Singing and Science

Singing and Science: Body, Brain, and Voice

Jean Callaghan

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To Ruth and Kate
with love and admiration

Preface

When I began teaching singing 35 years ago I asked myself such questions as 'What is the accepted body of knowledge about singing?' and 'How is *teaching* singing different from singing?' As a student I had encountered the rival claims made by different teachers about how to manage the breath, how to achieve ideal resonance, and so on – knowledge that they had gradually acquired through their own singing and through years of teaching, listening, and observing. Although I knew from experience what worked best for me as a singer, I had no way of knowing whether what worked for me would also work for students of different voice types, with different physiques and different personalities. I was also conscious of the gap between being able to do something and being able to teach someone else to do it. I felt that while an experiential knowledge of the act of singing was important for teaching, so, too, was an understanding of how the voice works physically, of how it operates as a musical instrument, and of how these kinds of knowledge are best conveyed to students.

This motivated a critical assessment of the literature on singing and the teaching of singing, a body of knowledge going back to the 17th century. Much of that literature reflects the fact that player and instrument are one: the singer or singing-teacher author makes no distinction between the knowledge of voice and the practice of teaching. In the 35 years since I began teaching, scientific knowledge of vocal function and vocal health has increased greatly: new technology can show images of brain activity, display the larynx in operation, measure muscular effort, and acoustically analyse vocal sound. It is now possible to take a more objective approach to the singing voice and how it works.

The centuries-old master-apprentice tradition of pedagogy continues, despite a breakdown in many of the assumptions underpinning it, and despite modern educational pressures. However, this continuous tradition is increasingly becoming fragmented, since teachers now confront a proliferation of genres and styles encompassing a wide time span and geographic spread. Teachers must be time efficient and work with students of all voice types and across a wide repertoire.

To meet these demands requires an understanding of the physical factors that safely and efficiently produce the aesthetically appropriate vocal sound, as well as of a teaching approach best suited to a range of students. While there are basic musical and vocal principles that may well be taught in small groups, the need remains for individual work geared to the specific needs and abilities of the student.

In 1998 I published the results of an investigation into Australian singing teachers' knowledge of this area (Callaghan, 1998), based on my own doctoral research involving in-depth interviews of 50 singing teachers at tertiary institutions across Australia. I found that while practitioners demonstrated an admirable commitment to experiential learning and to individual students' development, their knowledge of vocal physiology, acoustics, and health was often at best incomplete, and at worst misinformed. This, too, has been gradually changing, with more research in the area, and publications, courses, and workshops on singing and the teaching of singing making information on vocal function in singing much more readily available.

Since the first edition of *Singing and Voice Science* in 2000 what has changed is the amount of research on the role of brain and mind in music and language, and in psychomotor learning and performance. Since singing involves all of these things, any knowledge of how best to harness the mind for the teaching, learning, and performance of singing is of vital importance for teachers. Another area that has continued to develop is the use of technology, not only in research, but in application to teaching and learning, with commercially-available computer applications to show articulatory manoeuvres and give real-time feedback on the acoustic features of the voice.

This work addresses the need for those working with the singing voice to add to their armoury the relevant knowledge that is accumulating in voice science, teaching and learning, and performance. I identify issues of physiology, acoustics, and health that are pertinent to singing pedagogy and examine scientific understandings of voice relevant to those issues. I then explore thinking on how complex psychomotor tasks such as singing are best learnt and performed.

The main focus of the first edition of *Singing and Voice Science* was an examination of the voice science literature on breath management, phonation, resonance and articulation, registration and vocal health, and the clarification of its application to singing and the teaching of singing. There was also some consideration of the singer as a 'vocal instrument' and of the kinds of knowledge and skills required to teach singing. In this second edition I update the material on the physical aspects of singing, but the emphasis is more on our greatly expanded knowledge of the factors involved in teaching and learning. These are manifold and emerge from research in physiology, medicine, speech pathology, acoustics, linguistics, education, psychology, and neurology.

