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A Comparison Between Habitual Pitch and Optimum Pitch in Preschool-Aged Children

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ABSTRACT

The purpose of this study is to determine if the habitual pitch (HP) produced by normally developing preschool-aged children was different across structured speech tasks and free play and to determine if the HP across the same tasks differed from optimum pitch (OP) produced by these children. HP measurements were performed on ten normally developing preschool-aged children (2.6 to 6 years), without a history of speech, language, or hearing impairments, during both structured speech tasks and free play. In addition, pitch glide tasks were used to determine each participant's modal F_0 range from which OP was derived using a modified 25% Method recommended by Britto & Doyle (1990). The main finding of this study was a significant difference in HP during free play and OP for preschool-aged children. No other comparisons were found to be significantly different; although a considerable difference was noted between HP in conversation/story retell tasks and free play. Findings suggest that vocal usage of preschool-aged children during free play may be inefficient and putting these children at risk to develop voice disorders. Furthermore, findings recommend that acoustic data for the evaluation of young children's voices should be collected from both structured speech tasks and free play. Collecting HP and OP data on preschool-aged children evaluated for voice disorders will enable Speech-Language Pathologists to better understand how they are using their voices. If treatment is warranted for the targeted voice disorders, education of self-awareness and self-monitoring of vocal usage can be provided to the particular group of children, as well as their families and care givers.

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CHAPTER ONE

INTRODUCTION

The dynamics of children's voice can be observed through many activities, both structured and play. As noted in previous studies, much of the research provided has been through acoustic analyses of the voice during structured activities (Colton, Casper & Leonard, 2006; Zemlin, 1998; Robb & Smith, 2002; Britto & Doyle, 1990). Although this research is important, little information has been provided on the acoustic characteristics and vocal behaviors of preschool-aged children during free play, in which the children spend much of their time. Because preschool-aged children are still developing vocal characteristics and behaviors, they continue to establish a habitual pitch (HP) at which they speak on a regular basis. Examining the use of HP across both structured and free play activities can provide better understanding on the vocal usage and efficiency for preschool-aged children.

Fundamental Frequency

Vocal pitch is the psychological/perceptual parameter commonly used when evaluating voice (Colton et al., 2006; Britto & Doyle, 1990). It can be measured both perceptually and physically. The physical parameter of vocal pitch is fundamental frequency (F_0), which is defined, as the frequency of vibration of the vocal folds (Colton et al., 2006; Zemlin, 1998; Robb & Smith, 2002). It has been found that F_0 is regulated by a variety of factors such as the length, mass, and tension on the vocal folds as well as the vertical position of the larynx in the body (Montague et al., 2000; Hollien & Hicks, 1979). Respiration control can also be critical to the determination and adjustment of F_0. For instance, the amount of subglottal pressure exerted can affect both the F_0 and vocal intensity (Titze, 1989). Evidence for F_0 determinants can be found in studies which examined F_0 values for men, women and children and demonstrated F_0 values to be different among the three groups due to anatomical and physiological differences existing in age and gender (Fucci & Lass, 1999; Colton et al., 2006; Zemlin, 1998). Hollien, Dew and Philips (1971) found the average speaking F_0 for men is between 100 and 150 Hz, while the average for women is between 180 and 250 Hz. Women usually have higher F_0s because they have shorter and less massive vocal folds when compared to men. Similarly, children's vocal folds exhibit both less mass and shorter length, which result in higher F_0 values when compared to adults (Fucci & Lass, 1999; Peterson & Barney, 1952; Lieberman, 1975; Fairbanks, Wiley & Lassman, 1949; Keating & Buhr, 1978). This premise is supported by various earlier studies which demonstrated mean F_0 values for children ranging from 250 to 500 Hz (Peterson & Barney, 1952; Lieberman, 1975; Fairbanks, Wiley and Lassman, 1949; Keating and Buhr, 1978).

The assessment of F_0 and/or vocal pitch are essential parts to a voice evaluation (Aronson, 1990; Boone & McFarlane, 1988; Colton & Casper, 1990; Prater & Swift, 1984). Obtaining an accurate measurement of F_0 can provide a baseline in determining whether a person has been misusing or abusing his/her voice. One of the indications for vocal misuse/abuse is to constantly phonate at an inappropriate pitch level (Colton et al., 2006; Lee, Stemple, Glaze, & Kelchner, 2004; Duff, Proctor & Yairi, 2004).

Historically, F_0 has been evaluated through a variety of phonatory tasks that can also assess many parameters of the voice. The most commonly used phonatory speech tasks in measuring F_0 include sustained vowel phonation, oral reading and conversational speech (Colton & Casper, 2006; Fucci & Lass, 1999; Britto & Doyle, 1990).

Habitual Pitch

HP is generally referred to the average pitch used in a continuous speech sample (Case 1996; Zemlin, 1998), which is considered to be primarily controlled by the function and placement of the anatomical structures of the larynx (Robb & Smith, 2002). Other factors such as the use of voice during social and cultural interactions also influence the determination of HP (Freeman & Fawcus, 2000). For example, family interactions and social experiences can influence and determine the use of voice and the HP level. Montague et al. (2000) referred to HP as the pitch best suited for the length, mass, and tension factors in an individual's larynx. Montague's concept for HP seems to be confused with the term 'optimum pitch' (OP) (Fairbanks, 1960; Pronovost, 1942). Although it is ideal that an individual's HP be produced at a level in which the anatomical features work most efficiently, this is not always the case (Pronovost, 1942).

Optimum Pitch

Optimum pitch is defined as the particularly suitable pitch for each individual, which is the most efficient level at which voice is produced (Fairbanks, 1960; Pronovost, 1942). When an individual does not use his/her OP regularly or exhibits an inappropriate use of pitch, he/she can become susceptible to vocal pathology (Colton et al., 2006). If /when vocal pathology is found to be associated with vocal misuse/abuse, voice therapy should focus on helping the clients adjust the HP to more closely approximate the OP (Britto & Doyle, 1990; Pronovost, 1942).

It has been indicated that the vocal quality appears to be the best when phonation occurs at OP (Colton et al., 2006). OP has been measured both physically and perceptually in clinical practice and previous research. An example of perceptual evaluation for OP includes instructing the individual to say "um-hum" with a natural raising inflection. The pitch level at which "um-hum" is produced is considered to be the OP. Similarly, a subjective OP level can be obtained when an individual produces sustained phonation of the vowel sound of /ɑ/. In various voice clinics, clinicians make their evaluation based on the pitch at which the best vocal quality was exhibited (Colton, et al., 2006).

Relationship between HP and OP

Previously, a variety of techniques have been used in determining physical measurements for OP. Among the many techniques, Murphy (1964) considered the 25% Method, which was first introduced by Pronovost in 1942, to be the "most accurate." This method is considered to be more objective and less variant than other techniques that are based solely on auditory perception. The 25% Method defines OP as the pitch that is 25% from the basal frequency of the speaker's F_0 range (including falsetto) (Fairbanks, 1959; Colton et al., 2006; Pronovost, 1942; Britto & Doyle, 1990). The derivation of OP may be compared to the HP to determine if the two pitches are comparable. Pronovost (1942) assumed that the HP was equivalent to the participants' OP in individuals classified as "superior" speakers. Accordingly, he hypothesized that the 25% Method would derive an OP that should be comparable to the HP. In the study, HP was examined using an oral reading task, in which the speakers were instructed to pretend they were reading to a group of twenty-five people (Pronovost, 1942). The HP value for each person was obtained by computing the mean F_0 for the reading task. Comparisons were made between the HP and OP, which was derived using a variety of OP derivation techniques including the 25% Method, 33% Method, 38% Method, Musical Third Method, 3.5 Tones Method, 5.0 Tones Method, 8.5 Tones Method, and 15.5 Methods. The findings from the comparisons of the HPs and a variety of derived OPs indicated that the OP values acquired through the 25% Method most closely approximated the HP across subjects. In subsequence, the 25% Method was recognized as the method of choice due to the simplicity of the calculation of OP (Pronovost, 1942).

