Mapping a beautiful voice: theoretical considerations

Abstract

The prime purpose of this paper is to draw on a range of diverse literatures to clarify those elements that are perceived to constitute a 'beautiful' sung performance. The text rehearses key findings from existing literatures in order to determine the extent to which particular elements might appear the most salient for an individual listener and also 'quantifiable' (in the sense of being open to empirical study). The paper concludes with a theoretical framework for the elements that are likely to construct and shape our responses to particular sung performances.

keywords

beautiful singing

perception of quality

psychoacoustics

vocal pedagogy

voice beauty

Introduction

Outside a performance hall (with its additional factors, such as being a member of an audience, having visual feedback, experiencing a live event), it is assumed that what we like or dislike when listening to a recorded sung performance is encapsulated in a captured sound-file. In the world of acoustic science, every piece of sound information that is available for our ears to receive, when we are listening to our favourite vocal performance in the comfort of our living-room, can potentially be isolated and analysed. This is not to say that listening is merely the sum of the acoustic input, but that the acoustic input is quantifiable. Whilst it is recognised that this is only one major component of the listening experience (the others being what the listener brings to the activity) the application of such an analysis may be useful in interpreting such comments as found in the *Gramophone Classical Good CD&DVD Guide 2005* (Roberts, 2004 p. 772): "Catherine Bott is a fine Dido, even-voiced across the range and powerfully expressive if occasionally a touch free with the rhythms". In what sense might this information 'identifiable' in the recorded sonic material? Might this particular performance be perceived as 'better' than another for this individual listener because of the 'timbre' of Catherine Bott's voice or maybe because of her vibrato rate or the variability of intensity? The narrative that follows seeks to build a multi-disciplinary framework of vocal beauty in performance, drawing on literature from the natural sciences, analytical musicology and social sciences. The proposed research framework attempts to understand how these different forms of evidence become interwoven when individual listeners experience a sung performance. The underlying hypotheses are that the human perception of sung performance is likely to be multifaceted and that commonality and diversity are evident in such perceptions[1].

Understanding vocal beauty from the perspective of the natural sciences

Production of voiced sound: the basic vocal instrument

Somewhat anecdotal evidence in support of a view that the human voice is perceived to be a unique performance instrument surfaces in the text of music reviews, critiques and analyses in the popular press and other media. Comments from a 2005 Sunday broadsheet supplement are typical: "*Cooder*'s voice, earthier than ever…". "*Martin*'s favourite song [on the new *Coldplay* Album] he sings, sounding like he's been up all night crying" and "*Eno*'s voice is contemplative and unassuming…" (The Sunday Times, 22 May 2005). It appears to be common for a review of a vocal performance to make reference to the actual instrument (the performer's voice), but this is rarely the case for reports of other, non-vocal, instrumental performances. Whilst acknowledging the skill of the expert instrument maker or luthier, we are disposed to take the sound quality of the actual (non-voice) instrument as a relative given and focus our attention on the nuances of performance. However, somewhat paradoxically, academic research studies continue to investigate the sound qualities of supposedly superior musical instruments, incorporating perceptual testing, physical modelling and a comparison of the actual physical properties/characteristics of the instruments (*cf* violins -*see* Lukasik, 2003, as well as the human voice, e.g. Sundberg, 2006).

The basis for the voice being an essential component in our species-wide communication, including musical performance, lays in a common vocal anatomy and physiology that is shaped by biological development and interfaced with experience, cultural imperative and tradition (Welch, 2005).

[INSERT FIGURE 1 ABOUT HERE]

Figure 1: The vocal tract and the vocal folds (*edited and adopted from the Netter Interactive Atlas of Human Anatomy*)

---

1 An empirical evaluation of this research framework will be published in a forthcoming issue. This will evaluate the robustness of the emergent theoretical taxonomy of underlying contributory factors by subjecting it to empirical evaluation through a multifaceted investigation into the psycho-acoustic and context-specific interpretation of sung performance quality.

Irrespective of race, ethnicity and gender, the human vocal instrument comprises three fundamental components (*see* Figure 1): (i) the respiratory system which produces the energy source for the voice; (ii) the vocal folds within the laryngeal assembly which vibrate in the airstream from the lungs to generate the basic sound; and (iii) the vocal tract (essentially the spaces above the larynx – the pharyngeal space within the neck and the oral cavity, complemented by the nasal cavity) which shapes the sound (*cf* Titze, 2000; Welch & Sundberg, 2002). In order to vocalise, the respiratory system compresses the lungs to generate an upward flowing airstream which sets the edges of the vocal folds in vibratory motion, resulting in pulsed sound waves that travel (mainly) upwards through the vocal tract where they are modified (*see* Figures 1 and 2), prior to being radiated outwards from the lips (Welch, Himonides *et al.*, 2004).

[INSERT FIGURE 2 ABOUT HERE]

Figure 2: The richness of voiced sound (the voice source-filter model)

Voiced sounds are acoustically rich, having many harmonics above the fundamental frequency. Acoustically, the vocal tract can be conceived as having several interconnected chambers, each of which individually and collectively filters and modifies the sound generated by the two sets of laryngeal muscles to create particular voice qualities (Figure 2). In addition, the tongue modifies the spaces in the oral cavity and upper pharynx (oropharynx) to create a complex variety of different sounds. This 'branding' of the sound within the vocal tract results in a rich and, more importantly, unique product, the human voice (*cf* Himonides & Welch, 2005). This distinctiveness is what makes the voice one of the key specialties in the science of biometrics (European Commission, 2005) and also the fields of forensic voice identification (Hollien, 2002), forensic phonetics and phonetic acoustics (*cf* IAFPA: International Association for Forensic Phonetics and Acoustics).

Pitch communication

Changes in vocal pitch are a product of variations in the mass and length of the vibrating vocal folds that arise from the relative interactive contraction of two sets of internal laryngeal muscles. The contractual dominance of one set of muscles (cricothyroids) has the effect of stretching and lengthening the vocal folds to create a longer, thinner, more taut muscular system. The lengthened folds tend to vibrate more quickly in the airstream from the lungs and produce a perceptibly higher pitch. Conversely, when the other set of muscles are dominant, being located within the vocal folds (thyroarytenoids), their contraction reduces the folds' length and increases their overall vibrating mass, resulting in a slower vibratory pattern with a perceptibly lower pitch (Welch & Sundberg, 2002).

Vocal loudness

Vocal loudness is mainly a result of changes in air pressure from the lungs: the higher the pressure, the louder the voice. Professional singers are very consistent in their use of the respiratory system, but there is no standard single type of breathing behaviour across singers (Thomasson, 2003). It seems likely that subtle changes in loudness during a sung phrase are the product of rib cage movement, whereas the movement of the abdominal muscles provides a more general 'platform' for the diaphragm to act on (Hixon & Hoit, 1999).

Timbre and formants

A general feature of voiced sound is that there are energy peaks in the spectrum of the sound that is radiated from the lips. These peaks in the acoustic terminology of the human voice are known as *formants*, created by vocal tract resonances that appear at certain frequencies and which enhance particular harmonics (whilst damping others) of the complex waveform emanating from the vibration of the vocal folds – so-called the source-filter model (*cf* Sundberg, 1987; *see* middle and end sections of Figure 2). There are five formants that are considered to be crucial to vocal communication and our perception of voiced sound (Titze, 2000). The relationship between the lowest two formants (F_1 & F_2) gives rise to our labelling of sounds as 'vowels' and are generally dependent on jaw opening and tongue shape respectively. The relationships between the other three formants (F_3, F_4 & F_5) relate primarily to vocal colour and also the carrying power of the voice (Sundberg, 1987). When the vocal tract is configured to cluster these three upper formants together (usually by opening the pharynx and lowering the larynx), there is a particular energy peak created, known as *the singer's formant cluster* (Sundberg, 1974; 1987; 2006). This is a form of (usually learned) amplification that allows the singer's voice to be heard with relatively little effort above the sound of a full orchestra, because the *singer's formant cluster* appears in a part of the frequency spectrum where the typical classical music orchestra sound is relatively weak. Evidently, it is also the most sensitive region perceptually in the human auditory spectrum (Hunter & Titze, 2005).