The book draws on material published in English over the last 40 years, a period marked by technological innovation and the beginnings of interdisciplinary collaboration and cross-disciplinary communication. It focuses on the vocal technique of the adult voice in singing, with an emphasis on

'classical' genres and styles. Research into voice use in other genres and styles is still in its infancy, but some reference is made to it here.

Singers are distinguished from other performing musicians in two obvious ways: firstly, for singers, their instrument is the whole person; secondly, singers perform language as well as music. In writings on singing and the teaching of singing one strangely neglected area is the relationship between music and language, the relationship between musical text and linguistic text and how these are learnt, embodied by the singer and conveyed to an audience. In this second edition I include these essential aspects of singing in my examination.

In the last 40 years or so much has been published on vocal physiology and acoustics, on cognition, neurobiology, and teaching and learning, as well as singing and voice science, but until recently much of this had not reached the majority of voice teachers. Recently more books have come out attempting to examine the range of factors involved in singing. This second edition builds on the work of Thurman and Welch (2000), McCoy (2006), Nair (2007), Bunch Dayme (2009), Chapman (2012), and Titze and Verdolini Abbott (2012).

The first chapter outlines the long oral tradition of voice teaching that began in Italy early in the 17th century, describes changes that took place in the 19th century, and summarises the new information on voice available in our own time. Chapter 2 gives an overview of the vocal instrument that is the body, drawing a distinction between two essentially different ways of observing and understanding the body: one is the first-person perspective of the singer, the other the third-person perspective of the scientist. Both types of knowledge are necessary for the teacher of singing. This overview provides the background to Chapters 3 to 7, which comprise an exploration of aspects of singing investigated in research studies. This research is assessed and related to practitioner understandings to provide the knowledge necessary for teachers. Chapter 3 deals with breath management, Chapter 4 with phonation, Chapter 5 with resonance, Chapter 6 with registration, and Chapter 7 with vocal health. Chapter 8 deals with the aspects of brain and body, body and mind, involved in singing. The final chapter examines how all the issues discussed in earlier chapters are related to teaching and learning, and makes recommendations for the professional education of singing teachers.

This is an account of how research in voice science and learning in music, language and psychomotor performance can inform our understanding of singing and the teaching of singing. I hope it will prove useful to singing teachers who wish, as I do, to find out all they can about the workings of that superb musical instrument, the human voice.

Jean Callaghan
Sydney, 2014

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Chapter 1: Science and Singing

> A knowledge of the voice is necessary for everyone, but above all this is necessary for a teacher of singing.
> (Bérard, 1755/1969, pp. 61-62)

The oral tradition

Current knowledge about the singing voice exists against the background of a long oral tradition, originating in Italy early in the 17th century and flourishing in the 18th and early 19th centuries. It implied intensive individual study with a master, encompassing musical, vocal, and performance matters relevant to the elegant vocal writing of the time. This approach to singing was later labelled 'bel canto' (beautiful, or fine, singing) and began to take on mythical significance. This master–apprentice approach in one-to-one tuition and imitation of the master singer represents the foundation of singing pedagogy in the Western European art tradition.

Through three centuries of cultural and musical change, the initial precepts and specific practices of bel canto have been so modified that it can no longer be said to exist. A multiplicity of tonal ideals and corresponding pedagogical practices have evolved in different national schools (Miller, 1977), and it may be that multicultural societies – such as Australia, New Zealand, Canada, and the United States – have always embraced a range of ideals and practices. Now, with international travel, international cooperation in performance, omnipresent availability of audio and audiovisual recordings of an extraordinary variety of singing voices and styles, and online information internationally accessible, expectations of what singing is and how it should be taught are changing.

Nevertheless, bel canto ideals and the bel canto approach to teaching live on in writings on singing technique – even in writings directed to different national schools, to vocal technique for repertoire far removed from that of bel canto, and in writings that are scientifically based. While there are now many resources available to singers and their teachers – in print, in audiovisual form, and on the Internet – practitioners continue in the master–apprentice tradition of teaching, and often continue using exercises and technical directives passed on from teacher to pupil over centuries. Because of the profound, pervasive, and continuing influence of the bel canto teaching tradition on singing pedagogy and vocal knowledge, I will begin with an examination of that tradition and of the forces that have made it no longer the complete and self-sufficient model for singing pedagogy that it once was.

