A PERCEPTUAL STUDY OF VOCAL REGISTERS
IN THE SINGING VOICES OF CHILDREN

DISSERTATION

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By

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CHAPTER I
INTRODUCTION

Vocal registers are a natural phenomenon which exist as a means of pitch control for the utilization of range. Register events in the singing voice occur as a function of vocal production in a given pitch range. One aim of vocal education involves the learning of smooth register transitions to facilitate artistic use of one’s entire singing range. The vocal range of children has been the topic of many research studies with widely differing conclusions. It would appear the disparity in range generalizations is, in part, due to the fact that these studies were conducted without regard to register effects or the pedagogy of vocal production necessary to sing throughout the entire pitch range presented. While some researchers have observed the presence of several registers in children’s singing voices, systematic studies of vocal registers have been conducted exclusively with adult subjects.

In the early elementary grades one of the major goals of music instruction is that children will find and be able to use their singing voices. Singing is at the core of elementary school music programs, yet far too many children never learn how to sing properly. Students who only have use of their speaking voice register are
severely limited in range and tone quality of the music they can produce with their own personal instrument, the singing voice. These children are labeled as inaccurate singers, non-singers, or even monotones by teachers who have not provided sufficient means for finding and developing the true singing voice of childhood, the "head" voice. Children who think they "can't sing" simply have not learned how to use their singing voices. Setting musically aesthetic goals for students without providing the tools to achieve those ends is like putting the cart before the horse.

Many teachers do not know how to teach singing skills to children in a group setting. They may not understand how to help children find their singing voices, expecting it to happen as a result of their musical activities. When this does not occur, the teachers do not know what to do. Too often they simply ask the children to sing louder, which, instead of helping, exacerbates the problem, harms young voices, restricts musical expressive abilities, and reinforces the attitude that singing is a special gift--not available to all. Good vocal production, specifically finding and learning to use the singing voice, must be a major goal of early music education.

Tone Quality

Tone quality is a psychological factor which is a response to physical properties. "Tone-quality, then, is a subjective reaction; it is not present as a physical element in the original stimulus but is
our unified reaction to the three variants of pitch, intensity, and duration" (Ortmann, 1935, p. 448). This definition explains the many descriptive terms we borrow from the other senses to express concepts of tone quality. Good vocal tone quality as perceived in children's singing voices is the result of application of sound pedagogical principles to carefully chosen repertoire in a musically artistic context. This may be learned formally (as a result of instruction) or informally (imitating a model), but it is learned. Posture, breathing, phonation, resonance, diction, and expression all contribute to the development of a good singing tone. In order to chart the process of developing tone quality, one must have a clear mental image of the desired product. Analysis of the product provides pedagogical implications for the development of each facet of vocal tone.

To understand the foundations for vocal development at any age, we must look at how children learn to sing. Developing the singing voice is contingent upon finding and being able to manipulate the singing voice.

Edwin Gordon (1971) wrote, "Anyone can learn to sing, just as anyone can learn to talk." Skilled music specialists and researchers alike have come to acknowledge that singing is a teachable skill. A three-year study of children and teachers conducted by A. Oren Gould (1968) produced the following conclusions: (a) every unhandicapped child can learn to sing; (b) teachers with varying degrees of vocal skill can learn to help children learn to sing; (c) in
regards to remedial work, the sooner the better; (d) this help can be adapted to any person of any age with the desire to learn to sing.

Each child should have the opportunity to develop his own natural instrument of self-expression under the guidance of a skilled music teacher (Atterbury, 1984; Gould, 1968; Rao, 1987). Music educators do not all prescribe the same sequence of events in teaching children to sing, but they do generally agree that the place to start is with pitch awareness. This aural skill then is linked with the kinesthetic "feel" of high and low sounds in speaking and singing. As vocal control of various pitch levels is developed, the question of appropriate ranges for children's voices arises.

Graham Welch (1979) has charted the results of research findings in the vocal ranges of children. However, little is known about the methods of investigation. Some data was based on pitch extremes produced, with little regard to quality of the sounds produced (Jersild and Bienstock, 1934; Wassum, 1979). Other researchers began with a tone the child could sing and moved outward (Gould, 1969; Joyner, 1971). The distinction between functional range and tessitura points out that while a child may vocalize a large number of pitches, he may not be able to sing all of them in structured song material. "Comfortable" ranges are documented in more recent studies (Joyner, 1971; Wilson, 1971). There is no shortage of evidence to imply that correct vocal range is a prerequisite for developing accurate singing.
Pedagogy

Vocal tone quality is a broad category in performance evaluation. It is the embodiment of all the principles of good singing: posture, breathing, phonation, resonation, registration, diction, and expression. The concept of vocal tone quality is founded in sound—a mental image of what good tone sounds like. Training the ear and the mind to perceive and identify aspects of tone quality is usually a blend of aural and verbal descriptors. When the brain is "programmed" with superior images, new aural events (performance or listening) can be compared with the sound model. This non-verbal process of learning must accompany the verbal communication process.

Vocal timbre or tone quality is determined by the relative strengths and weaknesses of reinforced overtones (Alderson and Alderson, 1979). The chief determinants of vocal tone are, thus, the factors which add overtones to the sound wave being produced at the laryngeal level: size, shape, and composition of the vocal tract, including muscles, bones, and resonators which comprise the vocal apparatus (Fields, 1977). The characteristics of vocal tone are determined by the airflow (subglottic pressure), by the laryngeal musculature, and by the tract resonance (Sundberg, 1987). Quality as an acoustical property is inseparable from pitch and intensity; together they form the tonal product. Fields (in Large, 1973)
concludes "the acoustical output is governed by a single response of the entire tract in obedience to preconceived tonal concepts" (p. 146).

The logical assumption is that in order to develop vocal tone quality in the singing voice, the singing voice ("head" voice) must be found and used regularly. This is not a foregone conclusion in elementary school music classes. Helen Kemp (1986; in Phillips, 1985; in Rotermund, 1985) has consistently promoted the fact that singing is a learned behavior. When Edwin Gordon (1971) wrote that anyone could learn to sing, he meant any child could learn to use and could develop his "head" voice, the true singing voice.

"Singing is a special way of using the voice," Doreen Rao, director of the Toronto Children's Chorus, tells her young singers. It is an extension of speech, a premise which allows the security of something familiar and which suggests a starting point for vocal development (Rao, 1987). The idea that singing is a psychomotor skill implies that the child has "voluntary control over the actions and movements of the body which coordinate to bring forth the singing voice" (Fortunato, in Phillips, 1985). Teachers of instrumental music have never expected the coordination of complex functions needed to play an instrument to happen automatically. Yet many teachers of children expect just that in regard to singing. Because they have not been equipped with the knowledge necessary to teach singing in group situations, they may assume there is "nothing to" singing correctly. Their lack of knowledge influences the
children's abilities and attitudes, producing far too many children who think they "can't sing".

As in the development of any skill, singing needs to be developed in a well-organized sequence of activities. The "drill" approach of Lowell Mason's era is no more appropriate for exclusive use than is the total "song approach" currently prevalent in elementary school music. A balanced approach includes some time spent developing the singing voice. However, because technical learning and musical experience are not separate subjects, the bulk of the time should be spent in application of technique, that is, in expressive musical experience.

The development of a good vocal tone in children's voices is the result of a sequentially-designed program of vocal training for children. Elementary music teachers can implement such a program in the music classroom for all children, not just those in select choirs. By spending five to eight minutes per half hour music class, a teacher can communicate principles of vocal development and apply them to song literature which has been carefully chosen to promote good singing.

Learning to sing is largely a kinesthetic experience. A. Oren Gould (1969) found, as a result of his three-year study, six steps to learning to sing:

In order to learn to sing, one must form:

1. a concept of the singing voice and the motor skill of sustaining vocal sounds;
2. a concept of the difference between high and low sounds and the motor skill of controlling pitch levels in speech and song;
3. a concept of the sound of a musical tone and the mental skill of translating a tone heard by the ear into a tonal image;
4. a concept of melodic relationships and the mental skill of moving from one tonal image to another;
5. a concept of unison and the combined mental and motor skills of matching the vocal mechanism and the tonal image;
6. a concept of the vocal quality of the true singing voice and the combined mental and motor skills of producing and manipulating the singing voice (p. 20).

Gould reported many reasons music teachers gave for their students' inability to sing, but reclassified these as symptoms of the problem, not causes. The most probable cause for a child's inability to sing is that the child is unable to manipulate the voice to match the musical sounds he hears. If the manipulation of the voice can be taught, then singing can be taught.

First of all, Gould says, the teacher and the student must have a positive attitude toward learning to improve the singing voice. Both teacher and student need to develop a concept of what it is they hope to master ("sound ideal") before attempting to develop skill. His sequence begins with experimenting with the speaking voice, a tool the child has been using for most of the years of his life. He then progresses from speech to song activities. Gould points out that the student must gain proficiency and security in these early activities before he is ready to move on--the child should have ample opportunities and should not be rushed. Next, the student must
experience unison—with the teacher's voice, with a fellow student's voice, with an instrument. He suggests short melodic phrases in the lower speaking range first, including opportunities for the child to select the pitch at this stage. When the child has gained security in matching in his conversational range, he is ready to find his true singing range. Gould's specific technique begins with the use of a two-note call, high, such as "yoo-hoo". He places these patterns in ranges that require head voice production, and progresses to teaching entire songs using the "oo" vowel. He has categorized songs into Type A, Type B, and Type C songs by their starting pitches and melodic movement, from simple to more complex. When working with the singing voice, tones are sung on "oo" (or another vowel such as "ah") until success in tone matching allows the child to add the words. Gould encourages teachers to reinforce singing activities with visual notation (traditional or iconic), body movement, and instruments (especially keyboard type) to parallel melodic contour and movement.

All children are capable of singing with a clear, resonant tone quality throughout the vocal range. Developing this capacity begins much earlier than tone-matching. Evaluating one's voice is often as much a kinesthetic response (how it feels) as an aural response (how it sounds). Bennett (1986) delineates five phases of vocal awareness which precede pitch matching. Although sequentially arranged, progress through the following steps may occur very quickly:
1. the child experiments with the quality and range possibilities of his voice;
2. the child describes how his voice feels as he experiments and how others' voices sound as they experiment;
3. the child matches the quality and range of the teacher and others in singing and speaking activities;
4. the child decides which labels best fit a given vocal production of his or another's voice (especially in range and dynamic level);
5. the child then produces a particular sound according to a given label.

Gould (1968) also emphasized the importance of starting with the known—the speaking voice. Phillips (1985) says children should be encouraged to develop their speaking voices as a natural part of voice training, primarily with regard to timbre (whisper/shout, speak/sing) and register (high/middle/low).

Vocal Registers in Singing

The voice exhibits two physiologically distinct registers which use different muscular actions. The light mechanism ("head" voice) is controlled primarily by the action of the cricothyroid muscles, whereas the heavy mechanism ("chest" voice) is controlled by the action of the vocalis or thyroarytenoid muscles. The upper
adjustment or light mechanism involves vibration only of the inner edges of the vocal folds, while the lower adjustment or heavy mechanism calls the vocalis muscle into play as well. Registers can be identified by production or perception, with most register studies devoted to the former (Keider, Hurtig, and Titze, 1987). Titze (1988) defines the term register as describing "perceptually distinct regions of vocal quality" (p. 183). Garcia's (1840) definition of registers is the most commonly quoted statement:

"By the word register we mean a series of succeeding sounds of equal quality on a scale from low to high produced by the application of the same mechanical principle, the nature of which differs basically from another series of succeeding sounds of equal quality produced by another mechanical principle" (in Large, 1973, p. 123).

Most vocal authorities support either a two- or a three-register theory. Those believing that there are three distinct registers label the area between raw chest tone and pure head tone as a middle register. Dykema and Cundiff (1939), Joyner (1969), Moorhead and Pond (1978), and Wassum (1979) subscribe to three-register theories. Most other authors describe two areas in children's singing voices even if they do not call these areas "registers". Some talk of high and low voices within the total voice range, some of speaking and singing voices. Those describing register shifts include labels such as high/low, upper/lower, head/chest, light/heavy, thin/thick, and so on. What is common is the acknowledgement that children
have different pitch regions in their voices that must be explored and developed.

At the turn of the century, Francis Howard was one of America's most influential authorities on the child voice. His 1895 book, *The Child Voice in Singing*, became one of the most extensively used texts on training children's voices. We acknowledge his role in American vocal music education today for several of his theses. He believed that every music teacher needed a physiological understanding of vocal production in children and that the only major way to improve was through the teaching of good vocal habits. Few will argue with these statements, yet current trends in music education do not reinforce them.

His entire technical premise centered around soft singing and singing only in the thin or head register. He justified his beliefs with three reasons:

1. The exclusive use of the head voice is physiologically safe for the delicate vocal organs of children.
2. Head tones are sweet and pure, and their use promotes the growth of musical sensibility and appreciation of beauty of tone.
3. The use of the thick or chest voice is dangerous in that it is almost impossible to confine its use to proper range limits.
Other music educators writing on the child voice in the early 1900's agree. "Head voice or 'placed' voice is the beautiful quality heard in the trained choirs of English cathedrals. . . . It should be found in every school, without exception" (Rix, 1910). Soft singing has less to do with dynamic expression than with a necessary element in the production of head tone and prevention of the use of the chest register. While most teachers of singing place the upper limit or natural break of the chest register at e4 or f4 above middle c (c4), research studies have documented the "break" or loss of control in young children to occur around second-space a4 (Young, 1971). This, then, must be the point at which cartilages and muscles controlling the two registers are ready to pass control from one to the other--the point of necessary change into head voice to sing ascending pitches.

Several authors suggest that young children can carry chest voice to fourth-space e5 due to an elasticity of the larynx, which accounts for a so-called "movable break". This ability is short-lived, and when it ceases to function, the child often concludes that he cannot sing high. He has never been taught to use his head voice. Bates (1907) concludes that the head voice beautifies and preserves the voice. Chest voice, which he calls a combination of the "speaking" and "shouting" voice, stiffens the throat and fixes the larynx, causing a greater effort to be used to produce the tone. In addition, the use of the chest voice deprives a singer of his "quality-making
resonators". Besides being harmful, the chest voice tone has a penetrating force that will never blend with other voices.

Vocal Registers and Tone Quality

Frederick Swanson (1977) asked ten boy choir directors for their definitions of the attributes of the ideal sound. They agreed on the following points:

1. The tones are clear and resonant, with no harsh overtones or muffled sounds.
2. The head tones are well developed and unforced.
3. The chest tones are full and rich, but not pushed and strident.
4. The two registers are so smoothly blended that the passage from one to another cannot be easily detected.
5. Tones are so well focused that the voices can be heard in the farthest reaches of a large auditorium.
6. There is enough control so that the loudest tones are full and resonant with no trace of stridency or harshness, while the soft tones float effortlessly.

Swears (1985) concurs with this list, adding that the ideal tone is free, light, and forward. The tone has focus and vitality. There is no vibrato, harshness, or pinching of the tone in her sound ideal.
The sound desired by these authors exists today in the English boy choir sound. Head voice (vibration of only the inner edge of the vocal folds) is used throughout the range. It is this head voice quality that teachers are seeking in trying to help children find their singing voices. It is a quality which must be discovered, therefore taught. It must be learned before the rest of the range (lower) can be produced correctly. Chivington (1989) states that most directors of children's choirs agree that use of this light mechanism is "healthy and appropriate" for children's voices. "Generally speaking the chest register is not healthfully produced by young children. Its use should be avoided, particularly in early stages of the child's vocal development" (p. 38). In the English sound model, the pitches of fourth-line d5 and above are clear and resonant, but the octave from middle c4 to third space c5 fades out in power, clarity, and resonance. Obviously, the bulk of the music for children's voices lies in the part of the child's range which does not benefit from pure head tone production.

The extreme opposite in production is a full or heavy chest voice production. It is louder, heartier, and some say, more "energetic", but it is also more raucous, less musical, and it is certain to cause vocal fatigue and ultimately vocal damage from forcing a sound beyond its natural limits. The overall sound lacks in expressive capabilities. Music ranges must be lowered to accommodate the pushed voices, adding new pitches to the bottom of the range. The resultant sound is not pleasing to the ear, yet it is
often accepted and even promoted by some unknowing teachers as an alternative to the less powerful sound of the English model.

A full tonal range should be explored with vocal activities in the early grades. However, elementary teachers must know and practice techniques for developing a good tone quality in all ranges. As Helen Kemp (in Phillips, 1985) has observed, by the time children are in the first grade, they have picked up one of two singing habits: "the breathy, puny voice or the loud, neck-swelling sound". The heavy chest voice singing that teachers are allowing to exist is producing a nation of non-singers. The upper voice must be properly established and in balance with the lower voice before children can be taught to sing in the lower register (Phillips, 1985). Developing the awareness and the ability to coordinate registers will aid children in their pitch-matching endeavors far more than lowering ranges of textbook song literature.

There is a third alternative for vocal pedagogy and resultant tone throughout the range. It is not a compromise in the negative sense between exclusive head voice production proponents and the chest voice advocates. Rather, it is a choice for the best sound possible throughout the entire range. This is the Vienna Boy Choir or the European boy choir tradition. The pedagogy is rooted in the concept of the head voice as the true singing voice of childhood, but also recognizes more than one register of vocal production. It teaches the students to develop and blend the special qualities of each register. Downward vocalization mixes and adds "body" to the
head register in the lower ranges, without promoting the harshness, the potential for damage, or the "pop" connotations of the raw chest tone. This integration, top down, produces voices that are clear, resonant, and musically expressive at any pitch level.

Integrating the registers is not a new idea. In 1902 John Dawson wrote that the strengthening of the lower octave of boys' voices by mixing the registration and proceeding downward from the head register would eliminate the "break" in boys' voices during puberty. He proposed a system that would keep all boys singing correctly and effectively throughout the "change of voice" period. The concept of developing and coordinating the registers has resurfaced in American vocal music education as educators have begun to take notice of the gap in vocal pedagogy materials, methods, and models for the young singer. Edwin (1987) observed that the "angelic neutered voice" proponents and the "belt, belt, and only belt" proponents have met head on and neither has fared well. Whether the emergent vocal techniques arose in reaction to these two camps, in response to cultural demands for a viable sound, or as a result of any other factor, we have now learned to acknowledge one specific fact and are seeking to fulfill its implications: singing is a learned behavior.
Conclusions

Singing ranges and registers are undeniably related. The set of tones produced in one register may logically be called a range for that register or mechanism of vocal production. The adult singing voice exhibits two or three major resonance registers which should be usable in any healthy voice. The inability to make the transition from one register to another as pitches change sets a limit on the singing range available to a given singer. Left on his own, the average untrained singer resists the change. Many singers do not know how to "shift gears" from a lower to a higher register. Some have only experienced the lower speaking voice register and, therefore, cannot find the higher "head" voice. Whatever the reason, the lack of ability to use the full pitch spectrum available in the singing voice severely limits the range in which a person can sing accurately. It has been repeatedly observed that those who cannot negotiate register transitions may think they have limited singing ranges. It has also been observed that teachers who do not teach proper vocal production complain of the discrepancies between textbook song ranges and the actual singing ranges of their children. Popular music, so prevalent in our environment today, exploits the use of the heavy mechanism or chest voice in singing. Microphone technique is replacing singing technique. Role models for healthy, well-produced singing voices are difficult to find.
Learning to sing is a continuum of psycho-motor skill development. Problems of beginning singers are similar regardless of age. Most register studies have been conducted with adults. By adulthood, the subjects have either learned to manipulate their singing voices to achieve what they desire, or have concluded that they can only sing in a certain limited range. (Many have concluded that they "can't sing" because of their limited ranges.) Children provide the largest population of untrained voices. While some have learned informally how to use their singing voices before Kindergarten, formal music training rarely begins before elementary school. The study of children's singing voices as they grow and develop and as they gain in musical experience should produce information valuable not only to those who teach elementary school children, but also relevant to those who work with beginning singers of any age.

In a summary of research findings, one educator suggests that voice production may be the link between the dichotomy of those who support the low ranges of children and those who support the higher ranges (Apfelstadt, 1982). Research has shown that: (a) children's voices exhibit several registers (Moorhead and Pond, 1978; Wassum, 1979); (b) children can vocalize in higher ranges than those in which they choose to sing (Jersild and Bienstock, 1931; Flowers and Dunne-Sousa, 1990); (c) children can produce tones in high and low registers, but often have difficulty ascending if they cannot negotiate the transition to "head" voice (Jersild and Bienstock,
1934; Joyner, 1969); (d) children begin to achieve success in singing when they learn that they can control the pitch fluctuations of their own voices (Forcucci, 1975; Gould, 1969; Roberts and Davies, 1976). Vocal production must be a significant factor in interpreting the results of studies of children's voices.

