ABSTRACT

THE EFFECT OF COGNITIVE CUES ON VOICE PRODUCTIONS FOR CHILDREN AGES 5.0 THROUGH 7.11 YEARS

By Katharine Ann Schroth

Accurate assessment of voice production in children with vocal pathology is essential prior to initiation of therapy. Frequency range and rate of speech are two measures of interest in a voice assessment. Cognitive cues as a task elicitation method are known to increase vocal variation in adults and children older than 9.0 years of age. The purpose of this investigation was to determine if cognitive cues elicit a significantly greater frequency range and/or slower rate of speech in children 5.0 through 7.11 years of age compared to more commonly used verbal cues. Thirty-seven children participated in this investigation. Significant differences were found between the cognitive cue trial versus verbal cue trial for maximum frequency tasks along with rate of speech tasks. Results indicated that cognitive cues have the potential for improving voice production assessment by enhancing a child’s capacity to reach their maximum frequency and reduce their rate of speech.
THE EFFECT OF COGNITIVE CUES ON VOICE PRODUCTIONS FOR CHILDREN
AGES 5.0 THROUGH 7.11 YEARS

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CHAPTER 1
Introduction

*Voice Disorders in Children*

A voice disorder is defined as a difference in quality, pitch, and/or loudness from individuals who are of similar age, gender, and cultural background (Aaronson, 1980; Stemple, Glaze, & Klaben, 2000). It is estimated that approximately 6% to 9% of children have a voice disorder; however it is believed that the incidence may be under-reported (Wilson, 1987; Wuyts, Heylen, Mertens, DeBodt & Van de Heyning, 2003). In one of the largest studies of the incidence of voice disorders in children, Powell, Filter, and Williams (1989) screened 847 children, ages 6.0 to 10.11 years and found 23% of the children had voice disorders. The most prevalent voice disorder reported by Powell et al. was chronic hoarseness. Etiologies of pediatric voice disorders range from congenital to acquired disorders. Congenital voice disorders include laryngeal web, subglottic stenosis, laryngomalacia, tracheomalacia, and vocal fold paralysis (Andrews, 1999). Specifically, laryngomalacia accounts for 75% of all congenital anomalies of the trachea and is the most common cause of stridor in children (Andrews, 1999). Voice disorders may also be acquired from abuse or trauma (Andrews, 1999).

Children who engage in vocally strenuous activities with excessive effort and tension of the vocal musculature are at an increased risk for development of an acquired voice disorder (Andrews, 1999). Vocal fold nodules are the most prevalent acquired voice disorder in the school-age population. In addition to nodules, voice disorders in the pediatric population can be due to chronic laryngitis, vocal fold polyps, contact ulcers, and vocal fold paralysis (McMurray, 2003). Trauma to the larynx from strangulation, falls, gunshot wounds, and motor vehicle accidents may also result in voice disorders in this population (Andrews & Summers, 2002). Trauma to the larynx can be life threatening secondary to collapse of the airway; therefore, re-establishing an airway through intubation or tracheotomy is vital to life preservation. Traumatic intubation and/or tracheotomy can have detrimental effects on the voice, such as the development of granulomas, as well as vocal fold and tracheal scarring (Andrews, 1999).

A thorough voice assessment is critical in determining the severity of a voice disorder. There are many measures included in a comprehensive voice assessment. One commonly assessed acoustic measure is frequency range, which is the range of frequencies, reported in terms of Hertz (Hz) or cycles that the vocal folds can vibrate per second (Stemple et al., 2000;
Sussman & Sapienza, 1994). If a lesion such as nodules or polyps exists on the vocal fold, the frequency range may be decreased due to increased mass and stiffness of the vocal folds. Paralysis of the superior laryngeal nerve may also significantly decrease frequency range. Rate of speech is the measure of the number of words or syllables spoken per minute (Shapiro, 1999) and is another measure that is sometimes included in a voice assessment, particularly if the clinician notes that an excessive rate of speech is contributing to vocal hyperfunction during phonation. Measurement of frequency range and rate of speech can be important components of a voice assessment because they provide objective measures of voice productions, as well as baseline and progress data to measure change in production over time. Frequency range and rate of speech represent only two of the many objective measures that are of interest to a clinician during a voice evaluation. Additionally, it should be noted that acoustic measurements serve as only one component of a thorough voice evaluation. Acoustic measures aid in determining the potential level of vocal functioning and to what extent a voice disorder exists.

**Task Elicitation Methods**

Tasks used to elicit voice productions can have a strong impact on assessment, and if not chosen with adequate thought, may provide inaccurate voice measurements. Task elicitation methods have been studied with both children and adults. Within the literature there is a discrepancy between the effects of task elicitation methods for children and adults. Specifically, Reich, Mason, Frederickson, and Schlauch (1989) found significant differences among task elicitation types for children performing a frequency range task that were not reported in a similar study conducted by Zraick, Nelson, Montague, and Monoson (2000) which examined adults. It is hypothesized that the task utilized by Reich et al. may have required additional thinking and self-monitoring skills that some of the child participants may not have acquired compared to the adult participants. Therefore, the difficulty of the task elicitation method is of concern when working with children.

Various tasks used to elicit vocal productions include providing verbal cues, visual cues, and/or cognitive cues. The use of cognitive cues as a task elicitation method stems from cognitive-behavioral therapy and focuses on prompting the individual to think about and feel a task prior to completing the task. Cognitive cues have been utilized when measuring voice productions and have been found to increase vocal variation in adults and children 9.0 to 11.11 years of age (Andrews, Shrivastav, & Yamaguchi, 2000; Bohnenkamp, Andrews, Shrivastav, &
Summers, 2002). When utilizing cognitive cues as an elicitation method, the researchers attempted to increase the frequency range and alter the rate of speech. For example, Andrews et al. (2000) measured vocal variation with various cues, which prompted participants to alter their voicing patterns. When targeting frequency range with the sentence, “The submarine sank to the bottom of the sea” the participants were cued to think about the surface of the water and show how the submarine goes down. Bohnenkamp et al. (2003) also targeted vocal variation. The study utilized cognitive cues in an attempt to alter rate of speech. Cognitive cues were given during elicitation of the sentence, “He ran as fast as he could.” The cues prompted participants to make the listener feel that he was running faster in order to increase rate of speech. Both studies found cognitive cues to have a significant effect on increasing vocal variation and to be a promising task elicitation method (Andrews et al., 2000; Bohnenkamp et al., 2002).

A key aspect of cognitive cueing is an individual’s level of cognitive development. In order for cognitive cueing to be effective, an individual must be able to form mental representations of objects and realize that objects exist even when they are not in sight (Piaget, 1952). Developmental specialists believe the ability to form mental representations develops from 2.0 to 8.11 years of age (Piaget, 1952; White, 1965). In addition to forming mental representations, the ability to reason is also critical when utilizing cognitive cueing. The ability to reason is thought to develop around 5.0 to 7.11 years of age, thus representing a minimum age range when cognitive therapy would have the potential to be effective (Piaget, 1952; White, 1965). Additionally, a child’s ability to recall and repeat sentences from imitation is a valuable tool for providing information about a child’s language abilities. It is thought that a child will imitate any sentence if the length of the sentence is within the child’s working memory capacity (Rummer & Engelkamp, 2001).

Statement of the Problem

As stated previously, approximately 6% to 9% of children have a voice disorder (Wilson, 1987; Wuyts, et al., 2003). Accurate assessment and identification of pediatric voice disorders is vital for a child’s educational and social development, in addition to physical and emotional health (Hoffman-Ruddy & Sapienza, 2004). Frequency range and rate of speech are two measures of interest in a voice assessment because they provide objective measures of voice productions.
Previous research demonstrates that task elicitation has an effect on measurement outcomes indicating that children in particular may perform to the maximum ability with specific types of cues (Reich et al., 1989; Zraick, Marshall, Smith-Olinde, & Montague, 2004; Zraick, Nelson, Montague, & Monoson, 2000; Zraick, Skaggs, & Montague, 2000). Previous research also indicates that the use of cognitive cues is effective in children for increasing vocal variation (Andrews et al., 2000; Bohnenkamp et al., 2002). However, the use of cognitive cues has never been studied with children under the age of 9.0 years. When utilizing cognitive cues as a task to elicit voice productions, it is necessary to consider the cognitive capabilities of the individual and what task would be best to capture the most accurate voice productions.

As stated previously, reasoning is thought to develop around 5.0 to 7.11 years of age and children are thought to form mental representations of objects and realize that objects exist even when they are not in sight from 2.0 to 8.11 years of age, thus representing a minimum age range when cognitive therapy would have the potential to be effective (Piaget, 1952; White, 1965). Therefore, it is of interest to determine if cognitive cues as a task elicitation method are effective in improving performance on specific acoustic parameters for children in this age range in which mental representations are beginning to form.

