1992

Vocal Registration: History, Analysis, and Modern Pedagogical Applications

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Vocal Registration:

History, Analysis, and Modern Pedagogical Applications

BY

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THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

MASTER OF ARTS IN MUSIC

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
CHARLESTON, ILLINOIS

1992

I HEREBY RECOMMEND THIS THESIS BE ACCEPTED AS FULFILLING
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Abstract

A controversial aspect of vocal pedagogy is vocal registration or common divisions of the compass of the voice. A history of theories of registration, beginning in 1250, is compiled in chronological order. From this list, five contrasting theories are examined. Practical suggestions have been presented for use and application of this information, especially by the high school voice teacher.

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INTRODUCTION

There are many aspects of vocal pedagogy worthy of research. One of the most controversial is vocal registration. Numerous experiments, theories, and differing conclusions exist and researchers may find this frustrating and inconclusive.

The term register was borrowed originally from organ terminology. In Italian, the stops of an organ are called the registers. It has been used in regard to the voice since the thirteenth century when people began to use registration to describe the timbre of the voice. Of all the writings since that time, perhaps Nadoleczny's in 1923 contains the most complete and descriptive definition of vocal registers. He believed that a register was a series of consecutive tones that were similar in timbre. To the musically trained ear the timbre of these tones would be distinguishable from tones belonging to another register. He believed registers to be caused by laryngeal adjustments, which respond to the demands of range and dynamics. He believed there to be a gradual transition between registers, and that several tones could be sung using more than one register, although not with the same intensity (Large, 1972).

Nadoleczny's definition of vocal registers, based on laryngeal function was accepted by many theorists. Four other common definitions were based on range, timbre, the area of the voice located between breaks or lifts, or the different areas of resonance. Definitions based on areas of resonance such as the head, mouth or throat, and chest are very misleading. These differences in terminology have caused theorists to disagree on the number and names of the registers.

The definition one chooses depends on their skills and knowledge. Voice teachers depend on their auditory discrimination, which refers to what they hear during singing and possibly on their perceptual discrimination, which refers to sensations during singing, to develop their theory of registration. The voice scientists rely on the results of their scientific experiments and other scientific data.

Chapter 1 is a compilation of a chronological history of writing on registers. Voice teachers, voice scientists, and singing voice scientists were selected, due to their impact on the history of registration. Some contributed more than others, but implications of all were significant and have added much to our knowledge of registration. In Chapter 2 theories of registration advanced by one voice teacher, two voice scientists, and two singing voice scientists are explained along with their experimental data. Finally, Chaper 3 presents suggestions for the use and application of these theories, especailly by the high school teacher.

CHAPTER 1

HISTORY OF REGISTRATION

The concept of vocal registers has been an important part of vocal pedagogy for at least 740 years. The earliest identification of registers came from two medieval theorists named John of Garland (c. 1193-c. 1270) and Jerome of Moravia (c.1250). They believed the voice to have three registers (Hanson, 1987). In 1250, John of Garland, in De plana musica, wrote:

> It must be known that the human voice exists in three forms; it is a chest voice, throat voice, or head voice. If it is a chest voice, then it is in the low register; it ought to be placed in the lowest part of the piece. If it is a throat voice, it is in a middle position in relation to each, that is to the low and the high. And just as far down the chest voice is in the low register, so the head voice is high and in the upper register. And, in regard to the way of singing, chest voices ought to be placed in their proper place, that is in the lower part, throat voices ought always to have the middle place in the upper sections (Gardiner, 1968, p. 200).

Increasing attention was given to vocal registration in the seventeenth century. The controversy over the number and names of registers began to develop (Hanson, 1987). In the beginning of this century, Le Nuove musiche was written by Giulio Caccini (1546-1618). Caccini was a well known singer, composer, and singing teacher. His reputation was based more on his singing and teaching ability than on his gifts as a composer. Caccini wrote about the "noble manner of singing" in which he emphasized breath control, dynamics, and registers. Caccini recognized two registers: "voce piena" and "voce finta". This literally means full voice and distinguished voice (Henderson, 1938).

Caccini encouraged singers to extend their chest voice up into the middle part of their range. This meant all tones but the highest, which utilized falsetto, were to be sung in chest voice. He wanted this upper middle range to take on a slightly new timbre. Caccini remains a very important teacher because he was perhaps the first to perceive and explain the blending of registers (Hanson, 1987).

Domenico P. Cerone (1566-1625), an Italian who associated himself with the music of Spain and the Spanish-owned Kingdom of Naples, was the music theorist and chapel singer of Philip II and Philip III. His work, El melepeo y maestro, tractado de música theoretics y practica, is a valuable resource of information and insights into composition and musical practices in the sixteenth century. It contains his theory of the existence of two registers, chest and head (Fuchs, 1964).

Two Italian masters, Pietro Francesco Tosi (1647-1732) and Giovanni Battista Mancini (1716-1800), identified two registers. They used the terminology of chest register and head register. Mancini also referred to head register as falsetto.

Tosi, a singer and teacher, wrote Opinioni de' cantori antichi e moderni in 1723. It is an important treatise in singing that reflects the vocal practices of the seventeenth and the beginning of the eighteenth century. This may be the first indication of a terminology problem concerning vocal registers. It is unclear whether Tosi actually believed in three registers named chest, head, and falsetto or two registers named chest and head, which could also be referred to as falsetto. Tosi's translators added footnotes that identified falsetto as different from head register.

William Vennard (1967), a singing voice scientist, believed Tosi continued his theory on a two register system, because Tosi did not consider falsetto a useful register. Tosi's opinion of the falsetto register may have been influenced by the fact that he was a castrato. In the seventeenth and eighteenth centuries when the powerful and sweet voices of the castrati were available, it was highly unlikely that those in the great professional vocal circles would have valued falsettists (Miller, 1987).

Mancini wrote Pensieri, e riflessioni pratiche sopra il canto figurato in 1774, in which he described the physical and technical aspects of vocal pedagogy with an emphasis on performance practices. In this treatise he suggests that chest voice is the natural part of the voice and the strongest. He even believed that in rare instances chest register was the only one used throughout the voice (Curtis, 1973).

The early theorists and teachers named vocal registers according to the origin of sensations and the illusions of singers. Those tones that they believed produced sensations or resonance in the chest were produced by chest voice. Those tones that they believed produced sensations or resonance in the head were produced by head voice.

In 1774, the same year Mancini was defining his theory of two registers in Italy, a German composer and theorist named Johann Adam Hiller (1728-1804) was writing his own theory of registration that included chest voice, head voice, and falsetto voice. His work is entitled Anweisung zum musikalisch-richtigen Gesang (Sadie, 1980).

Hiller influenced Johann Paul Aegidius Martini (1741-1816), another German composer, teacher, and organist who was active in France. He wrote a pedagogical work, Mélopée moderne, which draws heavily on the findings of Hiller and named his three registers chest, throat, and head (Sadie, 1980).

Vincenzo Manfredini (1737-1799) wrote Regole Armoniche in 1775 in Venice. He wrote the second edition in 1797. This included new sections on singing in which Manfredini described his belief of two registers, those being chest and head or falsetto.

Many attempts were made to study vocal processes. Antoine Ferrein in 1741 conducted the first experiments with excised larynges. He supported the theory that air was necessary in order for vocal cords to vibrate and that the vibrations of the vocal folds were necessary for vocal production.

