<td>15</td>
<td>223**</td>
</tr>
<tr>
<td>8</td>
<td>15</td>
<td>220*</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>226</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>255</td>
</tr>
<tr>
<td>9</td>
<td>15</td>
<td>230</td>
</tr>
<tr>
<td>9</td>
<td>24</td>
<td>264</td>
</tr>
<tr>
<td>9</td>
<td>15</td>
<td>232**</td>
</tr>
</tbody>
</table>
## Speaking Fundamental Frequency ($F_0$) of Normal Male Children (continued)

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean (Hz)</th>
<th>Range (Hz)</th>
<th>SD (Hz)</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>15</td>
<td>232*</td>
<td>—</td>
<td>23</td>
<td>(Morris, 1997)</td>
</tr>
<tr>
<td>9-10</td>
<td>10</td>
<td>240</td>
<td>—</td>
<td>—</td>
<td>(Ferrand &amp; Bloom, 1996)</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>228</td>
<td>—</td>
<td>—</td>
<td>(Hasek et al., 1980)</td>
</tr>
<tr>
<td>10</td>
<td>25</td>
<td>256</td>
<td>141-409</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>215**</td>
<td>—</td>
<td>30</td>
<td>(Morris, 1997)</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>225*</td>
<td>—</td>
<td>20</td>
<td>(Morris, 1997)</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>223</td>
<td>—</td>
<td>8</td>
<td>(Whiteside &amp; Hodgson, 2000)</td>
</tr>
<tr>
<td>11</td>
<td>24</td>
<td>245</td>
<td>167-378</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
<tr>
<td>12</td>
<td>22</td>
<td>230</td>
<td>125-328</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
<tr>
<td>12</td>
<td>10</td>
<td>216</td>
<td>—</td>
<td>—</td>
<td>(Perry et al., 2001)</td>
</tr>
<tr>
<td>13</td>
<td>16</td>
<td>190</td>
<td>119-285</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
<tr>
<td>14</td>
<td>11</td>
<td>177</td>
<td>101-272</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
<tr>
<td>15</td>
<td>11</td>
<td>125</td>
<td>95-251</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>108</td>
<td>—</td>
<td>—</td>
<td>(Perry et al., 2001)</td>
</tr>
<tr>
<td>18</td>
<td>10</td>
<td>129</td>
<td>84-239</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
</tbody>
</table>