Research Questions

1. Will the use of cognitive cues elicit a significantly greater frequency range in children ages 5.0 to 7.11 years of age compared to use of verbal cues?
2. Will the use of cognitive cues elicit a significantly slower rate of speech in children ages 5.0 to 7.11 years of age compared to use of verbal cues?
CHAPTER 2
A Review of the Literature

In addition to the main points highlighted in chapter one, it is imperative to discuss the identification of pediatric voice disorders and review the basic anatomy of laryngeal structures in the pediatric population. This review will be followed by a discussion of the concept of cognitive development and the use of cognitive-behavioral therapy when eliciting voice productions. Finally, this review will provide a detailed examination of the use of cognitive-behavioral therapy during voice tasks.

Voice Disorders in Children

Identification and management of pediatric voice disorders is vital for the child’s educational and social development, in addition to physical and emotional health (Hoffman-Ruddy & Sapienza, 2004). Voice disorders can have adverse affects on a child’s education. For example, a child may limit his or her classroom participation in an attempt to conceal an atypical voice. Consequently, the attempt to conceal an atypical voice may occupy a child’s thoughts and interfere with concentration during school. A child may also become socially withdrawn or the extreme opposite may occur and the child could be aggressive and deviant when trying to compensate for a voice disorder. Children with voice disorders have the potential to be evaluated in negative ways by educators as culmination of all of the behaviors previously mentioned (Andrews & Summers, 2002; Hoffman-Ruddy & Sapienza, 2004).

A team approach is often utilized for the diagnosis and treatment of voice disorders. Otolaryngologists diagnose vocal pathologies and prescribe medications if warranted for the patient. An otolaryngologist often refers the patient to a speech-language pathologist for voice therapy (Stemple, Glaze, & Klaben, 2000). Speech-language pathologists are frequently involved with the initial evaluation as well as behavioral management of voice disorders in the pediatric population (Corbin-Lewis & Johnson, 2000). The treatment of voice disorders depends largely on the age of a child. Children with voice disorders are treated by speech-language pathologists working in schools, clinics, outpatient centers, and private practices (Stemple et al., 2000). A multidisciplinary team is utilized in the school setting to determine eligibility for special education services for treating children with voice disorders.
Voice Assessment

A pediatric voice assessment involves many components and a number of professionals, such as an otolaryngologist and speech-language pathologist. When obtaining a detailed case history, it may be necessary to interview the child’s parents, teachers, or other care providers. These individuals may assist in the identification of inappropriate habits or behaviors, such as shouting incorrectly, screaming, talking loudly, making vocal noises, and clearing the throat excessively. Assessment also includes a visualization of the vocal mechanism, aerodynamic measurements, and perceptual measures (Corbin-Lewis & Johnson, 2000). A case history should include demographic information along with the medical, educational, behavioral, and psychosocial history.

Visualization of the vocal mechanism. The use of an oral endoscope or flexible nasendoscope can provide the clinician with a view of the larynx and velopharyngeal function. During a stroboscopic procedure, a clinician may rate glottic closure pattern, vocal fold mobility, amplitude, mucosal wave, phase closure and phase symmetry of the vocal folds, as well as overall laryngeal function (Stemple et al., 2000). Abnormalities such as lesions, paralysis, or altered vibratory patterns may be seen with a direct view of the larynx (Corbin-Lewis & Johnson, 2000).

Perceptual, aerodynamic and acoustic measurements. In addition to viewing the vocal mechanism, it is important to obtain perceptual, aerodynamic, and acoustic measures. A clinician can perceptually rate a child’s voice by listening to the parameters of pitch, quality, loudness, and resonance (Colton & Casper, 1990). However, perceptual ratings are subjective measurements due to the variability between listeners. While perceptual ratings are valuable for assessment, obtaining objective acoustic measurements of the voice are also essential components of an assessment (Sisterhen, 2004). One type of objective measurement is aerodynamic analysis. An aerodynamic assessment examines the airflow characteristics through the glottis and timing of vocal fold closure (Stemple et al., 2000). Average airflow rate, peak airflow rate, and open quotient (the amount of time during one cycle of vibration that the glottis is open) are examples of aerodynamic measures.

Acoustic measurements also provide objective measures of voice production (Zraick, Nelson, Montague, & Monoson, 2000). Acoustic measures, such as fundamental frequency ($F_0$), frequency range, and intensity, can be captured with a microphone and analyzed using a variety
of clinical software programs. Acoustic analysis provides a noninvasive approach to explore differences in speech production that may be due to anatomical variations and problems (Sussman & Sapienza, 1994). Fundamental frequency is the acoustic correlate of pitch and is measured in Hertz (Hz). Frequency range consists of the highest to the lowest frequencies an individual can produce and is measured in Hz or semitones (Stemple et al., 2000). An individual’s intensity or loudness is measured in decibels (dB) using a sound level meter. Obtaining acoustic measurements are vital, in that if a lesion exists on the vocal fold, the \( F_0 \) and frequency range will be altered, thus indicating a potential pathology. Obtaining acoustic measures also allows the clinician to compare a patient to normative measures for age and gender. While acoustic measurements serve as only one component of a thorough voice evaluation, they aid in determining the potential level of vocal functioning and to what extent a voice disorder exists. In addition, repeated acoustic measures under standard conditions provide excellent baseline and progress data to measure change in production over time.

**Anatomic and Physiologic Differences in Pediatric and Adult Laryngeal Structures**

It is important to consider the fact that anatomical structures of the larynx differ between adults and children when completing an assessment. These structural differences are significant with respect to acoustic analysis and voice quality measurement. The most significant difference is that the pediatric larynx is one-third the size of an adult larynx (Andrews, 1999). A newborn’s vocal folds are 2.5 to 3 millimeters in length, which represents a much shorter length when compared to adult vocal folds which range from 11 to 15 millimeters in an adult female to 17 to 21 millimeters in an adult male (Hirano, Kurita, & Nakashima, 1983). In addition to differences in size, the larynx of a newborn sits superiorly in the neck, at approximately the third or fourth cervical vertebrae as compared to an adult larynx, which sits approximately at the sixth or seventh cervical vertebrae (Stemple et al., 2000). Also, the narrowest portion of an infant’s airway is the subglottal space, whereas the narrowest portion of an adult’s airway is the glottis.

The membranous versus cartilaginous structures of a child’s laryngeal anatomy also differs from that of an adult. The membranous portion of a pediatric vocal fold comprises less of the total vocal fold length in comparison to an adult vocal fold. In a child, the anterior, membranous area of the vocal folds is a proportionally smaller part of the glottis whereas the posterior, cartilaginous area of the vocal folds forms a larger proportion of the glottis. Smith and Gray (1993) believe the larger posterior portion forming the glottis is related to the respiratory
and protective functions of the larynx. In an infant, the anterior portion of the vocal folds is at high risk for edema due to its membranous structure.

Histological differences also exist between child and adult vocal fold structures. The vocal fold mucosa is thinner in a child when compared to an adult and the layered structure of the vocal folds is not well defined in children under the age of 4.0 years as it is in an adult. Additionally, the shape of a vocal fold in a child is short, thick, and circular compared to an adult vocal fold, which is long and thin. Also, the vocal fold edge of a child is thought to be thick and rectangular in shape (Corbin-Lewis & Johnson, 2000). The aryepiglottic folds and arytenoids cartilages are also disproportionately large in a child when compared to an adult.

**Acoustic Measurement Differences between Pediatric and Adult Populations**

As previously stated, the anatomical distinction in laryngeal structures causes differences in acoustic measures in children compared to adults. Specifically, children’s $F_0$ and formant frequencies are elevated compared to adults (Hasek, Singh, & Murry, 1980). Generally, both $F_0$ and formant frequencies lower as a child ages and both the vocal tract and vocal folds lengthen (Lee, Potamianos, & Narayanan, 1999). A limited number of research studies have been conducted to collect acoustic measures for children ages 5.0 to 18.11 years. Researchers have examined relationships between frequency and gender, frequency and age, and frequency measurements obtained from varying tone conditions.

In the text, *Voice Problems of Children*, Wilson (1987) provides a composite chart of fundamental frequencies for ages 1.0 to 18.11 years, which is representative of studies conducted between 1940 and 1970 (e.g. Curry, 1940; Fairbanks, Herbert, & Hammond, 1949; Hollien & Malcik, 1967). For children ages 5.0 to 11.11 years, the mean $F_0$ was reported to be 254.00 Hz for male participants and 260.00 Hz for female participants.

Since the pioneer studies in 1940, researchers have continued to examine fundamental frequency by gender and age. In one such study, Glaze, Bless, Milenkovic, and Susser (1988) studied 121 children ages 5.0 to 11.11 years with perceptually healthy voices. Acoustic measures were obtained by each participant sustaining /a/ at a comfortable pitch and loudness level. Voice productions were recorded and analyzed using the CSpeech computer software program. Results indicated a significant relationship between frequency and gender, with higher frequencies for female participants. Specifically, $F_0$ was found to be 231.88 Hz (SD=23.12) for all participants in the study with 225.92 Hz (SD=20.32) for males and 237.56 Hz (SD=24.32) for
females respectively. Results also implied that $F_0$ appears to decrease as age, height, and weight increase, although only the gender difference achieved statistical significance.