Much of what is known through research concerning the child voice is not available to those who teach children or to those who are learning to be teachers of children. "In order to instill correct vocal concepts in children, it is of paramount importance that the instructional materials put into the hands of the teachers are complete. . . . Teacher's manuals of elementary music series should contain certain facts about the child voice, the normal expectations at each grade level, and teaching strategies that develop desired results" (Kavanaugh, 1982). "The ability to sing is not an innate ability but rather a skill which can be learned if it is taught at the optimum time" (Atterbury, 1984). The results of research must be linked with the essentials of vocal pedagogy, and this material must become a part of teacher training if we wish to help children experience the joy of musical experiences utilizing the potential inherent in their own personal instrument, the singing voice.

This descriptive study is designed to provide information about the vocal registers which appear in children's singing voices. What occurs mechanically in the laryngeal musculature as pitch frequency varies has been documented conclusively in recent years. This study involves the perception of the resultant tone qualities of each
register. Research areas include the pitch ranges of each register in children's singing voices, the "lift" or "break" points, and the degree of overlap of registers. Register transitions may be both induced and inhibited in order for the researcher to observe the effect of certain factors upon vocal production. The ability to negotiate smooth register transitions will be evaluated as one indicator of vocal development. By measuring the singing voices of children in grades K-6, it should be possible to observe developmental and/or experiential effects on the ability to use the natural resonance registers of the singing voice.

Beginning singers at any age encounter similar problems in learning to manage their singing voices. The findings of this study, therefore, have validity not only to teachers of children, but also to those who teach the fundamentals of singing at any level.

Research Questions

From the research which has been conducted, one can make some general assumptions and can pose some new questions to be addressed in this study. It has been shown conclusively that two different physiological conditions appear at the laryngeal level based on the dominance of one set of muscles at given pitch and intensity levels. The muscular antagonism which exists, primarily between the cricothyroid and the vocalis muscles, results in a changing dynamic balance, rather than two different production mechanisms.
At one end of the spectrum is production using the heavy mechanism, sometimes called the chest or speaking voice. At the other end is production using the light mechanism or head voice. We can assume that the child voice will exhibit the same two register extremes or heavy and light mechanisms, or chest and head tone production. The research questions which drive this study are:

1. What are the register boundaries for the two major registers?
2. Are there other registers occurring outside of or between these two primary registers?
3. Where do transition points occur between registers?

Studies with elementary school children have revealed that inaccurate singers are more often boys than girls, and that the number of inaccurate singers decreases with age and experience. This study will also investigate the ability of elementary school children to negotiate register transitions smoothly. This ability will be evaluated in terms of age/grade, gender, and singing accuracy.

Voice teachers work toward developing voices, smoothing them through all the singing registers to achieve artistic goals. This pedagogy is adaptable to children in group situations and should be a part of the musical training of teachers of children. It is hoped that this study will shed light on the dichotomy which exists on the issue of vocal ranges of children by illuminating the neglected factor in
previous range studies, vocal production. Beginning singers who use their speaking voices as the basis for singing encounter the same production problems regardless of age. Pedagogical implications resulting from this study, therefore, are applicable to those who work with beginning singers of all ages.

Glossary of Terms

Register: An adjustment of the vocal mechanism which produces tones of a particular quality for demands of range and expression.

Chest Register: The adjustment dominated by the thyroarytenoid muscles; resonance sensation felt in the chest area; the lower part of the pitch range.

Head Register: The adjustment dominated by the cricothyroid muscles; resonance sensation felt in the head area; the higher part of the pitch range.

Heavy Production: Laryngeal adjustment in which the vocal bands are thick; also called "open" singing.

Light Production: Laryngeal adjustment in which the vocal bands are thin.
Mixed Registration: Laryngeal adjustment having some qualities of both light and heavy registration; a timbre which is neither entirely head nor entirely chest; middle voice.

Pitch Numbering System

\[c_3 \quad c_4 \quad c_5 \quad c_6\]

(Middle c)

141 Hz \hspace{1cm} 262 Hz \hspace{1cm} 523 Hz \hspace{1cm} 988 Hz
CHAPTER II
REVIEW OF LITERATURE

I. THE CHILD VOICE

The voice of the child has often been described in terms such as "light", "clear", "thin", "flute-like", and so on. Yet in real life, we hear a wide variety of vocal sounds: from the hearty playground calls to a breathy soft speaking tone; from a high-pitched cry through an entire gamut of imitations of environmental sounds. Surely the singing voice of the child should be one of the most unique, valued sounds in our world. How the singing voice is developed--what happens naturally and what must be taught--is a major concern of all those who work with children and have the joy of leading them to music through singing voices.

Many cultural and educational influences have shifted, if temporarily, our focus on the vocal tone ideal and the means of vocal skill development. As we hear more and more children who "cannot sing", we are realizing the need for teaching the development of basic vocal skills at all levels. Researchers through the century have provided data concerning the child voice. We have traveled ideologically from Lowell Mason's "Singing School" concepts of music
education to the opposite extremes of concept-centered music education that unintentionally ignores skill development. The realization that appreciation and love for music is directly proportionate to the involvement with and skill mastery in music has begun to bring concerned music educators back to the awareness that skills, like concepts, must be developed along specific, well-structured guidelines. However, elementary music texts no longer provide courses of study which teach vocal development. Pedagogy texts concerning the young singer are virtually non-existent. The search for the desired information, however, is not futile. In fact, a vast amount of research and pedagogical literature is available, although often dated, if one is willing to search further. The results of this search include a wide variety of desired vocal sounds for children and respective methods of production of each quality, physical growth and maturation patterns, research documentation—primarily of children's vocal ranges (with implications drawn by a variety of authors substantiating most any viewpoint imaginable), and a historical perspective of the role of singing in music education in America.

As we look at the development of public school music programs since their beginnings a little over 150 years ago, we notice a great deal of growth and change. The content and resources of music curricula have expanded in quantum leaps beyond the expectations and imaginations of early music educators. Opportunities exist for almost any musical experience to be a part of the school music
program. Yet in the progression from singing schools to comprehensive musicianship we have lost the need, the desire, and the pedagogy for teaching children how to sing. Teachers lament the poor quality of singing in the elementary grades but do nothing to improve the situation. They may either believe that the ability to sing is innate and will develop on its own, or that the ability to sing is a neurological function not affected by teaching. Either viewpoint absolves the teacher of the responsibility of teaching children how to sing (Atterbury, 1984). Instead of defenses and justifications, educators need strategies and techniques available to them to achieve the goal of developing the instrument basic to music activities, understandings, and attitudes in the elementary grades—the singing voice.

Music educators do not all prescribe the same sequence of events in teaching children to sing, but they do generally agree the place to start is with pitch awareness. This aural skill then is linked with the kinesthetic "feel" of high and low sounds in speaking and singing. As vocal control of various pitch levels is developed, the question of appropriate ranges for children's voices arises.

Vocal Range Studies

Research studies into the vocal ranges of children have been undertaken since the end of the last century. The criteria for measurement display a wide variety. In addition, the research
findings differ enough to appear to be contradictory. Nevertheless, the results of recent research reveal some common trends that provide guidance for structuring our music programs with consideration to the abilities of the children we teach. One general consensus addressed by research is that the child's vocal range changes with age, growing larger in both pitch directions with maturity and development.

Graham Welch (1979) charted the early research findings:

![Musical Staff Diagrams]

(Boys= []; Girls= o)

Figure 1. Vocal Ranges of Children from Early Research as Collected by Welch (1979)

In the earliest studies, methods of investigation are not known. The Fröschels study revealed the highest and lowest tones the children could sing without vocal strain. Each child sang scales, matching the
starting pitch of a tuning fork, an adult, or another child. Very little
is known about the Gutzmann research; his data was reported
without details or comments. It is included because of its extreme
low range feature (Welch, 1979).

The 1934 study of Jersild and Bienstock involved the ability of
children to sing given tones, and did not judge the quality produced.
This fact might account for the large ranges at age six which are in
conflict with other research (Welch, 1979).

\[ \text{Figure 2. Vocal Ranges by Age} \]
\[ \text{as Found by Jersild and Bienstock (1934)} \]

One technique begun by Jersild and Bienstock, and since
utilized by Gould (1969) and Joyner (1971), was to find a tone the
child could produce easily and work outwards from there, rather
than to begin at a predetermined, given pitch level. In Jersild and
Bienstock's 1931 study of the vocal ability of three-year-old
children, they found that the voices of children were placed lower
than previously supposed. Middle c4 and d4 were more readily sung
than the upper c5 and d5. They also found that many children of
this age could easily sing below the commonly accepted range, singing g3, a3, and b3 below middle c. Very few of the children sang high e5 and f5, notes which were found in most literature on children's voices.

Another part of the testing recorded the spontaneous vocalizations of the children. Although wide individual differences existed, in general, the children preferred higher pitches in spontaneous vocalizations as compared with their performances on song and pitch tests.

In a study by Kirkpatrick (1962) on the relationship between the singing ability of pre-Kindergarten children and their home environment, the data reported was based on songs chosen and pitched by each individual child. A similar technique had been used by Hattwick in 1933. He found that students in pre-school and grades one and two choose independently to sing in a range approximately a fifth lower than the song was pitched in print and in presentation. Hattwick made an important distinction between "pitch range" (extreme limits of notes produced) and "pitch level" (tessitura). This distinction points out that while a child may vocalize a large number of notes, he may not be able to sing all of them in structured song material. Both Hattwick and Kirkpatrick came to the conclusion that pitch levels in children's music textbooks were far too high for their "natural" pitch. As noted in other literature, the "natural" voice is frequently used to define a chest voice quality, that which is closest to the speaking voice. Smith (1963) suggested that
children have both a low (Middle c to a4) range and a high (a4 to e5) range, but that they develop pitch accuracy in the lower range first.

Cleall's (1970) research documented extremes of range, and, as in the study by Jersild and Bienstock, was not concerned with the quality of tone production. He also noted differences in sex and academic abilities of his subjects in relation to ranges.

IB = Infant Boys, Aged 5-7
IG = Infant Girls, Aged 5-7
JGI = Junior Girls, Upper Stream, Aged 8-11
JGII = Junior Girls, Lower Stream, Aged 8-11
JBI = Junior Boys, Upper Stream, Aged 8-11
JBII = Junior Boys, Lower Stream, Aged 8-11

Figure 3. Vocal Ranges by Age, Gender, and Academic Level as Found by Cleall (1970)

Cleall suggested a transposition downward of published music, believing that poor pitch singing was a result of "vocal strain and discomfort, resulting from attempting to sing music which was pitched too high" (Welch, 1979). Cleall's findings are backed up by
those of Joyner (1971) whose study investigated the relationship between pitch, pitch perception, tonal memory, and development of the larynx. Joyner reports "comfortable ranges", not extreme range limits.

Mean Age: 5.6 6.7 7.9 8.8 9.7 10.9

Figure 4. "Comfortable Ranges" as reported by Joyner (1971)

Also documenting "comfortable ranges" was D. S. Wilson (1973) in possibly the most complete study in recent years. She concluded that "marked individual differences in children's voice compass and span exist at all levels", and "the pitches selected by children as comfortable for singing are lower than pitches traditionally recommended for children's singing" (Wilson, 1973).
Wassum (1979) tested vocal ranges of children to assist in estimating characteristic vocal ranges. Again, as outer perimeters were measured, voice quality was not a consideration. Voices were tested using scale patterns played on bells. Later the children were asked to sing a familiar song, unaccompanied, with no suggestion of starting pitch. She concluded that vocal range develops with growth, and that range levels are higher and greater in span than have generally been reported. Wilson's and Wassum's documentations of the positive correlation between growth and range development are further reinforced by separate studies of young children conducted by Boardman (1964) and Zimmerman (1968).
Figure 6. Vocal Ranges by Grade Level
as found by Wassum (1979)

There is no shortage of evidence to imply that correct vocal
range is a prerequisite for developing accurate singing. Teachers
must identify all children's vocal ranges, and base teaching strategies
on the combination of this information and the knowledge of vocal
pedagogy.

Much of what is known through research concerning the child
voice is not available to those who teach children or to those who are
learning to be teachers of children. "In order to instill correct vocal
concepts in children, it is of paramount importance that the
instructional materials put into the hands of the teachers are
complete. . . . Teacher's manuals of elementary music series should
contain certain facts about the child voice, the normal expectations at
each grade level, and teaching strategies that develop desired
results" (Kavanaugh, 1982). "The ability to sing is not an innate
ability but rather a skill which can be learned if it is taught at the
optimum time" (Atterbury, 1984). The results of research must be
linked with the essentials of vocal pedagogy, and this material must
become a part of teacher training if we wish to help children experience the joy of musical experiences utilizing the potential inherent in their own personal instrument, the singing voice.

II. VOCAL REGISTERS IN SINGING

Definition

The term "register" has traditionally been used to describe different regions of the voice. Derived from organ terminology, registers in the voice refer to distinct areas of vocal sound differing in quality and production from other areas of the vocal spectrum. Garcia's (1840) often quoted definition provides a basis for understanding the concept of vocal registers:

By the word register we mean a series of succeeding sounds of equal quality on a scale from low to high produced by the application of the same mechanical principle, the nature of which differs basically from another series of succeeding sounds of equal quality produced by another mechanical principle (Garcia, 1840, in Large, 1973, p.8).

Nadoleczny extends this definition:

The concept of register is understood to be a series of consecutive, similar vocal tones which the musically trained ear can differentiate at specific places from another adjoining series of likewise internally similar tones. Its homogeneous sound depends on a definite, invariable behavior of the harmonics. These rows of tones correspond to definite
objectively and subjectively perceptible vibration regions on
the head, neck and chest. The position of the larynx changes
more in a natural singer during the transition from one such
series of tones to another than in a well-trained singer. The
registers are caused by a definite mechanism (belonging to that
register) of tone production (vocal fold vibration, glottal shape,
air consumption), which allows for a gradual transition
however from one into an adjoining register. A number of
these tones can actually be produced in two overlapping
registers but not always with the same intensity (Nadoleczny,
1923, in Large, 1973, p. 8).

Vennard expresses the same ideas most concisely defining a
register as an "adjustment of the larynx which produces tones of a
particular quality, for particular demands of range, dynamics, etc."

The vocal folds vibrate differently at low and high pitches. The
different modes of vibration at these pitch levels contribute to
the distinct vocal qualities which singers and teachers call
registers. While scientists tend to approach the study of
registers as mechanical problems, and voice scientists as an
acoustical study, singers are concerned whether the sound is of
equal quality and intensity throughout the singer's range (pp.
68-69).

Hollien's (1974) definition of a vocal register first appears to
confuse the issue: "A voice register is a series or range of
consecutive phonated frequencies of nearly identical voice quality;
they are totally laryngeal events, and there is little or no overlap in
fundamental frequencies between adjacent registers" (Hollien, 1974,
in Cooper, 1977). However, as a speech scientist, Hollien is referring
to the speech registers, which in the average, healthy voice include
pulse, modal, and loft registers. The singing voice, he proposes, has a second system of registers. These, which he calls resonance registers, originate in the vocal tract and roughly parallel or overlap the laryngeal registers. Current schools of thought include glottal fry at the bottom of the voice, a large modal area, and falsetto, flute, and whistle registers at the extreme top. Bunch (1982) states, "the real question perhaps is whether registration is purely a function of the vocal folds or a combination of factors including the supraglottic vocal tract. As yet, there are no satisfactory answers to this problem" (p. 70).

The topic of vocal registration is fraught with semantic confusion. The term register has many definitions in current use, including (a) a part of the vocal range, (b) a resonance area, (c) a phonatory process, (d) a certain tone quality, and (e) a region of the voice occurring between "lifts" or break points (McKinney, 1982). A clear, current definition of the phenomenon of vocal registers does not exist as a simple statement because to understand vocal registration, one must understand the entire production of vocal sound. Hollien (1974) maintains that an operational definition must be supported by perceptual, acoustic, physiological, and aerodynamic evidence. The precise definition of vocal registers continues to be debated and expanded as developing technology provides new insights for vocal researchers.

One point research has made clear is that register transitions are more identifiable than registers themselves (Titze, 1983). It is
difficult to identify one register without reference to an adjacent register.

The natural transition between two adjacent registers may be compared to the gearshift of a car. The gears of a combustion engine must overlap considerably for mechanical reasons. The same absolute vehicle speed can be maintained by driving either with high rpm in low gear or by fewer engine revolutions in the next higher gear. Driving with the minimal amount of gas flow at a given speed is the most economical manner with regard to gas consumption and engine conservation. . . . The so-called REGISTER BREAK . . . is similar to the noisy gearshift in a rundown truck. . . . In a fine new car with automatic transmission the gear shift is almost unnoticeable. Nevertheless, even the fine car must accelerate by going through consecutive gear shifts and it would be silly to claim that such a car needs no gears. Conversely, every normal voice must function with several register mechanisms (Arnold, 1969, in Large, 1973, pp. 138-139).

Registers are more distinct when the transitions or breaks are more abrupt. If we consider one aspect of vocal quality to be a continuum between heavy (or full) voice on one extreme and light voice on the other extreme, we can choose (somewhat arbitrarily) two paths through this continuum, a ramp or a stair-step. The ramp would be analogous to the one-register voice, whereas the stair-step would be analogous to the multiple-register voice (Titze, 1983, p. 21).

While the "even scale" or "seamless line" throughout the singing range is a goal of vocal education, the smooth transition between registers implies that all of the registers are present and functioning efficiently. Therefore, registers are important, when obviously identifiable due to production extremes, as cues that point toward the vocal needs of the beginning singer.
Theories of Registration

The literature on vocal registers is characterized by great confusion with regard to the numbers and names of registers. One may observe one register/no register theories, as well as two-, three-, four-, and more register systems. There are even those who claim there is a register shift on every note in the vocal range. There are three major categories of registration theories:

1. One-register theory: There is one register which is even in timbre and production throughout the range.

   Fröshels, 1920

2. Two-register theory: The voice has two physical mechanisms, therefore only two registers are possible. Both mechanisms are involved to some degree at all times.

   Mancini (1774): Chest and Head or Falsetto
   MacKenzie (1899): Short Reed and Long Reed
   Stanley (1929): Lower and Upper
   Wilcox (1935): Light and Heavy Mechanisms
   Reid (1950): Chest and Falsetto

3. Three-register theory: This is the most popular theory, however, the names of the registers vary widely.

   Garcia (1855): Chest, Falsetto, and Head
Curwen (1875): Thick, Thin, and Small
F. Lamperti (1877): Chest, Mixed, and Head
Brown and Behnke (1884): Thick (Upper and Lower), Thin (Upper and Lower), and Small
Marchesi (1890): Chest, Medium, and Head (Female)
G. B. Lamperti (1905): Chest, Medium, and Head
Shakespeare (1905): Chest, Medium, and Head
Husson (1950): Voix de poitrine, Voix de fausset, and Voix Mixte
Vennard (1967): Chest, Head, and Falsetto (male), and Chest, Middle, and Head (female)
Appelman (1967): Chest, Middle, and Falsetto (male), and Chest, Middle, and Head (female)
Large (1968): Chest, Middle, and Head
Van den Berg (1968): Chest, Mid, and Falsetto or Head
Sundberg (1987): Chest, Medium, and Head (Female)

Vennard (1967) summarizes:

The vocabulary of registration is as confused as the knowledge of its function. There is considerable prejudice against the use of the word "register", so it is just as well to speak of "heavy mechanism" and "light mechanism". . . dynamically related. . . to minimize the possibility of various static adjustment according to pitch (p. 66).