The role of formants in the perception of singing

Even though teacher and student may not be aware of the basic acoustic explanation, much conventional singing teaching relies on metaphor related to underlying formant manipulation in order to shape vocal behaviour (Callaghan, 2000). This is presumably in the hope that the student will be able to use the guidance subsequently to self-monitor singing quality in rehearsal and performance. For example, vocal timbre that is perceived as characteristically 'dark' in tone quality has formants that are relatively lower in the spectrum compared to voices whose quality is described as 'light' or 'bright' (Sundberg, 1974). The relative spectral alignment and strength of the formants is also implicated in perceptions of the 'placement' of the singing voice, such as being either 'forward' ('in the mask') or 'backward' (Vurma & Ross, 2003). 'Forward placement' is usually regarded as a more ideal vocal quality for Western classical singing performance (Emerich *et al.*, 1997) and can be achieved by increased jaw opening and moving the tongue forward, thus raising spectrally the first two formants (F_1 and F_2) and increasing the relative power of the *singer's formant cluster* (for an overview on 'formant technique' *see also* Sundberg, 1975).

The diversity of the vocal instrument in performance

Although the manipulation of vocal timbre associated with such singer's formant clustering (*see* above) is a characteristic of singing in Western classical music, it would likely be perceived as 'inappropriate' in the performance of other vocal genres. For example, a clustering of the first, second and third formants (F_1, F_2 & F_3) is a characteristic of the timbre of indigenous 'throat music' such as found in Tibet and Mongolia (Levin & Edgerton, 1999). In contrast, 'country singing' is more similar acoustically to speech, with the greatest energy focused on the lowest two formants (Clevelant, Sundberg & Stone, 2000). Likewise, sung performance with a 'belt' or 'show' singing style (so-called because of its high intensity in stage performance) is comparable acoustically to loud speech (Stone *et al.*, 2002). Compared to classical Western classical singing, each of these diverse singing genres relies on different co-ordinated manipulations of the vocal system (respiratory system, vocal folds and vocal tract) in order that their characteristic timbres may be produced. In general, a relatively 'untrained' singer tends to use or rely on habitual speech co-ordinations, often resulting in upper sung pitches that can only be produced with higher lung pressures and relatively extreme and effortful muscular tension (Titze, 2000).

In essence, the overall vibrating dimensions of the vocal folds at any given age, coupled with the degree to which they can be stretched/lengthened or contracted/shortened, underlie the voice's basic pitch range (*tessitura*) and form the physical basis for the conventional 'labels' that are applied to singing voices in performance, such as *soprano*, *alto*, *tenor* or *bass*. However, when it comes to defining the nature of 'quality' in voice production, voice scientists' perspectives suggest that this is more problematic. For example, Titze and Story (2002) rehearse some of the ongoing challenges in matching conventional labels with scientific explanation:

Descriptions of voice quality have traditionally consisted of qualitative terms such as warm, shrill, twangy, creaky, shrieky, breathy, yawny, gravelly, hoarse, ringing, dull, nasal, resonant, rough, and pressed. While commonly used in both clinical and non-clinical situations, the acoustic and articulatory correlates of these terms have not been well defined. In comparison, the characteristics of vocal registers have been somewhat better defined and are often given the generally accepted labels of modal, fry, and falsetto in speech, and chest, head (or mixed), falsetto and whistle in singing. Work is now ongoing to address a few of these voice qualities on a physiologic and acoustic level. (op. cit. 2002, p. 3)

The labels in general use for voice quality in speech are somewhat contentious and, notwithstanding the above comparison that suggests that singing generates a greater level of consensus, there continues to be controversy surrounding definitions of vocal registers (including their nomenclature and number) (Thurman *et al.*, 2004).

Understanding Vocal Beauty from the perspective of the music being performed

Musical Structure

Another major ingredient in the perception of beauty in sung performance relates to the musical material. Within the broader field of *musicology*, the study of musical structure has been connected to numerous philosophical, meta-philosophical, and æsthetic as well as cognitive and meta-cognitive theories. Attempts have even been made to establish musical meaning solely within the boundaries of the musical structure itself (e.g. Subotnik, 1996; Del'Antonio, 2004).

Musical morphology and structure have been hypothesised as contributing to the perceived quality of a performance. Whilst this may seem obvious, one challenge is to understand any possible relationship between the listener's perceived structure of the music and the perception of the quality of its performance. The composer's intent (Scheirer, 1996) in creating the music may have been to introduce *key-moments* in the unfolding of the musical structure. As such, it may be that the structure itself embodies (or suggests) moments of lesser or greater significance than others. Consequently, one's perception of a performance could rely on an interpretation of the performance in relation to specific passages (or moments) that musicological analyses might be able to suggest as particularly salient (such as *motif*).

For example, Ockelford (1999, 2005) has presented a Zygonic theory-based model to explain the perceptual processing of different features of musical structure. Within the model, Ockelford (2005) suggests

Music's perceived content and structure (as set out in Zygonic theory) constitute only two of many elements that reside within and contribute to the 'cognitive environment' of the listener. For example, the listener's cognitive environment is likely to be influenced by extramusical forces, pertaining both to the inner world of the person concerned (which is in turn determined by internal and external factors, past and present) and to his or her reaction to the immediate circumstances in which the performance is being heard.

Ockelford argues about the power of association, of the assignment of extramusical attributes to the experience of listening.

For example, the Wedding March played following the death of one's partner may still be recognized as essentially joyful, even though it may elicit intense grief, and be perceived as musically coherent, despite the fact that its effect in æsthetic terms is the opposite of that which the composer intended.

Other factors relate to personal biography, to those key episodic moments in which powerful emotional experiences have happened alongside music. For example, Elton John's 'Candle in the wind' will be powerfully associated with the televised funeral service for Diana, Princess of Wales. Clarke (2005) refers to these as 'different perceptual capacities' as well as 'different musical values' that relate to different 'kinds of musical experience', whilst Langer (1942) discusses 'ghosts of experienced reality'. Ockelford (ibid.) agrees that aesthetic response can be influenced by extra-musical associations, i.e. connotations of non-musical entities or events established through previous experience that may be stimulated by further hearings of a piece or feature of it. Other influences include the physical environment of the experienced performance, as well as the observed physical behaviours of the performer (Davidson, 2002).

Various alternative perspectives on the basis for our perception of musical structure exist, such as those by Schenker (1954), Nattiez (1990) and Lerdahl and Jackendorff (1996). Their respective emphases are on a systematic description of musical structure and 'note hierarchy' (Schenker), semiotic meaning and 'relationality' in musical form (Nattiez) and the hierarchical structuring of musical form with dominant and non-dominant features (Lerdahl and Jackendorff). Collectively, they argue that the experience of music is inextricably interwoven with salient features of the underlying musical structure that have been created by the composer and discovered (recovered) by the listener's mind. The complexity of musical experience and its relation to musical form is also highlighted by Scherer and Zentner (2001) who suggest that "an emotion that is actually experienced by a listener while listening to music is determined by a multiplicative function consisting of several factors: experienced emotion = structural features X performance features X listener features X contextual features" (op. cit. p. 365).