Andrews and Summers (1988) also measured fundamental frequency in children; however, the study only examined children age 11.0 to 11.11 years old. In addition to $F_0$, the researchers measured the lowest frequency produced, also known as “basal pitch.” The mean $F_0$ was found to be 227.00 Hz for males and 237.00 Hz for females, which is almost identical to the mean $F_0$ that Glaze et al. reported in the previous study. The basal pitch was found to be lower in males with 186.00 Hz as compared to 196.00 Hz for the female participants. Results of both studies illustrated a lower $F_0$ for male children ages 5.0 to 11.11 years of age when compared to female children ages 5.0 to 11.11 years. Results also suggested that even though $F_0$ is known to decrease as age increases, the mean $F_0$ for children ages 5.0 to 11.11 was very similar to the mean for children 11.0 to 11.11, suggesting that significant changes in $F_0$ do not occur until after the age of 11.11 years (Andrews & Summers, 1988; Glaze et al., 1988).

Additionally, Ferrand and Bloom (1996) reported gender differences in children’s intonational patterns. A speech sample was elicited through spontaneous speech for participants age 3.0 to 10.11 years of age. The samples were analyzed for minimum and maximum $F_0$ and mean $F_0$. It was reported that prepubertal voice differences between males and females begin to occur after ages 7.0 or 8.0 years. Specifically, the mean $F_0$ of the males decreased at around age 7.0 to 8.0 years.

In addition to fundamental frequency measurements, studies have also been conducted to determine normative values for frequency range. Reich, Mason, Frederickson and Schlauch (1989) studied maximum frequency range in 40 children ages 8.0 to 11.11 years old with normal voice quality. Five stimulus-tone conditions of (a) discrete steps, (b) slow steps, (c) fast steps, (d) glissando, and (e) fast glissando were recorded for each participant. For the discrete steps tasks, the participants took a breath in between each note whereas, for the glissando steps the participants did not take a breath in between notes. The tasks were done in both slow step conditions and fast step conditions. Results indicated that all the stimulus conditions evoked significantly higher maximum frequencies than the discrete steps condition, which generated the smallest frequency ranges when compared to the other conditions. The slow steps and fast steps trials were found to yield significantly higher maximum frequencies than the slow glissando trials. Furthermore, the study examined the minimum frequencies and reported that the female
participants demonstrated a larger frequency range than the male participants. Again, all the stimulus conditions produced a significantly larger frequency range than the discrete steps conditions. The average frequency range for boys was found to be 528 Hz (discrete steps), 736 Hz (slow steps), 723 Hz (fast steps), 676 Hz (slow glissando) and 702 Hz (fast glissando) compared to the average F$_0$ range for girls which was 624 Hz (discrete steps), 946 Hz (slow steps), 960 Hz (fast steps), 807 Hz (slow glissando), and 834 Hz (fast glissando) condition.

Wuyts, Heylen, Mertens, DeBodt and Van de Heyning, (2003) studied the effects of age, sex, and disorder on voice range profiles in children ages 6.0 to 11.11 years. A voice range profile determines the highest frequency and lowest frequency at which the vocal folds can vibrate (with the added component of intensity measures at each frequency). Ninety-four participants with healthy vocal folds and normal voices were in the control group and 136 children identified with voice disorders were in the experimental group. A voice range profile was obtained for each participant using the Phonomat (Homoth Medizin-electronic GmbH & COKG, Stimmfeldmessung V3.0) automatic voice field measuring device. Each voice range profile consisted of: lowest frequency, highest frequency, frequency range, number of semitones in modal register, number of semitones in falsetto register, and semitone range. Wuyts et al. reported that age also has a different effect for girls when compared to boys. It was found that girls’ voices change gradually from 6.0 to 11.11 years, whereas boys’ voices can be grouped into two categories either below or above 8.0 years of age. The results demonstrated that the total frequency range (difference between the highest and lowest frequency) for girls ages 6.0 to 11.11 years was 698 Hz, while the frequency range for boys ages 6.0 to 7.11 years was 532 Hz and for boys ages 8.0 to 11.11 years was 740 Hz.

Rate of Speech

In addition to F$_0$ and frequency range measurements, assessment of the rate of speech can also be included in a voice evaluation due to its potential effect on the use of poor breath support and hyperfunctional voicing behaviors. Rate of speech that is too fast may contribute to laryngeal pathologies (Stemple et al., 2000; Wilson, 1987). Vocal misuse related to hyperfunction is evident when speakers produce speech in too rapid of a manner; however, this is a poorly studied area and needs to be researched further. Voice therapy sometimes involves slowing down the rate of speech, which frequently decreases vocal hyperfunction (Andrews, 1999). Speaking rate can be measured by either counting words or syllables per minute.
Normative data for speaking rates for children using syllables per minute as the parameter of interest reveal that the speaking rate increases with age. Specifically, Pindzola, Jenkens, and Lokken (1989) reported that a child, age 5.0 to 5.11 years, speaking rate ranges from 109-183 syllables per minute. Peters and Guitar (1991) also studied rate of speech for school age children and reported that 6.0 to 6.11-year-old children’s rate of speech ranges from 140-175 syllables per minute, 8.0 to 8.11-year-old children’s rate of speech ranges from 150-180 syllables per minute, and 10.0 to 10.11-year-old children’s rate of speech ranges from 165-215 syllables per minute (Peters & Guitar, 1991). Speaking rate continues to increase with age and the conversational speaking rate of an adult is approximately 270 syllables per minute (Calvert & Silverman, 1975).

Rate may affect the way an individual uses each breath during speaking and reading tasks. An individual with pulmonary insufficiency may use shorter phrases because of the limited breath capacity (Andrews, 1999; Stemple et al., 2000). Individuals with normal pulmonary function may have a habit of using tidal volume with insufficient breath support (Andrews, 1999). An individual’s rapid speaking rate may be a sign of poor coordination of airflow and voicing, as well as increasing laryngeal tension (Andrews, 1999; Stemple et al., 2000).

Cognitive Development

Cognitive development is an area that is often not discussed in the design and interpretation of previous studies of acoustic measures and assessment procedures. However, examining cognitive development relative to the manner in which measurement tasks are presented is critical to warrant accurate results. Understanding cognitive development may assist in tailoring assessment procedures for a specific child. It is vital for clinicians to be aware of a child’s cognitive capabilities, such as understanding the task required and cooperation with task protocols to obtain the most accurate measures during assessment. There are two theoretical orientations that dominate the cognitive development literature: (a) Piaget’s theory of development, and (b) the information processing theory of development. Piaget’s theory encompasses the age range from birth to the end of adolescence and focuses on memory for objects, causality, imitation, and logic in sets of schemes (patterns of regularities in experiences); on the other hand, the information processing approach focuses on the mind as a system for storing and processing information in a series of stages comparable to a computer (Howard, 1983; Piaget 1952).
Specifically, Piaget (1952) discussed four stages of cognitive development: (a) sensorimotor, (b) preoperations, (c) concrete operations, and (d) formal operations. Sensorimotor development covers the period of infancy from birth to 2 years of age. The preoperation stage occurs from 2 to 8 years of age. During the preoperational stage, children form mental representations of objects and realize that objects exist even when they are not in sight. The third stage, concrete operations, occurs until 11 or 12 years of age. Children within this stage are able to form mental operations for operating objects. During the final stage of formal operations, adolescents are able to think about abstract thoughts.

The information processing approach is also a widely accepted theory by cognitive development scholars. The information processing theory involves the occurrence of a stimulus and the production of a response. Information processing begins with information coming from the environment and entering sensory receptors where the information is then encoded. The encoded information then activates either short-term or long-term memory functions, while the central processor oversees the processing. The response system controls the final output of the original sensory information from the environment. Thus, the five major components of information processing are: (a) sensory register, (b) short-term memory, (c) long-term memory, (d) central processor, and (e) response system (Anderson, 1985).

Both historical and current research reveals a number of significant changes such as causal reasoning capabilities and multidimensional thinking that occur between the ages of 5.0 to 7.11 years. Psychologists have come to agree that a shift occurs in cognitive development around the ages of 5.0 to 7.11 years. White (1965) officially labeled the developmental changes as the “5 to 7-year shift.” During this time period, there is a shift in the characteristic tendencies of a child’s cognitive performance from one-dimensional to multidimensional thinking. Siegler (1996) states that a 5-year-old child can only represent a single feature of a situation, whereas a 7-year-old child can represent multiple views of the same situation. A child 5 years of age has fragmented, partial representations of a task which are processed separately, whereas a child 7 years of age is able to make whole representations from multiple dimensions. In addition to dimensional thinking, a child’s causal reasoning differs from that of an adult until the age of 7 or 8 years (Piaget, 1930; Werner & Kaplan, 1963).

As stated above, there appears to be a distinct difference in a 5-year-old child’s cognitive capabilities compared to a 7-year-old. Children under the age of 7 years may respond differently
to the tasks and may be less able to process cognitive cues than children 5 years old. It has been reported that performing voice assessments with children under the age of 7 years can be challenging. Bohme and Stuchlik (1995) attempted to study voice range profiles of 277 healthy children between the ages of 5 and 14 years. A note was played on a piano and the participants were directed with only verbal instructions to sing a note as softly or loudly as possible. The study reported invalid measures for children ages 5 to 6-years because the participants were unable to follow the verbal instructions and only produced the initial target pitch when asked to sing higher or lower. However, by age 7 years, the voice profile appeared to be representative of the participants’ voice capabilities with the participants demonstrating the ability to sing higher and lower when instructed.