The history of the development of bel canto has been well documented, both by general music historians (Bukofzer, 1947; Palisca, 1968; Weaver, 1980) and by writers with a more particular interest in singing (Heriot, 1956; Galliver, 1974; Manén, 1987; Celetti, 1991). Bibliographical surveys of bel canto sources have also been undertaken (e.g. Duey, 1951).

The teaching of singing as a solo virtuoso art goes back to Italy in the early 17th century, where it developed in response to the demand for solo vocal virtuosos to sing the new monody and opera. While the poet–lutenist–singer had been a familiar entertainer at courts throughout the Renaissance, he was not primarily a vocal virtuoso. Palisca (1968) quoted a contemporary witness as observing that the solo professional singer began to emerge as an important figure in musical life around 1570. At around the same time, society was giving increasing attention to emotional expression and the cultivation of virtuosity. With the development of opera came the training to meet these demands.

The 17th- and 18th-century tradition of bel canto was based on the continuity of objectives, of technique, and of criteria for musical judgement. It was also dependent on the close relationship between composer and performer, teacher and student, performer and audience. The teacher (who was often also a composer) was an accomplished performer in the musical style who acted as an example to the student. The student practised assiduously and, by trial and error, eventually produced the approved sound, learned what sensations accompanied production of that sound, and thus learned how to reproduce it.

The teaching of the bel canto masters

The bel canto tradition was largely an oral one, which presents obvious – perhaps insuperable – problems to historians aiming to document the practice of the 17th and 18th centuries. There are no recordings of 17th-century vocal sound, and the technical teaching of the singing studio can be deduced only from the writings of singers and teachers, published technical exercises, and the repertoire for which singers were training.

The primary aim of voice teaching was to produce 'beautiful' tone and agility, allied to a sensitive ear. Singers cultivated good breath control for the singing of extended phrases. Voice teachers taught techniques (musical as much as vocal) for emotionally expressive singing and for vocal ornamentation. The tradition emphasized the natural abilities of the pupil and the obligation of the teacher to develop these abilities. The experience of the teacher, as a singer but often also as a composer, was the most important component of the process, and teaching proceeded by example on the part of the master and repeated trial and error on the part of the pupil:

> In giving the precise rules to a student let the teacher not only tell him and explain to him, but let him illustrate his meaning by making himself an example. . . . Let the experienced teacher follow this method and he will soon be convinced how much more preferable are practical demonstrations to general rules. (Mancini, 1774/1777/1967, p. 103)

In keeping with the new status of the singer as virtuoso, an understanding of the vocal instrument was expected. In Italy, Tosi (1743/1987, p. x)

advocated 'a little less Fiddling with the Voice, and a little more Singing with the Instrument.' In France, Bérard asserted that:

> A singer who does profound research on the mechanism of the voice will have a great facility in forming high and low sounds. He will command his organs in any way, he will hasten or retard their movement according to his convenience. He will draw from them strong, vigorous, and mellow sounds, as well as tender, light, and mannered sounds. (1755/1969, p. 61)

Many writers emphasized the obligations of the teacher. Tosi, for example, wrote:

> let him hear with a disinterested ear whether the person desirous to learn has a voice and a disposition, that he may not be obliged to give a strict account to God of the parent's money ill spent, and the injury done to the child by the irreparable loss of time, which might have been more profitably employed in some other profession. (1743/1987, p. 2)

There was an emphasis on the innate gifts expected of the singing student: a pleasing appearance, adequate breathing capacity, no malformation of face, mouth, or body, and a good ear. Posture and facial expression were to be 'graceful' or 'natural.' A positive mental attitude, both in study and performance, was advocated. Most of the old masters were interested primarily in breath management and the ability to sing extended phrases. Many of the Italian sources contain rules on where the performer may breathe in long passages and give hints about cutting some notes short in order to obtain needed breath (Duey, 1951).