An early nineteenth century researcher from Germany named Johannes Peter Müller (1801-1858) was particularly important because of his investigations in 1837 using excised larynges and models of larynges. He described the laryngeal vibrations in two different registers. When producing chest tones the entire surface of the cords vibrated. For falsetto tones, vibrations were reduced to inner margins of the folds (Large, 1972).

In 1829 Dr. Benjamin Babington invented an instrument called the glottiscope. Its purpose was to allow him to observe the vocal processes. It was a single laryngeal mirror that reflected the sunlight by a small looking glass or hand mirror. It was very clumsy to use, because it took two hands to work it properly. Bozzini unsuccessfully attempted to perfect the glottiscope by reflecting light on a mirrored image. Avery tried to improve its function by using artificial light. Warren in 1844 decided to apply prisms as reflectors to the glottiscope. None of the above improvements were successful in making the glottiscope easy to use (Getz, 1982).

A Spanish baritone and singing teacher named Manuel Patricio Rodriguez Garcia (1805-1906) became what is known today as the "Pioneer of the Scientific Teaching of Singing" (Fillebrown, 1911). This was due largely to the fact that he was the first man to study the living larynx during phonation and that he invented an instrument called the laryngoscope in 1854. This was nothing more than a small mirror fastened at the proper angle to a long handle. Until this invention there was no way to look down the throat. Many people associate Garcia with his invention of the laryngoscope, but he taught singing, not surgery. His ability to demonstrate his theories in a pedagogical manner allowed others to understand and accept them (Getz, 1982).

Garcia presented his first published work, Mémoire sur la voix humaine, to the Academy of Science in 1840. In this treatise, Garcia explained results of experiments he conducted on his own students concerning the position of the larynx during the singing of tones in various registers. He explained how the larynx was raised and lowered in the throat, according to the register used for producing the tones. He also described the position of the tongue and soft palate (Monahan, 1978). This established Garcia as the first to emphasize laryngeal adjustment as an explanation for vocal registers (Large, 1974).

This treatise was reported upon and accepted only after the investigating committee called Garcia in and he was able to demonstrate these theories with his students. The number of students Garcia used or their abilities was not listed. Garcia defined a register as follows:

> 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 mechanic principle, the nature of which differs basically from another series of succeeding sounds of equal quality produced by another mechanical principle (Large, 1972, p. 18).

Garcia conducted experiments with his laryngoscope and published his results in 1855 in his paper "Physiological Observations on the Human Voice" at the Royal Society of London (Garcia, 1980). Initially he experimented upon himself. This laryngoscope allowed him to see the distinct vibratory patterns of living vocal folds in the different registers. Garcia described three registers instead of two: chest, falsetto (middle), and head. This was in many respects a reflection of Caccini's model, except that he put falsetto between chest and head registers. This terminology had been customary for voice physiologist for most of the nineteenth century. In this location falsetto became the male voice upper register and the female voice middle register.

Based on configurations of cartilaginous and ligamentous portions of the glottis in singing, he subdivided chest and falsetto registers into two parts each. This is the reason that Garcia is sometimes connected with a five register theory. A few years later Garcia modified his theory to a three register theory (Curtis, 1973).

Garcia found that vocal cords vibrate loosely and at their full extent in chest register. In falsetto or middle register, the vocal cords are stretched thinner and the vibrations take place just at the edges of the vocal cords. In head register, the vibrations were produced exclusively by the ligaments. In addition, Garcia found that in the highest portion of head voice, the ligaments diminish in length and in width. This refers to that portion of head register where the vocal cords vibrate while stretched to their ultimate length (Large 1972).

His experimentation with the laryngoscope led to clarification of prior information, much of which was inaccurate and undocumented, with regard to the anatomy and function of the vocal mechanism. His academic achievements led to widespread interest in laryngoscopic research. (Monahan, 1978).

A German named Max Joseph Oertel was the first to apply more delicate and scientific methods to the examination of the vocal cords. He did this with an instrument called a laryngo-stroboscope and published the results in

1878. The stroboscope is an instrument which enables us to see the intrinsic movements of any vibrating object. With the aid of the stroboscope, Oertel described action of the vocal cords in two registers he called chest register and upper register (Curtis, 1973).

A study by Emil Behnke and Lennox Browne in 1883 indicated that the vocal registers had five divisions. They were named lower thick, upper thick, lower thin, upper thin, and small. This correlates with the three registers found by Garcia as well as the subdivisions he indicated (Getz, 1982).

Sir Morrell Mackenzie (1837-1892) was a famous English laryngologist. He considered himself the voice doctor of his time. Mackenzie conducted careful experiments and laryngoscopic investigations in regard to registration. In 1886 he published his conclusions. He believed the voice to have two registers, the same number Caccini had found three centuries earlier. He called them long-reed and short-reed. He described the vocal cords as they correspond to the vibrating reeds of the oboe. According to this theory, changes in pitch are caused by changing the contour of the glottic aperture, by altering the elasticity of the margins of the cords, and by varying the contour of the entire resonating system (Appelman, 1967).

Mackenzie's theories were often rejected by voice teachers. Mackenzie was a laryngologist and approached his theory from a strictly medical aspect. There was little thought for the teaching of this long-reed and short-reed theory. Mackenzie's research of vocal registers, however, deserves serious attention (Large, 1972).

Giovanni Battista Lamperti (1840-1910) wrote of three registers in 1905. He referred to them as chest voice, medium voice, and head voice. He indicated some opposition to the teachings of Garcia. He described how Garcia's student, Jenny Lind, lost her voice when she was young. She studied with Garcia for quite some time in Paris and failed to regain her voice. Jenny Lind went home, worked out her vocal problems, and became the greatest singer of her age. Lamperti referred to his belief that coaching by too many voice doctors can undermine the control and power that nature gives a singer (Lamperti, 1931).

In 1923 Nadoleczny made one of the most comprehensive studies of vocal registration to date. In 1938 he rewrote his definition of registers to reflect findings by Weiss that the acoustic coupling (resonance interaction) of the supraglottal system (system above the glottis) to the larynx might account for registers. The resonance which affects the acoustics of the voice is found in the supraglottal cavities. Nadoleczny concluded that registers are produced by the coupling between the larynx, the vocal tract and the trachea. He did not feel that the form of the vibration of the vocal folds was of great importance to the registers (Large, 1972).

In 1932 two French scientists, Husson and Tarneaud applied the stroboscope to the larynx. The stroboscope is an optical instrument used to stop the motion of rapidly moving objects. In 1950 Husson proposed the "Neurochronaxic Theory of Voice Production". This refers to the ability of the vocal cords to vibrate without air current, solely in response to neural impulses. From this theory, Husson believed the voice had four registers consisting of two main registers and two additional registers designated for the high part of the voice. The "premier registre" or "registre monophasé" corresponds to chest register. The "second registre" or "registre biphasé" corresponds to male falsetto or women's head register. The "troisieme registre" or "registre triphasé" corresponds to whistle register. The whistle register is usually the highest register of a woman's voice. The "quatrieme registre" or "registre quadriphasé" was even a higher frequency register only attainable by unusual singers. In time, Husson disproved the theory of whistle register (Burgin, 1973).

In 1939 Bell Telephone Laboratories investigated the action of the vocal cords with a remarkable motion picture camera called the Fastax camera. One year later Daniel Farnsworth coupled the Fastax camera to the laryngoscope. He discovered that the vocal folds begin to open from underneath and the opening progresses upward and outward. The lower portion is the first to close as well. This was known as the vertical phase difference (Large, 1972).