Understanding vocal beauty: a social science perspective

Emotions and music

Although the present research study is closely related to studies focusing on the induction of emotions while listening to music (Gabrielsson, 2002; Gabrielsson & Lindström, 2001; Meyer, 1956; Juslin, 2001; Sloboda, 1991; Goldstein, 1980; Scherer & Oshinsky, 1977; Scherer & Zentner 2001), it is important to note that its distinctive focus is the understanding of 'singing performance quality' within the precincts of a specific musical score (*cf* Himonides & Welch, 2005). Gabrielsson and Juslin (1996) adopted the term *communication chains* in order to present the different contexts or different communication routes that should be researched. They further reported that any given musical event may ensure more than one of these *chains* (ibid., 1996). In their 1996 work, in order to highlight that sole emphasis on musical structure is not liable to "capture the essence of musical activity", Gabrielsson and Juslin (op. cit.) provide a lustrous example of how these different *chains* might be 'tangled' by quoting Shaffer's (1992) work on methods related to interpreting music: "listeners tend to hear moods and emotions expressed in music, performers feel that they are conveying these moods and emotions, and composers may conceive of these moods and emotions as part of the musical intention" (p. 264). It appears that there is an opaque symbiotic relationship between inherent emotion, communicated emotion and finally, perceived emotion (Juslin, 2000).

The implicit psychological (or emotional) 'meaning' of the musical structure, as well as the 'emotions' that this might induce in the listeners, are part of the overall explanation (*see* also Gabrielsson, 2002 on ‘perceived’ emotions vs. ‘felt’ emotions). This does not mean, though, that ‘musical structure’ can simply be ‘filtered out’ fin any empirical analysis. On the contrary, based on the research literature that is being presented within this paper, musical structure can be seen as the ‘compass’ that ‘enables’ the skilled performer (or, condemns the unskilled one!) to highlight certain features in their performances (*cf* Senju & Ohgushi, 1987), in order for emotions and affect ‘æsthetic appreciation’ (i.e. the perception of performance quality) to be communicated.

The ‘beautiful’ and the ‘ugly’ voice

As reported in the literature (*cf* Himonides & Welch, 2005; Lukasik, 2003), evaluations or *critiques* of non-vocal instrumental performances rarely refer to the actual quality, craftsmanship, status, rarity or significance of the musical instruments that were used for the performances. With the exception of liturgical music, where a specific ‘organ’ in a specific ‘loved’ venue may be treated as ‘totem’ (Steed, 1881; Bicknell, 1996), it is highly unlikely that we would be able to find a review about a musical performance (a classical music performance, in particular; such as an oboe performance, for example) that discusses the make, model and/or quality of the instrument that the performer used for their performance. Evidently, this contrasts with reports concerning vocal/singing performances. Timbral beauty is an important aspect of the singer’s voice but, as Sundberg (2006) claims, certainly also elusive. He states: “... what is beauty and from what does it emerge? Yet, the beauty of a voice is often striking, but perhaps, and even more so, the ugliness of some voices” (p. 137). In the same paper, Sundberg (op. cit.) provides two examples of characteristically ‘ugly’ voices and performances, namely those of soprano Florence Foster Jenkins “attempting” to sing the aria of the *Queen of the Night* from Mozart’s *Zauberflöte* and tenor-baritone Thomas Burns who performs excerpts by Gounod’s opera *Faust*. Sundberg (op. cit.) quotes a review of those performances as published on the World Wide Web[2], mentioning that the *ugliness* of the performers’ voices were commented upon quite eloquently:

“The disc concludes with something extraordinary, indeed. If you thought that Jenkins was bad, wait until you hear the selections from Gounod’s *Faust* as sung by Jenny Williams (soprano) and Thomas Burns (baritone). Having translated the French text into English (a dubious endeav[ou]r), they proceed to out-do Jenkins in their awfulness. Actually, Williams is merely mediocre (i.e. a few notches above Jenkins). But Thomas Burns is extravagantly bad. In all truth, he sounds uncannily like Elmer Fudd, with the same nasal voice and portentous, tragic vibrato. Hearing his litany of “O! Marguerita”s and “I love you!”s belted in earnest, throaty groans is to witness the airy heights of absurdity....” (op. cit., p. 137).

Sundberg’s fascination with the above examples and the relevant critique of the performances led to an investigation of the ‘causalities’; singing out-of-tune (a performance/competence oriented factor, hence related to musicianship) did not appear to be the basis for this review. Rather, it seemed that the perceived ‘ugliness’ was affiliated with the singer’s vocal timbre (the instrument itself).

---

2 http://www.epinions.com/content_84551175812)

Comparative spectrotemporal analyses between Burn's recorded performance and that of Swedish tenor Nicolai Gedda's recorded performance of the same musical piece were performed by Sundberg (2006). These suggested that perceived 'ugliness' in the former soloist's voice could be interpreted by a set of specific variables. Upon verifying the subjectivity of 'ugliness' for the two performances using a panel of singers and singing teachers, Sundberg (op. cit.) compared the performances in terms of tone production characteristics such as vocal pressedness or hyperfunction (as related to the amplitude of the voice source fundamental), the existence (or not) and characteristics of the singer's formant cluster (Sundberg, 1975; 1987; 2001) and vibrato. Burn's voice did lack a singer's formant, his vibrato was found to be irregular and his phonation was constantly hyperfunctional.

Sundberg (op. cit.) concludes:

"These results are interesting, since all of the reasons for timbral ugliness seem related to functionality. Lack of a singer's formant implies that the voice will fail to/be difficult to hear against the background of a loud orchestral accompaniment. An irregular vibrato implies that the perceived pitch of a tone constantly varies so the pitch contour is not accurately realized. A constant use of hyperfunctional phonation is likely to limit the singer's range of timbral variation which would be needed for the purpose of expression. Against this background it is tempting to speculate that part of the criteria of timbral beauty in a singer's voice do not emerge from a randomly developing cultural tradition, but rather are rooted in the acoustic conditions under which singers create their vocal art." (p. 139).

Human Evaluation

As Kenny and Mitchell (2006) report, there are few empirical studies that attempt to classify good timbral quality in singing. Some perceptual studies have attempted to describe the features of good singing and link these to acoustic features of the singing voice (e.g. Sundberg, 2006). Research to date suggests that expert listeners who participate in relevant research projects are likely to generate statistically consistent results when rating 'overall' quality of musical performances (Wapnick & Ekholm, 1997; Ekholm *et al.*, 1998; Boyle & Radocy, 1987; Campbell, 1970). This also appears to be in line with the findings of research studies that relate to assessment and music education (Abeles, 1973; Sagen, 1983; Cooksey, 1977; Fiske, 1975; Thompson, Diamond & Balkwill, 1998) and is supported also by meta-research in performance evaluation (Wapnick *et al.*, 1993; Watkins, 1942; Weekley, 1989; Stanley *et al.*, 2002) as outlined in Thompson's recent research work (Thompson & Williamon, 2003; Thompson, 2005)[3].

---

3 Further discussion concerning the parallels between the evaluation of performance quality of a supra-normal state (i.e. the highly trained professional voice, which is one of the foci of this article) and the assessment of performance work in the educational setting can be found in Himonides & Welch (2005) and Himonides (2008).

Kenny and Mitchel (op. cit.) also report that ratings of good or poor performances are correlated most strongly with tone quality and intonation and that

“Strong correlations have also been observed among different descriptors that assess quality, such as colo[u]r/warmth, resonance/ring, clarity/focus, and appropriate vibrato, which indicate that these factors converge on the same underlying construct of overall vocal quality” (p. 56).