Working Memory. There is compelling evidence that working memory processes contribute to the recall of sentences (Glanzer, Dorman, & Kaplan, 1981). Working memory is the maintenance and manipulation of information that is recently encountered. Working memory is limited in storage and processing resources. Therefore, when task demand exceeds working memory resources there is a breakdown in processing information. In regards to working memory and sentence recall, it is thought that a child will imitate a sentence perfectly if the length of the sentence is within the child’s memory capacity (Rummer & Engelkamp, 2001). Therefore, increasing the length of words in a sentence leads to a significant reduction in recall accuracy. The capacity for working memory is thought to develop dramatically between 4.0-11.11 years of age (Gathercole, 1999).

Willis and Gathercole (2001) studied working memory and the process of spoken sentences with 4-year-old and 5-year-old children. The study reported that repetition was significantly influenced by word length and varied syntactic structure. Additionally, the study found that children with high phonological working memory (the ability to interpret auditory stimuli) were found to be superior at repeating sentences than children of lower phonological working memory ability. Willis and Gathercole proposed that a child’s ability to repeat sentences is limited by his or her phonological memory capacity. Therefore, the task of repeating sentences is directly influenced by memory related factors such as length, number of words in a sentence, and individual differences in memory skills.
History of Cognitive-Behavioral Therapy

Cognitive development is not only a key consideration when analyzing acoustic measures and assessment procedures in children; it is also the foundation of cognitive-behavioral therapy. Cognitive-behavioral therapy was developed out of the knowledge of mental representations and reasoning capabilities (Piaget, 1952; White, 1965); these principles can be used to change behaviors during a voice assessment. Cognitive-behavioral therapy combines the two therapy techniques of cognitive therapy and behavioral therapy. Cognitive-behavioral therapies surfaced in the early 1960s as an outgrowth of the traditional behavioral therapy (Ellis, 1962). It was not until 10 years later that the first writings on cognitive-behavioral modification were published (Kendall & Hollon, 1979; Mahoney, 1974; Meichenbaum, 1977). Since the first publications, cognitive-behavioral approaches have continued to generate significant attention (Carr, 2000; Friedberg & McClure, 2002; Kendall, 2000). Cognitive-behavioral therapy targets both cognition and behavior as primary change areas and focuses on three main principles: (a) cognitive activity affects behavior, (b) cognitive activity may be monitored and altered, and (c) desired behavior change may be affected through cognitive change (Dobson, 2001). Cognitive-behavioral therapy works to formulate coping skills, problem-solving skills, and cognitive restructuring methods. Cognitive restructuring is the change in an individual’s maladaptive thoughts to more constructive, adaptive thought patterns (Dobson, 2001). Cognitive restructuring is often the long-term goal for therapy and typically begins with the therapist attempting to elicit information regarding the development of specific symptoms from multiple sources, such as caregivers, teachers, and the client. Within the therapy program, every attempt at self-monitoring is rewarded and the effectiveness of the intervention plan is evaluated through rating scales and behavioral observations (Reinecke, Dattilio, & Freeman, 2003).

Cognitive therapy is the branch of cognitive-behavioral therapy that focuses on cognitive thought processes. Cognitive therapy is founded upon the assumption that behavior is adaptive and that there is a relationship between an individual’s feelings, thoughts, and behaviors (Dobson & Dozois, 2001; Freeman & Reinecke, 1995). Cognitive therapy is perhaps best known as one of the most effective methods for treating depression, although the realm of cognitive therapy encompasses much more (Scott, Williams, & Beck, 1989). Cognitive therapy has been applied to an array of clinical populations, such as patients with panic disorders, obsessive and compulsive disorder, hypochondria, cancer, eating disorders, drug abuses, and suicidal patients.
The goal of cognitive therapy is to train the patient to look at their ideas and examine their thought patterns.

Both cognitive therapy and cognitive-behavioral therapy are respected practices within the field of psychology. Throughout the last five decades professionals have come to agree that cognition has the power to make a meaningful contribution in formulating functional behavior (Ingram & Siegle, 2001). Cognitive-behavioral therapy has been found to be effective in a wide range of clinical problems, including depression, anxiety, anger and aggression, eating disorders, learning problems, and autism. Specifically, cognitive-behavioral therapy has been found to be beneficial for improving behaviors essential for academic success, such as ability to plan, organize, self-instruct, self-monitor, and self-evaluate (Bradley-Klug & Shapiro, 2003).

Cognitive-Behavioral Therapy and Children

Cognitive-behavioral therapy for children works with a foundation set in developmental psychology, focusing on development of self-control, social cognition, learning and memory, and metacognitive skills (Reinecke et al., 2003). The child’s level of cognitive and affective development is crucial for therapy to be successful. Memory and attention capacity, in addition to verbal fluency, comprehension, and the ability for conceptual reasoning, are key factors that must be addressed prior to therapy. In order for cognitive therapy to be effective, the child must possess the cognitive capacity to reason. As stated previously, reasoning is thought to develop around 5.0 to 7.11 years of age and children are thought to form mental representations of objects and realize that objects exist even when they are not in sight from 2.0 to 8.11 years of age, thus representing a minimum age range when cognitive therapy would have the potential to be effective (Piaget, 1952; White, 1965).

Cognitive-behavioral strategies with children use performance-based procedures to produce changes in thinking, feeling, and behavior (Kendall, 2000). When utilizing cognitive-behavioral therapy with children, several strategies are generally considered common. For example, problem-solving tasks are completed to determine maladaptive behaviors. Cognitive restructuring can then be utilized to redirect irrational thoughts with modeling and role-playing of appropriate behaviors. Behavioral contingencies may also be set up as a system of rewards to reinforce desirable behaviors (Graham, 2005). The ultimate goal of cognitive-behavioral therapy with children is to develop a constructive problem-solving attitude by targeting cognitive
restructuring, self-regulation, relaxation training, modeling, role-playing and behavioral contingencies as mentioned above (Braswell & Kendall, 2001).

**Previous Studies of Cognitive-Behavioral Therapy with Voice**

The use of cognitive-behavioral therapy is not a new concept to the field of voice training. Mental imaging has been used for many years by voice instructors and speech-language pathologists to elicit vocal shape for production of song and speech in aspects such as resonant voice therapy and stuttering intervention therapy regimens (Andrews, Shrivastav, & Yamaguchi, 2000). Resonant voice therapy utilizes principles of skill acquisition to produce forward focus voice with oral vibratory sensations on the anterior alveolar ridge or higher in the face (Verdolini, 1997). Individuals participating in resonant voice therapy are encouraged to think about producing their voice with nasal sound production and imagine generating their voice in a forward focused manner in the “facial mask” versus “back in the throat.”

Both resonant voice therapy and stuttering therapy utilize self-monitoring as a means of treatment. Certain types of stuttering therapy utilize cognitive fluency shaping programs, such as slow versus fast speech and smooth versus bumpy speech (Shapiro, 1999). Venkatagiri (2005) studied recent advances in the treatment of stuttering and found that many children and adults who stutter are able to produce nearly stutter-free speech by developing a cognitive set to speak without disfluencies and self-monitor their speech. A cognitive set is a conscious act of thought in which the individual uses their cognition to alter their speaking pattern and ultimately reduce disfluencies (Bradlow & Bent, 2002; Payton, Uchanski, & Braida, 1994). Speaking situations which commonly involve cognitive sets include speaking to children, nonnative speakers, and the hearing-impaired (Bradlow & Bent, 2002).

While aspects of cognitive therapy have been incorporated into the area of voice, there are a limited number of research studies exploring its use in voice and voice training. As mentioned previously, Reich et al. (1989) utilized aspects of cognitive training to elicit five stimulus-tone conditions of (a) discrete steps, (b) slow steps, (c) fast steps, (d) glissando, and (e) fast glissando when studying F0 range in children ages 8.0 to 11.11 years with healthy voice quality. Each task required the participants to think about their voice and produce a fast, slow, smooth, or divided voice production. For the slow and fast steps trials, the participants were instructed to “go to the top of the ladder with your voice” either slowly or quickly. In the slow glissando and fast glissando tasks, the participants were cued to “go to the top of the roller
coaster with your voice” either slowly or quickly. In addition to the cognitive cues given, the participants were also prompted visually with upward and downward hand-stepping motions. The effectiveness of the cognitive cues utilized in this study was not measured; however the study provides an example of how cognitive cues can be integrated into voice task measurements.