† Gender Unspecified
* White
** African-American
*** Hispanic
Appendix B

*Speaking Fundamental Frequency (F₀) of Normal Female Children*

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Age</th>
<th>N</th>
<th>Mean (Hz)</th>
<th>Range (Hz)</th>
<th>SD (Hz)</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>10</td>
<td>244</td>
<td>—</td>
<td>—</td>
<td>(Perry et al., 2001)</td>
</tr>
<tr>
<td></td>
<td>4-10</td>
<td>20⁺</td>
<td>243</td>
<td>206-281</td>
<td>—</td>
<td>(Wertzner et al., 2005)</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>15</td>
<td>257</td>
<td>—</td>
<td>—</td>
<td>(Hasek et al., 1980)</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>18</td>
<td>247</td>
<td>211-295</td>
<td>—</td>
<td>(Weinberg &amp; Zlatin, 1970)</td>
</tr>
<tr>
<td></td>
<td>5-6</td>
<td>10</td>
<td>243</td>
<td>—</td>
<td>—</td>
<td>(Ferrand &amp; Bloom, 1996)</td>
</tr>
<tr>
<td></td>
<td>5-7</td>
<td>10</td>
<td>275</td>
<td>—</td>
<td>0.6 tones</td>
<td>(McGlone &amp; McGlone, 1972)</td>
</tr>
<tr>
<td></td>
<td>5-11</td>
<td>61</td>
<td>238</td>
<td>—</td>
<td>—</td>
<td>(Glaze, Bless, Minelenkovic, &amp; Susser, 1988)</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>15</td>
<td>254</td>
<td>—</td>
<td>—</td>
<td>(Hasek et al., 1980)</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>19</td>
<td>247</td>
<td>217-274</td>
<td>—</td>
<td>(Weinberg &amp; Zlatin, 1970)</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>50</td>
<td>211**</td>
<td>137-297</td>
<td>—</td>
<td>(Wheat &amp; Hudson, 1988)</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>3</td>
<td>242</td>
<td>—</td>
<td>23</td>
<td>(Whiteside &amp; Hodgson, 2000)</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>15</td>
<td>261</td>
<td>—</td>
<td>—</td>
<td>(Hasek et al., 1980)</td>
</tr>
<tr>
<td></td>
<td>7-8</td>
<td>10</td>
<td>252</td>
<td>—</td>
<td>—</td>
<td>(Ferrand &amp; Bloom, 1996)</td>
</tr>
<tr>
<td></td>
<td>7-15</td>
<td>63</td>
<td>244</td>
<td>205-293</td>
<td>—</td>
<td>(Linders et al., 1995)</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>15</td>
<td>264</td>
<td>—</td>
<td>—</td>
<td>(Hasek et al., 1980)</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>11</td>
<td>283</td>
<td>152-423</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>10</td>
<td>224</td>
<td>—</td>
<td>—</td>
<td>(Perry et al., 2001)</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>3</td>
<td>234</td>
<td>—</td>
<td>11</td>
<td>(Whiteside &amp; Hodgson, 2000)</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>15</td>
<td>246</td>
<td>—</td>
<td>—</td>
<td>(Hasek et al., 1980)</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>25</td>
<td>267</td>
<td>187-437</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
<tr>
<td></td>
<td>9-10</td>
<td>10</td>
<td>253</td>
<td>—</td>
<td>—</td>
<td>(Ferrand &amp; Bloom, 1996)</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>15</td>
<td>253</td>
<td>—</td>
<td>—</td>
<td>(Hasek et al., 1980)</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9</td>
<td>244</td>
<td>193-300</td>
<td>—</td>
<td>(Hollien &amp; Copeland, 1965)</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>14</td>
<td>266</td>
<td>146-367</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>4</td>
<td>226</td>
<td>—</td>
<td>18</td>
<td>(Whiteside &amp; Hodgson, 2000)</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>19</td>
<td>264</td>
<td>185-494</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>21</td>
<td>236</td>
<td>178-338</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
</tbody>
</table>
### Speaking Fundamental Frequency ($F_0$) of Normal Female Children (continued)

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean (Hz)</th>
<th>Range (Hz)</th>
<th>SD (Hz)</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>10</td>
<td>224</td>
<td>—</td>
<td>—</td>
<td>(Perry et al., 2001)</td>
</tr>
<tr>
<td>13</td>
<td>13</td>
<td>251</td>
<td>180-394</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
<tr>
<td>14</td>
<td>10</td>
<td>228</td>
<td>169-293</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
<tr>
<td>15</td>
<td>11</td>
<td>228</td>
<td>179-310</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>206</td>
<td>—</td>
<td>—</td>
<td>(Perry et al., 2001)</td>
</tr>
<tr>
<td>18</td>
<td>10</td>
<td>246</td>
<td>199-310</td>
<td>—</td>
<td>(Iseli et al., 2007)</td>
</tr>
</tbody>
</table>