Paul Oncley proposed a dual concept of voice registers in 1952 comprising both physiological registers or laryngeal adjustments and acoustic registers. He believed the voice had two physiological registers, but several acoustic registers resulting from the enhancement of different harmonics as the frequency is varied and formants are held essentially constant (Large, 1972).

Janwillem Van den Berg, a voice scientist, supported the theory of Nadoleczny concerning subglottal and supraglottal couplings affecting the vibration form of the vocal folds. He agreed with Fant in 1963 that the main factor governing the production of different registers is probably the different muscular adjustments of the vocal folds. Van den Berg became the leader of opposition to Husson and his neurochronaxic theory of registers. He identified three main registers, the chest, mid, and falsetto or head register, and two auxiliary registers, the flageolet or whistle register for females and strohbass or church-bass for males (Large, 1972).

Mörner, a Swedish voice teacher and scientist reviewed all the different sets of terminology for registers in 1963. She suggested new names for five basic registers. In English these translate to: deepest range, deep level, mid level, high level, and highest range (Large, 1973).

D. Ralph Appelman, another voice scientist studied registers by means of planigraph, radiograph, and spectrograph. He spent a great amount of time studying the transition from middle register to upper register. In 1967 Appelman identified three registers for males: chest, middle, and falsetto; and three registers for females; chest, middle, and head (Appelman, 1967).

John Large was a voice scientist, as well as an educator and talented performer. He believed after reviewing register theories by Garcia, Nadoleczny, Van den Berg, and Oncley that a new approach to registers was necessary. In 1972 he named his model of registers "the Integrated Physiologic-Acoustic Theory of Vocal Registers". He identified three registers and referred to them as chest, middle, and head or falsetto (Large, 1972).

William Vennard (1909-1971) was a voice scientist and voice teacher. Vennard's theory of registration was based not only upon scientific details, but also from his teaching experiences. He confirmed Van den Berg's theory of registration, but in 1967 divided the voice into two registers. Vennard's terms for registration were "heavy mechanism" for chest voice and "light mechanism" for falsetto (Large, 1972).

Victor Alexander Fields was a theorist and educator. He gathered information on vocal registers in 1970, but never mentioned registers or register breaks in his teaching. He believed the glottal musculature would be most accurate for singing when the student displayed proper posture, when the ear controlled vocal output, and when expression rather than technique was the motivating factor (Fields, 1977).

In 1987 Johan Sundberg, who has been described as the world's foremost expert on the acoustics of singing, based his theory of registration on the acoustics of the singing voice. Sundberg identified two registers for the male voice: modal and falsetto. He identified three registers for the female voice: chest, medium and head (Timberlake, 1990).

It would seem, given this history of registration that the main reason for the confusion surrounding registers is that the word is used to describe so many things. The following table aids in demonstrating the lack of consistency regarding the naming and the number of registers (see Table 1).

Table 1

Terminology of Registers

Name	Preferred	Names of	Registers
John of Garland (1250)	chest voice	throat voice	head voice
Jerome of Moravia (c.1250)	vox pectoris	vox gutturis	vox capitus
Caccini (1601)	voice piena (naturale) natural voice	voice finta, feigned voice	
Cerone (1613)	chest voice	falsetto voice	
Tosi (1723)	voice di petto	voce di testa (falsetto)	
Mancini (1774)	voce di petto	voice di testa o falsetto	
Hiller (1774)	chest	natural / head	falsetto
Martini (1792)	chest	throat	head
Manfredini (1775)	chest	head / falsetto	
Müller (1837)	chest	falsetto	
Garcia (1841)	chest		falsetto-head
(1856)	chest	falsetto	head
(1894)	chest	medium/falsetto (male)	head
Oertel (1878)	chest		upper
Behnke and Brown (1883)	thick lower thick/upper thick	thin lower thin/upper thin	small
MacKenzie (1885)	long - reed	short - reed	
G.B. Lamperti (1905)	chest	mixed	head
Nadoleczny (1923)	not indicated		
Husson (1950)	premier registre registre monophasé	second registre registre biophasé	registre troisieme registre triphasé
Oncley (1952)	not indicated		
Van den Berg (1963)	chest	mid	falsetto/head
Mörner (1963)	deepest range / deep level	mid level / high level	highest range
Appelman (1967)	chest	middle	falsetto(male) head (female)
Large (1968)	chest	middle	head/falsetto
Vennard (1967)	heavy mechanism (chest)		light mechanism (falsetto)
Fields (1970)	none		
Sundberg (1987)	modal (male) chest (female)	medium (female)	falsetto(male) head (female)

CHAPTER 2

CURRENT THEORY, RESEARCH, AND PEDAGOGY

A great number of people, as shown in Table 1, identified registers and applied them to theories. Voice scientists Paul Oncley and Janwillem Van den Berg, and singing voice scientists John Large and William Vennard, and voice teacher Victor Fields, figure so prominently in the field of vocal registration, that their theories are worthy of attention.

Paul Oncley, Voice Scientist

Paul B. Oncley was born in Chicago on June 22, 1911. His professional career has included conducting youth symphonies, teaching acoustics and vocal pedagogy at the college level, and working for Bell Telephone Laboratories. Although he is most often referred to as a voice scientist, he has a significant background in teaching (American Men and Women in Science, 1989).

Oncley presented a theory of registration which involved laryngeal adjustment and lifts as two distinct and unrelated causes. He believed there were two registers, using different muscular action, which comprised the physiological aspect of his concept. The lifts, or changes in voice quality, were purely acoustic in origin. He called his theory, the dual concept of singing registers (Oncley, 1970).

Oncley agreed with William Vennard, singing voice scientist, with regard to the voice having two registers based on laryngeal adjustments. Oncley viewed high speed motion pictures to study the relationship between the resonance shifts and the skill or talent of a singer. He concluded that a well-trained singer had learned a sophisticated control of laryngeal muscles and could limit resonance shifts. Conversely, a non-singer did not have the ability to control the laryngeal muscles and his resonance shifts were apparent (Oncley, 1970).

Oncley observed a series of changes in voice quality that were often called lifts. He believed they originated due to acoustics. He found proof of this in a sound spectrum which charted the vowel /a/ (ah) sung by a male voice on six different pitches over the range of about one octave. Evidence of the lifts correlated with different harmonics of the voice which were enhanced as the frequency was varied. The vowel formant resonance in the throat and mouth were held constant.

Oncley believed perceptions of a singer might be entirely different. A singer who believes he feels a different register adjustment or that he hears a different register, might be reacting to the acoustical phenomenon caused by the formants of the voice. Oncley referred to this as formant-induced changes. These formant-induced changes were more clear in a well-trained singer than in a non-singer. This was true because well-trained singers had more strongly developed harmonics and were trained to sing vowels that did not migrate.

Oncley (1970) based part of his theory on the well known work of Daniel Farnsworth at Bell Telephone Laboratories in 1940. He viewed the laryngeal musculature through a high speed motion picture coupled with the laryngoscope. Farnsworth included trained and non-trained singers in his study.