Theories of phonation were based on incomplete or incorrect information. The anatomy of the throat was well understood for all practical purposes, but the physiology of the vocal organs was not. While some writers presented simplified – and often incorrect – descriptions or diagrams of the vocal organs, these seem to have little to do with their descriptions of vocal technique. Singers made no attempt at conscious control of particular muscle groups. Instead, teachers urged the singer to keep a natural and free muscular balance of all physical faculties in order for the body to respond naturally and quickly to the sense and idea of both text and music. Blanchet was unusual in advocating conscious muscular control of the larynx and, significantly, he was not a musician (Duey, 1951). Perhaps current neurological research and body-use techniques (discussed in Chapter 8) will give us better insight into how best to combine these two approaches.

Teachers gave directions on resonance that were linked to the coordination of respiration and sound production. Singers were concerned with keeping the voice free and producing it orally rather than nasally. The great masters

spoke of 'opening the throat,' 'loosening the neck,' and 'singing the tone forward, at the lips.' Many wrote of the different qualities and emotional effects of particular vowels.

All the early writers had something to say about the registers of the voice and how they should be blended. Unfortunately, because these writers formed a great deal of their opinions by observing castrati, the information is now difficult to interpret. Registers were named according to the singer's sensations of sympathetic vibration, for example, the chest or head registers. There is some confusion for modern readers in the use of the term 'falsetto' which may refer to either what other writers call 'head' or to the lighter, breathier tone of the male voice above its full-toned 'head' range. (Register terminology is examined in detail in Chapter 6.)

The earliest Italian writers, such as Caccini (1602/1970), did not advocate use of the head voice. This may be because they wrote for a male public and also because of the narrow range demanded by the early declamatory style. Later writers, such as Tosi and Mancini, considered the head voice to be an essential quality and the blending of chest and head voice to be vital before attempting to acquire agility.

Writers stressed the importance of a good ear and the necessity for precise intonation. It was assumed that the teacher had a good enough ear and sufficient singing experience to be able to identify and correct faults of intonation or tone. The masters generally agreed that moderation in eating, drinking, and living was important to vocal health. Vocal strain was to be avoided in order to preserve the voice. Bel canto developed and flourished within the context of a particular musical style that dominated art music in Italy and many other parts of Europe for over two centuries. Notwithstanding changes and developments within that style, there was little serious disagreement among practitioners from the early 17th century until the early 19th century about the musical function of the singing voice or about what constituted good singing. This musical style formed the accepted context for the teaching of singing.

Over the last 200 years or so, the musical and social assumptions underlying this model for the teaching of singing have ceased to be self-evident. Some of the factors underlying this change are discussed in the rest of this chapter.

New uses of the singing voice

Many musical developments from the late 18th century and during the 19th century contributed to different, heavier demands on singers. Public concerts meant larger venues and larger orchestras, gave increasing importance to the conductor, and contributed to the separation of the roles of composer, performer, and teacher.

During the 18th century, the functions of voice and orchestra in opera had been clearly defined: the orchestra accompanied the singers and played by itself only on specified occasions. The 19th-century desire to blur boundaries led to use of the orchestra not only to create mood but also to enter into the drama as a continuous web of instrumental sound. In the late works of Verdi, for example, the voices compete with a large orchestra employed as part of the drama. With larger concert halls and increasingly chromatic music, the orchestra grew in size and importance, culminating in Wagner's music dramas, in which the orchestra develops the entire action while the voice declaims in melody strictly moulded to the text. These lengthy works, and later the operas of Puccini and the works for voice and orchestra of Mahler and Strauss, all called for hitherto unimagined vocal and physical stamina.

In our time, singing encompasses a wide range of 'classical' styles as well as many other genres and the styles used in them. There are a wide variety of world musics, jazz, rock, pop, and music theatre. The aesthetic expectations in these musics can be very different, and the physical coordinations needed to produce the appropriate vocal sounds quite different. Unfortunately, research into these differences is in its infancy.