Kenny and Mitchell (op. cit.) present some interesting outcomes of similar research investigations (Merritt *et al.*, 2001; Thompson *et al.* 1998). According to those, the fact that the research participants were asked to rate separate features of a musical performance did not seem to offer additional insights into the evaluation of the performances. They say: “It seems that judges apply personal constructs to assist with their judgment strategies as they often cannot articulate the components of sound quality on which their judgments were based” (p. 56). This particular claim is being revisited, briefly, hereinafter but also in Himonides (2008).

On ‘dimensions’

Music may express as well as incite emotions in distinct ways (Gabrielsson & Juslin, 1996; Dowling & Warwood, 1986). Gabrielsson and Juslin (op. cit.) report three central classes of such musical incitement, namely empathy, anticipation, and reflection. First, empathy refers to the ability that music has to make us become associated with certain real life situations, circumstances and/or experiences (*see also* Scherer, 2004 on *discrete emotions*, underneath). Second, anticipation concerns the potential that music has to generate variations from expected forms and structures (what Gabrielsson and Juslin, op. cit. call deviations from expectations), as argued by Meyer (1956), Berlyne (1971), Gaver and Mandler (1987), Johnson-Laird and Oatley (1989), as well as systematically reviewed by David Huron in one of his latest works *Sweet Anticipation* (Huron, 2006). Finally, from a psychophilosophical perspective, music may express as well as arouse emotions by “mirroring the structure of emotions” (Gabrielsson and Juslin, op. cit., p. 68) as previously argued by Susanne Langer (1942; 1953), Dowling and Harwood (1986), and later revisited by Åhlberg (1994) with a particular focus on the actual representation of these emotions in music.

In the conclusion of a major study that reviewed research literature on the kinds of emotions that can be induced by music, the underlying mechanisms and how these can be measured, Scherer (2004) notes the importance for researchers to realise the complex nature of the related subjects and the need to select or develop research instruments that are “up to the task”, rather than choosing “convenience or tradition”. According to his research overview, there have been three key methods for recording the triggering of emotions whilst listening to music, but he claims that none of the three is “well suited to the task”. First, research studies have focused on what past literature has presented as ‘basic emotions’ or the *discrete emotion model/theory* (*see among others* Darwin, 1872; Tomkins, 1962; Ekman, 1984; Ekman, 1992; Izard, 1971; Izard, 1990). According to Scherer (op. cit.) the discrete emotion theory appears to be inadequate (for numerous reasons) in describing the impact that music has on the induction of emotions. The vast richness of the emotional effects that music seems to cause appears to be impossible to describe through such a small number of discrete primary emotions (this is also mentioned in Scherer's 'plea' for a new approach to measuring emotional effects in music (Scherer, 2003) at the *Stockholm Music Acoustics International Conference '03*. Furthermore, mixed emotions (even if they were only primary) were reported to be virtually never studied in discrete-emotion-based research on the emotional effects of music (op. cit., p. 246). Additionally, the *discrete emotion model/theory* connects the manifestation of basic emotions to fundamental life states or conditions (what Scherer calls *prototypical situations* such as loss and threat). He argues that music can usually accompany such states, but it is rarely the cause of them. Scherer writes

"While there is no doubt that in all cultures music often accompanies socially significant events that generate strong emotions, the latter are generally elicited by the nature of the event rather than the music itself. Listening to music for pleasure, one of the prime achievements of human culture[,] can hardly be considered to be comparable to such typical emotion-eliciting events and situations, many of which are considered to reflect similar motivational states across species" (p. 246).

Finally, according to the research findings of a previous study by the same author (Scherer, 1992), subjects that are listening to music are very rarely demonstrating "highly specific autonomous response patterns" and there has been no evidence reported on the manifestation of such emotions through the study of listeners' facial expressions. Scherer (2004) believes that there is little or no research evidence that music produces substantially shared emotions in terms of "emotion-specific profiles of physiological response patterns, motor expressions, and feeling states, in the members of an audience"; the induction of core emotions by music appears to be an individual rather than a uniform phenomenon.

Following a discrete emotion model/theory, the vast majority of contemporary studies in the field of music and emotion have been based on early experimental research by Wundt (1904), perceived by many as the father of experimental psychology. Researchers in the field utilise *n-Dimensional modelling of emotions* (*n* is the number of dimensions that a researcher decides to utilise, e.g. *unidimensional, two-dimensional, three-dimensional* etc.). Wundt himself employed a three-dimensional model for his work on the description of feelings, the three dimensions being: *pleasantness* ↔ *unpleasantness*, *rest* ↔ *activation* and *tension* ↔ *relaxation* (*see* Figure 3).

[INSERT FIGURE 3 ABOUT HERE]

Figure 3: A three-dimensional model for the description of feelings (after Wundt, 1904)

Although Wundt's three-dimensional model has been reported as having a strong impact on research regarding the psychology of affect and emotion (Scherer, 2004), the third dimension (tension-relaxation) has been difficult to implement effectively in experimental testing. Empirical research projects in the field (*see among others* Wedin, 1972) usually require participants (listeners) to report their perception regarding a musical piece's 'emotion evoking properties' by placing appropriate marks either on paper or on a digital graphical model (*cf* Lavy, 2001; Thompson & Williamon, 2003; Thompson, 2005); a process that has been proven to be heuristically as well as ergonomically challenging to perform within spaces that are formed by more than two dimensions. An 'extreme' example of a multi-dimensional instrument for the measurement of affective responses to music is the *9-Affective Dimensions (9-AD)* instrument proposed by Asmus (1985), comprising *evil, sensual, potency, humour, pastoral, longing, depression, sedative* and *activity* dimensions. It would seem that, Asmus (op. cit.) was not in a position to employ rare geniuses that were able to score their feelings in nine-dimensional space for his research; rather he 'distilled' these nine dimensions by performing qualitative analyses and groupings of the adjectives/keywords that his subjects used when they were asked to describe their feelings. The challenges that have been reported above have led to a simplification of the model to a two-dimensional version comprising the measurement of *valence* on one axis and the measurement of *activation* across the other axis, thus forming a two-dimensional response surface. The *valence/activation* (or *valence/arousal*, as appearing in other research studies) models of emotion mapping have essentially governed the majority of contemporary research studies in affective responses to music (e.g. Schubert, 1999; Schubert, 2003; Juslin & Laukka, 2004; Sloboda & Lehmann, 2001; Witvliet, 1996). As Scherer (2004) reports, although the utilisation of such two-dimensional models offers certain benefits in the mapping of feelings, such as helping us to visualise connections and/or commonalities between mapped feelings and their bordering ones in the two-dimensional space (Feldman Barrett & Russell, 1999), threats and disadvantages do exist. Gabrielsson and Juslin (2003) argue that the fusion of the *rest* ↔ *arousal* and *tension* ↔ *relaxation* dimensions (*see also* Figure 3) into one dimension is especially problematic, since *tension* ↔ *relaxation* appears to be a very important facet in the morphological (or broader musicological) analyses of musical form.

Scherer (2004) concludes:

"Many of the established techniques have serious shortcomings, as shown above. Inappropriate measurement instruments not only carry the danger of missing essential aspects of the phenomenon or obtaining biased data, they also prevent accumulation and comparability of results in a domain that critically depends on coordinated efforts for its further development" (p. 250).