Oncley (1970) also studied results of research by Dr. Charles Hirt and Dr. Harry Rubin, who attempted to isolate the mechanical principles, or the workings of the laryngeal musculature, that aid in producing falsetto and normal registers. Dr. Hirt and Dr. Rubin confirmed the two register theory, based on a whole cord vibration for normal voice and female chest voice. During male falsetto voice and female head voice, only a portion of the cords vibrated. The cricothyroid muscle caused the cords to get tighter, and lengthen, and consequently, the pitch to rise. Oncley found much validity in these two studies. However, he questioned the ability of anyone to sing with their natural quality as their throat was being invaded by an instrument.

The other type of register adjustment that Oncley stressed was acoustical and was a result of the formants of the voice. Oncley (1970) referred to the formants as the peak frequencies produced by cavities of the resonance system. He discussed two types of formants. The first type was vowel formants. They are sometimes referred to as F_1 and F_2 and change depending on the vowel produced. These vowel formants are individually variable, because the vowels are formed by the resonances of the mouth and part of the larynx. These areas change in shape as the vowels are changed due to the movement of the jaw and tongue.

Oncley spoke of the upper two formants, F_3 and F_4, which are referred to as quality formants. The characteristics of these upper formants are directly related to the individual making the sound, particularly the make-up of their upper naso-pharynx and lower pharynx. Oncley believed these areas of resonance produce the quality formants.

Oncley interpreted much research that referred to shifting registers as an actual shift in the vowel formant frequencies so that they fall near or on a harmonic pitch being sung. For example, when singing from g3 to a♭3 there is a transfer of resonance from the fourth to third harmonics for F_l, and from sixth to fifth for F_2. Approximately a minor third higher there is a transfer from the fifth to fourth harmonics involving F_2 and between c4 and c#4 resonance shifts from third to second harmonics involving F_1. The shifts become more audible as the pitches ascend, because there are fewer prominent harmonics in the higher pitches. Oncley (1970) pointed out that register shifts are related to laryngeal changes while resonance shifts are acoustical changes and are formant-induced. Although for many people, induced change may be triggered by resonance change, Oncley considered the two quite separate and distinct.

Oncley is a well-known voice scientist, and also a voice teacher who relates his findings to teaching. He believed formant-induced changes of the voice were helpful in voice classification. He was aware that the resonance shift from a♭4 to a4 was important to the tenor voice. The shift between e5 and f5 was important to the soprano voice. He believed the importance of the resonance shifts is greatest at the top of the normal range of the voice and that these varied, due to the shape and size of the individual's mouth.

He believed the trained singer could limit register shifts by controlling the laryngeal muscles. He correlated the findings of Dr. Hirt and Dr. Rubin to his teaching. He believed the student should be able to sing a descending scale and bridge the gap between head and chest registers in the female voice. The active portion of the cords would lengthen until the whole glottis was active. Then the singer could continue down as the whole cord vibrated and this would eliminate the gap.

In closing, Oncley advised teachers to make a chart on each of their students which would reflect basic formant frequencies for each individual.

This analysis would be an inexpensive method of studying formant-induced change and would give the student a basic awareness of acoustic registers.

Oncley (1970) believed the phonetician who sees the muscular mechanism shift and the voice teacher who hears the formant-shift adjustments should consider both theories relevant, but separate from each other. The acoustic and physiological theories are important and together make up Oncley's theory of registration.

Janwillem Van den Berg, Voice Scientist

Janwillem Van den Berg, born November 26, 1920 in Groningen, Netherlands, was well known for his laryngeal research. He was Professor and Department Chair of Medical Physics in Groningen and has written numerous journal articles.

Van den Berg's theory of registration was based on the properties of the vocal ligaments and the conditions under which they are used. His findings, published in 1960, described three main registers identified as chest, head, and falsetto. He believed mid voice overlapped chest and falsetto voice and that it was actually a mixture of chest and falsetto, not an independent register. He was also aware of two less important registers called strohbass of the male and whistle register of the female (Van den Berg, 1960).

Van den Berg believed the characteristics and adjustments of the vocal ligaments are essential in determining the type of vibrational pattern of the vocal cords. The vocal ligaments contain two types of fibers, elastic and collagenous. In chest voice, where there are small elongations, only the elastic fibers oppose the stretching force and the vocal response is low pitches. In falsetto, where there are large elongations, the collagenous fibers become stretched, allow no further stretching, and the vocal response is high pitches. Between the two extremes lies the mid voice (Fink, 1975).

Van den Berg's theories were constantly being revised by new experiments. The most precise way to understand the development of his theory is to review his research and conclusions. Van den Berg formed his theory of registration on experiments conducted with excised larynges. Most of the time he would use human cadaver larynges, but when none were available, he used canine larynges. He stripped the larynges of their extrinsic structure except for a small section of the trachea. He added a weight to the the cricoid cartilage and used the weight to attach the cartilage to the apparatus. In order to simulate the activity of the lateral adductor muscles, the interarytenoid muscle, and the cricothyroid muscle, Van den Berg attached three sets of threads. The trachea was attached to the false subglottal system (Baer, 1981).

There were a few problems with experimentation on excised larynges. The usefulness of the information was limited, because the non-living larynges contained dead tissues which would have different mechanical properties than live larynges. The vocalis muscle would not be properly stimulated and that part of the vocal cords is usually active during phonation. As mentioned earlier, if human cadaver larynges were not available, Van den Berg would experiment on excised canine larynges. This was not applicable to theories based on human cadaver larynges, because there were major differences between the two (Baer, 1981).

There were positive aspects to these experiments. Van den Berg (1962) was able to study the effect of a variation of one parameter at a time, while he kept the others constant. He was also able to vary several parameters at a time and study their effects on the experiment.

As early as 1953, Van den Berg formed a theory of registration. He believed three things were necessary. The first was the coordination of the laryngeal muscles with the air flow from the trachea. This produced tones with different register characteristics. The second was the change in the coupling mechanism of the resonator and the vocal cords. The third was the muscle itself had to perform a specific action, especially in transition from chest to falsetto register. This became important, once again for Van den Berg in 1962.

In 1956 Van den Berg became interested in researching air pressure in the vocal mechanism. He believed subglottal pressure behavior was essential in controlling the fundamental frequency and intensity of phonation. The first experiment regarding this air pressure was carried out in that year. Van den Berg attempted to use esophageal pressure as a substitute of subglottal pressure. He inserted a balloon into the esophagus by connecting a tube with a pressure transducer attached to its exterior end. His conclusions had some merit, but the method of measurement was limited due to the intervening tissues and structures between the subglottal space and the pressure sensing device. The most common method of reaching the subglottal space was to use a puncture needle. This was successful in measuring air pressure in the subglottal space, but it was painful and left permanent scars on the subject. There were also medical risks in this procedure (Koike,1981).

Van den Berg devised another method for measuring subglottal pressure in 1956. He inserted a thin polyethylene catheter through the glottis. This created problems once again in the method of measurement, due to the distance between the transducer and the point of measurement in the trachea. This led two scientists to improve the measuring device so that the sensor was placed directly into the desired location of the larynx. They conducted an experiment on one male subject a few years later and published results on only one subject. The importance of these experiments was not in the results obtained, but that Van den Berg became aware of the need to study the relationship between the physiological motion of the glottis and the acoustic occurrences in the larynx (Koike, 1981).

In 1957, Van den Berg became interested in glottal aerodynamic properties (Titze, 1981). This interest was related to studies by Ferrein in 1741 who conducted the first experiments with excised larynges and was the originator of the first myoelastic explanation. This dealt with the elasticity of the muscles. Ferrein supported the theory that air was necessary to the vibration of the vocal cords and that vibrations of the vocal cords were necessary for vocal production (Fink, 1975).