We may also consider citing auxiliary registers if the definition of register includes the physiological range (all the notes which a
person can produce). Most often mentioned are the Strohbass or church bass (extreme low notes) and the flageolet or whistle register of the high soprano voice. In addition, a terminology problem exists between speech and singing voice scientists. The speech voice scientists use the terms vocal fry or pulse, modal or normal, and falsetto, loft, or upper voice. Singing voice scientists in the United States seem to prefer chest, middle, and head voice as the names of the primary registers of the adult female singing voice. By means of clarification, these two sets of register terms are not strictly parallel. Vocal fry or pulse register occurs below the range of the normal singing voice. Both chest and middle registers are a part of the modal or normal speech register. The head or upper singing voice shares many characteristics of the loft or falsetto category used by speech scientists, but this, too, is debatable, depending on the definition of the head register. It is only the pure head tone, not the head mixture, which has some parallels with the loft register in speech. In some circles, falsetto is considered a secondary or auxiliary register of the singing voice, and is, therefore, not synonymous with the head voice register. The lack of parallel labels between speech and singing voice scientists gave rise to Oncley's humorous comment that the primary registers of the singing voice might just as well be called "modal" and "yodel" (Oncley, in Large, 1973, p. 36).
Voice Production

In simplest terms, vocal sounds are produced by vibrating vocal folds which are activated by a stream of air emanating from the lungs. The pitch (frequency) and loudness (intensity) are dependent primarily on the tension of the vocal folds and on the subglottic air pressure. The perceived end quality of the sound produced is determined not only by the laryngeal action but also by the transmission (resonance) properties of the vocal tract. These principles comprise the "myoelastic-aerodynamic theory" of voice production.

Physiologically, the voice shows two distinct registers. In this century scientists have used high speed cinematography, radioscopic methods (x-rays), electromyography, and most recently, fiberoptic video techniques to find the mechanical principles which characterize the different registers. This technology has confirmed that:

1. Chest voice (male and female) involves whole cord (full vocal fold) vibration.
2. Falsetto production involves vibration of only a portion of the vocal folds.
3. In the whole cord (full fold) mechanism, a rise in pitch is produced by tightening and lengthening the vocal folds, primarily under the influence of the cricothyroid muscle.
4. Falsetto production shortens the length of the active portion of the vocal folds.

5. Cricothyroid exertion on a given pitch is greatest for head voice; vocalis effort is greatest for chest voice production.

6. Vocalis activity is correlated with intensity (loudness) in both registers; the cricothyroids compensate by correlating inversely with loudness. Cricothyroid activity correlates in frequency (pitch).

7. Heavy registration (chest voice production) is primarily myoelastic, with airflow needed only to maintain phonation. Here the cricothyroids are the primary pitch agents.

8. Light registration is primarily aerodynamic, with the musculature active only enough to maintain phonation. Here breath is the primary pitch agent.

The muscular antagonism mainly between the cricothyroid and vocalis muscles serves as a basis for physiological understanding of vocal registers. Refinement of these registration basics provides a clearer picture of what happens in singing as well as an avenue for ongoing research. The actual length of the vocal folds does not change so much throughout the full singing range as to be the only pitch change factor. Density, thickness, tension, and width of the vocal folds are also important. The contraction of the thyroarytenoid and vocalis muscles create varying degrees of firmness or looseness in the vibrating medium. The denser the glottal "margin", the lower
the pitch. Thickening of the vibrating medium lowers pitch; thinning raises it. Tensing of the folds raises pitch; slackening lowers it. The resonating system works together with the phonatory mechanism. Conscious enlargement of the resonators is equally as important to the study of registers as is the muscular control of the vocal folds.

All pitch skips that involve moving from one register to another demand a conscious adjustment of the coupled resonating system and the phonatory mechanism in one synchronous act. Enlargement of the resonators is no more important than controlling the vocal folds. Each act must complement the other (Appelman, 1967, p. 87).

The position of the larynx in the phonatory tube changes more when passing between the registers in the trained voice than in the untrained voice. The untrained singer resists the change in quality and production that comes with the transition out of chest or speaking voice production. By using his vocal folds to resist the pitch raising process, he is increasing the muscular antagonism to the cricothyroid muscles. When he lets go and lets the breath take over, the aerodynamic release provides a sensation of relief. The trained singer attempts to enlarge the pharyngeal tube to assist the passing of muscular domination. The untrained singer who resists transition experiences a spasmodic readjustment or "break" in the voice. The major break or unassisted transition point occurs around f4 above middle c (c4) in men's and women's voices. "The point of transition
occurs by acoustical law and through an adaptation of the total resonating space, always on the level of the same frequencies, around E flat, 311 Hz and F, 350 Hz" (Appelman, 1967, p. 87). In adult females and in children's voices this is the transition between the chest and the middle registers if we subscribe to a three-register theory. The head voice is relatively continuous with the middle register in these voice types.

Some of the perceptual problems incurred in register studies derives from the premise that there are frequency areas which may be produced by means of either register mechanism. In other words, some register areas overlap. These transitional tones have been called "amphoteric tones". Large (1968) uses the term "isoparametric tones" to label pitches of the same frequency, sung with the same sound level and phonemic category in different registers. In a study of female chest and middle registers, he found that in the production of isoparametric tones, the female chest register exhibited greater energy in the higher partials while the middle register showed more energy in the fundamental.

Every voice has a potential of roughly two octaves of "light mechanism" and two octaves of "heavy". These compasses overlap by one octave; that is, one octave can be sung in either laryngeal adjustment. In this area... it is possible to achieve a production that combines the best properties of both (Vennard, 1967, p. 73).

"Registration is considered primarily as a method of pitch control for the exploitation of range" (Vennard and Hirano, in Large,
1973, p. 48). Thus, the ability to use the normally expected singing range of at least two octaves involves tonal production in two or more registers and the ability to make effective transitions between the registers. One uses a little over an octave span in speaking. Therefore, the untrained singer has little difficulty in singing pitches within that (speaking voice) range. However, as he ascends in pitch towards the end of that range, he will often involuntarily raise his chin and his larynx. As he continues upward, the change in vocal quality becomes more apparent, and will soon break off or shift abruptly into a falsetto quality. Miller (1986) continues the Italian bel canto tradition of naming the first shift (the point at which the laryngeal elevation occurred) the "primo passaggio" (first register shift), and the second point, about a perfect fourth higher, the "secondo passaggio" (second register transition). The area between these two points, called the "zona di passaggio" (passage zone), requires an increase in breath energy and use of the heavier mechanism, similar to the action used in calling or shouting for the untrained singer. One mark of the trained singer, and therefore a goal of vocal education, is register equalization or easily negotiated register transitions. The "seamless" line which results is characterized by a predominance of singing voice production and a lessening of speaking, calling, or shouting vocal productions.

The child voice is closer in anatomical size and vocal production to the adult female voice than it is to the adult male voice. It may, therefore, be postulated that register events and related production
difficulties are similar to some degree in children and adult females. Perceptual register studies have been conducted with adult men and women, trained and untrained singers, but to date no register studies have been conducted with pre-pubescent children. Vocal range studies using children of all ages have mentioned the existence of registers (Wassum, 1979). In order to gain a framework for study, an examination of register findings pertaining to adult females is warranted.

Registers in the Adult Female Singing Voice

The primary point of transition for the female occurs between the chest voice and the middle voice. The second transition point, into falsetto for males, is not so marked when the female singer makes the transition into head voice. "Falsetto" used as a term to designate an auxiliary register in which a male attempts to imitate a female voice, is an inappropriate term for any aspect of the female singing voice, whether in observed production or in perceived quality.

The shift from chest register in women's voices to the next higher register, the "primo passaggio", is primarily a mechanical necessity to effect pitch change. The "secondo passaggio" is a transition into "pure" head voice. Occurring around f# 5 (top treble staff line), "the gradual thinning of the vocal-fold edges, which has taken place gradually over the ascending scale, now becomes
pronounced; much less vocal-fold mass is available to offer resistance to subglottic pressure" (Miller, 1986, p. 143).

It is pedagogically convenient to call a vocal register in which the thyroarytenoids are predominant, the heavy mechanism, and to call those registers in which the cricothyroids are predominant, the light mechanism, so long as it is understood that there are not actually separate mechanisms, but changing dynamic balances among the laryngeal muscles. . . . Separating the chest register from the head register results in driving up the chest voice beyond the "primo passagio" terminal point through heavy thyroarytenoid action. . . . However, bringing the head voice downward into the low register is not an act of register separation, but rather a technique for register combining (Miller, 1986, pp. 133-134).

Bunch (1982) summarizes:

The characteristics of heavy registration are:
1. thick vocal folds that close firmly for each vibratory cycle;
2. a large amplitude of vibration (movement away from the midline);
3. closure and opening of the vocal folds beginning at their lower edges; and
4. a loud tone rich in harmonic partials. . . .

The characteristics of light registration are:
1. vocal folds that are stretched thin by the combined action of the crico-throids and posterior crico-arytenoids, and at the highest pitches only the vocal ligaments are vibrating (this produces falsetto);
2. glottal closure is brief and incomplete for each cycle because of the high tension in the vocal folds; and
3. the tone has fewer partials and is not as loud as that produced in heavy registration (Bunch, 1982, p. 70)
Below the "primo passaggio" is chest voice; above the "secondo passaggio" is head voice. All that which falls in between is a mixture of both: mixed voice or middle voice. In adults, the points of transition are relative to vocal quality or classification. Mathilda Marchesi, a pupil of Garcia, was one of the most celebrated singing teachers of the late 19th century. Based on observations made in her teaching, she proposes, "the highest note in the chest register in all female voices--contralto, mezzo-soprano, dramatic soprano, and light soprano--varies between E4, 330 Hz, and F4-sharp, 370 Hz; the highest note in the medium register varies from F5, 698 Hz, to F5-sharp, 740 Hz" (Marchesi, in Large and Murray, 1980). John Large collected data from numerous studies which measured register boundaries in adult singing voices. Although there were many different results cited, the average findings placed the lower limits of the middle voice in the area of d4 (294 Hz) to f4 (349 Hz), with the upper limits of the middle voice ranging from d5 (587 Hz) to f5 (698 Hz). The resultant observation was that as the classification of the voice became lighter, the transition points became higher. (Large, 1973). Appelman reports that the transition into chest voice occurs between the b below middle c (c4) and the e\textsuperscript{b} (e\textsuperscript{b}4) above it, depending on voice classification. While some females can extend chest voice quality to g4 or a4 above middle c (c4), he agrees with Garcia and other bel canto singing masters in admonishing chest voice production above e\textsuperscript{b}4. Appelman cites the secondary point of transition as occurring on e5 or f5 at the top of the treble staff. This
transition is less evident to the listener, but is felt by many singers as an area of instability when ascending in pitch (Appelman, 1967). Miller includes both transition tones and register "zones", recognizing that registers overlap, allowing for tones which can be produced in one of two registers (see Figure 7). He also indicates timbre or resonance change places perceived by some voices midway in the middle register, making a lower and an upper middle register.
SOPRANO REGISTERS AND TRANSITION TONES

(Primo Passaggio)         (Secondo Passaggio)
\[ g^3 \quad b^b^3 \quad e^b^4 \quad c^5 \quad c^#^5 \quad f^#^5 \quad g^5 \quad c^6 \]

|------Chest------| |------Upper------|

|------Lower Middle------| |------Upper Middle------|

MEZZO-SOPRANO REGISTERS AND TRANSITION TONES

(Primo Passaggio)         (Secondo Passaggio)
\[ e^3 \quad c^4 \quad e^4(f^4) \quad b^b^4(b^4) \quad e^5(f^5)(f^#^5) \quad b^b^5(b^5) \]

|------Chest------| |------Upper------|

|------Lower Middle------| |------Upper Middle------|

CONTRALTO REGISTERS AND TRANSITION TONES

(Primo Passaggio)         (Secondo Passaggio)
\[ d^3 \quad f^4 \quad g^4(a^b^4) \quad a^4 \quad b^b^4 \quad d^5 \quad e^b^5 \quad a^5 \]

|------Chest------| |------Upper------|

|------Lower Middle------| |------Upper Middle------|

Figure 7. Female Registers and Transition Points as reported by Miller (1986)
Conclusion

Because vocal production affects the usable singing range, the study of registers, as the audible result of a certain production in a given pitch range, should provide information relevant to the functioning and needs of the untrained singing voice. If the one-register concept is the vocal ideal, then the obvious presence of different registers in the singing voice may be an overt manifestation of production problems. Attention to registers, therefore, is warranted as a means of assessment of vocal proficiency. The perception of register events ("breaks", "stops", "yodels") in the functional range of a person's singing voice signals a need for specific pedagogical procedures to facilitate full, efficient, and healthful production of the singing voice. This study is designed to describe the ways in which vocal production and resultant registers affect the singing ranges of a large group of untrained singers, elementary school children.
CHAPTER III

STUDY DESIGN

Register events in the singing voice occur as a function of vocal production in a given pitch range. Having the ability to use the entire singing range implies the ability to make register transitions. This study was designed to show where register transitions occur in the singing voices of children. By means of a production approach to range study, it will be possible to describe some of the conditions under which students do or do not negotiate smooth register transitions. These findings will have direct bearing on the disputed issue of "proper" ranges for singing in the elementary school. The implications for vocal pedagogy are relevant to beginning singers of all ages.

Studies of children’s singing voices fall primarily into two categories: range studies and pitch accuracy studies. Often the study of one area has produced additional findings in related areas. Because vocal production governs the usable pitch range, it was decided that testing procedures in this study would be based, in part, on range study procedures.

In their studies, several researchers noted the presence of different registers or areas of different tone quality based on
production (Young, 1971; Moorhead and Pond, 1978; Wassum, 1979). Jersild and Bienstock (1931), Joyner (1969), and Smith (1970) found lower range intervals to be more accurately sung than intervals requiring a transition between higher and lower ranges, implying the presence of registers with different range boundaries. Others concluded that the relationship between poor pitch singing and vocal production difficulties was strong (Jersild and Bienstock, 1931; Smith, 1963; Joyner, 1969; Forcucci, 1975; Roberts and Davies, 1975).

Studies documenting the ranges of children's singing voices have been conducted by numerous researchers who have approached the topic from various directions. Some have investigated "comfortable" ranges, finding that these center around the speaking voice pitch (middle c4 or d4) and move outward. These, then, would be the ranges of the "natural", untrained singing voice. The limits of these ranges are governed by vocal production. Students who have not learned, either formally or informally, to use the true singing voice, the head voice, cannot ascend beyond the upper limits of speaking voice production. This problem is common to beginning singers of all ages. A testing instrument needed to be designed to reveal the presence and location of registers in children's singing voices. Tasks would have to be selected to induce or inhibit register transitions to show normal and extended boundaries for the registers present in the child voice.
The Instrument

A singing test was designed by the investigator to be administered to elementary school students in grades K-6. The content of the test was based on research findings and pedagogical principles of vocal development. Prior studies using children had shown that musical accuracy was more likely to occur when the children sang individually rather than in groups (Goetze, 1985). For that reason, this study was designed to record the singing voices of children performing one at a time in direct response to the instructions of the researcher. Each child sang unaccompanied, based on the success in singing a cappella over singing with full accompaniment noted by Gould (1969), sometimes in a key of his choice, sometimes in a key given by the researcher. The tasks were divided into two groups: song literature exercises (sung with text) and pitch pattern echoing exercises (sung on a neutral syllable).

Song Literature Section. Studies using song material (with text) to measure ranges and/or pitch accuracy were used by some researchers. Hattwick (1933) and Kirkpatrick (1962) used songs pitched by the child. Smith (1970) and Wassum (1979) prescribed the pitch level of the song performances in their studies. For this study, the song "Row, Row, Row Your Boat" was chosen. The song progresses from low tonic stepwise to the dominant ("Row, row, row your boat Gently down the Stream"). It then leaps upward to the high tonic and descends by intervals which spell out the tonic chord
("Merrily, merrily, merrily, merrily"). The last phrase begins on the dominant and descends by step ("Life is but a dream"). The low starting pitch of this song gives the student a chance to begin at a comfortable pitch level. Hattwick (1933) and Wassum (1979) showed that the self-chosen starting pitch of any song was likely to be at or below the speaking pitch level, regardless of the pitch level at which the song had been presented. The melodic progression (ascending/descending and step/skip/leap) is also research-based. A brief summary of findings shows that children sing steps and thirds more easily than wider leaps (Jersild and Bienstock, 1931; Clegg, 1966, cited by Goetze, 1985; Updegraff, Heiliger, and Learned, 1937, cited by Goetze, 1985). Yet Gould (1969) found that students could find and bring down head tone when they leaped to it rather than attempting to ascend stepwise to head tone. Drexler (1938) found descending intervals easier than ascending, with the ability to ascend increasing with age.

**Pitch Pattern Section.** The types of exercises chosen were based on procedures used in previous research studies measuring singing ranges and pitch matching accuracy in children. Register studies using adults, both trained and untrained singers, provided additional sources of singing tasks. In some cases, pedagogical tools used for the unification of the registers were reversed to induce more noticeable register transitions. Three types of pitch patterns were chosen for the study: descending stepwise patterns, ascending scales, and leaps in both directions, all sung on a neutral syllable.
Goetze (1985) found that the use of the neutral syllable "loo" produced more accurate pitch singing than the use of text, as did Gould (1969), Moog (1972), Moorhead and Pond (1978), and Gordon (1984). The syllable "ah" was chosen for the study to open up the sound of register changes. By not allowing the amount of breath output that "ah" allows, the syllable "loo" would inhibit the exaggerated productions desired to reveal register information.

The first pattern, a five-note descending pattern ('sol-fa-mi-re-do'), was sung beginning on the pitches g4, f4, and eb4. Two patterns were demonstrated loudly in a heavy chest production and one was sung softly in a light mixed production. All three patterns were sung legato. The range of the descending patterns was ab3 to g4.

The second pattern was an 8-note ascending scale begun on middle c (c4) and on f4. The choice of scale-step pitch motion was based on previous research. Scales were used by Fröschels (1920), Wassum (1979), and Geringer (1983) in child voice studies. Register studies with adults also used scales to measure range boundaries (Vennard, Hirano, and Ohala, 1970; Large and Murray, 1980; Schoenhard and Hollien, 1982; Keider, Hurtig, and Titze, 1987). The ascending scales with the ranges of c4-c5 and f4-f5 were chosen to induce register changes; these scales necessitate a change in production to sing correctly all eight pitches.

The third pattern was sung differently using h's to articulate the pitches of the 'do-sol-do' pattern. This insertion of h's is a pedagogical tool which allows the voice to shift registers by
momentarily taking it "out of gear". The pattern was presented beginning on middle c (c4), f4, b♭4, and either a♭4 or c5, depending upon the success of the previous pattern. The range tested by the third set of patterns was c4 to f5 or g5.

The singing test had a set sequence of measurement tasks, but also had some flexibility built into the procedure. If the standard tasks did not succeed in exhibiting the student's ability to use more than one register with regard to pitch range and vocal production, an additional set of tasks was proposed to attempt, through remedial procedures, to find the unused register. If the student had not found any sort of head tone in either of the two previous sections of the test, he was asked to imitate a "cuckoo". The researcher modeled, singing the falling minor third f#5 to d#5 three times in succession. The student was asked to imitate that sound. Gould (1969), Jones (1971), and Young (1971) found the falling minor third ("yoo-hoo") to be the most frequently matched interval.

Pitch matching studies have shown that students are more successful when attempting to match another voice, specifically a female voice, rather than matching pitches produced by instruments. The effective use of a female model for pitch matching has been documented by Clegg (1966) cited by Goetze, 1985, Boardman (1964), Sinor (1985), Small and McCachern (1983), and Sims, Moore, and Kuhn, (1982). Each testing pattern was sung by the researcher in person rather than on tape, due to the flexibility built into the
procedure to meet each child where he sang. Tone bells were used to
give consistent starting pitches to the researcher.

The entire procedure, lasting five to seven minutes for each
child, was recorded on tape. The researcher later transcribed the
taped performance of each student, evaluating range, production, and
register events on a rating sheet.

Register Transitions. Register transitions were noted by means
of circling pitches in the transcribed student performances. Ability
to make register transitions were rated using descriptors to chart one
aspect of the vocal development of each student based on this ability.
Evaluation of singing responses by pitch transcription appears in the
studies of Boardman (1964) and Sears (1965), cited by Goetze, 1985.
Rating scales based on numbers with specific descriptors were used
in the evaluation processes of Clegg (1966), cited by Goetze, 1985,
Smith (1970), Smith (1963), Buckton (1983), cited by Goetze, 1985,
Sinor (1985), and Rutkowski (1989). Five categories of vocal
development based on the ability to negotiate register transitions
were delineated:

1) The student sings only in one register; range is severely
limited.

2) The student independently chooses only one register, but
   can find a second register with help.

3) The student uses head and chest registers, but exhibits
   marked breaks in production.
4) The student can lighten production to increase range, but lacks a clear head tone.