Britto and Doyle (1990) conducted a study, with slight modifications to Pronovost's protocol, to re-exam the application of OP using the 25% Method. The study compared the HP results to the OP values which were derived using the 25% Method in a normal population. While reassessing the 25% Method, Britto and Doyle's main research questions were: 1) Is the OP as derived using the 25% Method consistent with HP in individuals with normal larynx structure and function? 2) Are the consistent patterns between the OP and HP values exhibited in both male and female speakers? 3) Are the OP and HP values affected by different vocal tasks (i.e., spontaneous monologue vs. oral reading vs. sustained phonation)? Twenty adult men (average age = 24.6) and 20 adult women (average age =23.6) participated in Britto and Doyle's study. Subjects were asked to participate in five tasks; (a) oral reading of "The Rainbow Passage"; (b) a 1-minute spontaneous monologue; (c) three productions of a sustained /ɑ/ at the same F_0 following a monotone starter of "one, two, three"; (d) five sustained phonations of /ɑ/ at his/her lowest (basal) F_0 level excluding vocal fry; and (e) five sustained phonations of /ɑ/ at his/her highest F_0 level including falsetto. Habitual pitch was obtained by measuring F_0 across the first three tasks (a-c). Optimum pitch was derived using the 25% Method based on F_0 measurements across the last two phonation tasks (d-e).

Results from the Britto and Doyle (1990) study indicated that the mean F_0 for men was 115.9 Hz during spontaneous monologue, 114.6 Hz during oral reading and 124.4 Hz during sustained phonation. The mean F_0 values for women were 199.0 Hz during spontaneous monologue, 198.6 during oral reading and 218.4 during sustained phonation. The study also indicated that the F_0 values for both men and women during spontaneous monologue and oral reading were within the normal HP range for young adult speakers reported by previous studies (Fitch & Holbrook, 1970; Hollien & Jackson, 1973; Hollien & Shipp, 1972; Stoicheff, 1981; Ramig & Ringel, 1983). Further analyses indicated that, among the three speech tasks, HP measures of spontaneous monologue and oral reading were more comparable to each other than to the HP derived from sustained phonation. This finding concludes that either oral reading or spontaneous monologue can be used as an appropriate speech task for measuring HP (Britto & Doyle, 1990).

To measure OP for the participants, the values of the F_0 range (i.e., the range of frequencies an individual can produce (Baken & Orlikoff, 2000; Colton & Hollien, 1972) were first obtained through acoustic analysis (Britto & Doyle, 1990). The F_0 range was used for derivation of the OP using the 25% Method. The mean derived OP value was 151.9 Hz for men and 250.6 Hz for women. Britto and Doyle's results indicated differences between the derived OP and HP results obtained from the spontaneous monologue, oral reading and sustained phonation tasks. The OP values ranged between

27.5 and 37.3 Hz higher for men, and ranged between 32.5 and 52.3 Hz higher for women, as compared to the HP values obtained from the three tasks for men and women. Although Britto and Doyle support the idea of OP, their analysis demonstrated that the derived OP was located approximately 8-10% above the bottom of the F_0 range, rather than the 25% point level from the basal F_0 in the range. In addition to Britto and Doyle's empirical findings, their clinical observations also confirmed that many normal speakers generally do not speak in a HP that is 25% from the lowest frequency in their pitch range (Britto & Doyle, 1990).

According to Britto and Doyle (1990), a variety of factors could have contributed to the disparity of the findings between their findings and those of Pronovost (1942). For instance, Pronovost did not choose subjects with normal larynges. Six participants were selected from a group of twenty-five men as having "superior" voices. All of these participants were considered to be adequate subjects without screening physical and voice conditions to confirm normal functioning larynges. In specific, age and smoking history were not specified criteria when selecting the participants, both of which can cause changes to the larynges. On the other hand, the participants in Britto and Doyle's study were selected based on a set of specified criteria including: 1) between 20 and 30 years of age, 2) lifelong nonsmoker, 3) normal laryngeal mechanism verified though laryngoscopy performed by a board-certified otolaryngologist, 4) no history of laryngeal pathology, 5) no formal vocal training, 6) no history of speech/ language/ reading difficulties, and 7) native English speaker. The lack of the subject selection criteria by Pronovost likely resulted in inconsistency among the participants' larynges between the two studies, and could have consequently resulted in disparities regarding the comparisons of HP and OP in the two studies.

Differences in data collection procedures could have also affected the results. For example, participants in Pronovost's (1942) study were instructed to read the passage for the oral reading task as if they were reading to a group of twenty-five people, while Britto and Doyle's (1990) participants were instructed to read at their normal conversation level. As a result, it is probable that Pronovost's participants spoke at an increased vocal intensity, one much greater than the vocal intensity used during normal conversation. Increases in vocal intensity are not only caused by the compression of the vocal folds in combination with increased respiratory support, but are also related to the increase of F_0 (Coleman, Mabis & Hinson, 1977). Titze (1992) suggested that at certain pitch levels it is difficult to keep F_0 from rising when subglottal pressure is increased to raise intensity. As such, the greater vocal intensity produced by Pronovost's participants might have resulted in increased HP values; while Britto and Doyle's participants' lower intensity levels might have controlled intensity and produced a pitch level more reflective of their HP (Britto & Doyle, 1990). Therefore, the HP values indicated by Pronovost appeared to be higher when compared to Britto and Doyle's (Britto& Doyle, 1990).

Britto and Doyle's (1990) study provided new insights and recommendations for the future derivation of OP based on their findings that indicated disparities in using the 25% Method for quantifying the OP. Britto and Doyle's results revealed that the HP fell between approximately 8-10% from the basal F_0, lower than 25% as suggested by Pronovost (1942). Assuming HP is comparable to OP, Britto and Doyle suggest that OP should probably be derived from the range between the highest and lowest frequencies, which should both be in the range of the modal register. Revising the methods of OP derivation to find the most accurate method to determine OP is essential. Britto and Doyle (1990) continue to believe that each individual has a most efficient F_0 (OP) and emphasize the importance of identifying a proper method for derivation of OP. They further comment that discovering a technique to accurately derive OP will assist in proper evaluation during a voice evaluation. In specific, comparison of the HP to the OP can provide pertinent information to determine if an individual is voicing at the most suitable F_0.

Development of HP

As indicated in previous research (Britto & Doyle, 1990; Pronovost, 1942; Colton et al., 2006; Pronovost, 1942), the HP an individual uses in their speech productions is not always equivalent to the anticipated OP. Freeman and Fawcus (2000) reported that during childhood children experiment with speech and language skills while discovering their voicing characteristics. Children develop voicing skills through experience as well as self-analysis and feedback from others during the use of speech and language in daily routines throughout both structured tasks and free play (Freeman & Fawcus, 2000). Because basic voicing skills are acquired through an active learning process throughout the preverbal years, it is possible children may use an HP that is not comparable to the OP (Andrews, 1986).

Structured speech tasks tend to use a more controlled vocal quality, while free play often exhibits a dynamic display of tones and imitations, which may exhibit pitches well out of their optimum level and which are hard for children to self-monitor (Freeman & Fawcus, 2000). It is important that speech-language pathologists (SLPs) pay attention to the possible variations in habitual frequency ranges during both structured speech tasks and free play. Whereas previous studies have reported acoustic characteristics of children in structured speech tasks (e.g., narrative speech samples, counting), much of children's time is spent engaging in free play (Frost, Wortham, & Reifel, 2001). The acoustic characteristics and vocal behaviors children display in structured speech and free play may differ in many ways. For instance, it is easier to monitor the pitch at which speech is produced in a more structured task. Under normal circumstances, throughout structured speech tasks, children speak at a reasonably consistent HP range. During free play, children manipulate their voices displaying a wide variety of F_0s which are intended to produce imitative vocalizations to portray a certain character or experience, or to express excitement or other emotions (Frost et al., 2001). Ferrand and Bloom (1996) reported that the average F_0 range for children between 3 and 10 years old during structured tasks is between 150 Hz and 350 Hz. Little is known about the average F_0 range during free play. By far, no studies reporting on objective measurements of children's average F_0 during free play can be found.

Anatomy and Physiology Determining HP

A number of anatomical and physiological factors have been found to determine the HP in both adults and children. Sapienza, Ruddy and Baker (2004) described the differences between larynges of the children and adults. An important factor in generation of HP is the size of the larynx. The child larynx is much smaller in size when compared to the adult larynx (Sapienza et al., 2004). In addition, vocal folds differ in length and mass depending on age and development. Apparent sex differences in vocal folds (mass and length) do not develop or become apparent until puberty, usually between 10 and 14 years of age. Prior to puberty, boys and girls tend to have comparable frequency ranges because of the similarity in the size of the vocal folds. The lengths of the vocal folds undergo continual growth from approximately 2.5-3.0 mm long during infancy, to approximately 17-21 mm long in adult males and 11-15 mm long in adult females (Sapienza et al., 2004). As the vocal folds increase in length, the vocal pitch lowers for both men and women. This supports that the fact that development and size of the anatomical structures in children tend to produce higher-pitched voices when compared to adults (Keating & Buhr, 1978).