Another theory emerged in 1950 from Husson, identified as the neuro-chronaxic theory. This theory explained that the frequency of the vocal cord vibration was determined by the chronaxy of the recurrent nerve, and not by breath pressure or by muscular tension. Chronaxy refers to the speed of the vibration. The recurrent nerve refers to a branch of the nerve that supplies all laryngeal muscles except the cricothyroid (Vennard, 1967). In short, he meant that each vibration was due to muscle contraction.

Van den Berg became the leader of opposition to Husson (Large, 1972). Van den Berg led studies to support the myoelastic-aerodynamic theory of phonation. This theory added the aerodynamic considerations defined by the Bernoulli effect to Ferrein's explanation of the myoelastic theory. The Bernoulli effect refers to the respiratory airflow through the glottis causing closure of the glottis whenever the folds are separated by less than three millimeters (Fink, 1975). The quality of sound was a result of the shape of the glottal pulse and the transmission characteristics of the supraglottal tract (Large, 1973).

Van den Berg verified the myoelastic-aerodynamic theory in his experiments in 1962. He concluded that the cricothyroid muscle was contracted tightly during transition from chest register to falsetto register (J. B. van Deinse, 1981).

In 1963, Van den Berg (1960) developed a new concept for the origin of registers based on experiments with excised larynges. He published "Vocal Ligaments Versus Registers" which described and defined the various registers in terms of vocal ligaments and vocal muscles, adjustment of the larynx, flow of air and coupling of the larynx itself, to the supraglottal, and the subglottal system. He believed that the longitudinal tension in the vocal muscles was an important aspect in determining the response in the main registers of chest, middle, and falsetto. At this point, Van den Berg still believed head and middle registers to be the same (Large, 1980).

By 1968, Van den Berg had conducted more experiments and concluded that head and middle registers could no longer be equated. Instead, he renamed head register as falsetto register. He realized that the cricothyroid muscles, assisted by the vocalis muscle and lateral cricoarytenoid muscles remained contracted as long as possible. When they could not increase the tension, they gave up and the voice cracked. The phonation switch to the lighter register of falsetto and control over phonation frequency was taken over by another mechanism (Sundberg, 1987).

In 1968, Van den Berg analyzed the difference between chest and falsetto registers. He believed chest and falsetto voices were achieved by exclusive laryngeal adjustments. His subjects were asked to sing an ascending scale from their lowest to highest pitch in chest register. They experienced a switch in registers. This occurred because they needed to change from a laryngeal adjustment with the most active tensions in the vocalis muscle to a laryngeal adjustment with much more relaxed muscles. The relaxation was necessary in order to get the most elongation and tension in the vocal cords by the cricothyroid muscle. The vocal cord tension was then passive. Van den Berg believed that contraction of the vocal muscle shortened the glottis and raised the pitch (Fink, 1975).

The research conducted by Van den Berg has served as a basis for continuing research by other scientists. His research is valued and has offered much to voice scientists and voice teachers.

<u>John Large, Singing Voice Scientist</u>

John Large was a well known performer, teacher, and was well respected in the area of acoustical science. He had a keen interest in voice science and a desire to interpret scientific findings in comprehendible terms with a voice teacher's insight.

John Large in 1972 developed his own theory of registration. He referred to it as the "integrated physiologic-acoustic theory of vocal registers" and it was developed as a result of four areas of registration that have been investigated: (1) laryngeal adjustment, (2) supraglottal coupling to the larynx (interaction between the larynx and vocal tract above the larynx), (3) subglottal coupling to the larynx (interaction between the larynx and the area below the glottis), (4) formant enhancement of different partials (using different cavities of the resonance system to produce different components of tone). Large did not believe he could develop his own understanding of registration without integrating these findings. Therefore, he named his theory the integrated physiologic-acoustic theory of vocal registers. It included the three main registers of chest, middle, and head voice and the additional and less important registers of strohbass, whistle, and falsetto (Large, 1972).

Large conducted a study in 1968 that dealt with the acoustics of isoparametric tones in female chest and middle registers in singing.

Isoparametric tones are tones of the same pitch, dynamic level, and vowel in different registers (Burgin, 1973).

He discovered through sonographic research that important similarities existed in the distribution of energy among partials within the same register. In between registers there were distinct differences. It also supported the idea that for a given pair of isoparametric tones, chest voice had greater energy in the higher partials and middle voice had a stronger fundamental (Large, 1969).

In 1969 Large (1969) devised a more rigorous test in order to select voice register samples for future acoustical and perceptual studies. He recorded 21 samples of sopranos sustaining the vowel /a/ (ah). While holding the vowel, volume, and pitch constant, the singers shifted from chest to middle register in 9 samples, and from middle to chest register in 12 samples.

The recorded samples were presented to 10 male and 10 female judges who were students. Some were well-trained singers, others had very little voice training. The judges heard each sample and were asked to identify the register in which the voice began and whether the singer shifted into the adjacent register. The accuracy of the judges' perception was not linked to their sex or length of musical training. The results of this test indicated that the judges were accurate 98% of the time and this encouraged another acoustical and perceptual study (Large, 1973).

In 1970, Large investigated the air flow rates of isoparametric tones in female chest and middle registers. The study involved five female trained voice students. They were selected on their ability to maintain their chest and middle registers separately while singing notation starting on a3, and ascending one octave (a3 to a4). Each student was asked to use e4 as the transition note and sing the /a/ (ah) vowel using normal vibrato at all times. Two segments of sustained e4 were chosen for comparison, one before transition began and the other after transition was complete. All subjects demonstrated a change of airflow between the two registers.

In conducting this experiment a pneumotachograph measured air flow with a pressure transducer and also recorded the singing voice, its fundamental frequency, intensity, voice signals, and laryngeal vibrations (Large, 1970). It was believed by Garcia that more air flow was used to produce middle register than chest register. In 1956, Van den Berg indicated that the variation of air flow rate resulted from the interaction of subglottal pressure and glottal resistance. These results led to speculation that equalization of registers might be related to the laryngeal mechanism of medial compression. This refers to the action of the lateral cricoarytenoids in causing the vocal processes to press together during each cycle of vibration (Vennard, 1967).

Large's (1973) study supported the theory that tones of chest register are produced by one mechanical principle and tones of middle register are produced by a different mechanical principle. The pneumotachograph showed that air flow increased from middle register to chest register by one-fourth to two-thirds for the five singers.

In 1974 Large conducted another study concerning isoparametric tones. Again, he used tape recordings of female voices to be judged by 10 subjects. The goal was two-fold. Large was studying acoustic differences between isoparametric tones and wanted to demonstrate that if the tones were equalized, those acoustic differences would not be present. Equalized tones are those which are shaded from two overlapping areas of the voice so that there is no perceptible line of demarcation between them. They are also referred to as blended tones.

Large (1974) conducted his research by using a tape recording of female voices producing isoparametric tones in middle and chest registers and he devised and administered listening tests for perceptual evaluation of tone pairs. He compared these listening tests with results of sonographic tests which dealt with acoustics.

The singers prepared 34 tone pairs on e4 using the /a/ vowel. To get isoparametric tones, they sang ascending notes in chest voice from a3 to a4, holding e4 for four seconds. They continued singing a descending pattern from a4 to e4 in middle voice, holding e4 for four seconds.