Science and singing

The Spanish singer Manuel Garcia (1805–1906) is a legendary figure in vocal pedagogy and voice research. His studies in Naples with Ansani provided him with links to the bel canto traditions of Porpora. His studies in France with his father exposed him to the new style of singing introduced into France by the tenor Duprez in 1837 (Paschke, 1975). His own vocal problems motivated him to invent the laryngoscope, a mirror apparatus used to view the larynx with the intention of showing how it produced sounds and registers (Garcia, 1894/1982). (While we now have videoendoscopy, doctors still sometimes use the laryngoscope to view the larynx.)

Garcia had the idea that bel canto was produced by vibrations of the vocal cords only, caused by a full breath propelled by a bellows-like action of the muscles of the chest, forcing air from the lungs through the vocal cords (*coup de glotte*). On the foundation of his vocal cord theory, Garcia built up a method for the training of singers, published in 1840 under the title of *L'art du chant*. In 1856, he published a revised version of this manual, called *Nouveau traité de l'art du chant*, which became a standard text.

Garcia's development of a method of teaching based on his experimental investigations reflects the growth and increasing importance of the natural sciences in the 19th century. However, his emphasis on the vocal folds and on the separate elements of the vocal mechanism failed to explain their interdependent working. Although his work represented an important advance

in scientific knowledge about the voice, it also represented the beginning of fragmentation of knowledge about vocal technique.

The serious attempts at scientific study of the voice continued into the 20th century. Garcia's work was continued by his pupil Mathilde Marchesi (*c.* 1901; n.d., 19–). A scientific stance is also apparent in Emma Seiler's *The Voice in Singing* (1890). Seiler, a pupil of the German acoustician and physiologist Helmholtz, taught singing in America. She advocated study not only of the aesthetic side of the art of singing, but of the 'physiological and physical side also, without an exact knowledge, appreciation, observance, and study of which, what is hurtful cannot be discerned and avoided' (p. 34).

Nonetheless, voice science and vocal pedagogy remained independent of each other, despite such attempts to bring them together. Works describing the mechanism, usually by doctors or physiologists, often emphasized how to avoid vocal problems. Works by singer–teachers more often described the singer's sensations when producing particular sounds, and espoused 'correct' methods for producing 'good' sound. Rarely did the two approaches meet. This division persisted well into the 20th century.

There is still a problem with incorporating the findings of voice science into a theory of singing and singing pedagogy. Scientific studies are often of necessity confined to one or two small elements of the overall mechanism, they often use a small number of participants, and can only test aspects of voice for which there is appropriate technology that is neither harmful nor so invasive or restrictive that it produces unrealistic results. Often the terminology used in voice science and medicine is different from that traditionally used in singing, making interpretation of results difficult.

Singers need the integrated, holistic working of mind and body promoted by the bel canto masters. To help them achieve this economically, singing teachers need the detailed knowledge of the physical aspects of the vocal mechanism that can come from scientific studies, but they also need to know how these aspects are coordinated to produce the aesthetically appropriate vocal tone, and how to convey that information in a way that helps the singer achieve integrated mind–body control of voice in the service of music and language.

Since the 1960s works attempting to integrate the scientific and the experiential, written by singers with scientific interests or doctors and physiologists interested in singing, have become more common. Some of these works are discussed later in this book.

Contemporary voice science

Modern voice science and vocal pedagogy are products of the last 50 years or so. During that period, voice science has been transformed by new tech-

nologies that can scan brain activity, view the larynx in operation, measure muscular effort, and provide real-time feedback on vocal acoustics. The period has also seen the emergence of interdisciplinary collaboration between voice specialists in research, clinical, and performance disciplines. Interdisciplinary collaboration and the use of new technologies have raised new questions for voice research, and the answers are leading to a better understanding of how the vocal instrument works and how its health can be maintained. Voice science is both increasing our understanding of the ways in which the performer's voice may most efficiently be employed and, in some areas, confirming the wisdom of traditional pedagogies.