The layers that compose the vocal folds are naturally much more immature at birth and are not yet fully developed into apparent layers (Sapienza et al., 2004). As the child develops the membranous makeup of the vocal folds increases (Sapienza et al., 2004) and the differentiations of the membranous layers become more apparent. Hirano, Kurita and Nakashima (1983) indicated that the ligamentous component of the vocal fold does not appear until 1 to 4 years of age. In addition, there is a greater percentage of collagen in the vocal folds of children and less “anchoring strength” of the laryngeal structures (Sapienza et al., 2004). The immaturity of the laryngeal structures cause the pediatric vocal folds to be much more flaccid when compared to the adults. The flaccidity of the pediatric vocal folds in combination with the shape and size of the vocal tract, enable the child to produce a wider range of frequencies (Sapienza et al., 2004).

The position of the pediatric larynx is also relatively higher than the adult larynx. Fried (1983) reported that the larynx descends from the level of the first and third cervical vertebrae at infancy to approximately the sixth and seventh cervical vertebrae by adulthood. Furthermore, the shape of the epiglottis changes and the diameter of the glottal and subglottal areas increase with advancing age (Sapienza et al., 2004). The anatomical changes in the vocal tracts following maturation create a narrower vocal tract which enables an individual to produce a sharper, clearer vocal quality (Sapienza et al., 2004).

Fundamental Frequencies in Children

In previous research many studies reported F_0 (including crying utterances) in infants could range from 373 Hz to 585 Hz (Fairbanks, Wiley & Lassman, 1949; Fairbanks, Herbert & Hammond, 1949; Fairbanks, 1942; Sheppard & Lane, 1968). Peterson and Barney (1952), in analyzing production of citation-form English vowels, determined that children before the age of puberty used F_0s between 250 and 275 Hz. Lieberman (1975) stated that the F_0 range of children can reach as high as 500 Hz. Keating and Buhr (1978) provided additional data suggesting that children could use a much broader range of F_0 than described in previous studies after further examination of F_0 ranges in children was performed. The vocalizations of six children (ages 33 -169 weeks) during communication interactions with their mothers in the home environment were measured. The utterances were considered "non-cry vocalizations" and were instances of babbling, and productions of words or small phrases. Fifty utterances were obtained from each child and F_0 was measured over the 300 utterances. The mean F_0 values among the children ranged from 30-700 Hz. Overall, the "normal" range identified in this study was much broader than previously reported.

Effect of Task on the Determination of HP

Once children develop a range of F_0s, an average pitch (i.e., the HP) they use on a regular basis is established. Montague, Skaggs, and Zraick (2000) conducted a study to determine if there was a task effect in measuring HP. The study compared three groups of participants including: adult women (19- 48 years), adult men (20-30 years) and a group comprised of both male and female children (5-10 years). The HP of each participant was obtained through seven structured tasks: 1) counting from 1-10, 2) reading a short passage, 3) production of a spontaneous speech sample, 4) sustaining the vowel /ɑ/ for 8 seconds, 5) production of "um-hum" (with mouth closed), 6) counting the numbers "one, two, three" while sustaining /i/ at the end of the word "three," 7) and production of "uh-huh" (with mouth open). The participants were provided with an auditory model for all seven tasks prior to each speech sample. Within-group analysis revealed no evident effect of task for the male and child groups, while a statistically significant effect of task was found for the female group. As a result, it appears that any of the seven speech tasks can be used to measure HP in children.

Prevalence of Voice Disorders in Preschoolers

Many studies have reported the prevalence of voice disorders in school-aged children (Boone & McFarlane, 1988; Powell, Filter, & Williams, 1989; Sangia & Carlin, 1999; Beitchman, Nair, Clegg & Patel, 1986; Pont, 1965; Baynes, 1966; Silverman & Zimmer, 1975). Prevalence estimates of voice disorders vary widely in this population among different studies. Boone and McFarlane (1988) estimated between 5% and 9% of school aged children have a voice disorder, while Powell et al. (1989) reported a prevalence rate as high as 23.9%. A large scale study was conducted by Duff et al. (2004) examining the prevalence of voice disorders in preschool-aged children. The voice characteristics of 2,445 participants between the ages of 2 and 6 years were examined through observational analyses. To determine if the participants displayed characteristics of voice disorders, teachers, speech-language pathologists (SLPs) and parents all provided information about the children's voices, including: hoarseness, breathiness, nasality, or vocal tension. Based on the SLPs' perceptual judgment, 95 (3.9%) of the preschoolers presented a voice disorder.

Play Behaviors in Preschoolers

Limited research has been performed on preschool children, especially in the area of voice during free play. The existing research performed in the area of pediatric voice was conducted through structured speech tasks and observations. There are no reported objective measurements, such as acoustic analyses of HP, for preschool children during free play. Frost, Wortham and Reifel (2001) examined the role of free play and the effects it has on communication and language development in children. Throughout play, children were found to use many modalities of communication including gestures, imitative of sounds, and speech (Frost et al., 2001). Speech and language become a key component of free play as children carry out various roles and events. According to Frost et al. (2001), the most popular types of play in the preschool population are symbolic play and sociodramatic play. Symbolic play is a reflection of the children's developing thoughts of real life experiences represented during play. Sociodramatic play is the more sophisticated form of social and symbolic play which allows children to represent life-events enhanced by a combination of imitation and imagination. During free play children use a variety of tones of voice and expressions to portray certain characters during symbolic or role playing. Furthermore, the ideas and situations in free play are elaborated and supplemented with the children's excitement and emotion, which are reflected by gestures, expression, and more importantly, vocal intonations (Russ, 2004).

It has been noticed that children often use varying vocal pitches to imitate characters, animals and life experiences during imitative free play (Frost et al., 2001).

The Voice during Play and Potentially Vocal Abusive Behaviors

It is likely that some speech behaviors children exhibit during play are considered potentially abusive and may lead to voice disorders. Colton et al., (2006) stated that not all of the behaviors exhibited by children are abusive, but many vocal sounds "involve strained vocalizations." Vocal abusive behaviors may include speaking at an abnormally high pitch or loudness, screaming, having an abnormal vocal quality, etc. As found by Barker and Wilson (1967), some children habitually exhibit vocally abusive behaviors such as speaking in a loud voice or yelling and screaming in communication interactions or free play. In addition, it is likely that the manipulation of voices that young children use to imitate different sounds could potentially be vocally abusive (Colton et al., 2006).

Purpose and Rationale

The purpose of this study was to examine the HP of preschool children in both structured speech tasks and free play. Although children's voices have been previously evaluated primarily by auditory perception and observation, a more objective measurement, such as an acoustic comparison between HP and OP throughout both structured tasks and free play can help better identify potentially abusive vocal behaviors for preschool-aged children. In addition, this study attempted to determine if there is a significant difference between the HP and OP. Previous research suggests when a difference between HP and OP occurs; an individual is likely not producing his/her voice at the most efficient level (Colton et al., 2006). Obtaining measurements of HP in both structured speech tasks and free play and OP for preschool-aged children helps determine whether the children are producing their voices efficiently. Furthermore, this information can help prevent misuse of the voice by instructing preschool-aged children to adjust their HP to more closely approximate the OP (Britto & Doyle, 1990; Pronovost, 1942).

Research Questions

This study addresses the following research questions.

1. For preschool-aged children, is there a significant difference in habitual pitch during free play compared to structured speech tasks?
2. For preschool-aged children, is the habitual pitch across structured speech tasks and free play comparable to optimum pitch?

Hypotheses

The following hypotheses were tested in this study.

Hypothesis One: There is not a significant difference in habitual pitch among structured speech tasks.

Hypothesis Two: There is a significant difference between the habitual pitch of structured speech tasks and free play.

Hypothesis Three: There is not a significant difference between habitual pitch during structured speech tasks and optimum pitch.

Hypothesis Four: There is a significant difference between habitual pitch during free play and optimum pitch.

CHAPTER TWO

METHODOLOGY

Participant Selection and Recruitment

Ten preschool-aged normally developing participants (2.6 to 6 years) without a history of speech, language, or hearing impairments were recruited for the study. Flyers for recruiting subjects for the study were distributed to parents of preschool-aged children in the Greater Pittsburgh area (Appendix D). The participants and their parents completed an informed consent form as well as a questionnaire/survey. All children and their parent(s) or legal guardian were informed that participation in this study was voluntary, and that they could discontinue their participation at any time (Appendix A). Parents signed the consent form prior to participation.