A spliced tape was prepared with all notes omitted except three seconds of e4 in middle voice and three seconds of e4 in chest voice which provided the isoparametric tones. The tones on the tape were randomly positioned consisting of chest to middle, middle to chest, chest to chest, and middle to middle. Samples included obvious timbre differences, slight differences, or no difference.

The judges listened to each tone pair twice and made judgements concerning identification of register, estimation of magnitude of timbre difference, and identification of vowel. Vowel changes were important, even though singers were instructed to sing /a/, because changes in the vowel would be expected to result in spectral changes as would changes in register.

The judges consisted of twelve voice teachers with experience ranging from 1 to 41 years of teaching. They judged the first two aspects and a trained phonetician was asked to make vowel judgements. The judges were 84% accurate in identification and magnitude of register-timbre difference. The test involved the singer's intention to display timbre differences. The judge with the highest number of years of teaching experience, disagreed the most often, 14 times, with the singer's intention. Another judge with 25 years experience only made four errors. Five judges with less than 4 years experience made even fewer errors. Large cited the lack of correlation between teaching experience and understanding the intent of the singer and suggested the misunderstanding of the judges with the most experience might be attributable to hearing losses as to any other factor (Large, 1974).

Singers were instructed to sing /a/ for all examples. The phonetician was to identify the vowels by using the phonetic symbols of the International Phonetic Alphabet. He recognized use of /a/, /ɔ/, and /ʌ/. He recognized /a/ 77% of the time. The results by the phonetician indicated that students had some difficulty producing the vowels intended. The acoustical analysis revealed that the change in vowel percept might be related to a change in the shape of the glottal pulse (Large, 1974).

From this study, the air flow studies, and laryngeal photography, Large concluded that laryngeal adjustment causes the change in registration from chest to middle register and the reverse. He believed that equalization of registers was related to the laryngeal mechanism of medial compression as Van den Berg had suspected in 1956. Large was not yet satisfied with the conclusions. He thought more expansive tests should be conducted using a greater number of subjects, both male and female.

In 1978, Large conducted another experiment in order to include head register. At this time, Large blamed most of the register research problem on differing methods of vocal pedagogy. For example, in certain instances chest voice is an acceptable part of the voice range. At other times, it is considered too masculine and is blamed for the cause of vocal disorders. This was relevant, because different pedagogical techniques would produce different types of singers. This would initially create an undesirable variable. Therefore, in 1978, Large perfected his experiments by choosing students who were trained by the vocal method of Mathilda Marchesi.

The findings revealed that when changing from chest to middle or middle to chest registers, there were major adjustments in laryngeal musculature. He extended his experimentation to head voice, used trained and untrained singers, and found the same conclusion. However, the adjustment was less dramatic. The experiment showed a greater air flow in medium voice, and that glottal resistance may have an affect on air flow as well as intensity. This study supported a change in register due to laryngeal adjustment for chest, middle, and head registers. He reconfirmed his prior finding that register blending was due to medial compression, another form of laryngeal adjustment (Large, 1980).

Throughout his experiments, Large was able to prove and reprove the basic premise that register changes were due basically to laryngeal adjustment. Of the five theorists analyzed, Large seems the most concerned with proper experimental controls and scientific documentation of this information.

William D. Vennard, Singing Voice Scientist

William Vennard (1909-1971) was internationally known as a teacher of singing and vocal pedagogy. At the time of his death, he was Chairman of the Voice Department of the University of Southern California. Even though Vennard's training did not include scientific training, he was classified as a singing voice scientist, because he conducted much scientific research on the vocal mechanism as it applied to singing. Vennard's main contribution was that he interpreted scientific research in a way a vocal music teacher could understand. When Vennard wrote about the work of trained voice scientists, he added his perspective as a studio voice teacher.

According to many writers, Vennard took a mechanistic approach to teaching. These writers considered a mechanistic approach to be one which is based on the mechanical details of technique (Vennard, 1967). Vennard, himself, believed this to be unfounded, because a major part of his teaching method was based on educational psychology, in addition to his understanding of laryngeal function (Vennard, 1967).

According to Vennard (1967), the vocal folds are acted upon by air flow, longitudinal tension, and the two adduction forces. If the vocalis muscle resists the forces exerted on it, it takes on an active adjustment. If the vocalis muscle relaxes as the forces are exerted, it takes on a passive adjustment. This is what Vennard believed to be the cause of the two extremes of vibration, or registers.

Vennard (1967) believed one register covers the upper two-thirds of the voice. The other register covers the lower two-thirds of the voice. One octave can be sung using either laryngeal adjustment. Vennard described chest voice as heavy mechanism and falsetto as light mechanism. He preferred the terms light mechanism and heavy mechanism, which refer to laryngeal adjustment, over chest voice and falsetto voice, which refer to acoustical properties of pitch.

Vennard explained that in heavy mechanism, the thyroarytenoids are contracted, because they are active. In the lowest tones, the vocalis muscle and cricothyroids are relaxed. The conus elasticus is forced together due to the Bernoulli effect. This means that suction is produced by the air in motion, because it has less density or pressure than the air not in motion. This causes the upper surface of the mucous membrane to ripple. In heavy mechanism there is a vertical phase difference in which the glottis closes at the bottom before it closes at the top, and opens on the bottom before it opens on the top.

Vennard found that in heavy mechanism, the vocal cords move quite a distance from the midline and the glottis opens widely each vibration which make this mechanism suitable for low tones (because it takes so long for them to occur that frequency can only be low), relatively loud tones (because compression builds up in each puff of air), and tones that are rich in harmonic partials (because their rippling creates complexity in the puffs of air and the increased energy in each cycle makes it possible to sound other frequencies besides the fundamental). Producing a rich tone means that other frequencies are sounded along with the fundamental. The dynamics of a low tone in heavy mechanism is dependent upon the amount of relaxation of the internal portion of the vocalis muscle and whether it joins the external cricothyroid in contracting (Vennard, 1967).

He explained as the pitch rises, the cricothyroids contract. In the lowest pitches, the internal thyroarytenoids are relaxed, and vibrate loosely. With a rise in pitch, the externals and cricothyroids pull on each other and the vocal cords are elongated. The cords are thick, but as the pitch rises, the cords hit together more rigidly and more breath is required. Eventually the voice arrives at its upper limits, the cricoarytenoids give in to the cricothyroids, and a crack in the voice results. Were the singer to continue singing, he would be in light mechanism (Vennard, 1967).

In light mechanism, Vennard believed what most theorists describe as falsetto is produced. The thyroarytenoids are almost passive. When the vocalis muscle relaxes, the cricothyroids are able to place great longitudinal tension on the vocal ligaments. Even after the maximum length of the cords is reached, the tension increases in order to raise the pitch. The cords thin out so there is little vertical phase difference. The vibration takes place almost entirely in the ligament. In falsetto, during high frequencies, the cords do not have much resistance. It takes a great deal of breath to sing loud high partials. This explains why a pitch in falsetto is much softer than the same pitch sung in chest voice. The glottis closes briefly and often times, not completely (Vennard, 1967).

Most singers have what Vennard referred to as the "unused register". They are most comfortable singing in one register and therefore, ignore development of the other mechanism. In order to achieve a full voice, the singer must work on developing the unused area of the voice and must switch to that mechanism by some type of laryngeal adjustment.