Science for singing teachers

The tradition of vocal pedagogy has been largely an oral one. This tradition continues in our time, despite a breakdown of many of the social and musical assumptions that previously underpinned it and despite the pressures of modern mass education. Today, many of the larger concerns of a rapidly changing society impact on the field of singing pedagogy: science versus art, elitism versus populism, the national versus the international, the rational versus the instinctive.

While many of the precepts of the bel canto masters, based on observation and experience, have largely been proven sound by scientific investigation, such a 'natural,' slow, and generalized approach to the teaching of vocal technique in singing is no longer adequate. The range of vocal styles current in the 21st century means that teachers may need to teach students who wish to train as professional performers in a vocal tradition other than the teacher's own, or to sing for self-expression and amateur music-making. Moreover, the human voice remains the most convenient, portable musical instrument for use in music education and group music-making at all levels (Atterbury & Richardson, 1995; Durrant & Welch, 1995; Welch et al., 2010). To achieve maximum results in minimum time and without vocal strain, a knowledge of vocal technique is useful to the music educator and choral director (Phillips, 1992; Miller, 1995). Most teachers need to work with students of voice types other than their own. Perhaps even more than in Tosi's day, teachers – particularly in post-compulsory education – are required to give strict account of the time and money spent in training singers. To meet these demands requires an understanding of the combination of physical factors that safely and efficiently produce the aesthetically appropriate vocal sound. That understanding also serves as the basis for diagnosing vocal faults.

All these factors – the disruption of a continuous single tradition of vocal pedagogy, the proliferation of vocal styles, the heavy physical demands of singing with electronic instruments or large orchestras in large spaces,

fragmentation of sources of knowledge about voice, and new information about vocal function and vocal health – had, by the 20th century, produced a state of some confusion in vocal pedagogy.

This confusion was recognized as early as 1947, when Victor Alexander Fields, in *Training the Singing Voice*, wrote of 'confusion in the vocal teaching profession' (p. 3), and the need to give a pedagogical interpretation to scientific discoveries about the singing voice. Fields isolated a difficulty in singing pedagogy that has since continued to grow and become even more significant:

> The laboratory research worker is often far removed in his thinking from the teaching practices of the classroom or studio. Conversely, the singing teacher often must handle unpredictable personality problems with intuitive insight and improvized instructional techniques that are not readily amenable to experimental analysis. (p. 15)

Fields' book essayed a reconciliation of these points of view through analysis of the working concepts of singing pedagogy embodied in works published in the period from 1928 to 1941. He commented that while there is no lack of printed material on the subjects of singing and voice culture, this material is inaccessible to teachers because it is extremely diversified and fragmentary, and diffusely distributed throughout a variety of books, periodicals, scientific papers, reports of experiments, and published interviews that have never been correlated from the standpoint of a definite vocal pedagogy. His statement, that 'what is written about the singing voice is so often overlaid and interwoven with conflicting theories and extravagant conjectures that misinterpretations are inevitable' (1947, p. 1), pointed to the gap between scientific reports and writings by practitioners. He went on to summarize a mass of critical comment, outlining 21 different categories of complaint voiced by authors, to support his claim that the field of vocal pedagogy stood badly in need of clarification. Fields' aims were to survey and correlate available sources of bibliographic information on methods of training the singing voice in order to provide both a core of organized information for the use of singing teachers and an orientation for research in the field. His bibliographic survey covered pedagogy, breathing, phonation, resonance, range, dynamics, ear training, diction, and interpretation.

Another landmark in 20th-century writings on singing technique, William Vennard's *Singing: The Mechanism and the Technic*, was published in 1949 – two years after Fields' book – and revised and greatly enlarged in 1967. Like Fields, Vennard was concerned with relating aspects of singing pedagogy to the acoustic, anatomical, and physiological facts of voice, but his work is a textbook for teachers and singers rather than a bibliographic survey.