5) The student makes smooth register transitions; there are no production problems related to range.

Summary. A summary of findings would chart the ranges used in the song literature portion, the pitch pattern portion, and the total singing range used in the test, with areas of production in various registers marked on the pitch range summary. The data could then be organized by grade level, by gender, and in relation to the prior evaluation of melodic accuracy or tunefulness. Independent raters would be used to corroborate the researcher's findings, rating one fourth of the student performances (n=71).

Pilot Study

In order to evaluate the effectiveness of the study design and measurement devices, a pilot study was conducted. Students (n=47) at Washington Elementary School, Tiffin, Ohio, in grades K-4 were randomly selected by the music teacher to participate in the preliminary study. During each music period several students were selected. The testing site was a Wenger practice room module in the lobby of the school.
The Procedure

As each child entered the testing room, the researcher talked briefly with him to explain what would occur. The students were told that the researcher wanted to hear how elementary school students use their singing voices. They were told that they would be asked to use their high voices and their low voices, their loud voices and their soft voices, but always their singing voices.

Song Literature Section. The first part of the project was described as a game using a song that the student knew well. "Row, Row, Row Your Boat" and "Twinkle, Twinkle, Little Star" were suggested. (If the child knew neither of these, other familiar childhood songs were suggested.) The child began on his own, singing unaccompanied in a key of his own choosing. Next, the researcher explained the "game" of singing the student-selected song starting on different pitches chosen by the researcher. Keys were chosen to span the expected upper and lower transition areas, inducing either a production/register change to stay in the tonality or a tonality modulation to avoid the necessary vocal change. The investigator took a pitch from the tone bell, sang the first phrase in that key, and instructed the student to sing his song in the new key. With some singers, it was necessary to begin singing with the child, and then drop out to establish pitch/tonality. The student was then complimented on some aspect of his performance to increase his self-confidence and motivate him to sing more confidently in the next
section. He was told that the second part of the project involved singing without words. The researcher demonstrated the non-verbal cueing procedure she would use to perform and have the student echo, instructing the student to match her voice in loudness as well as pitch.

**Pitch Pattern Section.** The second part of the procedure involved having the students echo tonal patterns on a neutral syllable. All students in the pilot study had previous experience with this procedure in their classroom music instruction. The first set of patterns were 5-note descending patterns, covering middle to low ranges. The second set included three ascending scales, moving progressively higher from middle to upper ranges. The third set involved a leap (do-sol-do) at intervals spread throughout the range.

If the student had not demonstrated any use of the voice other than in the low, speaking voice range, several remedial procedures were attempted to induce a higher range, head voice production.

The tape recorded performances of all of the students were evaluated by the researcher. For the pilot study, every fourth performance was dubbed onto new tapes and sent to three independent raters.

**Student Responses**

Students in grades K-4 were able to use their singing voices in a number of different ways in response to the verbal directives and
sung models given by the investigator. The tested range of ab3 to g5 required the use of more than one register to accommodate all of the pitches. Students who covered that range in their singing performances did indeed exhibit two or more registers. Chest tone and head tone qualities were recognizable, as was a large area of overlapping quality. How productions and resultant tone qualities were produced and identified varied greatly.

Song Literature Section. Corroborating earlier research (Hattwick, 1933; Wassum, 1979), it was observed that the initial starting pitch of the song chosen by the student was quite low, at or below the speaking voice pitch. Depending on the volume and effort of the first song attempt, the performance was almost always sung totally in heavy or light chest production. The next song attempt was to begin on a pitch given by the researcher. The pitch range of the second trial also encouraged chest voice usage for the first part of the song. While neither pitch range of the first two song attempts seemed worrisome to the student, he often chose a key or modulated lower within a song and found himself too low to sing accurate pitches even in his own tonality. In this case, he growled, whispered, or chanted the words with little semblance of pitch. The remaining two song trials were begun on pitches intended to encourage or require head voice production. Most students could lighten their vocal production to get somewhat higher, but not all of the students could find a clear head tone in the song literature. More frequently, students either modulated within a song to avoid uncomfortable
pitch ranges in the production in which they had begun, or disregarded the starting pitch given by the researcher to begin in a more comfortable range. Two of the four song trials were placed in keys which could be sung in a mixed production or middle register. Some students, by changing keys or singing incorrect pitches, sang everything in a mixed production/middle register, making register identification difficult in the song literature portion of the testing procedure.

Pitch Pattern Section. The pitch pattern echoing procedure revealed additional information about students' abilities to handle their singing voices. The five-note descending patterns were chosen to exhibit the transition into chest voice at varying dynamic levels. Primary register information was more perceptible at louder volumes, but the softer patterns yielded information about the lower range of a light, mixed production and the possibility of a "natural" chest tone occurring at a point just below the end of the mixed tone. These patterns were easily sung by the students. The lowest tested pitch, low ab, was seldom out of the students' range. Because of the amount of register information provided, three of these patterns, those beginning on g4, f4, and eb4, were kept for the study.

Ascending scales sung legato on [a] ("ah") were chosen to force a register/production change or to show the results of avoiding the necessary register change. The latter was prominent in at least one of the scales for most of the students. While initially distracting, inaccurate responses (wrong pitches) did provide register transition
information not tested by any other procedure in this study. For expediency, one scale was dropped. The notion of starting on a given pitch and singing step-wise to the end of the range was not successful with children. The student too often ran out of air sooner than he ran out of pitches. When he stopped to breathe, he often adjusted his vocal production, thereby distorting the register information desired in a continuous line. The 8-note scales beginning on middle c (c4) and on f4 were kept for the study.

The 'do-sol-do' patterns were successful for the student and the listener alike. The singer was able, usually, to leap to a different production, and the results were obvious to the listener. Those students who could not negotiate register transitions previously were often able to find head tone by leap. Pitches for these patterns were effective choices. The pilot study did reveal that the semi-staccato articulation using initial h's ("ha-ha-ha") was more successful in inducing register changes than the same pattern sung legato. For the full study, three initial pitches of c4, f4, and b♭4 were kept, with the fourth starting pitch being either a♭4 or c5, depending on the success of the previous pattern. The pitch range tested with these patterns would be c4 to f5 or g5.

For those students who at no time revealed any semblance of head tone quality, several remedial procedures were used: sirens, descending glissandos, animal sounds. The "cuckoo", a falling minor third from a high pitch, was the most consistently successful device in eliciting head tone. This one technique was kept for the full study.
Conclusions. The pilot study confirmed the organization and content of the singing test as originally designed. Refinements were made to eliminate redundant or ineffective measures. It was seen that finding a common test song without its being taught was unlikely. Therefore, the study was planned with an introductory session that taught or reviewed the chosen test song. The pitch patterns and remedial techniques were limited to those which provided the most information about the production and range of vocal registers.

Rater Responses

The rating form (Appendix B) for the pilot study was effective, but not efficient. The researcher had intended to seek corroboration on as much singing performance information as possible. In order to evaluate pitch accuracy, type of production, register, and later, register transition point, the judges had to make repeated listenings, which required inordinate amounts of time, and often resulted in questioning or even changing original perceptions of register/production. Accuracy ratings were irrelevant to the project's primary research questions, and often got in the way of perceptions of production. This rating item was removed from the raters' sheets for the full study.

Song Literature Section. Rater responses displayed close but not exact agreement on register and production choices between the
three judges and the researcher. Only three times in the 34 song trials heard by the pilot study judges (8.8%) were the raters' responses spread to include chest, head, and middle voice or heavy, light, and mixed production for a single performance. Beyond these examples, only once were chest and head voice chosen for the same performance; only twice were heavy and light production both marked for the same performance. Total agreement between the researcher and all three judges was reached 26.4% of the time in production identification and 32.3% of the time in register identification. Therefore, 55.8% of the time responses were spread either between chest and middle voice or head and middle voice. In 58.8% of the examples, the responses were split between heavy and mixed production or light and mixed production. It is interesting to note that the better balanced voices produced more disagreement. The poorly produced voices exhibited more clearly defined register characteristics which were more easily recognized by the raters.

A questionnaire was included in the packet (see Appendix B). Several judges remarked that while the form itself was not confusing, trying to choose a production type and a register was confusing. Personal background and bias entered into their choices in this area. When asked if the middle voice was a true register or an overlapping area between chest and head registers, all chose the latter. The choice of middle voice was removed from the study raters' sheets. The decision that the song performances in the study be evaluated only as being sung in predominantly chest register or
predominantly head register was made for two reasons. The focus of the study was vocal registers; therefore, any other area of evaluation was secondary and must not distort the focus. Secondly, if there are mechanically only two registers, then any tone must be somewhere on the continuum between raw chest tone and pure head tone. The judges would be asked if the sung responses were closer to chest (speaking) production or closer to head (singing) production. The limitation of the choices would force the issue.

Pitch Pattern Section. In the second section of the singing test, the judges were asked to circle the pitch in transcribed student responses where a production change occurred. The perception of production change and resultant register change is difficult, perhaps more so in children than in adults. The intensity of the response can facilitate register identification when sung loudly, and can make identification of register events difficult when sung softly. The good singer who can adjust his voice to accommodate changes in pitch, volume, and articulation was able to disguise register transitions that were more apparent in less able singers, especially those who sang everything in heavy chest production. All students responded to imitate the pitch direction and volume changes of the researcher’s model, but did not always provide the breath support or exaggerated breath pressure modeled to inhibit or induce register changes. Resonance and production changes were perceptible, although all of the judges responded that they had to re-hear many of the taped
examples to accustom their ears to the more subtle changes of child singers.

It was observed that register transitions were more easily perceived as occurring between two pitches, rather than on a given pitch. Agreement among the judges on specific pitches where production changed occurred in only 22% of the pitch patterns sung (in which a change of production was noted by any one or more of the judges). The examples that evoked agreement among the judges were usually heard and described as a wobble on a given pitch (before the voice was solidly in the new register on the next pitch). Because the judges were asked to circle the pitch where production changed, the rater responses were more frequently divided between two pitches, the last pitch in one production and the first pitch in a new production. This occurred in 32% of the examples (in which a production change was noted by one or more of the judges). The instruction was changed to "draw a line between the two pitches where you perceive a production change occurring" for the study raters' sheets.

Conclusions. The judges, two public school music specialists who work with elementary childrens' singing voices and one college voice teacher, agreed that the evaluation procedure and test items were well-designed. All agreed that the pitch pattern echo process provided more information about registers and register transitions, but that the song literature section was necessary and "more realistic".
To the researcher, the pilot study results provided the assurance that register events, though subtle, are perceptible in childrens' voices. In addition, the test procedure was condensed to the most effective procedures and the rating sheets for the judges were reduced to the most efficient, concise wordings possible. The pilot study confirmed the researcher's beliefs that production is directly related to range and that the head voice must be consciously taught, developed, and consistently encouraged by those who work with the singing voices of children.

The Study

The study was conducted in March 1990 using the entire student population of Lincoln Elementary School. Lincoln School is one of six elementary schools in the Tiffin Public School System, and is representative of the city's limited cultural and socio-economic diversity. The 285 students (see Table 1) in Lincoln School (K-6) receive classroom music instruction for 30 minutes twice weekly. The music teacher has taught public school music for 26 years, and has been in that school for the past 7 years. She has a strong vocal background, and is a performer and voice teacher outside of school hours.

String instruction is offered beginning in fourth grade. At the fifth grade level students may begin instrumental study on band instruments and/or audition for the choir, the "Lincoln Larks".
Before the testing procedure started, the researcher visited each music class, explaining and demonstrating what she would be doing in her project. The song "Row, Row, Row Your Boat" was rehearsed in each class, and was sung several times in different keys. Students were told that the researcher wanted to hear how they used their singing voices, both high and low and loudly and softly. Next, the students were asked to echo some patterns which would appear in the singing test. The students were reminded to imitate the researcher's loudness (or softness) as well as the pitches. When the researcher sang loudly in heavy chest production, many of the students laughed at the raucous quality. Students in each level attempted the exaggerated sound of that production in this introductory session. Soft singing by the researcher evoked more tuneful, more healthfully produced singing and fewer negative or surprised responses. The researcher attempted at all times to produce a clear tone free of excessive vibrato.

The Procedure

The students were sent from the music classroom (according to the alphabetically organized class lists) to the testing site, the teachers' lunchroom. Each student was greeted by the researcher and instructed to stand on the tape-mark X on the floor, six feet from the tape recorder. (A cassette recorder with a built-in microphone was chosen to be less invasive and less distracting--see Appendix A).
<table>
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While the student got into place, the researcher wrote down the student's name and grade level. She reminded each student that she was hearing every student in Lincoln School sing to see how each person used his or her singing voice both high and low and loudly and softly. The student was reminded that there were two parts to the procedure, the first of which was the singing of a song.

**Song Literature Section.** The student was asked to begin "Row, Row, Row Your Boat" on a pitch of his choice. If this song was not well known, "Jingle Bells" or "Twinkle, Twinkle Little Star" was suggested. In rare cases in which none of these songs were known, the student was asked to echo phrases of the original test song sung by the researcher. Regardless of the key chosen by the student, the researcher proposed that the student sing the song three more times, once in his high voice, once in his middle voice, and once in his low voice (spoken in appropriately varied pitch levels). The investigator used a set of fixed resonator bells to get starting pitches. She played the pitch, and then sang the first five words of the song followed by a return to the tonic for a sung "ready-go" cue. (If the student needed help, the investigator began singing with the student and then dropped out.) The song was sung on low a (range a3-a4), e4 (range e4-e5), and g4 (range g4-g5), each chosen to bridge a possible register transition. At the end of the song literature section, the student was complimented on some aspect of his performance to increase his self-confidence before continuing to the less familiar pitch pattern echoing section.
Pitch Pattern Section. The second section in the project was the pitch pattern echo section. The student was told that the patterns would be sung without words, on the syllable "ah”. The student was reminded to sing loudly if the researcher sang loudly and softly if the researcher sang softly (said at appropriately different dynamic levels). For each pattern, the initial pitch was played on the bells. The pattern was sung by the investigator, who then returned to the first note and sang "your turn" or "start here" as a vocal cue to begin. If the student had not found any sort of head tone in either of the two previous sections of the test, he was asked to imitate a "cuckoo". The investigator modeled, singing a falling minor third f#5 to d#5 three times in succession. The student then attempted to imitate that sound. At the end of the entire procedure, lasting approximately five minutes, the student was thanked and asked to send the next student to the teachers' room.
CHAPTER IV

PRESENTATION AND DISCUSSION OF FINDINGS

In order to describe the nature of the vocal registers in the singing voices of children, a singing test was administered to the entire population of an elementary school, grades K-6. Performances in the singing test were recorded on cassette tape, and were later transcribed and evaluated by the investigator. Two adjudicators independently listened to a random sample of 25% of the total 285 taped performances. The goal of using raters was two-fold. The raters' responses were used to corroborate the investigator's findings. In addition, the investigator used the raters' responses to see how well musically trained judges could identify registers and register changes in the singing voices of children. A reliability estimate was made by comparing the proportion of agreements to total judgments in a representative selection of test items. Aural perception and labeling of vocal register events produced a wide variety of responses. The low reliability estimate, .70, reflects the problem inherent in studies which seek to quantify vocal quality. The perceptual identification of obvious register events stands in contrast to the desired vocal education goal of register blending to make register transitions imperceptible.
In this study, register identification was facilitated by extremes of vocal production. At one end of the spectrum, the well-balanced voice that made smooth register transitions provided fewer aural clues as to the type and boundaries of the register of production. At the opposite end of the spectrum was the voice which resisted any transition out of the familiar, speech-like chest register. Judges were able to identify registers and register transitions with varying degrees of agreement. In many cases, written comments provided more information about the performance than did the requested response.

Register Overview

It was found in this study that the singing voices of children do exhibit the presence of two distinct vocal registers. Eighty-eight percent of the students tested were able to find two primary registers or areas of different tone quality based on vocal production in a given pitch range. The two primary registers in children's singing voices (see Figure 8) include both a lower and an upper register. The data revealed that the lower register may take the form of heavy or light chest production, and may be pure chest or a mixed chest tone production. The upper register may take the form of pure or mixed head tone production. In between raw chest and pure head registers is an overlapping section, or secondary register (see Figure 8), in which muscle control is distributed between the two major muscles
Primary Registers

Primary Point of Transition

\[ \begin{array}{ccccc}
  a_b^3 & d_4 & g_4 & a_4 & g_5 \\
\end{array} \]

[---Area of Transition---]

[--------Chest Voice--------] [--------Head Voice--------]

Secondary Registers: Middle Register

Secondary Point of Transition

\[ \begin{array}{ccccccc}
  a_b^3 & b_b^3 & g_4 & c_5 & d_5 & f_5 & g_5 \\
\end{array} \]

[-------Middle Register/Mixed Production-----] [Pure Head Tone]

[Pure or] [Natural] Chest Tone

Middle Register: Sub-Categories

\[ \begin{array}{cccc}
  b_b^3 & e_4 & g_4 & d_5 \\
\end{array} \]

[-----------------------------]

Lower Middle
(Predominantly Chest Quality)

-----------------------------

Upper Middle
(Predominantly Head Quality)

Figure 8. Register Boundaries in Children's Singing Voices
of pitch change. The mixed voice or middle register may have chest voice or head voice qualities depending on which set of muscles dominates.

There is a point of passage, the so-called "primo passaggio", at the place where the balance of control is passed from one set of muscles to the other. This point is influenced by the production of the tone (loud/soft, heavy/light, strident/breathy, supported/weak), and actually may span three to five pitches creating an area of transition rather than a specific pitch at which the register transition occurs.

As seen in Figure 8, g4 was found to be the point of transition between the primary registers. A secondary point of transition occurred, going from a mixed production into pure head tone, in the vicinity of d5. Acoustic properties of the tone produced in the middle register provided aural clues as to the dominance of the primary register.

Register Boundaries

Chest Register

At pitch extremes, registers were fairly easy to perceive and define. Full vocal fold vibration, the chest voice, was more consistently recognized by the raters at the bottom the performer's range. There appeared to be a pitch at which muscular control belonged fully to the thyroarytenoid muscles regardless of the intensity (volume) of the tone being sung. That is, even at a soft
dynamic level, there was a place in the voice that could not be produced in any sort of head tone. A resonance change was heard at this point. This "natural" chest tone came in at b-flat below middle c (b♭3) for the majority of the students.

Above this "natural" chest voice began the production of a mixed vocal tone which is predominantly weighted toward the chest voice, hence described as chest mixture. It may be described as a secondary register extending from the point at which the voice leaves the "natural" chest voice up to the point at which the head mixture takes over. Even with a light production or adjustment of the vocal mechanism, this portion of the vocal range exhibited sounds more characteristic of the chest voice than of the head voice. That is to say, the chest mixture, with the balance of control weighing more heavily on the thyroarytenoid muscles, has a sound more closely related to the speaking voice. It may be throaty sounding, with a feeling of resonant vibration at the level of the sternum. The chest mixture could span b♭3 to g4, a4, or even b♭ 4, with a lightly produced chest mixture possibly pushed even to d5 by some children. A mixed chest production was exhibited by 92.6% of the students with varying upper register boundaries (see Tables 2 and 3). For 32% of the total student body, chest mixture was the highest register of production. That is, everything they sang was in chest register, either with a heavy or mixed production. They had learned to lighten the production to extend their singing range, but were unable or unwilling to make the shift to any semblance of head tone
### TABLE 2

Chest Mixture Upper Boundaries By Grade (Percentages)

<table>
<thead>
<tr>
<th>Grade</th>
<th>e4 (and below)</th>
<th>f4</th>
<th>f#4</th>
<th>g4</th>
<th>a(^b)4</th>
<th>a4</th>
<th>b(^b)4</th>
<th>b4</th>
<th>c5</th>
<th>c(^b)5 (and above)</th>
</tr>
</thead>
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<td>3.3</td>
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<td>10.0</td>
<td>10.0</td>
<td>16.7</td>
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<td>17.9</td>
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<td>7.7</td>
<td>5.1</td>
<td>2.6</td>
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<td>-0-</td>
<td>-0-</td>
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<td>7.9</td>
<td>18.4</td>
<td>15.8</td>
<td>18.4</td>
<td>10.5</td>
<td>5.3</td>
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<td>11.1</td>
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<td>13.3</td>
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<td>6.5</td>
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<td>22.6</td>
<td>6.5</td>
<td>9.7</td>
<td>-0-</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Summary (Percentages)

|        | 4.9 | 7.6 | 4.9 | 24.4 | 9.2 | 14.1 | 8.8 | 12.9 | 8.8 | 5.0 |

### TABLE 3

Chest Mixture Upper Boundaries By Gender (Percentages)

<table>
<thead>
<tr>
<th>Gender</th>
<th>e4 (and below)</th>
<th>f4</th>
<th>f#4</th>
<th>g4</th>
<th>a(^b)4</th>
<th>a4</th>
<th>b(^b)4</th>
<th>b4</th>
<th>c5</th>
<th>c(^b)5 (and above)</th>
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</thead>
<tbody>
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<td>7.3</td>
<td>3.6</td>
<td>21.2</td>
<td>9.5</td>
<td>13.1</td>
<td>10.2</td>
<td>15.3</td>
<td>8.0</td>
<td>7.3</td>
</tr>
<tr>
<td>GIRLS</td>
<td>5.5</td>
<td>7.9</td>
<td>6.3</td>
<td>27.6</td>
<td>8.7</td>
<td>14.9</td>
<td>7.1</td>
<td>10.2</td>
<td>9.4</td>
<td>2.4</td>
</tr>
</tbody>
</table>
production. Chest mixture was carried up most often to g4 (24.4%), but could be driven up to c5 (8.8%), c#5 (1.5%), or even d5 (3.1%). One student was able to push this production to e5. After g4, the most frequent pitch serving as the upper limit of chest mixture was a4 (14.1%), then b4 (12.9%). Between these pitches were a♭4 (9.2%) and b♭4 (8.8%). The pitch f4 was the end of mixed chest production for 7.6% of the students, while f♯4 was the upper boundary for 4.9% of the students.