Vennard believed that in order to understand registration, he needed to consider three basic approaches of other theorists (Vennard, 1959). Vennard identified the idealistic approach as one in which the voice has one register to produce all pitches without any breaks or changes of laryngeal adjustment. Voice teachers strive for their students to develop just one register. If a teacher talks about just one register, students will often produce one register, expand the comfortable area of the register, and breaks will either disappear or become less noticeable (Vennard, 1959).

The realistic approach, as explained by Vennard, divides the voice into three registers, according to the tone qualities produced by different laryngeal adjustments. In the male voice, they are called chest, head, and falsetto. In the female voice, they are called chest, middle, and head. Teachers who use this acoustical type of terminology usually attempt to get their students to blend the registers.

The hypothetical approach, the one selected by Vennard, was that of two registers. He believed each voice could produce two octaves in heavy mechanism and two octaves in light mechanism, with an overlapping area of one octave in which either mechanism can be used, allowing the singer to combine the best qualities of both adjustments.

Vennard began writing a series of articles in 1970 on his findings from laryngeal experiments. He used an electromyograph, which is a device that amplifies electrical energy generated by a muscle. When a muscle is active it has a small electrical charge. He was able to tell the degree to which a muscle was exerting itself, observe its function, and describe it scientifically.

One article described the function of the intrinsic musculature of the larynx in chest, head, and falsetto registers (Vennard, 1970). Intrinsic muscles are those that are attached to the larynx. They are the thyroarytenoids, cricothyroids, cricoarytenoids, transverse and oblique arytenoids.

In Vennard's experiment, two sopranos, one tenor, and one bass sang scales of differing lengths, throughout their entire range. The transitions were more noticeable as the scales became longer. All but one subject could sing two octaves using light mechanism and two octaves using heavy mechanism. In all but the same subject, the lower octave of falsetto overlapped with the upper octave of chest. This experiment involved over one hundred-fifty scales, ascending and descending (Vennard, 1970).

Vennard defined head voice as the intermediate adjustment between chest and falsetto that is easy to distinguish in male voices. The term falsetto is also applied to the upper portion of the female voice and above falsetto, some women are able to produce a whistle register. Vennard identified the adjustment having some qualities of both light and heavy registration in the female voice as mixed registration.

In heavy registration, the cricothyroids were the primary pitch agent. In light registration, the breath was the primary pitch agent. Exertion of the cricothyroid was greatest for the head, and nearly equal for chest and falsetto. Exertion of the vocalis muscle, also referred to as the internal thyroarytenoid muscle, was greatest for chest, less for head, and least for falsetto. Air flow was greatest for falsetto, less for chest, and least for head (Vennard, 1970).

For his next series of electromagnetic studies, Vennard (1971b) selected a soprano, tenor, and bass as subjects for experimentation. The same number and types of scales and vocalises that had been used to test the intrinsic muscles were once again used to test the extrinsic laryngeal muscles. The extrinsic muscles attach to the larynx, but have their origin elsewhere and pull the larynx up or down to various outside points of attachment such as the skull, breast-bone, or jaw. The extrinsic muscles affect production, because when the intrinsic muscles are active within the larynx, it must be held by combined pulls of the extrinsic muscles. They affect pronunciation, because their movements change the shape of the mouth and the throat.

The digastric, thyrohyoid and sternohyoid muscles were selected for testing and could be reached through the skin. The thyrohyoid responded sensitively to intrinsic activity. It correlated with pitch and intensity, especially in the chest voice. The sternohyoid was pitch correlated, but not very active in normal phonation. It was used more for heavy registration than light registration. The other muscles showed no great consistency in being vowel correlated (Vennard, 1971b).

Later that year Vennard wrote an article which tied his results of electromyographic studies to vocal pedagogy (Vennard, 1971a). He had hoped that in time this would lead to more objective terminology. Vennard used four subjects who sang ascending and descending scales using a variety of production techniques. Some of these techniques produced tones that Vennard described as honky, twangy, pinched, shallow, and focused. The cricothyroid made no measurable changes at any time. In focused, or normal production the intrinsic muscles remained the same for different vowel production. In production where there is a great deal of tension, the closed vowels produced more effort in the vocalis muscle than the open vowels produced.

In light mechanism, Vennard found that focus and cover were indistinguishable and made full use of the vocalis muscle possible. It was determined that spread and open singing overloaded the vocalis muscle and might cause the voice to break. This experiment is particularly applicable to vocal pedagogy.

Vennard saw a need for stressing more in teaching than mechanistic details. Vennard believed he taught singers, not singing (Vennard, 1964). His primary goal as a teacher was to build the ego of the student. He believed the student needed faith in himself, in order to bring the voice under perfect control. Vennard learned a great deal concerning the mechanics of the voice, conducted his own experiments, and used the knowledge to teach his students and educate others through his writing (Vennard, 1964).

Victor Fields, Voice Teacher

Victor Fields taught voice and diction for 42 1/2 years at the City University of New York. He was a well known teacher, clinician, and author. Fields did not include a detailed description of vocal registers in his writings. He researched the subject in Training the Singing Voice, (1947) by compiling various theories of others and explaining them, but was very careful not to include his own philosophy. In Foundations of the Singer's Art, (1977) Fields described the structural aspects and functional aspects of the vocal organs. He explained that a teacher should understand the workings of the vocal mechanism enough to help his students.

Fields (1977) believed maintenance of the glottal closure against steady air pressure to be of great importance in phonation for singing. When functioning properly it determines pitch accuracy, strength of breath support, amount of volume and quality, and the firmness of vocal attack. During phonation all the internal muscles of the larynx aid in maintaining the elasticity and rigidity of the approximated vocal cords, with the support and balance of the extrinsic muscles. A result of weak efforts of all intrinsic and extrinsic muscles of the larynx can produce falsetto voice.

Fields (1977) believed that in teaching, one should combine three theories of registration into what he called the "neurochronaxic-myoelastic, aerodynamic" phenomenon. Fields differed from the prior four theorists, due to his desire not to discuss registration. He had no theory of registration, but instead referred to this phenomenon.

According to Fields (1977) neorochronaxic refers to nerve impulses. In the neurochronaxic theory it is believed that the frequency of the vocal cords at any pitch is a direct result of the corresponding number of impulses sent along the recurrent nerve. The recurrent nerve supplies the fibers of the vocalis muscle which end at the glottal edge and cause it to contract or relax during phonation. These nerve fibers require a rest period between a successive stimuli. When singing higher pitches, or those with higher frequencies, these fibers and other sets of tiny muscle fibers located along the glottal edge work together in causing the glottal edges to contract and relax.

A singer does not decide how to move his laryngeal muscles in order to produce a certain pitch. He must form a clear mental image to hear the pitch and then be able to sing it. This mental image controls the nerves that form the glottal adjustment which is started by the breath.

The myoelastic theory refers to muscular elasticity. According to this theory, the air pressure that is exerted from the underneath side of the closed glottis causes the rapid pulsation of the glottal edges. As the vocal folds are forced apart by the breath there is a small loss of air pressure which allows them to close again because of their elasticity. This action repeats until the tone has ended. The frequency and intensity of a tone are affected by the variations of internal contraction and longitudinal tension which are possible (Fields, 1977).

The aerodynamic theory refers to subglottal air pressure as it responds to the resistance of the vocal cords. The thyroarytenoid muscles are adducted and then adjust to a given tension, mass, and shape. At the same time, the exhaled air causes the suction which draws the vocal cords more firmly together. The continuous air pressure maintains the glottic closure through suction. It also induces vibratory action, due to the intermittent release of air through the cords. Fields believed the combination of these theories best explain the glottal adjustments for singing.