Questionnaire

A survey, which included questions concerning developmental history and speech and language developmental milestones, was completed by the parents (Appendix B). This survey was intended to verify that the participants were "normally developing" children. Children with reported developmental delays, learning disabilities, social/ emotional disturbances, neurological disorders, speech disorders, language disorders, and/or hearing impairments were excluded from the study.

Confidentiality

The confidentiality of the participants was protected using the following methods: 1) participants were identified by code rather than name on all research materials, and 2) results were stored in a locked file cabinet in the Speech Science Laboratory in the Speech-Language Pathology department. No identifying information, such as address or phone number was recorded on voice recordings or printed data. As per Institutional Review Board (IRB) requirements, data will be destroyed five years after completion of the research project.

Speech Materials

Three picture books were used to elicit a structured speech sample through a story retell task from each participant. Three books were chosen so a different set of stimuli would be presented for each of the three data collection sessions. The picture books were from the Carl the Dog series by Alexandra Day and included, *Good Dog, Carl, Carl Goes to the Park, and Follow Carl.*

The speech sample during the free play was elicited with various toys, during the participants' interaction with other participants in the play group. The toys did not produce any sound effects that limited the vocalizations the participants produced. Examples of toys that used include: baby dolls, trains and cars, farm play sets, and other action figures and manipulatives. These specific toys helped to elicit imitative symbolic play amongst the participants.

Data Collection

All subjects were scheduled for three sessions (one "get-to-know" session followed by two data collection sessions), each lasting approximately forty-five minutes.

The sessions took place at the participants' home. Each participant met with the investigator (a graduate student in speech-language pathology) during the "get-to-know" session (i.e., the first session). This session also enabled the participants to become comfortable interacting with the investigator and wearing the throat microphone. During this session, the investigator encouraged the children's participation in free play with the toys and peers. No data was collected in this session.

A Stryker Tactile Throat microphone (Clearer Communications) with a wireless transmitter was used for data collection. The throat microphone was selected to eliminate interference of background noise during data collection, especially during free play. More importantly, the use of the throat microphone enabled the participants to move freely around the play environment and engage in more natural play interactions with other participants. The microphone transmitter was placed in a small backpack worn by each participant during data collection. The speech signals picked up by the throat microphone were transmitted to a wireless receiver, and were then output to a laptop computer. The speech signals were recorded and digitized at 10,000 Hz using the software program Real Time Pitch (Model 5121, Kay Pentax).

Data collection began during the second session and continued through the third session. For the structured speech tasks, the data collection took place in a quiet, well-lit area. During free play, the participants were free to move around the home environment. During all data collection sessions (2-3), the same procedures and order were followed to ensure reliability in the participants' HP and OP results. The procedures for the data collection sessions were as follows.

Habitual Pitch—Structured Speech Tasks and Free Play

1. Each participant was asked to count "one, two, three" out loud and then sustained the vowel /ɑ/ for approximately six seconds. A model was provided by the investigator.
2. Each participant was asked to count "one, two, three" out loud and then sustained the vowel /i/ at the end of the word three for approximately six seconds. A model was provided by the investigator.
3. The investigator showed a picture book and told a story about the book to each participant. The story was predetermined by the investigator and told verbatim to each child. Prior to telling the story, the investigator instructed the child to listen carefully because he/she would be retelling it. After the investigator told the story, the participant was asked to retell the story while looking at the pictures.
4. Lastly, a two-minute spontaneous speech sample was collected. The participant was given a specific topic such as, "Can you tell me about your favorite movie?"

After the structured speech tasks were completed, each participant was instructed to engage in free play with the other participants in the group. A five minute speech sample was collected as the child engaged in the free play. The investigator was located in the free play scene, but the free play was directed by the child and his/her peers. (Appendix C).

Optimum Pitch

The pitch range task, from which OP was derived, followed the protocol from the *Quick Screen for Voice* (Lee et al., 2004). Two tasks were selected to determine the children's F_0 range (i.e., lowest F_0 limit to the highest F_0 limit or vice versa). The following verbal instructions were provided by the principal investigator and the participants performed each task two times. In addition, the investigator provided a visual model (i.e., hand gesture that corresponded with the direction of the pitch glide task).

1. "Make your voice go from low to high like this (demonstrate upward glide pitch on the word 'whoop')."
2. "Now go down from your highest to low (demonstrate rapid downward pitch glide like a bomb falling)."

Data Analysis

All speech samples collected from were analyzed on the same Pentium IV computer that was used for data collection, using the software program Real Time Pitch (Model 5121, Kay Pentax).

Habitual Pitch—Structured Speech Tasks and Free Play

From both sustained phonation tasks, only the sustained vowel segments were used to obtain a mean F_0 value. Using the "Edit" function in Real Time Pitch, the sustained vowel segments were selected and the counting segment was excised. The HP values were obtained using the mean F_0 values which were automatically identified using Real Time Pitch over the selected segment. A five-second, continuous speech sample was selected from the recording of both the conversation and story retell speech samples.

Using the “Edit” function in Real Time Pitch, the five-second, continuous speech sample (i.e., with minimal to no pauses in speech) was selected from the middle of the structured speech task and the additional segments of the sample were discarded. The HP values were obtained using the mean F_0 values which were automatically identified using Real Time Pitch over the selected segment.

The data analysis of the free play was performed in the same manner as the conversation and story retell samples. A five-second, continuous speech sample was selected from the free play activity speech sample. Using the “Edit” function in Real Time Pitch, the five-second, continuous speech sample (with minimal to no pauses in speech) was selected from the middle of the free play task and the additional segments of the sample were excised. The HP values were obtained using the mean F_0 values which were automatically identified using Real Time Pitch over the selected segment.

Optimum Pitch

The lowest F_0 and highest F_0 were identified across all four attempts of pitch range tasks and were used to represent the most accurate pitch range. As mentioned earlier, recommendations from Britto and Doyle (1990) suggested excluding the falsetto register and only using the modal register when determining a pitch range for the derivation of OP. Accordingly, a “modified 25% Method” was applied to determine the OP in the present study. In specific, speech samples used to determine OP were restricted to those produced in the modal register. The OP was calculated to be 25% above the basal frequency of the modal register. A professional voice coach listened to each recorded pitch-gliding sample and identified segments that were produced outside the modal register (i.e., falsetto). Using the “Edit” function in Real Time Pitch, speech produced in non-modal registers were excised and not included in any analyses. Real Time Pitch then was used to extract the pitch range from each sample.

CHAPTER THREE

RESULTS

Reliability of Measurement

Intra-judge reliability

The speech samples of two participants were randomly selected from the original ten participants' speech samples. The samples were re-analyzed by the investigator to assess intra-judge reliability. The average absolute error, between the initial and the reliability measurements, across all tasks (structured speech tasks, free play, and pitch range tasks) was 2.43 Hz. The Pearson Product Moment Correlation coefficient between the first and second measurement across all tasks was (structured speech tasks, free play, and pitch range tasks) 0.997.

Inter-judge reliability

The speech samples of two participants were randomly selected from the original ten participants' speech samples. The samples were re-analyzed by a second individual who was trained in using the acoustic analysis package to assess inter-judge reliability. The average absolute error, between the two individuals' measurements, across all tasks (structured speech tasks, free play, and pitch range tasks) was 1.91 Hz. The Pearson Product Moment Correlation coefficient between the first and second measurement across all tasks was (structured speech tasks, free play, and pitch range tasks) 0.997.

Habitual Pitch—Structured Speech Tasks and Free Play

The mean, standard deviation and range values for HP during the sustained phonation task are reported in Table 1. For the ten participants in this study the mean F_0 for /ɑ/ was 334 Hz with a standard deviation of 73 Hz. The F_0 ranged from 225 Hz to 511 Hz.

The mean, standard deviation and range values for HP during the sustained phonation task are reported in Table 1. For the ten participants in this study the mean F_0 of /i/ was 358 Hz with a standard deviation of 51 Hz. The F_0 ranged from 285 Hz to 438 Hz.

The mean, standard deviation and range values for the HP during the conversation task are reported in Table 1. For the ten participants in this study the mean F_0 was 323 Hz with a standard deviation of 44 Hz. The F_0 ranged from 263 Hz to 421 Hz.

The mean, standard deviation and range values for the HP during the story retell task are reported in Table 1. For the ten participants in this study the mean F_0 was 321 Hz with a standard deviation was 27 Hz. The F_0 ranged from 279 Hz to 378 Hz.