'Emotions' and Acoustics

As described earlier, the present research study shares some common ground with studies that have a focus on music and its power to express and arouse emotions; but this still begs the question as to what is the connection between *emotions*, *feelings*[4] and musical performance. Additionally, if there *is* a connection amid these, it is not clear how this connection affects our (the listeners') perception regarding the 'quality' of the musical performance. A review of the research literature suggests that there are numerous research studies that have focused on listeners' perceptions regarding either the

---

4 It is worth mentioning that although a vast body of past literature presents *emotions* and *feelings* as practically synonymous concepts, modern work in psychology (see among others Scherer's work) tends to treat feelings as the fundamental notions, sequences/combinations of which can construct *emotions* (the more complex notions). Alternatively, the neuroscientist Damasio (2000; 2003; 2005) suggests that feelings are the verbal tags for underlying emotional states.

emotional ‘cores’ of musical pieces -i.e. the musical scores’ potential to induce feelings and/or emotions to the listeners- or the different feelings and/or emotions that discrete performance cues can be communicated by the performers (and *not* the composers) to the listeners. In the former category, experimental researchers have primarily utilised two different means for their testing. First, they selected (either randomly or deliberately) a number of musical pieces and asked the research participants to rate their perceptions of the musical pieces’ emotional ‘charge’, beit *overall emotional charge* (when a piece should be ranked as evoking just one emotion) or ‘segmented’ and in more recent studies ‘continuous’- emotional charge (where the participants were able to perform their rating on numerous occasions or in real time during the musical piece’s duration). Second, the researchers utilised structural variations of bespoke musical compositions and asked the research participants to rate the emotional ‘properties’ of the different versions (again, either *overall* or in a *segmented/continuous* fashion). Among others, research under this specific category has been performed by Nawrot (2003), Crowder *et al.* (1991), Dolgin and Adelson (1990), Robazza *et al.* (1994), Schellenberg and Trehub (1996), Hevner (1935), Shatin (1970) and Maher (1980). The latter research direction, as mentioned above, has had a slightly different focus. By asking musical performers to try and express different emotions using different performance techniques[5] when performing set musical pieces, researchers have endeavoured to understand whether the performers’ intentions to communicate (or induce) such different emotions could be associated or correlated with the listeners’ perceptions of their felt emotions when listening to the performances in question (*cf* Kendall & Carterette, 1990; Sloboda, 1983; Juslin, 1997a; Juslin, 1997b; Juslin 2000; Gabrielsson & Lindström, 1995; Davidson, 1993). Both research directions (i.e. musical structure focused and performance behaviour focused) have offered considerable insights into the understanding of emotions and music/music performance. Findings from both research directions appear to be consistent and in many cases also supported by research findings in affiliated disciplines such as anthropology (Merriam & Merriam, 1964; Kaemmer, 1993), ethnomusicology (Titon, 2001; Miller & Shahriari, 2008), social-psychology (Farnsworth, 1969; Cook, 2000), developmental psychology (McPherson, 2006), neuroscience (Patel, 2007), human physiology (Schneck & Berger, 2006), pre- and post-natal human development (Malloch, 1999), biology (Zatorre & Peretz, 2001) and even genetics (Coon & Carey, 1989). It is highly unlikely, for example, to represent (or communicate) a sense of *seriousness* and *solemnity* or *sadness* (Rigg, 1964) with high-pitched, fast paced, rhythmically irregular and harmonically dissonant music ... possibly within ‘any’ culture and ‘any’ epoch. Accordingly, *happiness* is unlikely to be expressed with low and descending pitches, slow pace, minor mode and great dissonance (*see among others* Hevner, 1935; Scherer & Oshinsky, 1977; Rigg, 1940; Narmour, 1990; Narmour, 1992).

On the other hand, both research directions seldom treat music as the rich, colourful, constantly fluid, multimodal and inestimable model that it is; music is being assessed as a “privileged class of object with intrinsic emotional properties” (Lavy, 2001 p. vi), instead of being considered a perfectly ordinary and

---

5 usually by maintaining the correct musical notes (pitches) and having the freedom to adapt tempo, timing, dynamics, articulation, phrasing, vibrato, attack and timbre (see: Gabrielsson & Juslin, 1996).

natural human activity. As part of Lavy's (op. cit.) proposed four-faceted model concerning listeners and their relationship with music, music is heard in context. He writes

"Listeners do not exist in a vacuum: music is always heard within the context of a complex web of knowledge, thoughts and environment, all of which can potentially contribute to an emotional experience" (p. v).

Listeners who are being asked simply to rate or state the emotions that are evoked by selected short musical pieces are not operating within the context that they would normally listen to those pieces in real life. On the other hand, experiments that require listeners to perform ratings on manipulated musical structures or researcher controlled musical performances (e.g. when the researchers ask the collaborating performers to play given musical pieces in 'certain' emotional 'fashions') are likely to be biased because of the 'exaggerated' nature of the resulting musical performances (e.g. 'cartoon'-music-like vibratos, highly irregular rubbato, unnatural tempi, irregular accenting). This becomes even more complicated with research in vocal/singing performances in particular. The human voice, besides being a musical instrument, is also a most powerful agent for the expression of emotions outside the musical context and, unfortunately, these cannot be isolated. Lavy (op. cit.) presents this as *music as human utterance* in his above mentioned framework. He states:

"Humans have a remarkable ability to communicate and detect emotion in the contours and timbres of vocal utterances; this ability is not suddenly lost during a musical listening experience" (op. cit., p. v).

The above considerations were presented by Gabrielsson and Juslin (1996) in support of their argument that, to that date, no research study had considered variables in the microstructure of music performance; a task that they present as of extreme complexity and variation. Besides attempts to represent or treat music as language (at a structural level, i.e. the musical score), Kendal and Carterette's (1990) findings (as presented by Gabrielsson and Juslin, op. cit.) suggest that nothing as "strict" and "invariant" as musical grammar, performer grammar, or listener grammar could be derived from their data on musical performances.

Psychobiological processing of lyrics and sound

A model of neurological 'modularity' in the perception of sound (Peretz & Coltheart, 2003) and its adaptation for singing development (Welch, 2005) is also complemented by earlier research by Patel and Peretz (1997). In this 1997 work, the authors present similarities in the concept of 'accenting' between speech and music. In speech, accenting can occur by highlighting different words (or groups of words) with the variation of emphasis and prosody. In music, accenting can be performed by the modification of pitch, intensity and duration. Patel and Peretz (op. cit.) suggest that in both contexts different 'meanings' can be communicated by changing accents.

In one of the most comprehensive research overviews to date about the cognition of tonality, Krumhansl (2004) examines how tonality is defined within the realms of musicology - where she reports (pp. 253, 254) that tensions exist between different theoretical traditions- and the cognitive sciences. She defines the term *cognitive sciences* as a discipline that refers to a "rather loose affiliation among a number of established disciplines, including cognitive psychology, philosophy of mind, linguistics, artificial intelligence, and neuroscience" (p. 254). Arguably, it is therefore natural for cognitive sciences to resort to numerous vocabularies, methodologies and theoretical frameworks. Krumhansl reports that as an important early influence in the field was the work of Lindblom and Sundberg (1970) and their proposed theory for treating any form of musical conduct similarly to linguistics and natural language processing (i.e. Chomsky's work in linguistics). Lindblom's and Sundberg's (1970) theory was broadened by Lerdahl and Jackendoff (1996) and further extended by Lerdahl (2001). What is interesting to see is that the structural representations in applying Linguistics concepts to music, proposed by Lerdahl and Jackendoff (op. cit.) appear to be analogous to the 'set of rules' that were utilised for the KTH model for *analysis by synthesis* (*cf* Widner & Goebl, 2004; Sundberg, 2006; Dillon, 2003; Sundberg *et al*., 1991; Sundberg *et al*., 2003), as presented earlier.