Heavy chest tone could be driven up in pitch to the point where it stopped or broke into another production if fueled by enough air to achieve the desired loud volume. Of the total number of students in the study, 43% exhibited this heavy chest production in response to the investigator's model (see Tables 4 and 5). More than half of that amount (62%) was comprised of students in grades four, five, and six. Less than half of the students in each of the remaining lower grades used enough air pressure to cause the lower pitches to be produced with a heavy production. This observation reinforces Phillips' (1985) conclusion that group vocal training was effective only from grade two up because of the limited lung capacity and pressure exhibited by those under eight years of age. Heavy chest production was carried to g4 by 33.3% of the students who could sing in heavy chest production. While g4 was the highest note able to be produced in heavy chest voice by the greatest number of students, the highest pitch produced in this production fell in the range of e4 to g4 for 72.3% of the students. No one carried this
# TABLE 4

**Heavy Chest Tone Upper Boundaries By Grade (Percentages)**

<table>
<thead>
<tr>
<th>Grade</th>
<th>c4</th>
<th>c#4</th>
<th>d4</th>
<th>e♭4</th>
<th>e4</th>
<th>f4</th>
<th>f#4</th>
<th>g4</th>
<th>a4</th>
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<tbody>
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<td>K</td>
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<td>26.7</td>
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<td>-0-</td>
<td>18.8</td>
<td>-0-</td>
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</table>

**Summary (Percentages)**

|        | 3.2 | .8  | 8.1 | 9.7 | 15.4| 17.0| 6.5 | 33.3| 5.7 |

# TABLE 5

**Heavy Chest Tone Upper Boundaries By Gender (Percentages)**

<table>
<thead>
<tr>
<th>Gender</th>
<th>c4</th>
<th>c#4</th>
<th>d4</th>
<th>e♭4</th>
<th>e4</th>
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<th>f#4</th>
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<tbody>
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<td>19.4</td>
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<td>GIRLS</td>
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</table>
tone. The pitch g4, as the most frequently sung upper boundary of production higher than a4, with only 5.7% of the students being able to carry this production past g4 to a\textsuperscript{b}4 or a4. Twenty-two percent of the students could not carry heavy chest production up to e4, but 8.1% could take it up to d4 and 9.7% could take it to e\textsuperscript{b}4.

The upper extremes of heavy chest tone production point the direction towards the pitch area where one would expect the control to pass from the domination of the thyroarytenoids to the domination of the cricothyroids, from a mixture which is predominantly chest tone to a mixture which is predominantly head both heavy and mixed chest production, appears to be the transition point between the two primary registers. Although vocal production may alter the point of transition, the pitch area centering around g4 may be called the "primo passaggio".

**Head Tone**

Pure head tone was revealed at the upper ends of the tested range. However, it was also noted that a head-dominated mixture could extend as high as was tested for many students. Only 34.7% of the students tested sang in pure head tone at any time during their performances. While pure head tone could be carried down as low as f4, no one made the transition to pure head voice at that pitch level. It is the starting point of pure head tone that is of greater interest to the issue of register boundaries (see Tables 6 and 7). Students most
frequently started in pure head tone or switched to it at d₅ (23.2%). Others made the switch lower at c₅ (21.2%), or above d₅, at e₄b₅ (14.1%), e₅ (6.1%), or f₅ (18.2%). The so-called "secolo passaggio" or secondary point of transition, thus, occurred in the area of d₅, a fifth higher than the upper boundary of the chest voice. The mixed voice that is predominantly controlled by the cricothyroid muscles has a sound close to, but not the same as the pure head tone. Of the total student population, 67.4% exhibited properties of a mixed head tone production (see Tables 8 and 9). With the exception of Kindergarten, over half of the students at each grade level sang part of the testing procedure in head mixture. Lower boundaries of the head mixture are important because they signal the transition point or area known as the "primo passaggio". Head mixture extended down through e₄ for the greatest number of students, 31.8%. Some could go even lower, taking head mix to e₄b₄ (9.4%), d₄ (18.2%), or c#₄ (10.9%). Those for whom f₄ was the lowest pitch produced in a mixed head register constituted 11.9% of the students. Therefore, while e₄ was the most frequently sung lower boundary of head mixture, the transition area spanned c#₄ to f₄, with 82.2% of the students represented in this area.
TABLE 6

<table>
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<th>Grade</th>
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<th>e&lt;sup&gt;b5&lt;/sup&gt;</th>
<th>e&lt;sup&gt;5&lt;/sup&gt;</th>
<th>f&lt;sup&gt;5&lt;/sup&gt;</th>
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(Percentages)

TABLE 7

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<th>b&lt;sup&gt;4&lt;/sup&gt;</th>
<th>c&lt;sup&gt;5&lt;/sup&gt;</th>
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<th>d&lt;sup&gt;5&lt;/sup&gt;</th>
<th>e&lt;sup&gt;b5&lt;/sup&gt;</th>
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<th>f&lt;sup&gt;#5&lt;/sup&gt;</th>
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### TABLE 8

Head Mixture Lower Boundaries By Grade (Percentages)

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<td>7.1</td>
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<td>8.7</td>
<td>-0-</td>
<td>-0-</td>
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<td>-0-</td>
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</tbody>
</table>

**Summary (Percentages)**

|       | 5.7 | 10.9| 18.2| 9.4  | 31.8| 11.9| 1.6 | 4.7 | 2.1  | 3.6 |

### TABLE 9

Head Mixture Lower Boundaries By Gender (Percentages)

<table>
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<th>Gender</th>
<th>c4</th>
<th>c#4</th>
<th>d4</th>
<th>e^b4</th>
<th>e4</th>
<th>f4</th>
<th>f#4</th>
<th>g4</th>
<th>a^b4</th>
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<td>BOYS</td>
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<td>11.8</td>
<td>9.4</td>
<td>14.1</td>
<td>31.8</td>
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<td>7.1</td>
<td>3.5</td>
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</tr>
<tr>
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<td>10.3</td>
<td>25.2</td>
<td>5.6</td>
<td>31.8</td>
<td>11.2</td>
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<td>.9</td>
<td>2.8</td>
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</table>
Register Transition Ability

To assess the ability of elementary school children to use two vocal registers in the same musical phrase (making the transition between registers), a final item was included on the rating sheet. Five categories of vocal development based on the ability to negotiate register transitions were delineated:

1) The student sings only in one register; range is severely limited.
2) The student independently chooses only one register, but can find a second register with help.
3) The student uses head and chest registers, but exhibits marked breaks in production.
4) The student can lighten production to increase range, but lacks a clear head tone.
5) The student makes smooth register transitions; there are no production problems related to range.

In category one were the students who were stuck in heavy chest tone production. Students of both genders at each grade level fell into this category (see Tables 10-12). These students could not ascend above the pitch of g4. The total number of students who sang only in heavy chest production, thus limiting their ability to join in group singing in the classroom or to use their singing voices reliably as a tool for learning musical concepts constituted 12.3% of the school
population. At each level, the number of boys in this category was
greater than or equal to the number of girls in the same grade.
Second and sixth grade boys had proportionately more in category
one than boys in any other grades.

Category two was an outgrowth of category one. Students in
category two independently chose chest voice production, but were
able to find a head tone, whether mixed or pure, during the singing
test. There were fewer students in this category than in any of the
other categories, only 4.2%. Boys in category two outnumbered girls
two to one.

Category three singers were able to use both head and chest
tones in singing, but were not able to move back and forth smoothly
between the registers. Only 10.9% of the total student body were
originally assigned to category three. Again, the percentage of boys
in this category was greater than or equal to the percentage of girls
in every grade except Kindergarten. If those students who chose an
"all one register or all the other register" approach to singing musical
phrases were added, 5.2% of the total sample could be added to
category three to represent the two register/no smooth transition
group. That is, 16% of the total student population could sing in two
registers, but had not reached the stage of development that allowed
them to make smooth transitions between the registers.

Category four singers could lighten the production of their
voices enough to extend their vocal ranges, but they lacked any
### TABLE 10

Register Transition Ability Rating Scale By Grade (Percentages)

<table>
<thead>
<tr>
<th>Category</th>
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<th>2</th>
<th>3</th>
<th>4</th>
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<td>16.7</td>
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<td>8.9</td>
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<td>53.3</td>
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<td><strong>4.2</strong></td>
<td><strong>16.1</strong></td>
<td><strong>32.3</strong></td>
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<td><strong>(Percentages)</strong></td>
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### TABLE 11

Register Transition Ability Rating Scale By Gender (Percentages)

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<td>----</td>
<td>----</td>
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<tr>
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<td>18.2</td>
</tr>
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<td>-0-</td>
<td>10.5</td>
<td>84.2</td>
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</table>
semblance of a distinct head tone. These students sang in chest and chest mixture, and were able to control the weight of the production, but they resisted the transition to head voice. Category four represented 32.3% of the total student body. Of these, 58.7% were boys and 41.3% were girls. At each grade level except grades one and six, there were more boys in category four than in category five. It was heartening to observe a greater number of students in category five than in any of the previous categories, 40% of the total number of students. These students had enough ability to make transitions between registers so that register production did not limit range.

Predictably, the ability to make smooth register transitions increased with age, experience, and training. Fifty percent more of the students in grades four, five, and six fell into category five than in the lower grades. These are also the grades in which instrumental music and choir are offered to supplement the classroom music program. Almost 60% of the fourth, fifth, and sixth grade students who were designated as category five in their ability to make register transitions also had the benefit of additional music instruction in either strings, band, choir, or some combination of the three. Seventy-one per cent of the fifth and sixth graders scoring in category five were receiving additional vocal training in the choir. It is more plausible to explain this level of vocal development through increased musical experiences, especially singing in an auditioned choir, rather than solely as a function of age.
Discussion

The children participating in this study could recognize and imitate loudness and softness as well as legato and staccato, but could not always regulate the production which creates these effects in all ranges. As beginning singers, they resisted any changes in production demanded by the pitch range of a given song or pattern. As children, they were more concerned with pitch movement direction than with exact pitches, more concerned with song text than with maintaining the given tonality. As child beginners, if the production of a given pitch caused vocal effort or strain different from the production of the previous pitches, they simply sang different pitches or modulated to a comfortable key.

Singing Test Register Information

Chest Tone. All of the students tested (100%) sang in chest register at some time during the singing test. Heavy chest production was identified in the performances of only 43% of the students. The mixed chest register, that portion of the middle register dominated by chest voice qualities, was produced by the greatest number of students, 92.6%. The ascending scale on c4, the 'do-sol-do' pattern also on c4, and the first two song trials provided the most information on upper limits of the chest mixture. Those students who made smooth register transitions allowed the voice to
switch to head register (usually head mixture) around g₄ (hence, labeled as the primary point of transition or "primo passaggio"), while the students who had difficulty making the transition out of chest voice carried the mixed chest production as high as they could before stopping or breaking into a new production and resultant register.

If the singer resisted the shift in muscular balance and attempted to carry chest mixture too high, several features were noticeable. The muscular strain used to avoid transition to the new register was not only felt by the singer as throat tension, but also manifested itself in (a) intonation problems, (b) the need for additional bursts of air to force the tone higher (heard as forced "grunting" sounds), (c) vowel migration from [a] ("ah") to [∅] ("uh"), resulting from (d) the jutting forward of the lower jaw. Rarely could the singer who forced this production beyond normal limits make any kind of transition into head register. The forced tone either stopped (and the student concluded he could not sing any higher) or the tone broke into a new production and resultant new register. If students are limited to chest register, even if they have the ability to lighten their production, their ranges are limited to lower pitch levels whose span has an upper boundary of c₅ or lower.

Head Tone. The majority of the students who exhibited pure head tone quality could sing the pitches represented in either head mixture or pure head tone. If ascending stepwise in a mixed production, the production was unlikely to change to pure head tone.
However, if starting high (d5 or above) or leaping to a high pitch, the adjustment to pure head tone production was more probable. Thus, pure head tone was more often revealed in the 'do-sol-do' pattern (leaps) or in the 'cuckoo' pattern (starting high) than in the scales or song literature, confirming the observations that untrained singers resist any sensation (physical or aural) of change. These two successful patterns were designed to induce head tone by means of range and articulation. The 'do-sol-do' pattern was sung with initial h's ("ha-ha-ha") which, in effect, takes the vocal mechanism out of gear and allows a register change to take place. The 'cuckoo' pattern was high enough that, if correctly echoed, had to be sung in pure or mixed head tone. By starting high, with plenty of breath support for the initial note, the pitch was most frequently produced in a clear, pure head tone, which could then be carried lower. The hard 'c' and the [u] ("oo") vowel also kept the tone placed high in the head. Those who found pure head tone in the vicinity of d5 could then carry this pure (not mixed) tone quality down to b4 or a4, with several students being able to carry pure head tone down to g4 or f4. Based on the transition to pure head tone in an ascending line, the so-called "secundo passaggio" or secondary point of transition, thus, occurred in the area of d5, a fifth higher than the upper boundary of the chest voice.

The results of this study revealed the head mixture to be a forward, high-placed tone unlike the throaty chest tone or mixture. The head mixture was often far more breathy than the chest tone or
the pure head tone. The feeling perceived was light and free, but also energized. Unenergized singing was more likely to be chest mixture produced lightly which could not ascend without increased breath pressure or forced muscle tension, hence limiting the range in that production. The head mixture could extend fairly low, and overlapped the chest mixture for most of its span. Unless the mixture was very well balanced, an acoustic change was perceived at the point of transition from head mix to chest mix. The transition point was flexible, depending on (a) the intensity (volume) of the singing, (b) the pitch movement direction, and (c) the type of register production used in the preceding pitches.

It was observed that a phrase begun in chest mixture would switch to head mixture when ascending at a higher pitch than in a phrase begun in head mixture and descending. In the test song, "Row, Row, Row Your Boat", the first phrase ascends by step and was usually kept in chest mixture if begun on e4 or lower. However, at the jump to the high tonic ("Merrily"), a shift to head tone, pure or mixed often occurred, and this new register/production could be carried down lower than the end of the first phrase which had been sung in chest mixture. It was also observed in the 'do-sol-do' pattern that once the head voice had been found in the top note ("sol"), it was then carried note, the same 'do' which had been sung initially in chest production. Conversely, ascending scales inhibited the change of registers for most because the students were unable or unwilling to allow a production change. Students had to be able to produce
both a secure head tone (pure or mixed) and a secure chest tone (pure or mixed) before any transition was possible.

Register Transition Ability

The ability to negotiate transitions between vocal registers is a prerequisite to the desired "seamless line" which allows people to sing smoothly throughout the vocal range. This ability is one indicator of the level of development of the singing voice. The ability to sing in two vocal registers does not, however, preclude the ability to make transitions between registers. As observed earlier, most students in the study (87.7%) were able to find two registers (chest/head) or two productions (heavy/light), but not all of these students were able to make transitions between those registers or productions without stopping to adjust vocal production.

In category one ("The student sings only in one register; range is severely limited"), were the students who were stuck in heavy chest tone production. They sang with a forced, throaty, almost shouting production. Glottal closure was tight and air pressure was great. The larynx did indeed appear to be "stiffened". These students could not lighten the production in order to ascend in pitch. Most spoke very low, often in a husky tone. Not surprisingly, many admitted they did not enjoy singing. Some showed signs of vocal damage, apparent in their speaking voices as well as in their singing voices. Students of both genders at each grade level fell into this
category. These students could not ascend above the pitch of g4. At each level, the number of boys in this category was greater than or equal to the number of girls in the same grade. Second and sixth grade boys had proportionately more in category one than boys in any other grades.

Category two ("The student independently chooses only one register, but can find a second register with help"), was an outgrowth of category one. Students in category two independently chose chest voice production, but were able to find a head tone, whether mixed or pure, during the singing test. As did the category one students, their songs were sung totally in chest voice, obviously not in the keys given. Because of the octave range of the test song, each song trial was either sung in nearly the same key, or, more frequently, the pitch accuracy within each song trial was very low. Even if the tune was known, these students modulated to lower tonalities any time the pitch threatened to cause a production change. However, in the pitch pattern echo section, category two students were able either to leap to a head tone in the 'do-sol-do' pattern or to find the head tone when imitating a high-pitched 'cuckoo' pattern.

Category three singers ("The student uses head and chest registers, but exhibits marked breaks in production") were able to use both head and chest tones in singing, but were not able to move back and forth smoothly between the registers. The marked production breaks which occurred in register transitions were similar, using the gear shift analogy, to the jerking one experiences
when learning to drive a car with standard transmission. Until the gear shifting procedure of coordinating gear (muscles) with clutch (air) becomes more natural through practice, the shifting of the gears to accelerate (ascend) will be rough. Until these students learn to lighten the chest production when ascending to allow a register transition, the voice will stop, exhibit strain, and finally break over into a new register. Some students recognized the problem, but instead of attempting to discover how to solve the problem, simply avoided the problem by modulating to a new tonality which did not require a production change. They sang each phrase or pattern as accurately as possible all in one register or all in the other register. The ascending scale, therefore, was the most problematic for these students. As there was no opportunity to stop to shift productions, marked breaks appeared, especially on the scale beginning on middle c (c4) where the voice shifted roughly from chest to head production. One fourth of the students in category three had voices which exhibited a heavy chest production and a pure head tone production, with a minimum gap of three to five pitches between the registers. These students had no mixed voice. They needed to add air to their tone production to blend the registers. They could sing in two registers, but had not reached the stage of development that allowed them to make smooth transitions between the registers.

Category four singers ("The student can lighten production to increase range, but lacks a clear head tone") sang in chest and chest mixture, and were able to control the weight of the production, but
resisted the transition to head voice. In the singing performances of students in category four, it was easier to label production than to label register. Light production and head mixture were easily confused. However, total range usable offered some clues. These students were comfortable singing to a4, and could even push a lighter mixed chest tone on occasion to d5 or even eb5. In higher pitch patterns modeled by the researcher, the students in category four either sang flat, sang incorrect pitches, or transposed the entire pattern down to an accessible range. Most of these students had fairly good control of their voices and sang with a fair to good degree of pitch accuracy, but only within a given range of ab3 (or lower) to a4 (or possibly as high as d5). Category four singers have gone as far as they can independently go starting at a comfortable pitch and moving outward. They need to abandon the familiar speaking voice production to discover the different feel of the true singing voice, the head tone.

Category five singers ("The student makes smooth register transitions; there are no production problems related to range") were able to sing smoothly under normal conditions through register transition areas, observable especially in the song literature portion of the singing test. (Under the induced extremes of volume and pitch requested in the second section of the singing test, register transitions were often more clearly recognizable.) While the ability to negotiate smooth register transitions did not insure pitch accuracy,
accuracy singing in the keys given was not possible unless some sort of register transitions were made by the student.