The mean, standard deviation and range values for the habitual pitch of the ten participants during free play are reported in Table 1. For the ten participants in this study the mean F_0 was 383 Hz with a standard deviation of 60 Hz. The F_0 ranged 308 Hz to 517 Hz.

Optimum Pitch

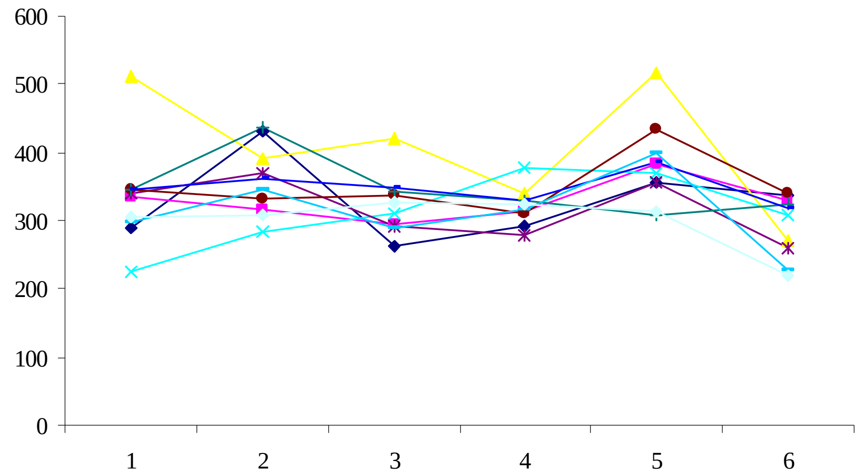
When performing the pitch range tasks, it was observed that some participants demonstrated difficulty in performing the pitch range tasks after being presented with both an auditory and visual model. In specific, the participants demonstrated increased difficultly when transitioning their vocal pitch from the lowest level to the highest level or vice versus. The lowest F_0 and highest F_0 were selected across all four attempts at the pitch range tasks (i.e., lowest to highest level on word 'whoop' and highest to lowest F_0 level while simulating a bomb falling in data collection sessions 2 and 3) were used to represent the most accurate pitch range. Furthermore, the trained voice coach perceptually identified three participants with producing falsetto. The segments noted to be within the falsetto register were excised using Real Time Pitch.

The OP was derived from each participant's pitch range using the modified 25% Method (Britto & Doyle, 1990). The mean, standard deviation and range values for the OP are reported in Table 1. For the ten participants in this study the mean F_0 was 294 Hz with a standard deviation was 45 Hz. The F_0 ranged from 220 Hz to 341 Hz.

Table 1. Habitual Pitch and Optimum Pitch: Mean, standard deviation, and ranges in Hertz (N=10)

Habitual Pitch	**Mean**	**Standard Deviation**	**Range**
Sustained Phonation /ɑ/	334	73	225 - 511
Sustained Phonation /i/	358	51	285 - 438
Conversation	323	44	263 - 421
Story Retell	321	27	279 - 378
Free Play	383	60	308 - 517
Optimum Pitch	**Mean**	**Standard Deviation**	**Range**
Derived OP	294	45	220 - 341

Figure 1. Mean HP (all structured speech tasks and free play) and OP values (in Hertz) for the Ten Preschool-Aged Participants. (Plot 1: sustained phonation /ɑ/, plot 2: sustained phonation /i/, plot 3: conversation, plot 4: story retell, plot 5: free play, plot 6: derived OP).



Statistical Comparisons across Measures of Habitual Pitch and Optimum Pitch

To evaluate whether significant differences exist in the mean values across values for HP elicited across different activities and OP, a one way ANOVA was performed (SPSS vs. 14, 2006). An *a priori* alpha was set at 0.05 in this study. The ANOVA detected a significant difference among the structured speech tasks, free play and derived OP values [F (59, 5) = 3.577, $p = 0.007$]. Post hoc analysis using pair-wise Bonferroni t-tests indicated no significant difference regarding HP among the four structured speech tasks (i.e., sustained phonation of /ɑ/, sustained phonation of /i/, conversation and story retell). No significant difference regarding HP was found between any of the four structured speech tasks and the free play. In addition, post hoc testing did not reveal a significant difference between the HP from any of the four structured speech tasks and the derived OP. Lastly, post hoc testing indicated that the HP value acquired during free play was significantly higher than the derived OP.

* Raw data for each of the ten participants are located in Appendices E & F.

CHAPTER FOUR

DISCUSSION

The main purposes of this study were to determine if the habitual pitch (HP) produced by normally developing preschool-aged children was different across structured speech tasks and free play and to determine if the HP across the same tasks produced by these children differed from their optimum pitch (OP). The main finding of this study was a significant difference between HP during free play and OP for preschool-aged children. No other comparisons were found to be significantly different.

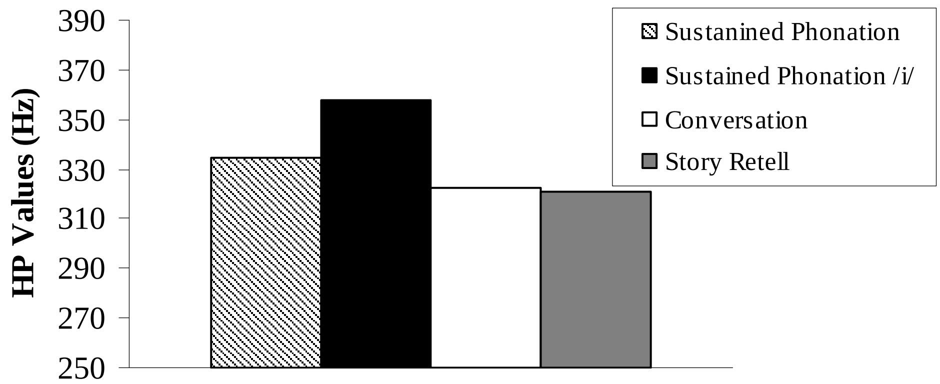
Hypothesis One: There is not a significant difference in the HP values among the various structured speech tasks.

Results from this study supported the first hypothesis. Analyses revealed no statistically significant differences in the HP during any of the four structured language tasks (two sustained phonations tasks, conversation and story retell task) (Figure 2). The mean HP results for structured tasks ranged between 321 Hz and 358 Hz. The HP values found in this investigation are consistent with previous data on normal children which found HPs between 250 Hz and 585 Hz during highly structured tasks (Lieberman, 1975; Fairbanks, Wiley & Lassman, 1949; Fairbanks, Herbert & Hammond, 1949; Fairbanks, 1942; Sheppard & Lane, 1968; Peterson & Barney; 1952).

Although no test for a statistically significant difference took place, an interesting observation was that the mean HP produced during sustained phonation of /i/ was found to be 24 Hz higher than the mean HP of the sustained phonation of /ɑ/. This is consistent with the "intrinsic pitch" effect, which is usually associated with the production of high vowel sounds such as the /i/ (Ewan, 1975). A possible explanation for intrinsic pitch relates to the extra laryngeal tension which results from the elevation of the larynx during the production of the /i/ sound, while the laryngeal position during /ɑ/ production is considered to be more "intermediate" and posterior (Ewan, 1975). An alternative explanation for intrinsic pitch is associated with pharyngeal constriction and anterior movement of the tongue (Ewan, 1975). In specific, greater pharyngeal constriction and tongue retraction tend to lower the intrinsic pitch, as noted in the production of /ɑ/ (Ewan, 1975).

The mean HP from both sustained phonation tasks was between 12 and 36 Hz higher than the mean HP during the conversation and story retell tasks. Similar to Britto and Doyle's (1990) results, HP during conversation and story retell tasks in the current study were more comparable to one another than when they were compared to HP during the sustained phonation tasks. This evidence is in agreement with the previous claim made by Britto & Doyle (1990) that conversation or oral reading/story retell tasks seem to provide a more suitable approach to measuring HP than sustained phonation.

Figure 2. Comparison of mean HP values (in Hertz) for the four structured speech tasks.