Andrews et al. (2000) integrated cognitive cues into voice task measurements and examined the role of cognitive cues on vocal output in adults. The study was conducted to determine if speakers exhibit increased variation in voice output for frequency and duration when cognitive cues are given. The study also examined the semantic content of sentences and how varying contexts influence the amount of vocal variability. Thirteen participants were included in the study, four of whom were classified as having a voice disorder. Eight sentences were constructed to target vocal variability. Each sentence was read aloud by the participants and two cognitive cues were given per sentence to target a mental image. The cognitive cues for each of the sentences were designed to elicit different voicing patterns and measurements. For example, the sentence, “The submarine sank to the bottom of the sea” was used with the cue “let me hear how the sailors felt as the submarine sank” and “think about the surface of the water—start your voice there and show me how the submarine goes down.” Frequency descent was significantly greater when cued with prompts to evoke thought patterns pertaining to pitch descent. In response to cognitive cues, which invoked thoughts of “slowness,” all subjects significantly increased the duration of their utterances for cued versus uncued trials. Adults with voice disorders also increased their vocal variation when they were given cognitive cues by exhibiting a significantly higher frequency variation in the cued trials. The healthy subjects exhibited greater frequency variations compared to subjects with voice disorders in both cued and uncued trials, resulting in no significant changes for the healthy subjects.

In a similar study, Bohnenkamp, Andrews, Shrivastav, and Summers (2002) studied the use of cognitive cues with children ages 9.0 to 10.11 years. This study compared children’s vocal patterns to determine if the semantic content of a sentence and type of instruction influences the vocal variability of the subjects. The study also examined differences between male and female school age children’s vocal responses. Fifteen school age children (9 males and 6 females) participated in the study. Four sentences were designed to elicit specific vocal responses. Sentence 1 was designed to target increase in duration, Sentence 2 targeted decrease
in duration, and Sentences 3 and 4 targeted increase and decrease in frequency. The participants were instructed to think about how they could use their voice to make the listener feel the meaning of the sentence. For example, Sentence 1: “The boy walked slowly to school, dragging his feet” was used with the cue “make me feel that he was walking slowly” and “think about walking slowly and dragging your feet; think about how you could use your voice to make me feel how he is walking. Use your voice to let me feel the boy walking slowly.” Results indicated that the subjects’ had greater variability when cognitive cues were given. The changes were most significant for the sentences which targeted frequency change with upward and downward motions. It was also found that male participants had much less frequency variability overall when compared to the female participants when no cues were provided. On the other hand, the male subjects had a greater increase in frequency variability than the females for the trials when cognitive cues were given. Significant changes were noted in both the frequency and duration parameters when cognitive cues were given for both males and females.

**Tasks to Elicit Voice Productions**

Several researchers have suggested that acoustic parameters may be influenced by how they are elicited (Reich et al., 1989; Zraick, Marshall, Smith-Olinde, & Montague, 2004; Zraick, Nelson, Montague, & Monoson, 2000; Zraick, Skaggs, & Montague, 2000). Tasks used to elicit voice productions can have a strong impact on assessment, and if not chosen with adequate thought, may provide inaccurate voice measurements. The value of any measurement is its repeatability over time. Validity in measurement of voice productions is vital for baseline and comparative norms. As stated previously, cognitive development of participants is of concern when comparing elicitation tasks. Depending upon the demands of a task, cognitive development can have a crucial impact upon results. In addition, cooperation and understanding of directions, which can vary with each participant, may also hinder task elicitation designs.

In one such examination of the influence of elicitation tasks, Zraick et al. (2004) studied four tasks commonly used to elicit intensity measures. The four tasks consisted of automatic speech (counting for 30 seconds), elicited speech (description of a picture), spontaneous speech (description of the testing room), and reading (30 second sample). Analysis of the results revealed that a statistically significant effect of task was found between habitual loudness elicited via automatic speech versus spontaneous speech and elicited via automatic speech versus reading aloud. Automatic speech was found to be significantly softer than reading aloud.
In another study, Zraick, Skaggs, and Montague (2000) studied the effect of task on determination of \( F_0 \) with 36 individuals: (12) adult males, (12) adult females, and (12) prepubescent children. Tasks commonly used to elicit habitual pitch in voice assessments were compared. The tasks consisted of (a) counting from 1 to 10, (b) oral reading of standardized passage, (c) spontaneous speech for 10 seconds, (d) sustained vowel production, (e) counting 1 to 3 and sustaining the /i/ vowel at the end of “3,” (f) producing a “um-hum” utterance, and (g) producing a “um-huh” utterance. For the children and adult male groups, the data demonstrated that producing “um-huh” gave the lowest mean \( F_0 \), while reading produced the highest mean \( F_0 \). Results indicated that for adult males and prepubescent children, no significant effect of task was found. However, for the adult female participants, a statistically significant effect of task was found. Each of the seven tasks was found to be significantly different from at least one of the other tasks for the adult female participants. Specifically, the effect of task on eliciting \( F_0 \) was influenced by the length of utterances, speaking style, gender, and age of the subjects. The results of this study indicated that clinicians should consider the task used based on the results from the female participants.

An additional study sought to examine if task elicitation had a significant effect on the determination of frequency range of young adult females with healthy voices (Zraick, Nelson, Montague, & Monoson, 2000). Two tasks commonly used to elicit this measurement, glissando and discrete steps, were compared among 30 healthy adult females. In the glissando task, participants were asked to take a deep breath and produce /a/ starting at a comfortable pitch and loudness level and go to the highest note they could produce in one breath. Participants were also instructed to take a second deep breath and go to the lowest note they could make in one breath. The discrete steps task involved a similar concept; however after taking a deep breath and producing /a/ at a comfortable pitch and loudness level, participants were instructed to take a short breath before moving up to the next note, until they felt like they could not produce a higher pitch. These instructions were repeated for singing down the scale as well. The mean frequency range for the glissando conditions was found to be 1030.73 Hz (SD = 180.07), whereas the discrete step condition mean frequency range was 1005.82 (SD = 158.57). The slight difference in mean scores between the glissando and discrete steps conditions was not found to be statistically significant for effect of task.
These results above from the Zraick, Nelson, Montague, and Monoson (2000) are not consistent with the study mentioned previously by Reich et al. (1989) who compared frequency range elicitation tasks of discrete steps, slow steps, fast steps, slow glissando, and fast glissando. Reich et al. studied only children and found a significant difference among task elicitation type; however Zraick et al. studied adult females and found that there was not a significant difference among task elicitation methods. It is plausible that a smaller F₀ range in the discrete steps condition was found for the children in Reich et al. study due to the enhanced difficulty of the task, compared to the glissando condition. It likely requires more concentration and skill to remember to stop and take a breath before proceeding to a higher note, rather than gliding up continuously to the highest note. It is anticipated that the higher levels of cognition and self-control possessed by the adult female participants in the Zraick et al. study would make the discrete steps condition measures as achievable as the glissando condition measures.

Purpose of the Study

This study will examine task elicitation with cognitive cues for frequency range and rate of speech measurements in children ages 5.0 to 7.11 years. Cognitive cue trials will be compared to verbal cue trials to determine if cognitive cues aid assessment procedures by increasing frequency range and decreasing rate of speech. Cognitive cue trials will prompt the participant to think and create a mental image of the task as they produce their response, whereas verbal cue trials will simply provide the participant with directions on how to complete the task. This study has the potential to improve assessment protocols for children and determine the most valuable task to use when measuring voice productions.

Research Hypotheses

1. The use of cognitive cues will elicit a significantly greater frequency range in children ages 5.0 to 7.11 years of age compared to use of verbal cues.
2. The use of cognitive cues will elicit a significantly slower rate of speech in children ages 5.0 to 7.11 years of age compared to use of verbal cues.

Null Hypotheses

1. The use of cognitive cues will not elicit a significantly greater frequency range in children ages 5.0 to 7.11 years of age compared to use of verbal cues.
2. The use of cognitive cues will not elicit a significantly slower rate of speech in children ages 5.0 to 7.11 years of age compared to use of verbal cues.
CHAPTER 3
Methods

Participants

Thirty-eight participants, twelve 5.0-5.11-year-olds, thirteen 6.0-6.11-year-olds, and thirteen 7.0-7.11-year-olds, were recruited from the Greater Cincinnati, Ohio area for this study. All children were enrolled in age and grade appropriate settings. Participants were native speakers of English. Participants were excluded if they were serviced with an Individualized Education Plan, had an unrepaired velopharyngeal disorder, were perceived by a speech-language pathologist to have a voice disorder, had abnormal oral-peripheral structures, or had a hearing loss. Four participants (two 7.0-7.11-year-olds, one 6.0-6.11-year-old, and one 5.0-5.11 year old) were determined by two certified speech-language pathologists to be unable to understand and complete the task. Normal hearing ability was determined from a hearing screening. If a child failed to respond to one or more of the screening tones he or she was excluded from the study. Parent/guardian consent for each child participating in the study was obtained prior to data collection.

Procedure

Hearing Screening

Prior to collecting the experimental sample, each participant enrolled in the study was required to pass a bilateral pure-tone hearing screening. A hearing loss has the potential to cause inaccurate feedback for voice productions, thus affecting the accuracy of the data. A portable pure-tone audiometer (MAICO, MA40) was used to screen each child. The participants were instructed to raise his or her hand whenever a tone was audible. Pure tones were presented at 25 dB HL and each participant was screened at 1000 Hz, 2000 Hz, and 4000 Hz. If the participant failed to raise his or her hand in response to one or more of the tones, the participant was excluded from the study.