Predictably, the ability to make smooth register transitions increased with age, experience, and training. Fifty percent more of the students in grades four, five, and six fell into category five than in the lower grades. These are also the grades in which instrumental music and choir are offered to supplement the classroom music program. Almost 60% of the fourth, fifth, and sixth grade students who were designated as category five in their ability to make register transitions also had the benefit of additional music instruction in either strings, band, choir, or some combination of the three. Seventy-one per cent of the fifth and sixth graders scoring in category five were receiving additional vocal training in the choir. It is more plausible to explain this level of vocal development through increased musical experiences, especially singing in an auditioned choir, rather than solely as a function of age.

**Rater Responses**

Two judges listened to a randomly selected 25% of the taped performances (n=71). They evaluated what they heard using a two-page rating sheet designed by the investigator (see Appendix C). The goal of using independent raters was two-fold. Obviously, the raters' responses were used to corroborate the investigator's findings. In addition, the investigator used the raters' responses to see how well
musically trained judges could identify registers and register or production changes in children's singing voices. Adjudicators labeled registers in the song performance portion of the test and marked places of perceived register and/or production change in the pitch pattern portion of the test. They also rated the ability of each student to negotiate smooth register transitions.

**Song Literature Section.** Agreement in the song literature section of the singing test was dependent upon the vocal production used by each singer. The judges were asked to circle the register dominant in each song trial, and were limited to the primary registers of chest voice and head voice. The first two song trials, one at a pitch level chosen by the student (usually low) and one in the low key of A (range: a4 to a5), produced greater agreement on register dominance than the higher two song trials. Agreement in the first two song trials occurred 82% of the time, whereas agreement in the two higher song trials occurred in only 56% of the performances.

An analysis of a representative portion of the rater responses was computed using the SPSS-X reliability program. Each of the four song trials was labeled "chest" or "head" register by the raters. Those performances with missing data or written in responses different from the two given choices were omitted in this analysis. A Cochran's Q test was chosen for analysis of variance due to the dichotomous nature of the data.
The reliability of the mean of \( r \) measurements is the variance due to true scores divided by the sum of the variance due to true scores and the variance due to the mean of the errors of measurement. Table 13 shows the reliability of the mean of the three raters (the investigator is Judge C) for each song trial. The reliability coefficient alpha was adjusted for anchor points, i.e. differences due to judges were not considered a part of error of measurement.

The difference in reliability estimates between the first two song trials (low) and the third and fourth song trials (higher) again highlights the fact that the raters' ability to identify chest register quality was greater than the ability to identify any form of head register in singing performances. The presence of an overlapping middle register (mixed production), while achieving the goal of blending the registers, defies reliable identification as to chest- or head-dominance, even among trained professionals. It is interesting to note that the trend of closer agreement between Judge A and the investigator (Judge C) persists throughout the four song trials (as it does in the entire singing test).

**Pitch Pattern Section.** The pitch pattern echo section of the singing test provided additional information about register boundaries. Because the judges were still working under the original limitation of two primary registers, only the most noticeable production changes were marked by the judges. Throughout this portion of the singing test, as in the song literature section, chest
<table>
<thead>
<tr>
<th>Item</th>
<th>Sample Size</th>
<th>% of &quot;Chest Register&quot; Responses</th>
<th>Q</th>
<th>Reliability (coefficient alpha)</th>
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<td>Judge C</td>
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<td></td>
<td>77.8</td>
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<tr>
<td>Judge C</td>
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<td><strong>Song #4</strong></td>
<td>57</td>
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<td>43.92*</td>
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<td>Judge A</td>
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<td>Judge B</td>
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* (p < .02)
voice responses received greater agreement. The higher the pitch of
the pattern, the greater the chance that there would be little or no
agreement on the place or existence of a register/production change.
With the exception of pure head tone production, any lightly
produced mixed registration was difficult to label. Above the
primary point of transition, g4, it would seem that register effects
are less obvious.

Register Transition Ability. Using a rating scale of numbered
descriptors to evaluate a student's ability to make smooth register
transitions did not evoke agreement among the three listeners any
more precisely than five categories could accurately describe the
singing voices of all children. Comments made by the judges helped
to explain the wide spread of the responses. Often the registers and
register transitions achieved in the pitch pattern section of the
singing test were quite different from those used in the song
literature section. Judges wrote that one rating was sometimes
appropriate for one section, while a totally different rating was
appropriate for the other.

The judges commented, using the evaluation sheets enclosed in
their rating packets, that they thought the descriptors were clearly
stated and appropriate for the study. Evidently, each judge worked
out his own system of assigning students to various categories which
did not necessarily agree or need to agree with anyone else's choice
of descriptors.
Conclusions. The use of independent raters for this study adds partial credence to the existence and location of the primary registers in children's singing voices as described by the investigator. The raters' responses helped show that register events are identifiable perceptually, although more so when rough (i.e. breaks) than when smooth (acoustic changes only). The difficulty in labeling the register of certain middle pitches illuminated the fact that the majority of pitches in the middle octave of the child's singing range can be sung in a light production which defies clear register identification, but also appears to embody the desired "seamless" line. The production in this octave may include both a chest mixture and a head mixture with a smooth transition between them being aided by the light production, or may be sung totally in either chest mixture or head mixture. If this range is sung in light chest mixture, its top is the top of the singer's range unless he flips or breaks over into a new register as he ascends. The judges' responses highlight the relationship between register and production. While a register is the result of a certain production in a given range, the two words are not synonymous. Production changes that are aurally identifiable are not necessarily register changes, especially when considering only the two primary registers. That is, a change from heavy to light production can occur without leaving the chest register, for example. Acoustic changes besides pitch (vowel placement, resonance, volume, etc.) are measurable at any given pitch. It is the aural recognition of production changes which makes register identification possible.
Finally, because of all the acoustic information one perceives in a series of tones, the raters' responses helped to reinforce the premise that there are only two primary registers in the singing range tested, and that there may be said to exist a variety of secondary (middle) register timbres within the chest to head tone continuum based on the effects of varying the vocal production in a given pitch range.

Related Observations

Pitch Accuracy

Although the primary concerns of this study were the presence and location of registers in the singing voices of children, it was impossible to ignore the related issue of pitch accuracy. The overall level of pitch accuracy (correct pitches at the pitch level given) in the individual student performances was abysmally low. However, some types of pitch movement and certain pitch levels produced more accuracy than others due to the vocal production involved. Many of these secondary observations corroborate the findings of previous studies and the writings of various practitioners who have worked with the singing voices of children.

Song Literature Section. The singing test for this study was divided into two sections, a song literature section and a pitch pattern echo section. Accuracy in each section appeared dependent on pitch range, vocal production, and types and direction of pitch
movement. In the first section, the student sang the test song "Row, Row, Row Your Boat" in four different keys. The first song attempt was in a key of his own choice. Predictably, most began the song at or below the pitch of the speaking voice. The most frequent starting pitches for all students were in the area of $b^b3$ to middle c (c4), which required a pitch span of $b^b3$ to $b^b4$ or c4 to c5 to sing the song correctly. It was expected that the student-chosen key would be the most accurate of the four song trials, but this was not the case. In all four song trials, pitch direction and interval degree within phrases were usually correct. What destroyed the accuracy was the number of modulations or tonality shifts within the song. When the student felt a change in vocal production coming due to range demands on production, rather than facilitate or even allow the production (and sometimes register) change, he simply changed to a lower key.

The first phrase, with ascending stepwise motion ("Row, row, row your boat, Gently down the stream"), encompassed the range of a fifth from the low tonic to the dominant. This portion of the song was usually sung correctly from any starting pitch. Students who modulated only once did so at this point--before the leap to the high tonic ("Merrily"). The leap from the dominant (last note of the preceding phrase) to the high tonic (first note of the next phrase) was seldom accurate. In any octave span, the feel of the production of the lowest tone is different from that of the highest tone, regardless of the pitch location of the octave. In fact, from any given pitch, a production shift seems necessary around the interval of a
fifth above the starting pitch, and is more obvious ascending than descending. Therefore, the leap to the high tonic for the second phrase would, in all keys, call for some degree of production change. That untrained voices tend to resist change is a known fact.

The degree of pitch and tonality consciousness was much more evident in the middle and upper grades. Lower grade students made more frequent tonality shifts and seemed less aware of the need to maintain tonality, especially if whole phrases or tonal patterns were sung correctly. Middle and upper grade students were more aware of maintaining tonality, and, hence, modulated fewer times and by fewer pitch degrees. Upper grade students more frequently sang the highest note flat or slightly lower rather than modulate to a new key. Lower grade students modulated not only at the leap to the second phrase, but also during the descending intervals ("Merrily, merrily, merrily, merrily") as a result of singing larger intervals than were correct. The leap to the final phrase ("Life is but a dream") was again a place of frequent modulation, often because the student had gotten too low on the previous descending phrase.

The keys of the first two song trials, the student-chosen key and the key of A, usually called for the student to begin singing in some form of chest voice. Because this production is more similar to the familiar speaking voice than is the head voice, the songs in the two lower keys were tonally more successful than the higher two song attempts. Weaker singers exhibited greater vocal control in the lower pitch range, the range which is exercised in daily speech.
Range extremes posed problems in the first two song trials. Ascent to the high tonic called for a light enough production to allow a register change out of chest voice. When this change was not permitted, the result was either (a) a forced tone production, pushing the chest tone beyond its natural boundaries, (b) a wrong tone, usually a step or two below the correct high tonic, or (c) a modulation to a lower key. On the lower end, the song was, at its onset, rarely out of the student's range. Sometimes the student modulated down to a key whose lowest pitches were indeed out of the singing range of that student. In these cases, the words were chanted or whispered as in speech on the lowest pitch the student could phonate, or growled (vocal fry).

The key of E in the third song trial provided an indication of the student's ability to use a different register. The pitch range of the test song, e4 to e5, was sung by some students completely in head mixture, but by the greater number in a mixed production that varied between chest and head. Students who began in a loud, heavy chest production could not ascend more than a few notes before they had to change production or change the key. Some students who did not attempt any production other than chest production disregarded the starting pitch given by the investigator (for both of the two higher song trials), choosing instead a lower, more "comfortable" key. For the students who sang accurately in the keys requested by the investigator, the key of E was vocally the best sung of the four keys.
The highest key was the most difficult of the four keys attempted. The test song in the key of G had a pitch range of g4 to g5. When sung accurately, the song was sung totally in one or more forms of head voice production. Some students switched to pure head tone at the leap to the high g5; others managed to keep a mixed production for the whole octave span of the song. Very few students actually sang the top note correctly. Many did not even attempt it. Again, the g4 to d5 range of the first phrase was more often accurate and well produced than the rest of the song.

Pitch Pattern Section. Many students who did not sing above b4 or c5 in the first section were able to produce higher pitches in the pitch pattern section of the singing test. Three patterns were used to examine the use and boundaries of vocal registers in the second portion. The first set of patterns, a five-note descending pattern (sol-fa-mi-re-do) was begun on g4, f4, and e\textsubscript{b}4. In this range, all pitches could be and usually were sung completely in chest production, whether heavy or light. Of the three different types of patterns used in the second part of the singing test, this set of descending patterns in chest voice region was the most accurate, both in intervallic correctness and in using the starting pitch given by the investigator. For all ages it seemed that pitch matching was more likely to occur in the pitch range covered by the more familiar, speech-like chest voice production. Pitch accuracy in the higher pitch areas, especially those out of chest voice range, came only when the student had control of the less-used head voice. When the five-
note pattern did have errors, the melodic alterations in order of frequency were:

1) the student began a half step higher or lower than the model--vocal pitch control was not yet fine-tuned;
2) the student began the pattern significantly lower than the model;
3) the student lowered the third tone, changing the half step to a whole step, making the pattern sound minor in tonality;
4) the student sang only the first four notes of the pattern;
5) the student sang each interval as a whole step, increasing the pitch span of the pattern to a sixth.

Most of the students in all grade levels could sing the low $a^b3$ in this context. It was observed that the students could sing lower when they were louder; the voice faded out sooner when they sang softly.

The second set of patterns included two eight-note ascending scales, beginning on c4 and on f4. These patterns were the least accurately sung of the three. Direction of pitch motion was almost always correct and stepwise motion was usually attempted. The c-scale was more accurately sung than the f-scale due to range and the production required by that range. Some students lowered the starting pitch of one or both scales. The most frequent error was that fewer than eight notes were sung. As the student approached a
register transition area, if he did not facilitate or allow the register change, he usually pushed the lower range quality as high as it would go, eventually breaking over in to head voice or stopping altogether. Those who used a heavy production remained at a certain pitch level and repeated the the final note of the production, unable to shift registers to continue the ascent. The ascending stepwise motion discouraged register changes; the scales were most often sung throughout in the register and production used in the initial pitch of each scale.

The final set of patterns, leaps of a fifth ("do-sol-do"), were almost always accurate in both pitch direction and type of motion (i.e. leap). When the interval of the leap was inaccurate, it was most often sung as a perfect fourth. Next in frequency was a leap of a sixth, or a leap to no particular pitch goal (a seventh, an octave, or higher). The first of these patterns moved from middle c4 to g4 and back to c4. This was the most frequently correctly sung example of the four patterns in the set, both in intervallic correctness and in the use of the given starting pitch. As in earlier responses, this pattern could be and usually was completely sung in chest register. Occasionally the student started on a note different from the given starting pitch, leaped up and returned to the correct tonic pitch, such as mi-sol-do or re-sol-do. This final set of patterns facilitated register changes more than any other pattern or song performance due to the aspirated articulation of the leaps ("ha-ha-ha") which allowed the voice to change register/production more easily.
Because the voice could change registers more easily, the higher
tones of f5 and g5 were more often sung in this set of patterns than
in any other portion of the test.

A "cuckoo" call (falling minor third) was used in a high pitch
area as a remedial device to induce head voice production if the
student had not previously been able to find his head voice.
Amazingly, the interval was almost always sung intervallically
correctly by all ages and genders. Usually the pitch level was the
same or very near to that modeled by the investigator. When the
interval was sung incorrectly, the most frequent error was that the
minor third was sung as a major third. This high, forward placed
head tone, when found, could be brought down. Rarely could head
tone be found by ascending to it, especially when the ascent was by
step. This corroborates the findings of A. Oren Gould (1968, 1969,
1970) who suggested two techniques for finding and securing the
head voice: (a) a "yoo-hoo" (or cuckoo) call of a falling minor third
placed high enough to be above chest voice boundaries, and (b) a
leap to a higher pitch so that the student aims his voice (and his air)
towards that higher pitch. Conversely, a song that begins too low
and/or ascends stepwise discourages change from the initial chest
voice production.

Music literature alone cannot teach correct vocal production
nor can it alone increase the singing range of a student. This was
obvious in the register and range results of the song portion of the
test. Music literature can inhibit vocal development if not chosen, in
range, register, and pitch movement, to reinforce the principles of good singing.

**Age/Experience Level Differences**

Vocal development from Kindergarten through the sixth grade was observed while measuring register boundaries and transition abilities. As found in many previous studies, pitch accuracy increased with age/experience overall. However, while the upper grades (4-6) had far more accurate singers than the lower or intermediate grades, the lines between the good singers and the poor singers were more distinct in the upper grades. For example, at the Kindergarten level, approximately half of the sample, both boys and girls included, could sing moderately to extremely accurately in both parts of the singing test. Ten percent of these Kindergartners sang with extreme accuracy, although not all of them sang at the pitch level given by the investigator. By the sixth grade age/experience level, 44.4% of the girls and 28.6% of the boys sang with extreme accuracy at the pitch levels given by the investigator. And additional 50% of the sixth grade girls and another 28.6% of the boys (total 94.4% of the girls and 57.2% of the boys) sang with a good degree of accuracy throughout the singing test. Few sixth graders scored in the moderately accurate category. They were either excellent, good or poor. The 21.9% of the sixth graders (both genders) who rated poor in musical accuracy sang in heavy chest production. They were
unwilling or unable to adjust their vocal production to accommodate range demands.

Another obvious age/experience difference was the awareness and/or attention to maintaining tonality. Sixth graders more frequently took the investigator's starting pitch and attempted to stay in that key. Kindergartners paid less attention to the starting pitches given by the investigator and modulated within songs much more frequently. It is easy to see why unison singing is less successful at the Kindergarten level—the students are simply not concerned with matching anyone else's pitch level. The students heard and imitated the contour of the pitch model, but preserving the key of the model seemed relatively unimportant to the six-year-old. At all ages, Kindergarten through sixth grade, the cuckoo (falling minor third) was more often accurately sung than any other pattern tested.

Kindergartners exhibited a larger singing range overall than reported in most range studies of children's voices. Most of their vocal production was a mixed production. Although some could make the mixed production heavier or lighter, few showed the extremes of heavy chest or pure head tone production. Identification of the chest register was difficult because it was lightly sung, it was a mixed production, and it was, as was the speaking voice of the Kindergartner, higher than that of older children. Because of the light production, register transitions were difficult to discern. Contrary to some beliefs, the typical six-year-old voice, as evidenced
in this study, is not the head tone (any more than it is head tone at any other age). However, the tone is light and breathy, and often mistaken for head tone. Without the production extremes of heavy chest and pure head tone production, the Kindergartners did exhibit a smaller total range than did the older students, especially in the song literature portion of the singing test. The extremes of vocal production take more air to support them. Some Kindergartners were able to force more air in bursts of air, but did not seem to have the muscular ability to sustain this breath support.

**Vocal Ranges**

Because of the link between vocal registers and singing ranges, the charting of the overall range used by each student was a part of the investigator's evaluation. Total ranges used in each of the two sections of the singing test were outlined on the investigator's rating sheets. The larger range was most often exhibited in the second portion, the pitch pattern echo section. The total range tested encompassed the span of low ab³ to high g5. Many students at each grade level were successful in reproducing this pitch range under the conditions of the test design. Those who did not use the entire range were limited by their vocal production. For a few students, these limitations were a matter of choice; they did not want to or did not put forth enough effort to produce a singing tone in certain pitch areas, usually the higher regions. For many more students, the
limitations derived from the lack of experience and/or training in the handling of their singing voices in certain pitch areas.

Range data as found in Figure 9 shows the vocal ranges (high/low pitch extremes) exhibited by greater than 50% of the students at each grade level. Ranges are divided into those produced in the song literature portion of the test and those exhibited in the pitch pattern section to highlight the difference between normal usage and potential singing ranges.

It may be seen that Kindergarten was the only grade level at which the boys and the girls shared the same (average) range; first grade boys and girls shared equal ranges only in the pitch pattern section. From second grade on, the girls used a larger singing range than did the boys. It is also evident that the ranges in the singing test did not change appreciably from second through sixth grade, especially when considered by gender. The pitch pattern echo portion of the singing test produced larger ranges at all grade levels. It was in this second part of the test that more students found and used both primary registers and a variety of vocal productions. It is this fact that explains the greater ranges exhibited in the pitch pattern portion.
Figure 9. Vocal Ranges (High/Low Pitch Extremes) by Grade and Gender
(Boys=♂; Girls=♀)
Additional Observations

Student responses in the singing project conducted at Lincoln School were quite positive, informative, and interesting. Almost all of the entire group of students exhibited either distinct vocal registers in their singing voices, or at least showed some ability to adjust (lighten or add weight to) their vocal production. Not only was each student able to exert some conscious control of the sounds he produced, but also was he able to recognize this ability. By the time he entered Kindergarten, he had done enough vocal exploration to realize on his own that his voice could go high or low, loud or soft. These, therefore, were effective verbal descriptors to couple with the sung models offered by the researcher. Physical gestures, such as pitch level conducting, to reinforce pitch direction were also used when needed.

By the third grade students responded verbally to quality differences. After hearing and/or attempting to sing the loud, heavily produced chest voice patterns modeled by the researcher, some told the researcher that they were not supposed to sing that way in music class. While Kindergartners and first graders held their ears or laughed at the raucous sounds of the same loud, low patterns, less than 25% of these younger students were able to force the same heavy production that effected full chest voice quality. Neither the air pressure nor the glottal closure were heavy enough to create sounds similar to those of the researcher's model.
In the upper range, especially in the song literature section, many students at each grade level told the researcher that they could not sing "high" in response to her words, "now let's try this song again using your high voice". While many of the students could actually sing all or part of the test song in this range, the word "high" brought forth a negative response. Many fifth and sixth grade boys, especially those not participating in additional musical experiences, balked at the higher range of some of the test portions. In light of these concerns, the most successful of the researcher's attempts to get the voice into a new register/production was the verbal directive "sing as you would have sounded in Kindergarten".