Unfortunately, although Krumhansl (op. cit.) surveyed an array of approaches to the understanding of the cognition of tonality, she believes that each approach suggests further questions. Information with regards to how musical pitch is encoded and remembered can be inferred (quite clearly, according to the researcher) from existing experimental results; the simplicity and lack of realism, though, of the majority of the materials that are being used in such research imposes problems. Furthermore, Krumhansl claims that results in psychological and cross-cultural studies suggest that Western listeners

...even those without formal instruction, have extensive knowledge of typical tonal and harmonic patterns. However, contrary to traditional assumptions, at least some aspects of this knowledge are acquired without extensive experience and training.

and continues

[c]rosscultural studies suggest listeners possess a relatively flexible cognitive system. Short-term statistical learning is one mechanism that may enable this flexibility. In addition, listeners appear to build on a set of basic perceptual principles that may adapt to different styles. (p. 266)

Similarly, Krumhansl presents unanswered questions from research in computational modelling, music theory and brain science. From the latter field, useful findings exist, but they still map "rather general processing mechanisms" (e.g. statistical topological averaging of blood-flow activity).

Krumhansl's epilogue is quite noteworthy: "Thus, despite an intense multidisciplinary effort, tonality remains remarkably elusive" (op. cit. p. 266). It would be interesting to see whether future research will centre upon the investigation of how closely the cognition of tonality and the interpretation of expressivity in a musical performance are associated.

Acoustics and Psychoacoustics: the effects of acoustic signal properties and acoustic signal manipulation

Although we cannot avoid hearing and responding to music as sound (*cf* Himonides, 2008), its actual perception has been argued as an individual interpretative activity in which the listener 'constructs' their own particular version of the music (*cf* Spender, 1987; Welch, 1998). In a clinical and/or laboratory experimental setting, the quality of a vocal performance could typically entail the analysis of the carefully monitored and captured vocal output. In a real world context, including a live performance context, there are numerous intrinsic, extrinsic as well as eso-exoteric determinants that affect not only the final autochthonous product (the *actual* performance), but also the discerned product (the performance that each individual receives either as a member of an audience or as a listener of a recorded performance).

Recently, during one of the *Saul Seminars* that was organised by the British Library (*see* British Library, 2005) the discussion moderator invited the panel (Sir David Willcocks, Dr John Potter and singer Robert Tear) to share their thoughts about what made the sound of *King's College Choir, Cambridge* the most famous choral sound in the world. Amongst some extremely interesting comments from all discussants, one specific matter was unanimously agreed upon; this was the acoustical properties of the *chapel* as a performance space. All three participants commented on their beliefs concerning the tremendous impact that this specific venue had (and still has) on the 'branding' of the sound. Furthermore, John Potter added that, not only was the shaping of the final sound something of great importance, but that there was also the real-time interaction of the individual singers, the conductor and the organist with the venue's acoustical properties.

Another example, not so positive, that again indicates the importance of the venue, comes from a Creativity Unleashed Limited (2005) online review:

There's no doubt that the choir of London's cathedral, St. Paul's, is world class, but they do labour under one problem. The cathedral itself is a beautiful building, but its acoustic is terrible for delicate choral music, with a complex echo that can render the most precise singing a little mushy. To be honest, the choir would do themselves a favour if they recorded somewhere else, but presumably they would see this as letting the site down. Even so, their CDs are often worth buying as they cover some essential music and on the whole do it very well. One other minor criticism -perhaps because of the acoustic- they occasional verge on the Victorian in the slowness of their tempos; but they're still a great choir.

In reviewing *Hyperion's 'The English Anthem, Vol. 4'* (catalogue number: #66678) and '*My Soul Doth Magnify the Lord - Anglican Evening Service'* (catalogue number: CDA66249), the same reviewer (op. cit., 2005) mentions that "... As usual, mixed feelings about the St Paul's choir - very accurate but, the building's acoustics are mushy and they do love to do things slowly" and continues, "... St. Paul's isn't the ideal acoustic for a crisp, precise recording, but there's plenty of verve in the performance to make up for the occasionally excessive echo". The contrasting examples above from the world of sacred music suggest that the acoustic space has a vital role in the experience of a musical performance, whether live or in a recorded/captured context.

In addition to the importance of the acoustic space of the actual performance, the utilisation, study and analysis of recorded music in research into music perception arguably often disregard other determinants that might be of importance in relation to the perception of music and sound. More specifically, in a live performance context, the performer, the listener and the venue coexist in a dynamic relationship (*see* Figure 4). Small (1999) presents a relevant tripartite relationship as part of a proposed theoretical model in a published lecture in *Music Education Research*. The performer communicates his/her music-sound to the listener; the listener at the same time is the (normally) sympathetic recipient of the performer's output. Concomitantly, the performer interacts with the acoustical properties of the venue. The performer is receiving constant acoustical feedback from the venue itself and, consequently, first monitors his/her own performance and second, adopts his/her performance in correspondence with the received feedback. At the same time, the listener's own personal experiences are shaped by the acoustical environment; an experience that is in dynamic relation to their position in the audience, to their surroundings, to the air temperature, the ambient noise levels, to the supposedly ever changing relative position that they hold in relation to the performer and, finally, the position of their head (as an instrument of auditory reception).

[INSERT FIGURE 4 ABOUT HERE]

Figure 4: The interaction between performer, listener and venue during a live performance

In the recorded-performance context, the model that is presented in Figure 4 is not quite the same. Figure 5 attempts to represent the additional parameters that take place in a recorded performance as well as their interrelation with the parameters that exist in the previous model (Figure 5). In a recorded performance (in this case, a live performance in front of an audience), the performer still receives feedback and interacts with his/her surrounding space and its acoustical properties. Moreover, the recording engineer is required to make scientifically informed as well as æsthetic judgements concerning the placement of the recording microphones, the recording technique that is going to be utilised (Wadhams, 1990), as well as the actual selection of the microphones for the recording project. Deservedly perhaps, Huber and Runstein (1997, p. 18) describe the audio engineer as *an interpreter in a techno-artistic field*. They say "It's the engineer's job to express the artist's music and the producer's concepts through the medium of recording". The recording engineer's decisions are meant to be in close accordance to the acoustics of the venue, the acoustical properties of the performer's instrument (in this case their voice) and the supposed dynamic nature of the performance. The latter is usually a function of the actual musical-score, the ethics/stylistics of the music production and the performer's vocal-characteristics.

[INSERT FIGURE 5 ABOUT HERE]

Figure 5: The dynamic relationships that concern a perceptual study of a recorded performance

At this specific level of decision (pace Figure 5), crucial determinants of the final product are being taken into account, although it is the following stage of music production that will render the performance in its final form. The recording engineer's decision regarding the miking (i.e. microphone placement) technique (Bartlett & Bartlett, 2002) determines the overall sense of stereophony (Howard & Angus, 2001; Owsinski, 2004) which will, accordingly, create the impression of space and placement to the listener's ears. The final production stage will process the recorded material and brand the sound according to the producer's and/or the house's stylistic and æsthetic preferences. During this process, the recorded audio will be 'manipulated' with special technology, such as equalisation, dynamics processing, spatial processing (Owsinski, 1999), and further psycho-acoustical processing, in order to become ready for the very final stage, prior to commercialisation, which is the audio mastering stage (Owsinski, 2000; Katz, 2002).