Data Collection

Half of the participants in each age group were assigned to the experimental group and half were assigned to the control group. Six female and six male participants comprised age group category of 5.0-5.11-years. Six female and seven male participants comprised age group category 6.0-6.11-years and seven female and six male participants comprised the age group category of 7.0-7.11-years. The uneven number of participants per group is due to the previously
mentioned participants who were excluded. The control group received verbal cue trials only; whereas the experimental group received a verbal trial followed by a cognitive cue trial for both frequency range and rate of speech tasks (see Table 1). Each participant was seated in a quiet room and instructed to follow directions provided by the investigator. A headset microphone (MicroMic Series, C420 PP) was worn by each participant with a mouth to microphone distance of two inches. Responses were recorded with a digital audio tape recorder (Tascam Sony, DAPI).

Table 1
Task Elicitation Design

<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Group</td>
<td>Verbal Cues</td>
<td>Cognitive Cues</td>
</tr>
<tr>
<td>Control Group</td>
<td>Verbal Cues</td>
<td>Verbal Cues</td>
</tr>
</tbody>
</table>

Experimental group. Nineteen participants, six 5.0-5.11-year-olds, six 6.0-6.11-year-olds, and seven 7.0-7.11-year-olds, were randomly assigned to the experimental group. One participant was excluded from the frequency range tasks due to a hoarse voice quality. The experimental group received a verbal cue trial followed by a cognitive cue trial for both frequency range and rate of speech measurements.

To elicit frequency range in Trial 1, the participants were instructed with verbal cues to glide from their lowest to highest frequency and then glide from their highest to their lowest frequency. The participants were then given additional cognitive cues to think about their voice and to form a mental image of their voice as they completed each of the tasks for Trial 2. The following instructions were given to the participants for Trial 1 (verbal cue trial): “Glide up from your lowest note to your highest note while producing the sound /u/.” The participants were then directed to glide down in frequency with the following instructions; “Glide down from your highest note to your lowest note while producing the sound /u/.” A clinician model was given for how to glide up and down and the participants were allowed two practice attempts. The following instructions were given to the participants for Trial 2 (cognitive cue trial): “I want to
practice and see if you can change your voice if you think about it. I want you to form a picture in your mind and then make your voice sound like what you are thinking.” The participants were cued to “think about an airplane on a runway- start your voice there and show me with your voice how high you can make the airplane go up when it takes off” while producing /u/. The participants were then cued to “think about an airplane up high in the sky- start your voice high up and then make your voice go lower to get the plane as low in the sky as you can” while producing /u/. Again, a clinician model was given and the participants were allowed two practice attempts. Following the practice attempts, each participant was directed to repeat their frequency range three times from the highest to the lowest and three times from the lowest to the highest.

Prior to conducting the rate of speech tasks, the recalling sentences subtest of the Clinical Evaluation of Language Fundamentals-Fourth Edition (CELF-4; Wiig, Secord, & Semel, 2003) was administered to determine the participants’ ability to listen to spoken sentences of increasing length and complexity and to repeat the sentences without changing word meanings, inflections, derivations, or sentence structure. To measure rate of speech, a sentence was read aloud to each participant and the participants were instructed to say the sentence back to the clinician. For Trial 1 (verbal cue trial) the following sentence was read aloud; “The boy walked slowly, dragging his feet.” The participants were directed to say the sentence aloud with the following instructions: “Now it’s your turn- I want you to say the sentence, tell me the whole sentence back from start to finish.” Following the verbal cue trial, the second trial added cognitive cues. The participants were instructed to think about how they could use their voice to make a listener feel the meaning of the sentence. The following instructions were given to the participants for Trial 2 (cognitive cue trial): “Now it’s your turn- I want you to think about walking slowly and dragging your feet, think about how you could use your voice to make me feel how the boy is walking. Use your voice to let me feel the boy walking slowly and tell me the whole sentence from start to finish.” Each participant completed the verbal trial three times and then the cognitive cue trial three times.

Control group. Nineteen participants, six 5.0-5.11-year-olds, seven 6.0-6.11-year-olds, and six 7.0-7.11-year-olds, were randomly assigned to the control group. The control group received verbal cues targeting pitch range. No additional cognitive cues were given to the
control group, thus allowing the researcher to compare trials between verbal cues and cognitive cues.

For the frequency range measurement task Trial 1 and Trial 2 (both verbal cue trials), the participants were directed to glide from their lowest frequency to their highest frequency and then glide from their highest frequency to their lowest frequency in order to measure the frequency range capabilities of each participant. The following instructions were given to the control group participants: “I want you to glide up from your lowest note to your highest note.” A clinician model was given for how to glide up in frequency range. The participants were then directed to glide down in frequency with the following instructions: “I want you to glide down from your highest note to your lowest note.” Again, a clinician model was given and the participants were allowed two practice attempts.

Data Measurement

The data from the digital audio recorder was digitized using Adobe Audition Software 1.0 and analyzed utilizing the Multi Speech Real Time Pitch software program (Kay Pentax). The Pitch Extraction function of the Real Time Pitch program was employed for the analysis of frequency range by reporting the maximum frequency and minimum frequency of the task. Sentences were digitized and the duration of each sentence was measured with the Adobe Audition Software 1.0. The length of production was measured and then divided by the number of syllables in the sentence utterance.

Statistical Analysis

Mean frequency range and rate of speech was determined from the three repeated trials for each task. A repeated measures analysis of variance (ANOVA) with the elicitation tasks as the within-subject factors, and gender, age, and group as the between-subject factors was completed. A paired t-test was completed to compare the means for the rate of speech trials.
CHAPTER IV
Results

Descriptive Analysis

Frequency Range Descriptive Analysis

The mean maximum frequency for glide up task by age group categories (5.0-5.11 years), (6.0-6.11 years), (7.0-7.11 years), and total (5.0-7.11 years) is displayed in Table 2. Table 2 also contains the range (difference between the highest and lowest values for the glide up task) for each age group category. The mean maximum frequency for glide up for all ages is displayed in Figure 1. The mean maximum frequency for glide up values for the control group versus the experimental group is displayed in Figures 2 and 3. The mean minimum frequency for glide down task by age group categories (5.0-5.11 years), (6.0-6.11 years), (7.0-7.11 years), and total (5.0-7.11 years) is displayed in Table 3 along with the range. The mean minimum frequency for glide down for all ages is displayed in Figure 4. The mean minimum frequency for glide down values for the experimental group versus the control group is displayed in Figures 5 and 6.

Table 2
Mean Maximum Frequency for Glide Up Task by Age

<table>
<thead>
<tr>
<th></th>
<th>Experimental Group</th>
<th>Control Group</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
<td>Trial 2</td>
</tr>
<tr>
<td>Ages 5.0-5.11 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (Hz)</td>
<td>589.22</td>
<td>735.82</td>
</tr>
<tr>
<td>SD</td>
<td>161.55</td>
<td>184.51</td>
</tr>
<tr>
<td>Ages 6.0-6.11 years</td>
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<td></td>
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<tr>
<td>Mean (Hz)</td>
<td>460.11</td>
<td>555.89</td>
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<tr>
<td>SD</td>
<td>86.08</td>
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<tr>
<td>Ages 7.0-7.11 years</td>
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<tr>
<td>Mean (Hz)</td>
<td>586.88</td>
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<tr>
<td>SD</td>
<td>96.85</td>
<td>106.82</td>
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<tr>
<td></td>
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<td>---------------------</td>
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</tr>
<tr>
<td></td>
<td>Trial 1</td>
<td>Trial 2</td>
</tr>
<tr>
<td>Total</td>
<td></td>
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<tr>
<td>Mean (Hz)</td>
<td>548.14</td>
<td>635.84</td>
</tr>
<tr>
<td>SD</td>
<td>130.14</td>
<td>161.91</td>
</tr>
</tbody>
</table>

Figure 1

*Mean Maximum Frequency for Glide Up Ages 5.0-7.11*
Figure 2
*Mean Maximum Frequency for Glide Up Task for Control Group by Age*

Figure 3
*Mean Maximum Frequency for Glide Up Task for Experimental Group by Age*
Table 3
Mean Minimum Frequency for Glide Down Task by Age

<table>
<thead>
<tr>
<th></th>
<th>Experimental Group</th>
<th></th>
<th>Control Group</th>
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</tr>
</thead>
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<td>Trial 2</td>
<td>Range</td>
<td>Trial 1</td>
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<td>Ages 5.0-5.11 years</td>
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<td>Mean (Hz)</td>
<td>268.05</td>
<td>285.98</td>
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<tr>
<td>SD</td>
<td>70.96</td>
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<td>Ages 6.0-6.11 years</td>
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<tr>
<td>Mean (Hz)</td>
<td>242.34</td>
<td>252.90</td>
<td>10.56</td>
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<tr>
<td>SD</td>
<td>34.27</td>
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<td>Ages 7.0-7.11 years</td>
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<tr>
<td>Mean (Hz)</td>
<td>241.27</td>
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<tr>
<td>SD</td>
<td>25.62</td>
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<tr>
<td>Mean (Hz)</td>
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<td>15.12</td>
<td>252.90</td>
</tr>
<tr>
<td>SD</td>
<td>46.11</td>
<td>70.58</td>
<td>24.47</td>
<td>39.35</td>
</tr>
</tbody>
</table>
Figure 4