† Gender Unspecified
** African-American
### Appendix C

*Maximum Phonation Time (MPT, in seconds) for Normal Male Children*

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>5</td>
<td>7.9</td>
<td>1.8</td>
<td>4.4-11.5</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>10.0</td>
<td>2.5</td>
<td>6.1-14.9</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>10.1</td>
<td>3.0</td>
<td>4.2-16.1</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
<td>13.9</td>
<td>3.0</td>
<td>8.1-19.7</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>6</td>
<td>53</td>
<td>10.4</td>
<td>5.1</td>
<td>3.8-16.8</td>
<td>(Harden &amp; Looney, 1984)</td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>14.2</td>
<td>3.3</td>
<td>9.0-19.0</td>
<td>(Beckett, Thoelke, &amp; Cowan, 1971)</td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>14.6</td>
<td>2.8</td>
<td>9.1-20.2</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>16.8</td>
<td>4.5</td>
<td>8.0-25.6</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>20.0</td>
<td>—</td>
<td>11.5-24.5</td>
<td>(Lewis, Casteel, &amp; McMahon, 1982)</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>16.8</td>
<td>6.1</td>
<td>4.9-28.7</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>22.2</td>
<td>4.7</td>
<td>12.9-31.5</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>24.9</td>
<td>—</td>
<td>15.9-39.0</td>
<td>(Lewis et al., 1982)</td>
</tr>
<tr>
<td>11</td>
<td>10</td>
<td>19.8</td>
<td>3.8</td>
<td>12.4-27.3</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>12</td>
<td>10</td>
<td>20.2</td>
<td>5.7</td>
<td>9.0-31.4</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>13</td>
<td>10</td>
<td>22.3</td>
<td>8.2</td>
<td>6.3-38.3</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>14</td>
<td>10</td>
<td>22.3</td>
<td>6.9</td>
<td>8.8-35.8</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>15</td>
<td>10</td>
<td>20.7</td>
<td>5.3</td>
<td>10.3-31.2</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>21.0</td>
<td>4.4</td>
<td>12.4-29.7</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>17</td>
<td>10</td>
<td>28.7</td>
<td>7.1</td>
<td>14.8-42.6</td>
<td>(Finnegan, 1984)</td>
</tr>
</tbody>
</table>
**Appendix D**

*Maximum Phonation Time (MPT, in seconds) for Normal Female Children*

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>5</td>
<td>6.3</td>
<td>1.8</td>
<td>2.8-9.7</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>8.7</td>
<td>1.8</td>
<td>5.3-12.5</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>10.5</td>
<td>2.6</td>
<td>5.4-15.5</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
<td>13.8</td>
<td>3.6</td>
<td>6.7-21.0</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>6</td>
<td>49</td>
<td>10.6</td>
<td>6.3</td>
<td>6.2-30.6</td>
<td>(Harden, &amp; Looney, 1984)</td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>15.4</td>
<td>2.7</td>
<td>12.0-22.0</td>
<td>(Beckett, Thoelke, &amp; Cowan, 1971)</td>
</tr>
<tr>
<td>7</td>
<td>9</td>
<td>13.7</td>
<td>2.4</td>
<td>8.9-18.5</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>17.1</td>
<td>4.6</td>
<td>8.1-26.2</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>19.1</td>
<td>—</td>
<td>11.9-23.0</td>
<td>(Lewis et al., 1982)</td>
</tr>
<tr>
<td>8-10</td>
<td>7</td>
<td>16.7</td>
<td>3.0</td>
<td>—</td>
<td>(Reich, Mason, &amp; Polen, 1986)</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>14.5</td>
<td>3.8</td>
<td>7.1-21.9</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>15.9</td>
<td>6.0</td>
<td>4.1-27.6</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>16.5</td>
<td>—</td>
<td>12.9-21.8</td>
<td>(Lewis et al., 1982)</td>
</tr>
<tr>
<td>11</td>
<td>10</td>
<td>14.8</td>
<td>2.1</td>
<td>10.7-18.8</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>12</td>
<td>9</td>
<td>15.2</td>
<td>3.9</td>
<td>7.6-22.7</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>13</td>
<td>10</td>
<td>19.2</td>
<td>4.6</td>
<td>10.3-28.2</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>14</td>
<td>10</td>
<td>18.8</td>
<td>5.2</td>
<td>8.8-28.9</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>15</td>
<td>10</td>
<td>19.5</td>
<td>4.7</td>
<td>10.4-29.9</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>21.8</td>
<td>4.5</td>
<td>13.1-30.6</td>
<td>(Finnegan, 1984)</td>
</tr>
<tr>
<td>17</td>
<td>10</td>
<td>22.0</td>
<td>6.3</td>
<td>9.6-34.3</td>
<td>(Finnegan, 1984)</td>
</tr>
</tbody>
</table>
Appendix E