All of the above mentioned factors play a deciding role in the perceived quality of a performance. For example, there are anecdotal reports that experienced, critical listeners of classical music recordings believe themselves to be in a position to distinguish the phonographic institution that has been involved with the production of a given recording and/or to have particular preferences regarding the desired recording techniques:

It is really shameful how the mighty have fallen. Compare the 1950s *Von Karajan* recordings of the Beethoven symphonies on *DG* with the 1980s recordings... the 1950s ones sound so much better it's not funny. Cleaner sound, far better sense of space, much less harsh on the top. (Dorsey, 2003 November 5)

Telarc is getting closer and closer every day. They're still making some very good stuff, but they are still way closer than I tend to like. Most of the better sounding discs are on smaller labels like *Pope Music*, *Nonesuch*, and the like, though. (Dorsey, 2003b)

The report and adaptation of research findings in the field of how humans perceive sound, known as *Psychoacoustics* (Howard & Angus, 2001 p. 65) is an integral part of this review. What needs to be further explained within empirical fieldwork (*see* forthcoming 'Part II') is that, within the context of perceptual testing and research concerning recorded performances (*pace* Figure 5), there exists the need for research to consider the additional implications that audio signal and digital signal processing and/or manipulation might introduce. The latter is generally referred to as 'applied psychoacoustics' (*see* Audio Engineering Society (AES) & Sporer, 1997) the findings of which are constantly being incorporated into sound/music recording and studio technologies. The prime concern of the recording industry (although exceptions might exist) is not to capture and deliver recorded performances as 'clinically accurately' as possible; it is to create a product that is more likely to 'please' the listener/consumer. This argument as well as its implications for this research will be further discussed within the forthcoming second part of this paper.

Emerging theoretical framework for mapping the beautiful voice

Based on the hereabove rehearsed forms of evidence, it is assumed that a new research framework might be welcome that attempts to understand how these different dynamics become interwoven when individual listeners experience beauty in a sung performance . The underlying hypotheses are that the human perception of sung performance is likely to be multifaceted and that commonality and diversity are evident in such perceptions, given the range of variables under consideration in figure 6.

[INSERT FIGURE 6 ABOUT HERE]

Figure 6, Theoretical elements that ‘construct’ the perception of beauty in a singing performance with indicative references (adopted from Himonides & Welch, 2005).

In essence, threre are different perspectives from contrasting disciplines on the nature of our perception of singing. A summarisation of key findings from the distillation of those rehearsed forms of evidense further celebrates the multidisciplinarity of the theoretical focus:

- Human communication via the voice is multi-faceted and open to individual characterisation. Each voice has a unique voiceprint (acoustic output);
- Cultural contexts shape vocal outputs of members, by emphasising particular features of voiced sound, such as pitch, timbre and loudness;
- Vocal ‘quality’ is culturally located and contested, with no evidence of common criteria across diverse musics;
- Any discussion of vocal quality is based on a filtering of perceived acoustic events into the dominant artistic discourse of cultural members. Language appears to offer relatively inexact metaphors in its description of voiced sound. Moreover, voice scientists are only rarely beginning to map acoustic features of sung performance with Western Classical music predominantly. Non-Western (and popular) idioms are relatively unrepresented;
- The ‘structure’ of music for the listener is created in the mind and, although related to individual design features, may be processed relatively individually;
- Recording engineers manipulate acoustic features of sung performance to take account of such variables as venue acoustics and performer idiosyncrasies;
- The human voice generates an emotional (feeling) response in the listener; the perception of vocal quality appears to be interrelated with emotional response through neuropsychobiological design;

Overall, this narrative combines to offer a new theoretical framework to provide a multi-faceted, integrated perspective on key disciplinary facets on the phenomenon of our relationship with the human voice in performance.

Conclusium: Reflections from the perspective of music education

As mentioned in Himonides & Welch (2005) and Himonides (2008), singing pædagogy is relatively poorly documented in relation to systematic, theoretically founded research. Improved specificity and research-based agreement in our pædagogic language for singing appears to be an essential requirement if we are to suggest robust improvements in the educational development of singers (Howard *et al*., 2004).

There is evidence that teachers of singing customarily use imagery (including kinæsthetic and visual imagery) in teaching vocal technique, often allied to a reliance on sensation and the development of aural awareness (Callaghan, 1998). However, their professional background is usually that of a successful performer, perhaps with some basic knowledge of an underlying voice science that has been gained from casual reading and/or attendance at conferences of professional associations (Callaghan, op. cit.). Teaching is essentially practice-focused, supported by linguistic imagery and (in some cases) by vocal and postural modelling. These techniques are employed in an iterative process (encouraging and responding to elements of singing behaviour, such as focus melodic fragments, phrases, or complete songs) within the one-to-one context of the lesson in the singing studio. In general, whilst singing pædagogy is relatively under researched (with the exception of recent studies by Mitchell *et al*., 2003; Mitchell & Kenny, 2004; Welch *et al*., 2005), such evidence as does exist indicates that teaching is often highly idiosyncratic and based on semitransparent methods that are likely to be driven by the teacher's own experience and personal reflections, both as 'learner' and performer. Their pædagogical knowledge is often based on their own experience (Olsson, 1997), but such craft knowledge (*cf* Tschannen-Moran *et al*., 1998), although useful for that teacher, may miss certain key features of performance that would be picked up by another teacher. Singing teachers draw on their personal experiences within an essentially hegemonic oral culture (Callaghan, 1998; Potter, 1998). Such experiences dominate and differentiate the language of singing pædagogy literature from that found in texts on the science of singing.

Nevertheless, although it is beneficial to possess an understanding of the physiological and acoustical features of the vocal instrument, it is a different challenge to be able practically to recognise these features and to manipulate and sustain optimal singing behaviour systematically in the rehearsal studio and/or performance venue. The discourse of the singing lesson is unlikely to embrace detailed features of voice acoustics. It is important, therefore, that singing teachers and their students have the opportunity to know that they are sharing common perceptions and conceptualisations of the student's singing behaviours as well as a somewhat clear understanding of what the 'ingredients' of a 'better' singing performance are.

List of References

Abeles, H. (1973). Development and validation of a clarinet performance adjudication scale. *Journal of Research in Music Education, 21*, 246-255.

Åhlberg, L. O. (1994). Susanne Langer on representation and emotions in music. *British Journal of Aesthetics, 34*(1), 69-80.

Asmus, E. P. (1985). The development of a multidimensional instrument for the measurement of affective responses to music. *Psychology of Music, 13*(1), 19-30.

Audio Engineering Society (AES), & Sporer, T. (1997). Objective Audio Signal Evaluation-Applied Psychoacoustics for Modeling the Perceived Quality of Digital Audio. *AES Preprint 4512, Convention 103*(August 1997).

Bartlett, B., & Bartlett, J. (2002). *Practical Recording Techniques: The Step-by-Step Approach to Professional Audio Recording* (3rd ed.). Boston: Focal Press.

Berlyne, D. E. (1971). *Aesthetics and psychobiology*. New York: Appleton-Century-Crofts.

Bicknell, S. (1996). *The History of the English Organ*. Cambridge: Cambridge University Press. [0521654092]

Boyle, J., & Radocy, R. (1987). *Measurement and Evaluation of Musical Experiences*. New York: Schirmer Books.

British Library. (2005). The most famous choir in the world: tradition and two individual talents. Sir David Willcocks (Cambridge), John Potter (York University), Robert Tear (London), *The Saul seminars: Studies in recorded Music 2005 (Tuesday 8 November 2005)*. London: National Sound Archive.

Callaghan, J. (1998). Singing teachers and voice science-an evaluation of voice teaching in Australian tertiary institutions. *Research Studies in Music Education, 10*, 25-41.

Callaghan, J. (2000). *Singing and Voice Science*. San Diego, California: Singular Publishing Group. [0-7693-0044-8]

Campbell, W. C. (1970). A computer simulation of musical performance adjudication. In *Experimental Research in the Psychology of Music* (Vol. 7, pp. 1-40). Iowa city: University of Iowa Press.