In the nearly 20 years between Vennard's first and second editions, scientific investigation of singing voice grew rapidly. In both editions, Vennard stated his aim as 'to compile under one cover objective findings from various reliable sources and to relate them to the art of singing' (1967, p. iii) and went on to hint at the same difficulties that Fields had articulated:

> As the title indicates, this book is frankly mechanistic. . . . There are those teachers who feel that applying science to an art is quackery, but I believe that our only safeguard against the charlatan is general knowledge of the most accurate information available.
>
> If you are one who has always preferred the empirical approach, perhaps you should read my last chapter first. You may then agree that the knowledge of literal fact is the only justifiable basis for the use of imagery and other indirect methods. Whether you are a singer or a teacher of singing, I hope you will find here truths which you may profitably add to your philosophy, or at least a rationale for harmonizing some of the apparent conflicts in our profession. (Vennard, 1967, p. iii)

These 'apparent conflicts' have not disappeared. In 1973, John Carroll Burgin published a study (*Teaching Singing*) of similar approach and structure to that of Fields, in effect bringing Fields' work up to date by analysing bibliographic data of the period between 1943 and 1971.

In 1978, Brent Jeffrey Monahan identified the need for yet another such study. He acknowledged the work of Fields and Burgin and of Philip A. Duey's systematic analysis of bel canto sources (*Bel Canto in its Golden Age*, 1951). Monahan's research (*The Art of Singing*, 1978) filled in the period from where Duey's work ended to where Fields' began – the period from 1777 to 1927. Like Burgin's book, it followed a similar format to Fields' study. Monahan drew together the earlier research by posing the questions:

> Are traditional concepts retained throughout the years, are they abandoned, or are they interpreted and expanded in the light of modern scientific investigation? When do concepts not mentioned in bel canto writings emerge? Do certain concepts enjoy only fleeting popularity, and is it possible to trace the history of a concept? (p. 4)

Monahan's work is significant in covering the 19th century, a period of change from an emphasis on the empirical methods of the 'old Italian school' to a more scientific approach. During this period, Manuel Garcia's scientific investigations of the singing voice formed part of the general climate of scientific investigations in the fields of anatomy, physiology, acoustics, and orthoepy (theories about the pronunciation of words).

Another work that has clarified some of the sources of disagreement and confusion in the teaching of singing is Richard Miller's *English, French, German and Italian Techniques of Singing: A Study in National Tonal Preferences and How They Relate to Functional Efficiency* (1977). Miller identified basic areas of vocal technique where national approaches frequently stand in opposition to each other: breath management, registration, resonance, vowel formation and modification, vocal coloration, 'cover,' 'placement,' laryngeal positioning, buccal and pharyngeal postures, the attack, vibrato rate, voice classification, and the uses of falsetto. His investigation attributed many national tendencies in singing to language and 'national temperament' factors:

> there are compelling reasons for associating varying national attitudes toward vocalism with overall cultural attitudes . . . vocal techniques are but the means for achieving certain sounds which most please a particular cultural unit. Specific kinds of vocal literature and specific kinds of vocal sounds have evolved which directly correspond to national temperaments. (p. 194)

Miller's comparison of the distinctly national techniques led him to conclude that 'extremes of nationalism in vocal pedagogy often are based upon the distortion of physical function' (1977, p. 203) and that 'a wise singer will look for that internationalization of technique which closely corresponds to the best elements of the historical tradition of the Italian School' (p. 206). It is on this basis that his 1986 book, *The Structure of Singing: System and Art in Vocal Technique*, was predicated. In that book, Miller presented categories of technical problems, exercises to assist in establishing technical skills dependent on optimum physical function, and information on the voice as a physical–acoustic instrument. The introduction articulates – yet again – the problem already outlined by Fields, Burgin, and Monahan:

> any vocal technique involves making assumptions, of varying degrees of specificity as well as of accuracy, concerning the physical production of sound. Differing viewpoints exist with respect not only to aesthetic preference but to the most appropriate physical means for producing the desired sound. (p. xix)