Fields (1972a) believed singing to be an art and a science. Science teaches us to know through laws, rules, and techniques with methodology, purposes, and goals. Art teaches us to do through learning and to produce a finished outcome with perfected expression. Fields (1972b) believed a vocal teacher needed to understand the philosophy and psychology of the learning process, how to diagnose and correct vocal problems, and demonstrate proper technique.

In teaching, Fields avoided discussions of registers, because he did not want his students to fear register breaks, or begin to cover certain pitches. He also stayed away from teaching high and low areas of the voice, because he thought that, too, would cause register breaks. Fields felt it would be counter-productive to teach to a concept that addresses and causes vocal problems. He believed the student should practice progressive technical and melodic exercises, throughout his entire singable range, with expression as the constant motivating factor. He believed the laryngeal muscles would most likely act correctly for singing when posture was correct, when the ear governed the output, and when expression rather than technique was the motivating factor. Fields stressed that the mind, muscles, and breath respond according to what the ear tells them to do. The ear tells them how to respond according to the desired expression or communication. The muscular responses that produce the voice are really effects of the expression, not the cause (Fields, 1972b).

Fields believed the vocal teachers main function was to free the voice from self-conscious behavior. It is important at this point to stress the word free. One does not free this behavior by repeating suggestions such as breathing from the diaphragm, opening the throat, or watching your diction.

If the student actually achieved these mechanistic instructions, they certainly would not feel freed from self-conscious behavior. Fields believed praiseworthy instruction which brought about joy in singing would unleash a beautiful, relaxed, healthy, expressive voice (Fields, l972b).

There has been no mention of experiments due to the fact that Fields based most of his philosophy on his teaching experience. He apparently saw no more relevance in sighting findings from experiments, than he did outlining a theory of registration. Possibly the less said on the subject, the more effective the singing of a student.

CHAPER 3

APPLICATION OF THEORIES TO TEACHING

The voice is the instrument of the mind, because it allows expression which is controlled by thoughts, or images. A mental image, when properly motivated, produces vocal tone that is full of meaning and purpose. The image, along with the desire to communicate, engages and governs the muscular activity that produces vocal tone. The muscular function is simply an effect of expression, not the cause of it. It is the mind that sings through the muscles. The mind must be trained before one attempts to train the muscles (Fields, 1972b).

The mind, muscles, and breath respond according to what the ear tells them to do. The hearing concepts of the singer send impulses to the neuromuscular controls during singing. These impulses, or communicative intent, must be clear and specific. The ear tells these neuromuscular controls how to respond according to the desired expression or communication. In other words, the ear, not the mechanism, governs the sound (Fields, 1972b).

Otis Simmons, a voice teacher and author, explained that a teacher should understand this process which describes how the voice learns to sing and apply this knowledge in his teaching. Instruction should be based on a conceptual approach to singing. A conceptual approach is one which remains in the mind following a learning experience. Four fundamental principles included in a conceptual approach to singing are: (1) a clear mental image of all tones, (2) frequent demonstrations of correct vocal production, by the teacher, (3) the ability of the singer to listen critically with his inner ear, and (4) systematic practice. Simmons (1969) believed a teacher would be most effective when guided by these principles.

The teacher's function is to guide and supervise the mental, physical, and moral growth of a student through the application of appropriate practice and study. Appropriate study includes developing a singing personality in the student, not a mechanical skill. A student's physical skills and mental skills rely on his self-concept. The teacher must free the student's voice from self-conscious behavior, because a student who cannot trust himself, cannot improve his voice (Fields, 1972b). The student must be taught to sing, not through manipulation of muscles, or with any type of fear, but just as an expression of joy. This can be accomplished by instilling self-reliance, faith, and allowing the voice to "sing itself", with confidence (Vennard, 1964).

The teacher's approach to developing a student's mental and physical skills will reflect his theory of registration. The theories of registration of one voice teacher, two voice scientists, and two singing voice scientists have been explained. The most important characteristics of their theories have been condensed into a table for easy reference (see Table 2).

Table 2

Comparison of Theories

Names	Causes of Register Changes	Names of Registers	Auxiliary Registers	Description of Theory of Registers
Oncley	Register shifts - laryngeal changes Resonance shifts - acoustical changes	2 registers based on laryngeal adjustments Also acoustic registers	not indicated	Dual concept Laryngeal/ acoustical
Van den Berg	Coordination of muscles with air flow from trachea Change in coupling mechanism of resonator and vocal cords Muscle performs specific action	chest - mid - falsetto/ head	strohbass /whistle	Myoelastic - laryngeal aerodynamic airflow theory of registration
Large	Laryngeal adjustment Blending due to medial compression	chest-middle-head	strohbass -whistle-falsetto	Integrated physiologic-acoustic theory Laryngeal adjustment and minor energy different in partials
Vennard	Laryngeal control	Heavy mechanism (chest) Light mechanism (head/falsetto)	Not indicated	Heavy - light mechanism
Fields	Laryngeal control determined by ear	No reference	Falsetto	Neurchronaxic Myoelastic-Aerodynamic Theory

Given this information, it would seem logical to apply Fields' theory of registration in the teaching of high school singers. A student should develop one voice, without any reference to registers. The voice must be free of tension, rigidity, interference, and resistance, but the mere mention of registers can bring these characteristics to the voice (Clippinger, 1917).

A teacher should focus, as Fields did, on his primary objective. Fields' objective was to teach the student to express himself through singing and for singing to be controlled, before and during production, by mental images (Fields, 1972b). Fields believed a teacher should instill the value of singing with expression, rather than singing with proper tone production. An effective teacher should also apply Fields' positive approach in achieving his goal. Suggestions should be carefully thought out and stated with kindness and encouragement. Explaining to a student that his vocal production is correct, due to the fact that he is communicating an idea, will do far more for his self-concept than undermining his confidence in the sound he is making. The effective teacher will remember, as Fields did, that the student's interest and enthusiasm are driving forces in the growth of his singing voice; that artistic singing contains the freedom of spirit; that joy helps to release the voice.

The theories of registration of Oncley, Van den Berg, Large, and Vennard are also important in teaching. A teacher must focus on his primary objective with an understanding laryngeal function and resonance shifts. Oncley and Van den Berg offer detailed explanations of their findings and descriptions of the experiments on which they base their conclusions. Large and Vennard interpret scientific findings in comprehendible terms with a voice teacher's insight. An effective voice teacher will find this information not only helpful, but necessary for a thorough understanding of vocal registers. It is not necessary to explain scientific facts to students, but it is essential to be able to apply them in teaching.

Fields offered a different approach to a theory of registration than did the other theorists, and it seems to be the most applicable in teaching the high school student. He had a complete understanding of the laryngeal mechanism, but the impact of his work was in his pedagogical suggestions and explanations. Fields saw the voice as a means of communication and expression. To develop this means of expression, the teacher must rely more heavily on the student's musical ability, than on the students knowledge of mechanical or scientific application.

Carlo Lamberti (1954), an author who usually condemned orthodox vocal pedagogy, expressed the following philosophy which Fields might have shared:

> The wrong interpretation given by the old school to so-called "registers" is nothing but a treacherous stumbling-block along the

road to real progress; that he can happily ignore registers entirely, thanks to his knowledge that there is only one level for his voice: above his mouth (p. 101).

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