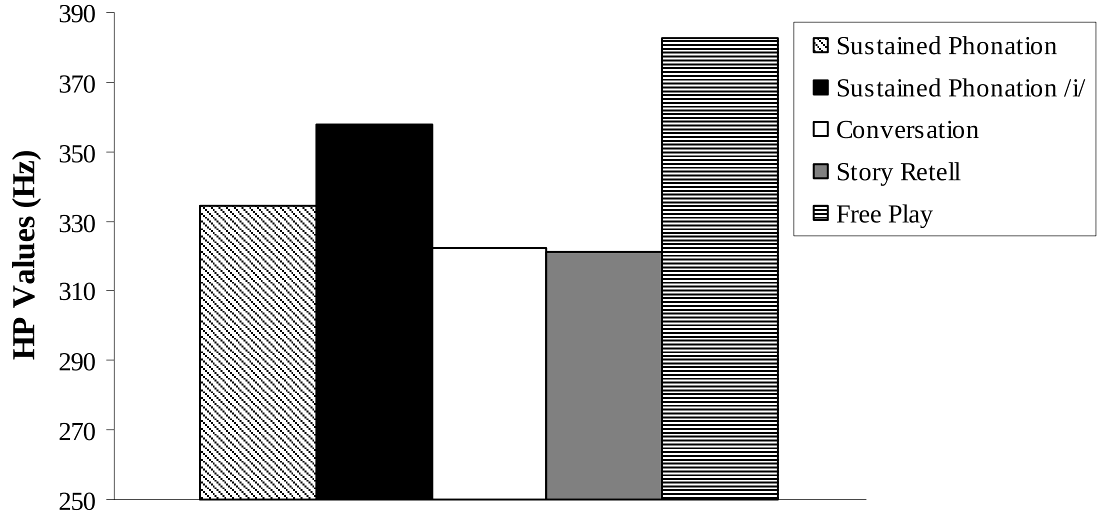


Hypothesis Two: There is a significant difference between the HP of structured speech tasks and free play.

Results from this study did not support the second hypothesis. Analyses revealed no statistically significant difference between the HP measurements during structured speech tasks and free play. The mean HP measured during structured speech tasks (i.e., sustained phonation, conversation, and story retell) was 49 Hz. higher than the HP value of free play (Figure 3). The specific differences in HP values between the structured speech tasks and free play ranged between 25 and 62 Hz. The minimum difference of 25 Hz existed between the HP measured during sustained phonation of /i/ and the HP during free play. The maximum difference of 62 Hz existed between the HP measured during the story retell and the HP measured during free play. Even though the differences in the HP values between any of the structured tasks and free play were not found to be statistically significant, the 62 Hz difference between conversation/story retell and free play may be meaningful.

The reason this difference occurred may be attributed to distinctive vocal behaviors that were noted during free play. Specific vocal behaviors the preschool-aged children exhibited included, imitative vocalizations and sound effects produced by varying F_0 ranges and increased intensity. In opposition to the structured speech tasks, the participants were free to move around the play environment during the free play. They were not provided with any direct verbal instructions to influence the course of the free play. The free play was directed and chosen by the participants as they engaged with their peers. Consistent with Frost et al. (2001) the participants exhibited forms of symbolic and sociodramatic play that included real life experiences represented through play activities, as well as imaginative play activities. Similar to other preschool-aged children, the participants demonstrated increased excitement and emotion as they portrayed different characters during role free play (Russ, 2004). Specific vocal behaviors the participants exhibited during the free play include increased volume, imitative vocalizations and sound effects, arguing with playmates. These vocal behaviors were reflected by a high range of F_0 values (308-517 Hz) (Table 1). Findings indicated that preschool-aged children may have the tendency to use a higher range of F_0s when engaging in free play. Furthermore, dynamic vocal characteristics such as vocal imitations, sound effects and various expressions of emotion were present in the free play. In addition, the non-significant difference in HP found between the structured speech tasks and free play was probably attributed to the small sample size of participants in the current study.

Figure 3. Comparison of mean HP values (in Hertz) in structured speech tasks and free play.

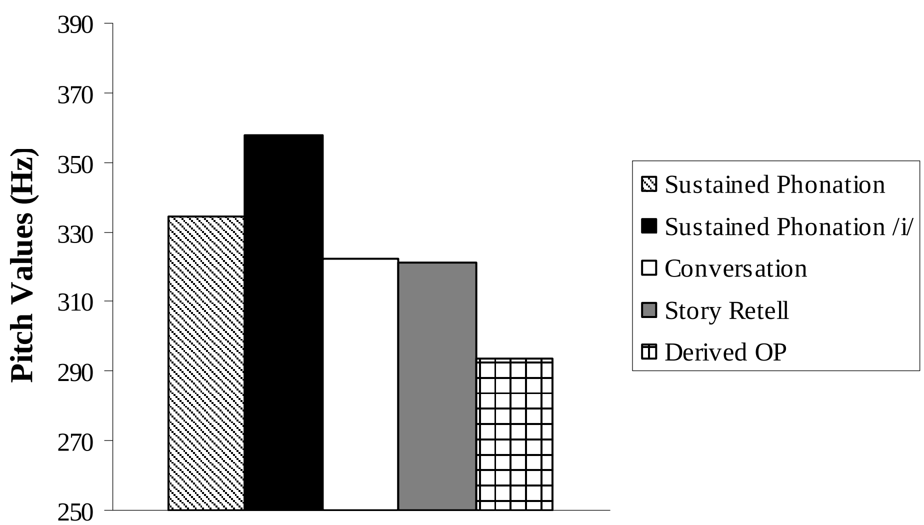


Hypothesis Three: There is not a significant difference between the HP during structured speech tasks and OP.

Results from this study confirmed the third hypothesis. Analyses revealed no significant difference between the mean HP measured during any of the structured speech tasks and derived OP. Although the results were not statistically significant, a slight difference of 28 Hz occurred between the HP measurement during conversation/story retell and derived OP (Figure 4). Previously, individuals have interchangeably used the terms HP and OP (Montague et al., 2000). A possible explanation for the interchangeable use of these terms could be, similar to this study, the HP and OP measurements are comparable under certain conditions.

The mean derived OP was calculated at the 25% level from the basal frequency of the modal phonation range (Britto & Doyle, 1990). The OP was found to be 294 Hz. The mean HP measured during conversation/story retell was 322 Hz, which measured to be 31% from the basal frequency of the phonation range. This evidence suggests that the HP from the conversation/story retell was not consistent with the 25% level from the basal frequency of the pitch range. The 25% Method has been the most widely used derivation method for OP due to the simplicity, as well as the convenience (Pronovost, 1942; Britto & Doyle, 1990; Colton et al., 2006). By no means does this study endorse the use of the 31% from the basal frequency to derive OP rather than the 25% Method. Rather, the findings in the present study suggest that discrepancies continue to exist between HP and derived OP. It remains to be answered whether HP (from conversation or story-retell) can be considered to be equivalent to OP. Alternatively, recognizing various methods as valid and reliable sources for deriving OP, it is suggested here that an "optimum pitch range" should be considered rather than a specific OP level. As such, possibly developing a protocol that generates an OP range may be more functional, realistic, and more widely accepted than determining an absolute OP value.

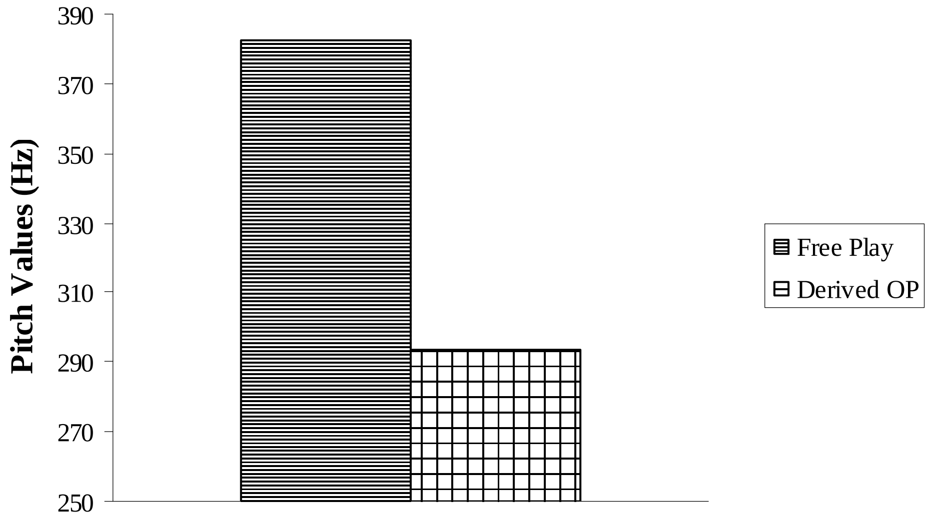
Figure 4. Comparison of mean pitch values (in Hertz) for the structured tasks and derived OP.



Hypothesis Four: There is a significant difference between the HP during free play and the derived OP.