But here a new criterion of judgement was introduced, surely an outcome of late 20th-century scientific certainties about voice:

> The success of any technical approach to singing must be measured by how nearly it arrives at the planned aesthetic result with the least cost.
>
> Freedom of function in singing ought to count heavily in determining which vocal sounds are most pleasing. The highest possible degree

> of physical freedom may well be the best indicator of the reliability of aesthetic judgment on the singing voice. (pp. xix–xx)

As discussed above, conflicts and confusions between the findings of voice science and the traditional assumptions of vocal pedagogy have been noted by Fields (1947), Vennard (1967), Burgin (1973), Monahan (1978), and Miller (1977, 1986). All these works are concerned with clarifying what physical means are used to achieve aesthetically desirable vocal sound. In addition, Miller's work makes explicit a concern that is implicit in many other writings, that is, that judgement of what is aesthetically desirable needs to be informed by judgement about 'freedom of physical function.' For teachers of singing to make a judgement of what is involved in freedom of physical function, they need to be knowledgeable about voice production.

There is still much scientific information relevant to singing appearing in journals in many different disciplines – neuroscience, psychology, physiology, medicine, speech pathology, acoustics, and linguistics, as well as singing and voice science – contributing to the fragmentation of knowledge on voice. In the last 50 years a great deal of scientific material has been published on various aspects of vocal physiology and acoustics. In the last 20 years some of this knowledge has been incorporated into books on singing and the teaching of singing.

Thurman and Welch's comprehensive *Bodymind and Voice* (2000) examines all aspects of singing against a background of the anatomy, physiology, and acoustics of voice. The *Oxford Handbook of Singing* (Welch et al., in press) updates that knowledge. Nair's *The Craft of Singing* (2007) brings together the physical with the aesthetic and applies it to song learning and performance. Chapman's *Singing and Teaching Singing* (2012) applies a range of interdisciplinary insights to singing and teaching singing, with particular emphasis on the Accent Method of breathing, while emphasizing the holistic nature of singing.

This book is concerned with the physical and mental bases of voice production: what we know about how the vocal instrument works. While some reference is made to the publications above, the main focus is on interpreting research findings in the overall context of singing and the teaching of singing. The next chapter gives a brief overview of the vocal instrument, while the following chapters assess the scientific literature on breath management, phonation, resonance, registration, vocal health relevant to the teaching of singing, and how these are brought together by the body, brain, and mind in singing. In the last chapter I return again to issues of teaching and learning, relating the specific physical and mental aspects of voice to broader pedagogical concerns.

About the author

Dr Jean Callaghan is an Australian singing voice specialist with advanced degrees in singing, a PhD in vocal pedagogy, and a second postgraduate research degree in music and language theory. She has sung and taught around Australia and in New Zealand, Singapore, Sweden, England, and Germany, working in universities, privately with individual singers and teachers, and giving recitals, masterclasses, lectures, workshops, and short courses for voice professionals. For the University of Western Sydney she designed and delivered Australia's first full postgraduate qualification in singing pedagogy.

Jean Callaghan has served as president of the Australian National Association of Teachers of Singing, the Australian Voice Association, and the Australian Association for Research in Music Education.

Her research interests are interdisciplinary and concern vocal pedagogy and the relationship between music and language. She was part of the research team that developed *Sing&See™*, specialised computer software providing acoustic feedback on the singing voice, and author (with Pat Wilson) of the accompanying manual, *How to Sing and See* (2004). In *Perspectives on Teaching Singing* (S. Harrison, ed., 2010) she has chapters on 'Singing Teaching as a Profession' and, with Diane Hughes, a chapter advocating interdisciplinary voice studies in Australian school education. With Shirlee Emmons and Lisa Popeil she wrote the chapter on 'Solo Vocal Pedagogy' in the *Oxford Handbook of Music Education* (G. Welch & G. McPherson, eds., 2012) and as solo author the chapter on 'Teaching the Professional Singer' in the forthcoming *Oxford Handbook of Singing* (G. Welch, D. Howard & J. Nix, eds.).