Volume and pitch level were often used to induce register changes which were sometimes abrupt. Register breaks were often noted by the student with a grimace, apology, or exclamation of surprise. Slighter register/production changes received fewer student comments. Those whose voices stopped during an ascending scale due to production difficulties often said, "I can't get up there." Likewise, those who could not or were reluctant to allow their voices to make the transition downward out of head tone also commented that they could not go any further down. At a rather obvious register shift in the second phrase of the test song, one third grade girl apologized, saying her voice "lost its place". Indeed, the feel of the new register was different, a "new place".

In the pitch patterns sung on the neutral syllable "ah", it was observed that most students having difficulty ascending had very
small mouth openings. Instead of giving more space to ascend, the students increased the air pressure (and let "ah" migrate to "uh"). For students having difficulty completing a phrase who were attempting to preserve tonality and sing correct pitches, the researcher's comment "try that again with more air" often facilitated the vocal production necessary to sing correctly in the pitch extremes.

Students showed more ability to control their singing voices at will in the lower and middle pitch ranges (bb3 to bb4). This pitch region could be sung with varying volumes in different registers. Those students wishing to avoid a register change could lighten the chest production enough to ascend to the higher bb4. Those singing lightly exhibited a production which allowed a gradual, usually imperceptible transition to a head voice mixture which could ascend a few pitches beyond the end of the chest voice mix, most often to d5. This, then, may be called the "comfortable range". It is the range which can be sung without much effort. Most of the production is similar to that of soft, melodious speech, which can be exercised using sustained speech at a variety of pitch levels. The difficulty arises when the volume is raised. The lower half of the range goes into heavy chest production. Because the student cannot carry that loud chest production higher, he will strain, break, or stop. Learning to adjust the production to facilitate the register/production transition comes with training and experience.
The "comfortable range" is not the full extent of the child's (or any beginner's) singing range. It was observed repeatedly that students could sing acceptably in a much larger range. The higher part of the pitch range (b\textsuperscript{b}4 and above), however, was sung only in the pitch pattern portion of the singing test by 33.2% of the students tested. Students were more comfortable finding and singing in their head voices under two conditions: either (a) they jumped to to higher head tone, or (b) they began higher in a head tone, usually at a pitch that could not be produced in chest tone. Once the student found this new production, he could carry it downward with relative ease. The 'do-sol-do' pattern often evoked a chest tone for the first note, a head tone for the higher second note, and the same head tone brought down for the final note—the same pitch which was formerly sung in chest tone production.

For many of the better singers, the transition area, the "primo passaggio", was a weak pitch area. The pitches d\textsuperscript{4} and e\textsuperscript{4} were difficult starting tones for ascending lines. With too much air or volume the notes wobbled and/or shifted into chest voice. These students who knew through experience or training to lighten (soften) to avoid the chest tone were generally secure in a head (mixed) tone production at f\textsuperscript{4} and above. The suggestion by many authors that the key of D is a good choice to promote healthy singing (because it can be sung in head tone throughout) must be balanced with instruction in handling the voice as it nears a register change.
Conclusions. Students were successful in achieving the "seamless line" of a well balanced vocal production when they consciously aided the transitions. Lessening the volume while descending smoothed out the head mix to chest mix transition, while increasing breath support (and volume to some degree) aided an ascending line in taking the head mixture higher. At a lower degree of proficiency, the student needed to know how not to inhibit the natural register transitions. His production must be light enough to allow the transitions to occur, but energized enough to produce a clear, resonant tone. With a lot of air and a light production that does not stiffen or "fix" the larynx, chest tone can be comfortably produced and pleasant to hear. The danger is that when more volume is desired, the light production will not hold in that register, especially for the untrained singer. Those teachers who advocate staying out of chest voice in singing are advocating preventative vocal care. At the beginning stages of learning to use the singing voice, the two registers must be found. But there can be no successful blending of the two registers until the head voice production is secure. It is easier to stay out of chest tone that to get out of chest tone. Teachers must work to develop the unused register, which in children is the register least like the familiar speaking voice.

The true singing voice of children, the head voice, must be taught just as any other physical skill is taught, along systematic guidelines. It was interesting to note that the vocal training offered
in the fifth and sixth grade choir was precisely that which was needed to promote good singing skills at all grade levels. While singing is a major part of classroom music instruction, one has to wonder if teaching the student how to use his singing voice is a goal of elementary music instruction. If teachers truly believe that this is a goal of classroom music, they are going to have to devote a small amount of time to group vocal techniques. The skill of managing one's singing voice smoothly throughout the full vocal range does not appear to happen solely as a function of age. Experience which develops the musical ear as well as the vocal mechanism by providing sound models and vocal training is the key to vocal development. To sing well, one must sing often and wisely. Production difficulties manifest themselves in the inability to sing in more than one register or the inability to move smoothly between registers.

While the student does not need to know much about registers, he does need to know how to produce his voice to accommodate the musical effects he wishes to achieve, the least of which is range. Teachers must teach vocal production--the sounds and the feel of a well-balanced voice. The range of a piece of music can encourage good vocal production (or hinder it), but range alone cannot teach the student how to sing properly. Findings regarding vocal ranges are valid only in the light of vocal production. It is vocal production that can explain the disparity among all the child voice range study findings. Registers in children's singing voices should be important
to all teachers who work with the singing voices of children.

Registers are the result of certain types of vocal production, the perception of which can help the teacher assess the level of vocal development of each student. The ability to negotiate register transitions provides implications for vocal instruction. Registers in the singing voices are clues to the efficiency of operation of the vocal mechanism of the singer. Pitch must be allied with production in the assessment and instruction of beginning singers.
CHAPTER V
SUMMARY AND CONCLUSIONS

Basic vocal production problems among untrained singers are similar regardless of age. Specifically, most beginning singers or non-singers exhibit distinct vocal registers, the production of which locks the singers into limited range and expression possibilities. The tone quality or timbre of a given register in a certain pitch range provides aural clues to the teacher about the vocal development and vocal needs of beginning singers. That child beginners exhibit the same tendency to choose (independently) and be limited by the choice of tonal production closer to speaking voice production as do adult beginners, does not imply that children should be taught as adults or vice versa, but rather that there are pedagogical principles basic to the development of the singing voice at any age. The choice of vocal registers made by any singer serves as one indicator of the level of vocal development of that singer.

A study was designed to investigate registers in the singing voices of children, as a representation of a large population of untrained singers. Prior studies using children had focused primarily on range and pitch matching abilities, with extremely limited
attention to the vocal production of the singers. The wide disparity among range findings cannot be explained, nor can pitch accuracy findings be validated without looking at the vocal production which generated the pitches sung. Register study was warranted as a means of classifying the tone quality resulting from a particular vocal production. Information was collected perceptually, as music teachers would use aural cues to evaluate and plan for the vocal development of their students.

Procedure

The entire population (n=285) of an elementary school was used for the vocal register study. Students were heard individually performing elements of an investigator-designed singing test. The first section of the procedure involved the singing of the song, "Row, Row, Row Your Boat". Each student sang the song first in a key of his own choosing, then sang it three times more in keys given by the investigator. The keys were chosen to display several registers and to span expected register transition areas, necessitating changes in vocal production to sing the melody accurately. The second part of the procedure included a series of pitch patterns which were sung by the investigator and echoed by the student. The choice of pitches, pitch direction, dynamic level, and vocal articulation were all chosen to induce or inhibit register transitions in a pitch region that was expected to bridge the two primary registers. A final remedial device, a descending minor third ("cuckoo" call) sung in a high range,
was added to the performance if the student had not previously sung in any form of head voice production.

All of the performances, lasting approximately five minutes each, were recorded on cassette tapes, and were evaluated by the investigator using an evaluation form created for this study (see Appendix C). Every fourth performance \((n=71)\) was dubbed on to new cassette tapes for subsequent evaluation by two judges. This second aspect of the evaluation process was included to corroborate the investigator's findings and to reveal the ability of trained vocal music teachers to perceive aurally register and production effects in children's singing performances.

A pilot study was conducted to refine and verify the validity of the procedures and rating sheets, and to confirm the ability of independent raters to perceive register events in the singing voices of children.

Findings

A variety of results emerged from the testing process. The data gathered both answered and amplified the research questions. Related findings provide implications for teachers of beginning singers.

In response to the first research question pertaining to the nature of vocal registers in children's singing voices, the major finding was that children do exhibit vocal registers similar to those of adults, most nearly paralleling the registers in the adult female
singing voice. Mechanically, the presence of two different pitch-making systems is a given fact. Therefore, head and chest registers were assumed to be present. The question was not if registers were present in children's singing voices, but rather where and under what conditions registers existed and were perceived. Most all of the students tested were able to use both head and chest registers and/or heavy and light production (88%), although the ability to manipulate their singing voices from one register to another was not inherent with the ability to find both registers.

Registers and Register Boundaries

The primary registers include both a lower and an upper register. The data revealed that the lower register may take the form of heavy or light chest production, and may be pure chest or a mixed chest tone production. A loud, heavy chest tone could be produced in the range of a⁷³ (lowest note tested) to g⁴. After that, the voice stopped or "broke" over into an new register. With a lighter production, chest voice (mixture) could extend to b⁴, and occasionally as high as d⁵.

The upper register may take the form of pure head tone or mixed head tone production. While a mixed production dominated by head tone production musculature spanned the range of a⁴ to g⁵ (highest note tested), a pure head tone quality (used only by 35% of the students tested) was produced when beginning at d⁵ and above. The pure head tone was perceptually different from any other tones
sung. Hence, there is some merit in Oncley's humorous comment (1969) that the two registers speech and singing scientists could agree on might as well be called "modal" and "yodel".

A third register, the middle register, appeared as a secondary register due to its overlapping nature. If lightly produced, it could span b₃ to d₅ or slightly higher. Middle pitch range singing was more difficult to identify by register because the production was usually mixed, having some qualities of both head and chest registers. Acoustic shifts were the only perceptible clues as to the dominance of head or chest voice musculature in the middle range of the better singers, whereas audible breaks (and other production difficulties) in the voices of the weaker singers provided more distinct register information. The desired "seamless" line between the primary registers is the result of free and efficient operation of the dynamic balance in the muscular adjustment of the singing mechanism in response to pitch changes.

Register Transition Points

It was observed that register boundaries varied greatly with production. The primary register transition between chest and head registers occurred most frequently at g₄, regardless of the weight of the production (heavy or light). Weaker singers resisted the transition and attempted to push chest voice higher while better singers allowed the transition out of chest voice to occur lower than g₄. Therefore, an area of transition from d₄ to a₄ may be added to
the findings depending upon vocal production and melodic demands. Factors influencing the point of transition in any given melodic phrase include (in order of degree of influence): (a) volume (intensity), (b) pitch direction of the phrase, (c) production employed in the previous pitches sung, (d) intervallic character of melodic progression (step, leap), and (e) articulation of the vocal tone (legato "ah" or aspirated "ha"). That this estimate of "primo passaggio" is slightly higher than that of textbook charts of adult female singers may be explained by the reluctance of this large body of untrained singers to allow register changes. The students were more "comfortable" in a pitch range and production close to that of the speaking voice (chest register). The unfamiliar head voice was a different feel and a different sound. Head voice production had to be securely anchored in the young voices before the transition from chest to head voice could even be considered. Many students had not yet reached that level of vocal development.

Pure head tone began, when ascending, at d5 or higher. Some students sang the upper range through f5 or g5 in a mixed head voice production, but found the pure head tone under one of two conditions: (a) the pitch pattern or melodic phrase leaped to a high pitch (d5 or higher), or (b) the pitch pattern or melodic phrase began high, again d5 or above. The secondary point of transition going into pure head tone occurred most frequently at d5, with a surrounding area of transition spanning c5 to g5, depending on the previously named factors of vocal production and melodic progression.
Many times when the feel of the head tone was found in the voice, it could be brought down (unmixed) below d5 to b4 or a4. More frequently, the production which allowed the pure head tone production facilitated the descent into a mixed production that went smoothly from the top to the bottom pitches. This was rarely the case in the reverse pitch direction. Especially in untrained singers, the tendency to resist a change in production necessary to ascend very far caused many vocal production problems (muscular tension, change in quality, intonation problems) because of the inability to "flip over" into a new register. At this level of inexperience, the feel of the singing voice may be more crucial than the sound of the voice to the singer.

Register Transitions

The ability to find, use, and make transitions between the two primary registers was evaluated as one indicator of vocal development. Results of the singing test showed that 12% of the students were unable to sing in any register but heavy chest production, which severely limited their singing ranges. An additional 4% could find head register, but did not independently choose it for their singing. Sixteen per cent of the students could sing in either chest voice or head voice, but exhibited marked production breaks or were unable to make any transition between the two registers. In a few cases, there were pitch gaps between the two registers. Others sang a melodic phrase either in one register or the
other, but never made any attempt at a transition. All of these
students had very low pitch accuracy ratings, as they had to
modulate to avoid register transitions. Their range of usable pitches
was limited by their vocal production.

A larger category of students (32%) were able to lighten the
production of their voices enough to increase their ranges without
ever leaving chest voice production. Their middle or mixed register
was entirely chest dominated. This register was their highest
register of production, so once again, their singing range was limited
by their vocal production. These students were often accurate
singers within limited pitch ranges, but they exhibited no semblance
of any distinct head tone quality. They were comfortable in the a3 to
a4 and b♭4 to b♭4 octaves. In some cases they could push the top to
c5 or even d5, but this was the end of their functional singing range.

Less than half (40%) of the students were able to use both
primary registers and make reasonably smooth transitions between
them so that their singing ranges were not limited by their vocal
production. The ability to make smooth register transitions
increased with age, experience, and training. Over 60% of the upper
grade students (grades 4-6) who rated highest in their ability to
make smooth register transitions also had the benefit of additional
music instruction at school (strings, band, choir). Seventy-one per
cent of the fifth and sixth graders in this top category were in the
select choir.
Rater Responses

In previous perceptual studies of registers in the singing voices of adults, rater agreement was higher when the subjects were trained singers demonstrating their ability to sing a given pitch pattern in two different registers (Large, 1968). In other words, register identification was facilitated by the comparison of a pair of responses. Register identification in the voices of untrained singers (who are less able to handle their own voices at will), especially those of children (whose voices exhibit less intensity and efficiency in singing) is more difficult. Obvious production extremes (heavy chest voice, pure head tone) were readily identifiable by the investigator and the judges alike. Difficult register transitions that caused a break, a stop, or a yodel were also easily perceived clues as to the register of production and its boundaries.

Song Literature Section. Raters were able to distinguish the two primary registers in this study in the students' song performances. Agreement was higher when pitch and production extremes provided more obvious aural information. Lack of agreement most often occurred when the song performance was characterized by light (usually breathy) production in a middle range. This lighter vocal production allowed an expansion of range by means of facilitating a mixed production for the majority of the pitches. This effect, while a desired quality, made register identification more difficult. Without audible register cues, it was purely the acoustic properties of the tone quality which helped the
listeners assign a register to the melody being sung. Raters were limited to the choice of the two primary registers. Without the choice of middle/mixed register, they had to judge each performance as being sung predominantly in chest or head register, whether mixed or pure, heavy or light production. As register transitions became smoother, register boundaries became less obvious and register identification became more difficult. The degree of rater agreement depended upon the perception of register events, the interpretation of the investigator's instructions, and the rater's own beliefs about the nature (and number) of vocal registers. Because of the difference in individuals, in auditory acuity and in vocal training in general, and in variety of previously formed beliefs about vocal registers in specific, a high degree of rater agreement for this type of perceptual study is unlikely.

**Pitch Pattern Section.** Pitch patterns, used in the second portion on the singing test, were more accurately sung and elicited a larger vocal range than did the song literature section for the majority of the students. Patterns or phrases which moved stepwise appeared to inhibit register transitions while those moving by leaps facilitated or at least allowed transitions.

**Related Findings**

Other related findings came out of this study as observations recorded concurrently with register perceptions. The most frequently chosen starting pitches when the students selected their
own pitch levels were in the area of $\text{bb}^3$ to c4 (middle c), at or below speaking voice pitch level. Pitch accuracy was not necessarily any better in the student-chosen key, but pitch accuracy overall was higher in the lower keys than in the higher keys. Pitch matching was also more accurate in the patterns lying in the pitch range of g4 and below.

In the upper pitch areas, pitch matching was more accurate in an area which avoided a register transition. Transition areas were weak pitch areas. Beginning a song phrase or pattern in a transition area was difficult for the singer because the volume level appeared to be the main factor affecting register choice. The pitch often wobbled between the two registers. Better singers lessened the intensity, but weaker singers modulated lower to a more familiar chest voice region. Students who independently chose chest voice for all of their singing but who could find the pure head voice often exhibited a loss of control in the upper region. Pitch accuracy was low because the feel of the pitch-changing mechanism in that upper register was not well developed. Those who used the upper register to extend their singing ranges had little or no difficulty singing accurately in pure head tone production. Pitch accuracy improved with age and experience, but in the upper grades (4-6) the gap between the inaccurate singers and the good to extremely accurate singers was wider. Lower grades revealed more moderately accurate singers whose pitch accuracy depended on pitch and production conditions.
The desire to maintain the given tonality of the song or pattern increased with age and experience. Middle and upper grade students more often took the investigator’s starting pitch and made an attempt to stay in that key than did the students in the lower grades.

Vocal ranges (high/low pitch extremes) were charted in the study of vocal registers with the conclusion that singable pitch ranges are limited primarily by vocal production. Students sang in larger pitch ranges in the pitch pattern portion of the singing test than they did in the song literature portion. Girls sang with larger pitch ranges than did boys from second through sixth grades, and the ranges did not change appreciably from the second through the sixth grade. In Kindergarten and first grade, there were few if any gender differences in vocal ranges of the students tested. At all grade levels (K-6), girls were more likely to make smooth register transitions than were boys.

For all students, getting out of chest voice (ascending) was more difficult than entering chest voice (descending). The better singers chose to stay out of heavy chest production in order to blend the registers in both pitch directions. Since staying out of chest voice is easier than getting out of chest voice, it would seem that this should be a major consideration in selecting music for the young singer.

It was observed that smooth register transitions were consciously aided. Students who sang often had figured out or had been taught how to move their voices up and down smoothly, using a production that would allow register changes. If the facilitating
process can be identified (which it can) and is achievable by elementary school students (which it was), it can be taught to beginners (which it should be).

The investigator's belief that vocal production is the missing link in explaining the vast differences in vocal range studies of children's voices was confirmed by this study. Because of the limited vocal training experienced by elementary school children, it was possible to project characteristics of range based on production for all beginning singers. In the song literature portion, the children showed their commonly used vocal ranges. The variety of keys helped to show production effects on their vocal ranges. The design and variety of the patterns in the second part of the singing test reinforced the findings of the first section and provided information about what more the students could do vocally, even with limited guidance.

The effects of volume, pitch direction, and interval had enough influence on the pitches sung to conclude that certain pitches can only be sung under certain conditions. Those authors and researchers who have outlined narrow ranges have excluded any of these circumstantial pitches from their range calculations, leaving only pitches which can be sung in chest or mixed chest production. Those advocating lower textbook song ranges have looked only at what students can do on their own, eliminating the effects of vocal teaching in the elementary school classroom. Obviously, the chest voice, that which is closest to the familiar speaking voice, is the choice of the untrained singer. The advocates of higher textbook
ranges realize that the singing voice can be more healthfully produced in slightly higher ranges. These teachers include vocal development as one of their conscious goals of classroom music. The difference between the two camps depends on vocal production.

It was found in this study that the overwhelming majority of students could sing in both primary registers and could control the weight (heavy/light) of the vocal production. Therefore, the range of classroom singing (or any singing by beginning singers) has got to depend on the goals of the person making the choices. So-called "comfortable" ranges, those in the lower, chest voice range, are applicable for work on pitch accuracy. Because of its similarity to the speaking voice, the students have more control of their voices with regard to pitch matching. Higher ranges, those which can possibly avoid any form of chest voice, must be practiced in order for students to gain vocal control. Vocal exercises including echoed patterns must precede the singing of song material in this range if accuracy is expected. Head voice range is not exercised by everyday speech. It needs preparation, conscious skill development procedures, to get it to the level of development one already finds in the chest voice range. Only when the head voice is firmly anchored in production, sound, and feeling, can the two registers be successfully blended. The register transition areas are the most difficult and hardest to control; register blending is a goal of vocal training at all levels. Vocal techniques and music literature must be chosen and consistently used to promote this part of vocal
development if the students are to have full use of their achievable singing ranges.