Results from this study confirmed the fourth hypothesis. Analyses revealed a significant difference was present when comparing the HP during free play and OP. Evidence from the acoustic analysis noted the HP during free play was 89 Hz higher than the derived OP (Figure 5). The HP during free play was 383 Hz, while the OP was found to be 294 Hz. This information provides an important insight as to how preschool-aged children use their voice during free play and how they should be educated to use their voice in a healthy manner. It is known that some children develop voice disorders which may be caused by the use of potentially abusive vocal behaviors (Colton et al., 2006). Using an inappropriate pitch, especially one that is too high as exhibited in play behaviors, is vocally abusive. This study demonstrates that in structured environments children use an HP that is comparable to OP and appear not abuse their voices; while engaging in free play, the children's HP may be significantly higher than their OP. This is a potential source of vocal abuse. The findings from this study provide empirical data confirming what every parent, teacher and SLP have already noticed that when preschool-aged children engage in uninhibited free play, they shout, scream and manipulate their voices in many ways.

Figure 5. Comparison of mean pitch values (in Hertz) during free play and derived OP.



Clinical Relevance of Findings

It must be understood that this study was not intended to discourage children from participating in free play or exploring different vocal characteristics and behaviors, but rather to investigate the acoustic characteristics and vocal behaviors exhibited during free play. Much of preschool-aged children's time is spent engaging in free play, in which they often exhibit limited control over their vocal pitch and other vocal behaviors (Russ, 2004). A more objective measurement of HP during free play is needed to supplement the vocal behaviors that are noted during these types of uninhibited activities. Due to the extreme differences in the vocal and behavioral characteristics associated with structured speech tasks and free play, it is equally important to compare the HP measurements obtained from the two environments to the derived OP. These findings provide information as to how efficiently preschool-aged children are using their voices and if potentially vocal abusive behaviors that may lead to voice disorders exist.

The present study adds empirical information regarding both HP and OP in preschool-aged children to the previously existing knowledge base. A significant difference was noted between the HP of free play and the derived OP, although it is inconclusive at this time whether the modified 25% Method should be considered as a standard protocol in deriving OP. Additionally, the present study indicated a considerable difference in the HPs between structured tasks and free play. This may suggest vocal characteristics and behaviors exhibited during free play are potentially inefficient in terms of vocal usage, which is not usually manifested during structures speech tasks. It has been found that younger children are susceptible to encounter difficulties in controlling their vocal tension and subglottal pressure, both of which are key determinants for F_0 (Colton et al., 2006). In addition, children tend to exhibit more difficulty in using an appropriate pitch in a variety of activities including, basic language tasks, expressing emotions and moods, as well as a various types of free play (Colton et al., 2006). These behaviors, if become habitual, can be detrimental to the vocal mechanism (Colton et al., 2006). Findings from this investigation suggest that acoustic data for the evaluation of young children's voices should be collected from both structured speech tasks and free play.

It should be noted that the use and recognition of appropriate vocal pitch is dependant upon the amount of knowledge of proper vocal use, as well as level of self-awareness and self-monitoring skills the children possess (Colton et al., 2006). Children may exhibit more difficulty in producing appropriate vocal pitch in activities that are more play-based (i.e., less structured). Many children (and even their parents and care givers) have limited knowledge with respect to proper vocal usage. This is usually characterized by behaviors that suggest children are often unaware that the strained vocalizations and high intensity levels produced in free play are, in fact, considered to be inappropriate. This is evidenced by the findings of Barker and Wilson (1967) who noted that children, especially with a noted hoarse voice, tended to be more behaviorally and vocally active in more unstructured tasks. Collecting HP and OP data on children evaluated for voice disorders will enable SLPs to better understand how preschool-aged children are using their voices. If treatment is warranted for the targeted voice disorders, education of self-awareness and self-monitoring of vocal usage can be provided to the particular group of children, as well as their families and care givers.

Technical Note

An innovative aspect of this study was the use of a throat microphone and wireless transmitter to record data. Only minor modifications to the microphone neck band (i.e., adding foam for comfort and securing the fit because the microphone was designed for adults) were required. Using this technology enabled participants to engage in more natural free play as compared to a situation where a hard-wired microphone system had been used. While this technology needs additional testing, it may allow for better data collection in future studies when only F_0 data are needed.

Limitations and Suggestions for Further Research

Several limitations in the present study may have resulted in the current findings. As mentioned earlier, the small sample size participants might have contributed to the non-statistically significant findings between the HP measured during structured speech tasks and free play. As such, future investigation with a larger population is warranted. It needs to be mentioned that the environment in which the data was collected might have also contributed to the lack of significant findings. The data of the present study was collected within the natural home environment. It is possible that preschool-aged children might have difficulty switching from their play activities with peers to the formality of structured tasks. In specific, the participants were transitioning back and forth between playing and performing the structured tasks. While waiting for their turn, the participants were playing with the other children in their play group. Upon their turn to perform the structured speech tasks, it was noticed that the participants were often still excited from the free play. This might have introduced some ambiguous vocal behaviors which may have contributed to insignificant difference between HP values collected from the structured speech tasks and from free play. Therefore, it is suggested future data collection for structured speech tasks and free play should be performed during separate sessions.

It may also be helpful for future studies to group preschool-aged children based on the amount of free play they regularly engage in relative to their amount of quiet or passive (i.e., TV) play. Children who participate in limited amounts of free play may demonstrate different vocal performance characteristics than do children who engage in large amounts of free play. The information with respect to the amount of free play and quiet play can be obtained from the children's parent/ guardian through verbal interviews or written questionnaires.

Conclusion

In conclusion, new insights have been provided on preschool-aged children's vocal behaviors during a variety of activities through objective acoustic analyses. Overall, the current data revealed a significant difference between HP measured during free play activities and derived OP. In addition, there is a considerable difference between the HP measured during conversation/story retell when compared to the HP in free play. It is important to take the HP values in both structured speech tasks and free play into consideration when evaluating children. It is imperative to evaluate the voice during both tasks to determine how the children truly use their voices every day.

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APPENDIX A

DUQUESNE UNIVERSITY
Speech Language Hearing Clinic

John G. Rangos, Sr. School of Health Sciences
Department of Speech-Language Pathology
406 Fisher Hall
711 Forbes Avenue
Pittsburgh, PA 15282
tel 412.396.4200
fax 412.396.1388

CONSENT TO PARTICIPATE IN A RESEARCH PROJECT

Title: "A Comparison of Habitual Pitch and Optimum Pitch in Preschool-Aged Children"

Principal Investigator: Katie Micco, B.S.
Graduate Speech-Language Pathology Student
Duquesne University
(724) 944-2663

Research Advisor: Yang Chen, Ph.D.
Associate Professor
Department of Speech-Language Pathology
Duquesne University
(412) 396-4206

Source of Support: Duquesne University Speech-Language and Hearing Clinic

PURPOSE:

I understand that my minor child has been asked to participate in a research project that examines the vocal behavior during various speaking tasks in different environments (e.g., structured and play activities). I understand that participants in this study are children between the ages of 2.5 and 6 years old. If my child participates, I understand that he or she will be asked to complete various speaking tasks in both structured and play environments that will be recorded for analysis. In addition, I understand that my child will receive a hearing screening. I understand that, as my child's parent or guardian, I will be asked to provide information about my child's developmental history. In addition to these measures, I understand that authorized personnel from this research study will analyze the voice recordings to obtain statistical information. If my child participates, I understand that three visits, each lasting no more than forty-five minutes, will be needed. The sessions will be completed at the child's home or day care facility. Data will be collected by the principal investigator.

RISKS AND BENEFITS:

There are no risks greater than those encountered in everyday life. The benefits of participating include contributing to the field's knowledge of the differences in how children use their voices when speaking during different activities.

COMPENSATION:

There will be no cost associated with participation in this study. No monetary compensation will be provided to me or my child, but my child will receive an age appropriate storybook upon the completion of the data collection.

CONFIDENTIALITY:

I understand that any information obtained about my child during the course of this study, including my child's voice recordings and questionnaire responses, will be coded and deidentified and will be kept confidential. The name, address, and phone number of my child will appear on the questionnaire during review of the responses. The principal investigator will review the questionnaire to ensure the responses meet the requirements of the study. Upon completion of the review, the identifying information will be removed and shredded and the participant will be assigned a code number. If my child does not meet the requirements, the entire questionnaire will be destroyed via paper shredder. This information will be housed within the Duquesne University speech research laboratory and will not be released to anyone without your written consent. Moreover, all of this information will be kept in a locked file cabinet in the Speech Lab, and will be accessible only to the principal investigator and research advisor. I understand that my child's identity will not be revealed in any description or publication of this research. Therefore, I consent to the dissemination of research findings for scientific purposes by professional presentation and/ or publication.