*Mean Minimum Frequency for Glide Down Ages 5.0-7.11*

![Graph showing mean minimum frequency for glide down ages 5.0-7.11](image)

Figure 5

*Mean Minimum Frequency for Glide Down Task for Control Group by Age*

![Graph showing mean minimum frequency for glide down task for control group by age](image)
Rate of Speech Descriptive Analysis

Eight participants were able to complete the task and comprehend the cognitive cue to reduce their rate of speech as judged by the investigator. The mean rate of speech and standard deviation for Trial 1 and Trial 2 are displayed in Table 4 for the participants who were able to comprehend the task. The mean age of the eight participants who were able to complete the task was 6.9 years-old (range = 5.3 years-7.11 years) (SD=.927). The mean standard score for recalling sentences subtest of the CELF-4 for the eight participants who were able to comprehend the task was slightly higher (11.25, range = 10-15) than the mean score of the participants who were unable to complete the task (10.36, range = 5-15).
Table 4

Mean Rate of Speech

<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (spm)</td>
<td>202.67</td>
<td>122.30</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>32.28</td>
<td>32.45</td>
</tr>
</tbody>
</table>

Note. spm=syllables per minute.

Inferential Analysis

Research question 1:
Will the use of cognitive cues elicit a significantly greater frequency range in children ages 5.0 to 7.11 years of age compared to use of verbal cues?

A repeated measures analysis of variance (ANOVA) with trials (Trial 1 and Trial 2) as the within-subject factor and group (either experimental or control), age (either 5.0-5.11, 6.0-6.11, or 7.0-7.11), and gender as between-subject factors was completed for mean maximum frequency values. The results revealed a main effect for trials, \( F(1,23)=15.991, p=.001 \). Both trials by group interaction, \( F(1,23)=5.356, p=.030 \), and trials by age interaction, \( F(2,23)=5.361, p=.012 \), were found to be significant. However, the trials by gender interaction was not significant, \( F(1,23)=.005, p=.944 \).

Due to the significant trial by age interaction, further tests were conducted to determine any differences between 5.0-5.11 years, 6.0-6.11 years, and 7.0-7.11 years in the experimental group. The results of a repeated measures ANOVA revealed a significant trial by age interaction between mean maximum frequencies for ages 6.0-6.11 years and 7.0-7.11 years, \( F(1,8)=10.725, p=.011 \). However, there was no significant trial by age interaction between ages 5.0-5.11 years and 7.0-7.11 years, \( F(1,9)=3.679, p=.087 \) or ages 5.0-5.11 years and 6.0-6.11 years, \( F(1,9)=.0001, p=.995 \).

A repeated measures ANOVA with Trial 1 and Trial 2 as within-subject factors and group, age, and gender as between-subject factors was also completed for minimum frequency tasks. The results revealed that there was no significant difference for trials, \( F(1,20)=2.820, p=.102 \).
Research question 2:

Will the use of cognitive cues elicit a significantly slower rate of speech in children ages 5.0 to 7.11 years of age compared to use of verbal cues?

A paired t-test was completed to determine if there was a significant difference between the mean of Trial 1 (verbal cue) compared to the mean of Trial 2 (cognitive cue). The analysis was completed with only the eight participants who were able to comprehend the task. Analysis revealed a significant difference between Trial 1 and Trial 2, $t(7)=-4.532, p=.003$. 

$p=.109$. The trials by group interaction, $F(1,20)=1.434, p=.245$, trials by age interaction, $F(2,20)=.050, p=.952$, and trials by gender interaction, $F(1,20)=.369, p=.550$ were also found to be not significant for minimum frequency tasks.
CHAPTER V
Discussion

Background

The present study examined the use of cognitive cues as a task elicitation method for frequency range and rate of speech measurements with children ages 5.0 to 7.11 years. The primary objectives of the study were to determine if cognitive cues elicit a significantly greater frequency range in children ages 5.0 to 7.11 years and to determine if cognitive cues elicit a significantly slower rate of speech in children ages 5.0 to 7.11 years.

Thirty-seven participants were involved in this study. Each of these participants passed a hearing screening and were perceived by two certified speech-language pathologists to be able to understand and complete the task of gliding up from their lowest note to their highest note and then down from their highest note to their lowest note. Additionally, the participants were judged by the investigator to either be able to comprehend the task of reducing their rate of speech when cognitive cues were given or unable to comprehend the task of repeating the phrase when also cued to reduce their rate of speech. After determining eligibility for the study, each participant was randomly assigned to either the control group or experimental group and instructed to complete frequency range and rate of speech tasks. The measurements from the recordings were analyzed to determine if cognitive cues had a significant effect on frequency range measurements and altering rate of speech.

Interpretations

Research question 1:

Will the use of cognitive cues elicit a significantly greater frequency range in children ages 5.0 to 7.11 years of age compared to use of verbal cues?

A significant trials effect was found for maximum frequency tasks. On average, improvement was made by all subjects from Trial 1 to Trial 2 when they were instructed to glide up from their lowest note to their highest note. The improvement between trials illustrates a learning effect occurred for this type of task and the participants were able to reach a higher frequency with each attempt. Participants in the control group completed the maximum frequency task with a verbal cue instruction 6 times each, whereas participants in the experimental group completed the maximum frequency task with a verbal cue 3 times and then a cognitive cue 3 times. Therefore, the control group participants had greater opportunity to
maximize on the learning effect for this type of task; however the experimental group still
demonstrated significantly greater values than the control group.

The increase between trials was also influenced by group as seen by the trial by group
interaction. Participants in the experimental group demonstrated significantly greater values for
maximum frequencies when cognitive cues were utilized as the task elicitation method compared
to participants in the control group with verbal cues as the task elicitation method. In fact, when
cognitive cues were utilized, the participants’ mean maximum frequency increased by 87 Hz,
whereas the control participants’ mean maximum frequency increased only by 27 Hz when
verbal cues were utilized. These results support previous research demonstrating that task
elicitation has an effect on measurement outcomes (Reich et al., 1989; Zraick, Marshall, Smith-
Olinde, & Montague, 2004; Zraick, Nelson, Montague, & Monoson, 2000; Zraick, Skaggs, &
Montague, 2000). The significant effect for the use of cognitive cues indicates that children in
particular may perform to the maximum ability with specific types of cues.

Overall, cognitive cueing was found to be a valuable task elicitation method for
increasing maximum frequency for children ages 5.0 to 7.11 years. A significant trial by age
interaction was found between ages 6.0-6.11 years and 7.0-7.11 years, however a significant trial
by age was not found for the other ages examined. It is of interest to note that the 6-year-old
participants had the lowest maximum frequency between the age group categories. The 6-year-
old participants reached a lower frequency (460.11 Hz compared to 589.22 Hz for 5-year-olds
and 586.88 Hz for 7-year-olds) for Trial 1. When instructed with a cognitive cue for Trial 2, the
6-year-old participants increased his or her frequency, however the average maximum frequency
for the 6-year-old participants was not as great as the other age groups studied (555.89 Hz
compared to 735.82 Hz for 5-year-olds and 611.80 Hz for 7-year-olds). There was a limited
sample size for each age group, making it difficult to determine if there was any difference in age
for responding to cognitive cues. Even though a significant trial by age interaction was found
between the 6-year-old participants and the 7-year-old participants it is assumed that perhaps
there is actually little difference in this age group of 5.0-7.11 years in response to cognitive cues.

Surprisingly, the use of imagery and reasoning skills associated with the cognitive cue of
making the airplane “go as high as it could go” was found to be most significant for the youngest
children (ages 5.0 to 5.11 years) studied. Previous research states that reasoning is thought to
develop around 5.0 to 7.11 years of age and children are thought to form mental representations
of objects from 2.0 to 8.11 years of age. These results indicate that children as young as 5-years-old were able to form mental representations of an airplane and had the reasoning capabilities to grasp the task.

In addition to the trial by group interaction and trial by age interaction, a trial by gender interaction was tested to determine if gender had an effect. The trial by gender interaction was found to be not significant revealing that for this age group, there was no difference in responding to cognitive cues for males or females. However, previous research found that female participants age 9.0 through 10.11 years demonstrated more frequency variability than the male participants for both cued trials and uncued trials overall (Bohnenkamp et al., 2002). In the previous study, the participants were instructed to read four sentences aloud. For the cognitive cue trial, the participants were cued to think about how they could use their voice to let the examiner feel the meaning of the text. The results of both the current study and previous research compares well to the data reported on prepubertal voice differences between males and females. Ferrand and Bloom (1996) reported that prepubertal voice differences between males and females begin after ages 7 or 8 years. Therefore, prior to age 7 or 8 years little variability in frequency range is suspected between males and females. However, after the age of 7 or 8 years females are expected to have a greater frequency range. Thus, this explains why a gender difference would be present for the previous research with participants 9.0 through 10.11 years and not significant for the current study with participants 5.0 through 7.11 years.