Research Informed Consent

Voice Characteristics of Preschool-Age Children

**Description of the Research.** There are currently very few studies that tell us about normal voice production in preschool-age children. The purpose of this study is to collect data that represents what is normal in terms of voice production in young children. We also hope that this study will tell us how many preschool-age children have voice disorders.

**Research Procedures.** Your child will be asked to go to a quiet room with one of the study investigators. Prior to collecting the recordings of your child’s voice, each child enrolled in the study will be required to participate in a basic hearing screening. A hearing loss may cause differences in voice productions. Your child will be instructed to follow directions provided by the investigator. For each task your child will speak into a microphone. To gather measures of your child’s typically used pitch, he/she will hold out a vowel sound for about five seconds, count from 1-10, and repeat a sentence. For measurement of your child’s pitch range, he/she will glide up in pitch, then down in pitch. Your child will also be asked to hold out a vowel for as long as possible, and the longest time will be recorded.

Following these tasks, the researcher will complete a screening form regarding your child’s voice to determine the presence or absence of a voice disorder. If a child is identified as having a voice disorder, he/she will be rechecked within a 4-week period in case the child was hoarse due to an illness or recreational activity (for example, yelling at a sporting event). Parents of children who are identified as having a voice disorder after the recheck will be contacted following the study by a speech-language pathologist at the Miami University Speech and Hearing Clinic to discuss further recommendations.

Both the earphones used for the hearing screening and the microphone used for the speech sample will be cleaned with an antibacterial/germicidal disposable wipe in between the children who are tested.
Time Required for Participation. Your child will be released from the classroom during regular school hours. Your child’s participation will take 10-15 minutes. Should your child need to be rechecked, this session will take place within 4 weeks of the initial session and last 10-15 minutes (will be completed at your child’s school).

Risks. There are no known risks associated with this study, and we do not foresee any potential for discomfort.

Benefits. This study has the potential to provide additional information about normal voice production in children.

Alternative Treatments. There are no alternative treatments in this study.

Confidentiality. The information obtained about your child in this study will be kept confidential during your child’s participation. Your child’s information will be kept in a locked file cabinet in the investigator’s office. Your child’s information will be assigned a code number and the key for this code will be stored separately from your child’s information. Once your child’s participation in the study is completed, all identifying information that could link your child to his/her 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. The study is not related to nor will it impact any evaluation of your child’s performance in school. If you choose not to allow your child participate in the study or if your child decides not to participate there will be no impact on any school related activities.

Questions about the Study. You may ask questions regarding the study and the study procedure at any time. You can reach the primary investigators for this study, Susan Baker, Ph.D. at (513) 529-2553 and/or bakersel@muohio.edu, and Barbara Weinrich, Ph. D. at (513) 529-2548 and/or weinribd@muohio.edu regarding questions about the study.
**Questions about the Rights of Subjects.** 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 child’s rights as a subject in this study.

**Consent/Assent From Subjects under Age 18.** Your child will be asked, “Would you like to come with me and say some sentences and words into a microphone for about 15 minutes?”

I have been informed about this study’s purpose, procedures, possible benefits, risks, and how my child’s 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 have my child participate in this study. By signing this form, I am not waiving any of my legal rights.