RIGHT TO WITHDRAW:

I understand that I may refuse to have my child participate in this study or may withdraw his or her participation at any time. If I chose to withdraw my child from participating in the study, I may request that his or her data be destroyed.

VOLUNTARY CONSENT FOR MY MINOR CHILD:

I certify that I have read the above statements, or that Katie Micco has explained all of the above to me, and that my questions have been answered. I understand that any future questions I have about this research can be answered by Katie Micco who I may call at (724-944-2663). I understand that should I have any further questions about my participation in this study, I may call Yang Chen, Research Advisor at (412) 396-4206 or Dr. Paul Richer, Chair of Duquesne University Institutional Review Board at (412-396-6326). Also, I understand that my child's participation is voluntary and that I am free to withdraw him or her from participation at any time, for any reason. On these terms, I certify that I am willing to allow my child to participate in this research study.

________________________________ ____________________________

Signature of Parent or Guardian **Date**

INVESTIGATOR'S CERTIFICATION:

I certify that I have explained to the above individual the nature and purpose, the potential benefits and possible risks associated with participating in the research study, have answered to the best of my ability any questions that were raised, and have witnessed the above signature.

______________________________ ______________________________

Signature of Investigator **Date**

APPENDIX B

Questionnaire
(All information will remain confidential)

Name of Child:____

Address: ____

Phone Number: ______________________

Date of Birth:___/___/_______

Please circle Yes or No for the following questions:

1. At approximately what age did your child say their first word? ____________
2. Has your child ever received speech or language services?

   Yes **No**

3. Has your child been identified as having a hearing impairment?

   Yes **No**

4. Has your child had any type of developmental delays?

   Yes **No**

5. Has your child been identified as having any type of learning disability?

   Yes **No**

6. Has your child been identified as having a social/ emotional disorder?

   Yes **No**

7. Has your child been identified as having a neurological disorder?

   Yes **No**

8. Does your child have any allergies?

   Yes **No**

9. Does your child have asthma?

   Yes **No**

10. Do you give Duquesne Speech-Language Hearing Clinic permission to contact you and your family about your child's speech and language development in 5 years?

   Yes **No**

Assigned Participant Code Number____________

APPENDIX C

PARTICIPANTS' INSTRUCTIONS FOR DATA COLLECTION

<u>*Structured Language Tasks*</u>

5. The participant will count from one to three to establish an accurate HP, and then sustain the vowel sound /ah/ for five to ten seconds (Britto & Doyle, 1990). The participant will be given an auditory model following instructions. "I want you to say 'One, two, three, /ah/' and hold out the /ah/ sound for five to seconds. This is what I want you to do. (Clinician demonstrates). Now you try."
6. The next task will be from the *Quick Screen for Voice* (Lee, et. al., 2004, p. 314). Each participant will be instructed to count from one to three while stopping at "three" and sustaining the /i/" sound for five to ten seconds (Lee, et. al., 2004). The participant will be given an auditory model following instructions. "I want you to say 'One, two, three, /i/' and hold out the ah/ sound for five to seconds. This is what I want you to do. (Clinician demonstrates). Now you try."
7. Next, the clinician will provide a picture book and story to the participant. The story will be predetermined by the clinician and told verbatim to each child. Prior to telling the story the clinician will remind the child to listen carefully because he/ she will be retelling it. After the clinician recites the story, the child will be asked to retell the story looking at the pictures.
8. Lastly, a two-minute spontaneous speech sample will be collected. The child given a specific topic such as, "Can you tell me about your favorite movie."

Pitch Range Task Used to Derive OP

1. The child will be instructed to "Make your voice go from low to high like this (demonstrate upward pitch glide on the word 'whoop').
2. "Now go down from your highest to low (demonstrate rapid downward pitch glide like a bomb falling)" (Lee, et. al., 2004, p. 315).

Habitual Pitch during Play Activities

After the structured language tasks are presented, the participant will be instructed to engage in free play with peers. A five minute speech sample will be collected as the child engages in the play activities. The clinician will sit with the participant, but the play activities will be directed by the child.

APPENDIX D

Recruitment Invitation

Dear Parents or Guardians:

Do you have preschool-aged children (age 2.5 – 6 yrs.) at home? If so, your children are eligible to participate in the study of ***A Comparison of Habitual Pitch and Optimum Pitch in Preschool-aged Children***. This study will help us examine the relationship of habitual pitch (HP) and optimum pitch as well as the use of the HP across both structured and play activities. It is hoped that upon the completion of the study, substantial information will be acquired on the development and efficiency at which children's voices are produced.

Please take a few moments to read the following *Frequently Asked Questions* and then decide whether you want your children to participate the study.

What does my child need to do if she/he participates in the study?

A: She/he will be asked to complete various speaking tasks in both a structured and play environments that will be recorded for analysis. Her/his voice will be recorded and digitized on a computer.

What type of information of my child will be released?

A: As the child's parent or guardian, you will be asked to provide information about your child's developmental history.

What are you going to do with my child's voice recordings?

A: The authorized personnel from this research study will analyze the voice recordings to obtain statistical information for HP and OP.

How much time commitment will it be to participate in the study?

A: There will be three separate visits. Each visit will last no more than forty-five minutes. The sessions will be completed at the child's home or day care facility. Data will be collected by the principal investigator.

Are there any potential risks to my child?

A: There are no risks greater than those encountered in everyday life.

Will my child's information be kept confidential?

A: Yes. Your child's voice recordings and questionnaire responses will be coded by subject number and will be kept confidential. This information will be housed within the Duquesne Speech-Language-Hearing Clinic, and will not be released to anyone without your written consent. Moreover, all of this information will be kept in a locked file cabinet in the Speech Lab, and will be accessible only to the principal investigator and research advisor. Your child's identity will not be revealed in any description or publication of this research.

Can my childe withdraw from the study if he/she does not want to continue?

A: Yes. Your child may withdraw his or her participation at any time.

If interested in participating in the study, please contact:

Katie Micco (Principal investigator)
Graduate Student of Speech-Language Pathology
Duquesne University
(724)944-2663
E-mail: micco440@duq.edu

APPENDIX E

Raw Data for Age (in years) and Gender Information of Each Participant, Tasks Used to Elicit Habitual Pitch Measures, and F_0 value (in Hz) Obtained from Each Data Collection Session

Participant	Age (yrs)	Gender	Sustained Phonation /ɑ/		Sustained Phonation /i/		Conversation		Story Retell		Free Play	
			F_0 (Hz)									
			DC #1	DC #2	DC #1	DC #2	DC #1	DC #2	DC #1	DC #2	DC #1	DC #2
1	5.8	F	288	292	519	345	254	273	296	287	389	322
2	4.7	F	340	332	322	308	294	296	283	345	368	401
3	4.9	M	584	438	347	434	470	372	360	322	484	550
4	3.3	F	285	165	296	274	316	304	389	367	361	380
5	5.9	F	349	330	381	360	307	278	293	265	337	376
6	3.3	F	311	380	340	325	329	347	312	311	431	436
7	5.5	F	351	237	430	445	348	339	318	339	303	313
8	5.2	F	393	297	355	371	348	347	337	322	391	384
9	4.3	F	299	296	369	320	293	284	296	335	432	365
10	2.6	M	308	307	307	312	326	327	331	316	310	317

DC= Data Collection Session

APPENDIX F

Raw Data for Age (in years) and Gender Information of Each Participant, Tasks Used to Elicit Optimum Pitch Measures, and F_0 value (in Hz) Obtained from Each Data Collection Session

Participant	Age (yrs)	Gender	Pitch Range Task Low to High		Pitch Range Task High to Low		Pitch Range Task Low to High		Pitch Range Task High to Low	
			F_0 (Hz)							
			DC #1		DC# 1		DC #2		DC #2	
			Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	5.8	F	276	580	230	613	230	525	221	689
2	4.7	F	208	424	380	551	368	689	334	689
3	4.9	M	345	689	298	689	344	689	130	689
4	3.3	F	181	689	501	580	345	649	254	297
5	5.9	F	165	649	115	315	290	689	276	649
6	3.3	F	225	501	236	525	324	689	356	689
7	5.5	F	256	324	283	345	315	459	479	525
8	5.2	F	290	459	306	580	345	689	197	689
9	4.3	F	141	426	X	X	192	240	149	490
10	2.6	M	X	X	X	X	193	516	121	451

DC = Data Collection Session
X = No Response or Invalid Response
Low to High = "Whoop"
High to Low = Simulating bomb falling