Conclusions

The singing voices of children do exhibit perceptually distinct registers, the production of which affects the usable singing range. Children can sing in chest register and in head register, the two primary registers of vocal production, and can vary the weight (heavy/light) of the production. However, a majority of students choose independently to sing in a chest voice production, using only the so-called "comfortable" range of bb3 to d5 or lower. While each register's boundaries can be defined, the specific limit of the register's range depends primarily on the intensity (volume) of the vocal production and the pitch direction and intervallic type of movement in a given singing situation. Production factors can change the point of transition within a limited pitch span, creating an area of transition.

The primary register transition (out of chest register) occurs in the area surrounding g4. A secondary point of transition (entering pure head register) occurs in the vicinity of d5.

Almost all of the range needed for classroom singing can be sung in a mixed production, the result of the dynamic balance of the laryngeal musculature in action. A light production that allows transitions between chest- and head-dominated portions of this
mixed production (or middle register, though a secondary register
due to its overlapping nature) must be taught at the most
rudimentary stages of singing to avoid vocal abuse or misuse. While
this range may be sufficient for recreational singing, it is not enough
for artistic expression. Even recreational singing in "comfortable"
ranges has limitations if vocal harm is to be avoided. The main
limitation of this range is volume. Soft singing will not cause vocal
damage, but loud singing engages a heavy production which cannot
be carried up very high without vocal abuse. The other, "unused"
register, the head voice, must be taught.

Initially, one can find head register by exercising the voice
above the area of possible mix, d5 or above. The feel and sound of
the head register must be experienced, practiced, and secured in the
voice before transitions between the registers can be attempted.
Downward vocalization from the head register to the chest register is
the basis of blending the registers. Singers must facilitate or at least
allow register transitions. Ascending through a register transition
area, more difficult than descending, the student must allow the voice
to "flip over" into a new production. The gear shift analogy is an apt
comparison. Making register transitions is similar to shifting the
gears in a car: one must put in the clutch to allow the shift and one
must practice the shifting process until he can feel when to shift
gears to make the process happen smoothly. Accelerating
(ascending) without shifting (negotiating a register transition), is an
inefficient and potentially harmful use of the car's engine. The clutch
action (air, muscular tension) must be coordinated with the gear shift
action (register transition) to make a smooth ride at all speeds (range).

The tendency to resist register change manifests itself in visible tension, audible strain, intonation problems, and vowel changes. The ability to make smooth register transitions increases with age and experience at a rate paralleling the student's ability to find and use the head voice--the true singing voice of childhood.

The obvious presence of vocal registers in beginners' singing voices is one measure of the level of development of the singers. At the lowest level are those students whose heavy production of the chest voice severely limits their singing ranges. Under certain testing conditions, some can find their head voices, but the head voice is not developed enough to be accessible for independent singing. Slightly more proficient are the singers who can lighten their production enough to extend their ranges. However, without learning to use the head voice and mix the registers, the student will not develop any additional range. Students who can sing in either register, but cannot bridge the two need to adjust their vocal production, adding air, lightening the weight, and freeing up the phonatory mechanism to facilitate transitions between the registers. Some students at every grade level have the ability to make smooth register transitions, but the number of the students with this ability increases with age, experience, and additional music training (instrument study and/or choir).

Throughout the study one fact became increasingly apparent: students must be given the tools to learn how to sing. The speaking
voice develops from daily use. The head tone, the true singing voice of childhood, is neither "natural" nor in daily use for any purpose other than singing. Its sounds and its sensations must be felt and heard by the singer. The environment of too few children provides experiences which reinforce the sounds of good singing. Learning to sing in such indirect learning situations is not likely without models, much less instruction. Most of the children in this study (those free of vocal or other health problems) could readily find that other register, the head voice. But unless singing activities are planned to use and develop that less-used register, the vocal control to sing in either or both registers will not exist. Neither will the ability to negotiate transitions between the registers develop on its own. Any study of the singing voice, whether range, accuracy, or any other area, must consider vocal production: what voices do on their own (beginners) and what voices can be trained to do (trained singers).

Pitch accuracy requires enough control of the vocal mechanism to match the voice with the mental concept of the tone. Poor vocal production limits pitch range and pitch accuracy. While the ability to negotiate smooth register transitions does not guarantee pitch accuracy, accuracy throughout the vocal range is not possible without the ability to make these transitions.

Registers, as the acoustic representatives of certain vocal productions in given pitch ranges, are the main perceptual clues a teacher has to monitor vocal progress in beginners. Teachers who want to develop vocal ranges and pitch accuracy throughout the ranges of their students must commit to designing and implementing
vocal production goals. They must do more than sing; they must teach singing.

There are obvious stages of vocal development observable in elementary school children's voices which are affected more by singing (and other musical) experience than by age alone. Based on the implications of the needs of these students at various developmental stages, a systematic, graded series of goals and procedures can be designed for use by their teachers. Fundamental to this is the commitment of the teachers to the need to guide the development of beginning singers. Teachers must do more than use singing; they must encourage, plan for, and teach the basic principles of good singing which are appropriate for any age. In this process teachers need aural cues to monitor students' progress. The presence, location, and flexibility of the vocal registers in the singing voices of children or any beginning singers are obvious indicators of levels of vocal development and inherent needs which cannot be ignored. A student's enjoyment of and desire to continue an activity such as singing is directly proportionate to his mastery of this skill. Teachers who provide the tools and guidance for success in singing not only reap the short-term benefits of a better quality of singing in their classrooms, but also know that they have touched the lives of their students by opening a door to the world of music.
Implications

For beginning singers, a light vocal production is the first step in smoothing register transitions or in facilitating the use of a larger range, even if the transition out of chest voice cannot yet be made. Teaching a light production, then, must be a primary goal in helping beginning singers. Although it is not the end goal of beautiful singing, it is crucial at the lowest level of proficiency (the beginner) in order not to harm the singing voice. At this rudimentary level the young singer needs to know how to avoid vocal abuse and how to keep from inhibiting a natural register or production shift as he adds pitches to his range. If he can "lighten up", he will not develop the hoarse, husky sound heard in some voices (both genders) in every grade level. And, he will be able to sing song literature in what is called a "comfortable range", most likely the octave a3 to a4 or bb3 to bb4. He may shift smoothly from chest mixture to head mixture with a light production, giving him a few more upper pitches, or he may never leave a lightly produced chest mixture, but he can sing functionally and accurately within a limited range without experiencing vocal strain. Any increase in volume demands or upper pitch range will cause problems for which he is unprepared.

At the next level of development is the location of the head voice. The student must feel, hear, and describe this new production in his own voice, and he must identify it in the voices of others. In most cases in this study, head voice was more easily produced when not contiguous with chest voice. Finding the head voice was more
successful when imitating a model of a pattern in a pitch range unable to be produced in chest voice. Regardless of age or gender, students can find their head voice by starting high (above d5) or by leaping to a pitch d5 or above. Once the head voice production is secured, the teacher can help the student extend this new range downward, adding air to allow the mixture and facilitate the register transition. The key is downward vocalization if good vocal production is the goal.

Experience far more than age or gender seems to be the factor most affecting a student's ability to make smooth register transitions. Those who sing often have better control of their singing voices and more desire to sing accurately.

Suggestions for Future Research

Research in elements of vocal production will always be warranted as teachers continuously seek the scientific and research base that is fundamental to their teaching methods. As technology develops, more and more information becomes available. This study might be replicated in a variety of ways. The same type of population and singing test could be used with the data being measured acoustically. Using fiberoptic technology, actual laryngeal changes can be seen during phonation of sound. It would be possible to record on videotape the action of the pitch-changing mechanism, describing visually what occurs in making transitions from one register to another. An experimental study could be conducted to
reveal the effects of vocal training on the ability of children to make smooth register transitions. Child and adult beginners could be compared in other aspects of vocal development to reveal more clearly the stages of vocal development which are production-based. Additional studies involving the refinement of parameters for evaluating vocal tone would greatly help the issue of reliability. While agreement on register names may never occur, finding ways of matching vocal timbres with sound models as well as descriptive labels would certainly aid vocal education.

Researchers can find many areas of needed study by communicating: listening to the teachers discuss their observations, problems, and concerns. In singing, knowledge of the psychophysiology of learning to sing along with an awareness of the ever-increasing body of research findings can provide a sound basis for vocal curriculum development. Communication between researchers and practitioners would provide relevant findings that would be welcomed by teachers who wish to combat the grim prediction that we are becoming a "nation of non-singers" (Kemp, in Phillips, 1985).
REFERENCES CITED


Drexler, E. N. (1938). A study of the development of the ability to carry a melody at the pre-school level. *Child Development, 9*, 319-332.


BIBLIOGRAPHY


Council for Research in Music Education (1986). Bulletin No. 86. Special Issue: Early and Middle Childhood Research in Music Education.


Drexler, E. N. (1938). A study of the development of the ability to carry a melody at the pre-school level. *Child Development, 9*, 319-332.


APPENDICES
APPENDIX A

INSTRUMENTATION

A Panasonic Model RQ-413S cassette tape recorder was used for the pilot study and the study. The portable unit and its built-in condensor microphone were chosen over a larger recording unit to be less intrusive. The machine was checked periodically for pitch accuracy in recording.

Memorex dBS 60-minute tapes were used exclusively throughout the pilot study and the study. Judges’ tapes were dubbed using a Fisher MC-715 Audio System. Because resonator bells were used in the study, each tape recorder used in the evaluation process was checked for playback pitch accuracy, matching known bell tones on the recording to the same pitches played live on the bells.
APPENDIX B

PILOT STUDY RATING FORM

Judges' Rating Sheets
Rater's Evaluation Sheets
Investigator's Rating Sheets
RATING SHEET

Student:

I. Songs
   A. Chosen Song in Student-Chosen Key: Rate on Musical Accuracy

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<tbody>
<tr>
<td></td>
<td>No sense of tune or total speech</td>
<td>Inaccurate; some imitation of contour</td>
<td>Moderately accurate; several modulations</td>
<td>Mostly accurate with 1-2 tonality shifts</td>
<td>Mostly accurate with no tonality shifts</td>
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B. Different Versions: Production and Register (Circle One)

1. Transposed Version #1

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<td>Mostly accurate with 1-2 tonality shifts</td>
<td>Mostly accurate with no tonality shifts</td>
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   Heavy Production | Light Production | Mixed Production
   Chest Voice       | Head Voice        | Middle Voice

2. Transposed Version #2

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<td>Mostly accurate with 1-2 tonality shifts</td>
<td>Mostly accurate with no tonality shifts</td>
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   Heavy Production | Light Production | Mixed Production
   Chest Voice       | Head Voice        | Middle Voice
3. Transposed Version #3

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<tr>
<td>No sense of</td>
<td>Inaccurate;</td>
<td>Moderately accurate;</td>
<td>Mostly accurate with</td>
<td>Mostly accurate with</td>
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<td>tune or</td>
<td>some imitation</td>
<td>several modulations</td>
<td>1-2 tonality shifts</td>
<td>no tonality shifts</td>
<td></td>
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<tr>
<td>total speech</td>
<td>of contour</td>
<td></td>
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Heavy Production      | Light Production                       | Mixed Production                       |                                        |                                        |                                        |
Chest Voice            | Head Voice                              | Middle Voice                           |                                        |                                        |                                        |

4. Transposed Version #4

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<tr>
<td>No sense of</td>
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<td>total speech</td>
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Heavy Production      | Light Production                       | Mixed Production                       |                                        |                                        |                                        |
Chest Voice            | Head Voice                              | Middle Voice                           |                                        |                                        |                                        |

II. Exercises: Circle pitches in student's responses where you perceive a change in production or register or where the voice "stops".

A. 5-note descending patterns

1. Presented: \[\begin{array}{c} \text{Presented:} \\
\end{array} \]
   Performed: \[\begin{array}{c} \text{Performed:} \\
\end{array} \]

2. Presented: \[\begin{array}{c} \text{Presented:} \\
\end{array} \]
   Performed: \[\begin{array}{c} \text{Performed:} \\
\end{array} \]

3. Presented: \[\begin{array}{c} \text{Presented:} \\
\end{array} \]
   Performed: \[\begin{array}{c} \text{Performed:} \\
\end{array} \]

4. Presented: \[\begin{array}{c} \text{Presented:} \\
\end{array} \]
   Performed: \[\begin{array}{c} \text{Performed:} \\
\end{array} \]
B. Scales-Ascending

1. Presented on: c1; Performed Range: 

2. Presented on: d1; Performed Range: 

3. Presented on: f1; Performed Range: 

C. Leaps-Do Sol Do

1. Presented: 
   
   Performed: 

2. Presented: 
   
   Performed: 

3. Presented: 
   
   Performed: 

4. Presented: 
   
   Performed: 

5. Presented: 
   
   Performed: 

III. Overall: Rate ability to negotiate register transitions in order to use full singing range

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<tbody>
<tr>
<td>Sings only in 1 register; range is limited</td>
<td>Independently chooses only 1 register but can find tones in 2nd register with help</td>
<td>Uses 2 (or more) registers with marked breaks in production</td>
<td>Uses 2 (or more) registers with ease, but must be reminded to change production</td>
<td>Independently uses 2 (or more) registers with ease; no production problems related to range</td>
<td></td>
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IV. Comments
RATERS EVALUATION SUMMARY

As a result of this endeavor:

1. Do you think children's singing voices exhibit 1, 2, 3, or more than 3 registers?

2. Do you perceive that a middle register is a mixture of chest and head or a totally separate register?

3. Is it easier to identify production (heavy, light) or register (chest, head)?

4. What events in each child's performance made it easier to identify production or register changes? Please rank your answers 1st, 2nd, etc.

5. How would you change the descriptors on either of the rating scales?

6. Are there additional questions you would add to the judges' rating sheets?

7. Which testing procedures gave you the most information about students' voices?
8. Can you describe any singing tasks you would add to these procedures?

9. How do you approach the subject of registers or vocal production with your children?

10. Are you interested in evaluating tapes for the full study?

Please offer any additional comments:
RATING SHEETS

Name: 	Grade: 

I. Songs

A. Song Chosen: 

Key: 

Range Sung:

Chosen Song in Student-Chosen Key: 

Rate on Musical Accuracy

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B. Different Versions: Production and Register (Circle One)

1. Transposed Version #1

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Presented in _____; Performed in _____ (Range: )

Heavy Production 

Light Production 

Mixed Production

Chest Voice 

Head Voice 

Middle Voice
2. Transposed Version #2

<table>
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</table>

Presented in _____; Performed in _____ (Range: )

- Heavy Production
- Light Production
- Mixed Production
- Chest Voice
- Head Voice
- Middle Voice

3. Transposed Version #3

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Presented in _____; Performed in _____ (Range: )

- Heavy Production
- Light Production
- Mixed Production
- Chest Voice
- Head Voice
- Middle Voice
4. Transposed Version #4

<table>
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</tr>
</tbody>
</table>

Presented in ____; Performed in _____ (Range: _____)

Heavy Production   Light Production   Mixed Production
Chest Voice         Head Voice           Middle Voice

II. Exercises: Circle pitches in student's responses where you perceive a change in production or register or where the voice "stops"

A. 5-note descending patterns

1. Presented: \[\text{Note sequence}\] Performed: \[\text{Note sequence}\]

2. Presented: \[\text{Note sequence}\] Performed: \[\text{Note sequence}\]

3. Presented: \[\text{Note sequence}\] Performed: \[\text{Note sequence}\]

4. Presented: \[\text{Note sequence}\] Performed: \[\text{Note sequence}\]

B. Scales-Ascending

1. Presented on: C1; Performed Range: \[\text{Range}\]

2. Presented on: D1; Performed Range: \[\text{Range}\]

3. Presented on: F1; Performed Range: \[\text{Range}\]
C. Leaps-Do Sol Do

1. Presented: ♩ ♩ ♩ ♩ ♩
   Performed: 

2. Presented: ♩ ♩ ♩ ♩ ♩
   Performed: 

3. Presented: ♩ ♩ ♩ ♩ ♩
   Performed: 

4. Presented: ♩ ♩ ♩ ♩ ♩
   Performed: 

5. Presented: ♩ ♩ ♩ ♩ ♩
   Performed: 

D. Remedial Procedures (Describe)

III. Summary

A. Range

1. Used in Song Material

2. Used in Exercises

3. Total Singing Range Used

B. Production/Registers

C. Rate ability to negotiate register transitions in order to use full singing range

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<td>Sings only in 1 register; range is limited</td>
<td>Independently chooses only 1 register but can find tones in 2nd register with help</td>
<td>Uses 2 (or more) registers with marked breaks in production</td>
<td>Uses 2 (or more) registers with ease, but must be reminded to change production range</td>
<td>Independently uses 2 (or more) registers with ease; no production problems related to change production range</td>
</tr>
</tbody>
</table>

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APPENDIX C

STUDY RATING FORMS

Judges' Rating Form
Raters' Evaluation Sheet
Investigator's Rating Form
RATING SHEET

Student:  M/F  Grade:  Tape #

I. Songs: Circle the register you perceive to be used predominantly in each performance

A. Song in Student-Chosen Key
   Chest Register  Head Register

B. Transposed Version #1
   Chest Register  Head Register

C. Transposed Version #2
   Chest Register  Head Register

D. Transposed Version #3
   Chest Register  Head Register

Conclusion

At the end of the total performance, circle the appropriate category. This student:

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<td>Sings only in 1 register; range is severely limited</td>
<td>Independently chooses only 1 register, but can find 2nd register with help</td>
<td>Uses head and chest registers, but exhibits marked breaks in production</td>
<td>Can lighten production to increase range, but lacks clear head tone</td>
<td>Makes smooth register transitions; no production problems related to range</td>
</tr>
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II. Exercises: Draw a line between pitches in student's responses where you perceive a change in production or register.

A. 5-note descending patterns

1. Presented: 

   [Musical notation]

   Performed: 

2. Presented: 

   [Musical notation]

   Performed: 

3. Presented: 

   [Musical notation]

   Performed: 

B. Scales-Ascending

1. Presented on: c1; Performed Range: 

2. Presented on: f1; Performed Range: 

C. Leaps-Do Sol Do

1. Presented: 

   [Musical notation]

   Performed: 

2. Presented: 

   [Musical notation]

   Performed: 

3. Presented: 

   [Musical notation]

   Performed: 

4. Presented: 

   [Musical notation]

   Performed: 

RATERS EVALUATION SUMMARY

As a result of this endeavor:

1. Do you think children's singing voices exhibit 1, 2, 3, or more than 3 registers?

2. Do you perceive that a middle register is a mixture of chest and head or a totally separate register?

3. Is it easier to identify production (heavy, light) or register (chest, head)?

4. What events in each child's performance made it easier to identify production or register changes? Please rank your answers 1st, 2nd, etc.

5. Which testing procedures gave you the most information about students' voices?

6. How do you approach the subject of registers or vocal production with your students?
RATING SHEET

Student: M/F Grade: Tape #

I. Songs: Circle the register you perceive to be used predominantly in each performance

A. Song in Student-Chosen Key

Song Chosen: Key: Range Sung:

<table>
<thead>
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<th>Head Register</th>
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B. Transposed Version #1

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c. Transposed Version #2

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D. Transposed Version #3

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A. 5-note descending patterns

1. Presented: \[ \text{[Musical notation]} \] Performed: \[ \text{[Musical notation]} \]

2. Presented: \[ \text{[Musical notation]} \] Performed: \[ \text{[Musical notation]} \]

3. Presented: \[ \text{[Musical notation]} \] Performed: \[ \text{[Musical notation]} \]

B. Scales-Ascending

1. Presented on: c1; Performed Range: \[ \text{[Musical notation]} \]

2. Presented on: f1; Performed Range: \[ \text{[Musical notation]} \]

C. Leaps-Do Sol Do

1. Presented: \[ \text{[Musical notation]} \] Performed: \[ \text{[Musical notation]} \]

2. Presented: \[ \text{[Musical notation]} \] Performed: \[ \text{[Musical notation]} \]

3. Presented: \[ \text{[Musical notation]} \] Performed: \[ \text{[Musical notation]} \]

4. Presented: \[ \text{[Musical notation]} \] Performed: \[ \text{[Musical notation]} \]
III. Overall

A. Rate ability to negotiate register transitions in order to use a full singing range

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IV. Summary

A. Range

1. Used in Song Material

2. Used in Exercises

3. Total Singing Range Used

B. Production/Registers