While a significant effect was found for maximum frequency tasks, there was not a significant effect on minimum frequency tasks for children ages 5.0 through 7.11 years. Conversely, previous research found cognitive cues to have a significant effect on increasing vocal variation for both glide up and glide down measurements for children ages 9.0 to 10.11 years (Bohnenkamp, et al., 2002). However, the present study found that cognitive cues as a task elicitation method did not have a significant effect on minimum frequency tasks for children ages 5.0 to 7.11 years. It is assumed that the participants in this study reached their lowest frequency with Trial 1 and could not go any lower when cued to do so in Trial 2. When either a verbal cue or cognitive cue was provided for Trial 2, the 5.0 through 7.11 year-old participants attempted to go lower and then began to make a glottal fry production. It is suspected that the growling noise from the glottal fry was an auditory cue for the participants that they had gone as low as they could and consequentially, the participants did not lower their frequency.
These results indicate that cognitive cues have the potential for improving assessment of voice productions by enhancing a child’s capacity to reach their maximum frequency. Additionally, the improvement by both the control and experimental groups for Trial 2 illustrates a learning effect for voice production tasks. Specifically for this age group, it is vital for clinicians to allow children multiple trials when obtaining voice productions to find the most valid measurement of their capabilities. The difference seen between trials exemplifies the need for practice and the improvement that can be gained from multiple exposures to a task.

Research question 2:

Will the use of cognitive cues elicit a significantly slower rate of speech in children ages 5.0 to 7.11 years of age compared to use of verbal cues?

Only 8 of the 19 participants who completed the rate of speech tasks were judged by the investigator to be able to complete the task of reciting the sentence, “The boy walked slowly dragging his feet” and comprehend the cognitive cue to reduce their rate of speech and make the boy walk slower. A significant difference between the cognitive cue trial and the verbal cue trial was found for the 8 participants who were able to understand the task. In fact, the average for the participants’ syllables-per-minute (spm) was reduced from 202.67 spm to 122.30 spm when the participants were cued to make the boy walk even slower. The syllables per minute for Trial 2 (122.30 spm) was lower than the average speaking rate of 140-175 spm for children 6.0 through 6.11 years (Peters and Guitar, 1991). Therefore, cognitive cues were effective in reducing the rate of speech for the participants who were able to comprehend the task.

Eleven of the 19 participants were judged to be unable to complete the rate of speech task. When instructed to repeat the sentence, “The boy walked slowly dragging his feet,” for Trial 1 the participants were able to say the entire sentence with minimal difficulty. For Trial 2 when the participants were cued to make the boy walk slower a majority of the participants were able to say “the boy walked slowly” however the participants were unable to remember the remaining part of the sentence “dragging his feet” and either paused for a long time or needed prompting from the clinician to remember the words. It is suspected that the additional task of trying to reduce his or her rate of speech exceeded the participants’ cognitive capabilities when the participants were also trying to remember the words of the sentence. As previously reported, the average standard score for the recalling sentences subtest of the CELF-4 was slightly higher (11.25, 10-15) than the mean score of the participants who were unable to complete the task.
(10.36, 5-15). However, only two participants who were unable to complete the task scored lower than one standard deviation below the mean. These scores indicate that the majority of the participants achieved the appropriate criteria for repeating sentences; however they were unable to repeat the sentence when also cued to slow down their rate.

It is suspected that the additional task of slowing down his or her rate was too difficult for the participants to comprehend in addition to remembering the words. Previous research found cognitive cues to be effective in altering rate of speech; however the previous study had the participants read sentences when cognitive cues were given (Bohnenkamp, et al., 2002). In the current study, the task required the participants to remember the phrase in addition to the cognitive cue. It is assumed that the task of reciting the phrase was more difficult for the participants in this study than the task of reading was for the previous study. Thus, cognitive cues may be helpful for individuals who can comprehend the task in the first place or for tasks that are less challenging such as reading. However, cognitive cues might be limiting for those who are unable to comprehend the task and for tasks that require additional cognitive processes.

It should be noted that the current study chose to have the participants repeat the phrase rather than read the phrase due to the age group studied. It was suspected that due to the grade level, some of the 5-year-old and 6-year-old participants would not have been able to read the phrase without assistance, thus allowing another extraneous variable to influence task performance.

Limitations

The sample for the study was drawn from a private school in Southwestern Ohio, creating a relatively uniform population. There were minimal cultural differences within the population and limited variability in the socio-economic status of the participants. For the frequency range task, it was assumed that the participants had some prior knowledge of airplanes and how they fly. Even though the majority the participants had not been on an airplane before, it is suspected that the participants had exposure to how an airplane takes off and lands on a runway from television and school instruction.

Due to the majority of the participants being excluded from the rate of speech analysis, it would have been beneficial to have a wider range of ages in addition to the children ages 5.0 to 7.11 years used in this study to determine at what age cognitive cues are effective for altering rate of speech. Bohnenkamp et al., (2002) found cognitive cues to be effective in altering rate of speech for children ages 9.0-10.11 years and it would have been valuable to include the age
ranges studied previously to compare results. Additionally, it would have been advantageous to use multiple phrases of varying length to determine at what length cognitive cues were effective for altering rate of speech or if cognitive cues were not effective for some participants despite the phrase length. Furthermore, it would have been of interest to compare cognitive cues for reading tasks to cognitive cues for repeating sentences from memory tasks for participants who were able to read the phrase to determine if cognitive cues were more effective in altering rate of speech for one task or another.

For the rate of speech task, there was also the potential for the rate of the participants’ speech to be influence by the clinician model. As mentioned previously, a clinician model had to be given due to the age group studied and the participants being unable to read the sentence. For Trial 1, the clinician recited the sentence and then verbally cued the participants to repeat the sentence, thus allowing the potential for the rate to be influenced by the clinician model. However, for Trial 2, there was no clinician model to illustrate a reduced rate of speech. The clinician used the same rate of speech as Trial 1 and then cued the participants to “think about walking slowly and recite the sentence.”

**Future Directions**

Future directions of this study include examining the use of a variety of cognitive cues in addition to the airplane scenario used in this study to determine if different cues provide greater vocal variation depending on gender and age factors. Additionally, examining children from multiple school settings with varying socio-economic background is recommended to determine if exposure to various cognitive cue scenarios such as riding in an airplane, scuba diving, or running on a track has any significance to the effect of the cognitive cue. Examining the use of a variety of cognitive cues with frequency range and rate of speech tasks in addition to tasks for increasing and decreasing intensity and resonance measures is recommended.

It would also be of interest to conduct this study by presenting glide up Trial 1 and glide up Trial 2 successively followed by glide down Trial 1 and glide down Trial 2 to determine if the presentation of tasks, such as alternating glide up and then glide down, had an effect on voice productions measurements. As explained previously, the participants who were unable to make any change in pitch were excluded from the study. Four participants were judged to be unable to change pitch for the glide down task; however half of those participants were able to change pitch for the glide up task. It is suspected that the participants were able to complete the glide up
task because it was administered first and then were unable to complete the glide down tasks because he or she continued to increase pitch rather than decreasing it for the second task. Specifically, it would be of interest to compare the glide down measurements from this study to a future study with varied trial presentations to determine if the glide down measurements were similar for the minimum frequencies reported. Additionally, it would be of interest to examine if presenting successive trials for glide up tasks and successive trials for glide down tasks increased/decreased the frequencies for the second trial. It is suspected that with the learning effect that occurred with this study, the second trials would have higher/lower frequencies with repeated practice of the same task. Thus the presentation of trials has the potential to enhance the maximum and minimum frequencies for the participants.

It is also possible based on previous research, to utilize cognitive cues in place of a clinician model (Andrews, Shrivastav, & Yamaguchi, 2000). For the ages examined with the current study, the participants required a clinician model in order to complete the task. However, individuals who are older may not need a clinician model to understand the task and therefore cognitive cues can be used to explain the task and provide the opportunity for the most natural production for the client. The use of cognitive cues in place of a clinician model could be particularly beneficial for situations when the clinician and client are not the same age or gender. Rather than the client attempting to imitate the clinician’s pitch and rate of speech, the client has the potential to maximize their own capabilities and produce their most natural voice productions.

Various tasks can be used to elicit vocal productions including providing verbal cues, visual cues, kinesthetic cues, and/or cognitive cues. It would be of interest to examine other types of cueing in addition to cognitive cues. Specifically, it is of interest to compare cognitive cues to visual cues to determine the most effective way for administering a voice assessment for children.

Aspects of this study support previous research conducted with voice productions and cognitive cues. The results of this study confirm that cognitive cues do have an effect on altering children’s voice productions. Clinical implications for these findings include utilizing cognitive cues for tasks used during a voice assessment to enhance productions when obtaining the maximum frequency. Cognitive cues also have the potential to reduce rate of speech and decrease vocal hyperfunction for children who speak in too rapid of a manner. The use of
cognitive cues as an assessment and therapy technique has the potential to enhance multiple disciplines and therefore should continue to be studied.
References