___________________________________  ______________
Print Name of Person Consenting  Print Child’s Name

___________________________________  ______________
Signature of Person Consenting  Date
Appendix F

Announcement at Schools

To obtain informed consent for research, classroom teachers will provide each participant with two copies of the informed consent form, accompanied by an announcement regarding the research study. The announcement will be worded as follows, “A Miami University student has asked that we help her with a research project. She wants to make a recording of each of your voices. I am giving you some papers to take home and give to your parents, so they can read all about it. Please tell your parents that one copy needs to be signed and brought back to school. The other copy is for your parents to keep. There is a lot of information on these papers, so please be sure that your parents get them as soon as possible.”
Appendix G

Cover Letter for Informed Consent Form

Dear Parent,

I am a graduate student at Miami University, and in the upcoming months, I will be at Oxford Early Childhood Center conducting a research study. With your permission, your child will be asked to participate in this study.

The research study will collect information about the number of students at a typical elementary school who are hoarse, or have another voice disorder. Voice disorders occur in about 6 to 38% of children. There are few studies that tell us about normal voice production in children. The purpose of this study is to collect data that represents what is normal in terms of voice production in children. We also hope that this study will tell us how many children in the public school system have voice disorders.

Your child’s participation will take only 10-15 minutes, for one session only.

Attached you will find 2 copies of an “Informed Consent” form (each 2 pages long). Please read the information carefully. If you would like your child to participate, please sign and date one copy of the Informed Consent, and have your child return it to school as soon as possible. Please keep one copy of the Informed Consent for your reference.

Thank you for taking the time to consider your child’s participation in this research study.

Sincerely,

Melanie Schuckman,
Graduate Student,
Miami University
Appendix H

Voice Screening Form

Subject #__________
Birth date _______________ Screening Date________________
Age______________________
Hearing Screening Date______________________    Passed    Failed

Tasks:

1. Counting     Instructions: “**Count from 1 to 10 in your regular voice.**”
   - Trial 1
   - Trial 2
   - Trial 3
   - Normal pitch and loudness
   - Abnormal pitch and/or loudness

2. Fundamental frequency—Instructions: “**Take a normal breath and say /a/ as I count to 5.**”
   - Trial 1
   - Trial 2
   - Trial 3

3. Sustained /a/   Instructions: “**Take a big breath and say /a/ for as long as you can.**”
   - Trial 1
   - Trial 2
   - Trial 3
   - Time (sec)

4. Sentence Repetition   Instructions: “**Repeat these sentences after me:**”
   - The key is blue.   We eat eggs.
   - Did he hit him?   My mama makes muffins.
   - We were away.   Peter will keep it.
   - Normal pitch and loudness
   - Abnormal pitch and/or loudness

5. Frequency Range Measurement   Instructions: “**I want you to glide up from your lowest note to your highest note. Like this…**” (Model)
   - Trial 1
   - Trial 2
   - Trial 3
“Now I want you to glide down from your highest note to your lowest note. Like this…” (Model)

☐ Trial 1 ☐ Trial 2 ☐ Trial 3

☐ Acceptable pitch range and flexibility
☐ Little pitch variation
☐ Voice breaks in pitch glides up or down

Check all that are present:

**Respiration**

☐ Normal respiration for speech
☐ Inhalatory stridor or expiratory wheeze
☐ Limited breath support for speech
☐ Infrequent breaths, talking too long on one breath
☐ Reduced Loudness or vocal weakness

**Resonance**

☐ Normal Resonance
☐ Hyponasality
☐ Consistent mouth breathing
☐ Nasal turbulence or audible nasal emission
☐ Hypernasality
☐ Juvenile resonance characteristics

**Phonation**

☐ Normal voice quality
☐ Rough or hoarse quality
☐ Breathy quality
- Vocal strain and effort
- Aphonia
- Persistent glottal fry
- Hard glottal attacks
- Conversational pitch is too high or too low
- Conversational voice is too loud or too soft
- Conversational voice is limited in pitch or loudness variability
Appendix I

*Speaking $F_0$ Sentences (Derived from CAPE-V)*

The key is blue.
Did he hit him?
We were away.
We eat eggs.
My mama makes muffins.
Peter will keep it.