Clarke, E. (2005). Ways of Listening: An Ecological approach to the Perception of Musical Meaning. Oxford: OUP.

Cleveland, T. F., Sundberg, J., & Stone, R. E. (2000). Long-Term-Average Spectrum Characteristics of Country Singers During Speaking and Singing. *TMH-QPSR, 2*(3), 89-94.

Cook, N. (2000). *Music: A Very Short Introduction (Very Short Introductions)*. New York: Oxford University Press. [978-0192853820]

Cooksey, J. M. (1977). A facet-factorial approach to rating high school choral performance. *Journal of Research in Music Education, 25*, 100-114.

Coon, H., & Carey, G. (1989). Genetic and environmental determinants of musical ability in twins. *Behavior Genetics, 19*(2), 183-193. [0001-8244 (Print) 1573-3297 (Online)]

Creativity Unleashed Limited. (2005). Church Music: St Paul's Cathedral. *The Church Music Site* Retrieved 04 November 2005, from http://www.cul.co.uk/music/perform7.htm

Crowder, R. G., Reznick, S. J., & Rosenkrantz, S. L. (1991). Perception of the Major/Minor Distinction: V. Preferences among Infants. *Bulletin of the Psychonomic Society, 29*(3), 187-188.

Damasio, A. (2000). *The Feeling of What Happens: Body and Emotion in the Making of Consciousness*. Spectrum, MT: Harvest Books. [978-0156010757]

Damasio, A. (2003). *Looking for Spinoza: Joy, Sorrow, and the Feeling Brain*. Orlando, FL: Harvest Books. [978-0156028714]

Damasio, A. (2005). *Descartes' Error: Emotion, Reason, and the Human Brain*. New York: Penguin (Non-Classics). [978-0143036227]

Darwin, C. (1872). *The expression of emotions in man and animals* (3rd ed.). London: Harper Collins.

Davidson, J. (2002). Communicating with the Body in Performance. In J. Rink (ed.) *Musical Performance.* (pp. 144-152) Cambridge: CUP.

Davidson, J. W. (1993). Visual perception of performance manner in the movements of solo musicians. *Psychology of Music, 21*(2), 103-113.

Dell'Antonio, A. (Ed.). (2004). *Beyond Structural Listening? Postmodern Modes of Hearing*. Berkeley, CA: University of California Press. [0-520-23760-9]

Dillon, R. (2003). Classifying Musical Performance by Statistical Analysis of Audio Cues. *Journal of New Music Research, 32*(3), 327-332.

Dolgin, K. G., & Adelson, E. H. (1990). Age Changes in the Ability to Interpret Affect in Sung and Instrumentally Presented Melodies. *Psychology of Music, 18*(1), 87-98.

Dorsey, S. (2003, November 5). Microphone Placement [Msg 2]. Message posted to http://groups.google.com/group/rec.audio.pro/msg/5e15e29bba40d13c?dmode=source.

Dorsey, S. (2003b, November 5). Microphone Placement [Msg 4]. Message posted to http://groups.google.com/group/rec.audio.pro/msg/69ad215e6f24f303?dmode=source.

Dowling, W. J., & Harwood, D. L. (1986). *Music Cognition*. New York: Academic Press.

Ekholm, E., Papagiannis, G. C., & Chagnon, F. P. (1998). Relating objective measurements to expert evaluation of voice quality in Western classical singing: critical perceptual parameters. *Journal of Voice, 12*, 182-196.

Ekman, P. (1984). Expression and the nature of emotion. In K. R. Scherer & P. Ekman (Eds.), *Approaches to Emotion* (pp. 319-344). Hillsdale, NJ: Erlbaum.

Ekman, P. (1992). An argument for basic emotions. *Cognition and Emotion, 6*, 169-200.

Emerich, K. E., Baroody, M. M., Caroll, L. M., & Sataloff, R. T. (1997). The singing voice specialist. In R. T. Sataloff (Ed.), *Professional Voice: The Science and Art of Clinical Care* (pp. 735-753). New York: Raven Press.

European Commission. (2005). *Biometrics at the Frontiers: Assessing the impact on Society: For the European Parliament Committee on Citizens' Freedoms and Rights, Justice and Home Affairs (LIBE)* (No. EUR 21585 EN). Brussels: European Commission, Joint Research Centre (DG JRC)& Institute for Prospective Technological Studieso.)

Farnsworth, P. (1969). *The social psychology of music*. Des Moines, IA: Iowa State University Press. [978-0813815473]

Feldman Barrett, L., & Russell, J. A. (1999). The structure of current affect: Controversies and emerging consensus. *Current Directions in Psychological Science, 8*(1), 10-14.

Fiske, H. E. (1975). Judge-group differences in the rating of secondary school trumpet performances. *Journal of Research in Music Education, 23*(2), 186-196.

Gabrielsson, A. (2002). Emotion perceived and emotion felt: same or different? *Musica Scientiae, special issue 2001–2002*, 123-147.

Gabrielsson, A., & Juslin, P. N. (1996). Emotional expression in music performance: Between the performer's intention and the listener's experience. *Psychology of Music, 24*(1), 68-91.

Gabrielsson, A., & Juslin, P. N. (2003). Emotional expression in music. In R. J. Davidson, K. R. Scherer & H. H. Goldsmith (Eds.), *Handbook of Affective Sciences* (pp. 503-534). New York: Oxford University Press.

Gabrielsson, A., & Lindström, E. (1995). Emotional expression in synthesizer and sentograph performance. *Psychomusicology, 14*, 94-116.

Gabrielsson, A., & Lindström, E. (2001). The influence of musical structure on emotion. In P. N. Juslin & J. A. Sloboda (Eds.), *Music and emotion: Theory and research*. New York: Oxford University Press.

Gaver, W. W., & Mandler, G. (1987). Play it again, Sam: On liking music. *Cognition and Emotion, 1*(3), 259-282.

Goldstein, A. (1980). Thrills in response to music and other stimuli. *Physiological Psychology, 8*, 126-129.

Hevner, K. (1935). The affective character of the major and minor modes of music. *American Journal of Psychology, 47*, 103-118.

Hevner, K. (1935). The affective character of the major and minor modes of music. *American Journal of Psychology, 47*, 103-118.

Himonides, E. (2008). *The Psychoacoustics of Vocal Beauty: A New Taxonomy*. London: International Music Education Research Centre Press.

Himonides, E., & Welch, G. F. (2005). Building a Bridge Between Aesthetics and Acoustics with New Technology: A Proposed Framework for Recording Emotional Response to Sung Performance Quality. *Research Studies in Music Education, 24*, 58-74.

Hixon, T. J., & Hoit, J. D. (1999). Physical examination of the abdominal wall by the speech-language pathologist. *American Journal of Speech-Language Pathology, 8*, 335-346.

Hollien, H. (2002). Forensic Voice Identification. San Diego, CA: Academic Press.

Howard, D. M., & Angus, J. (2001). *Acoustics and Psychoacoustics (Music Technology)* (2 ed.). Oxford: Focal Press. [0240516095]

Huber, D. M., & Runstein, R. E. (1997). *Modern Recording Techniques* (5th ed.). Burlington, MA: Focal Press. [0-240-80456-2]

Hunter, E. J., & Titze, I. R. (2005). Overlap of hearing and voicing ranges in singing. *Journal of Singing, 61*(4), 387-392.

Huron, D. (2006). *Sweet Anticipation: Music and the Psychology of Expectation*. Cambridge, MA: MIT Press, Bradford Books. [978-0262083454]

Izard, C. E. (1971). *The face of emotion*. New York: Appleton-Century-Crofts.

Izard, C. E. (1990). Facial expression and the regulation of emotions. *Journal of Personality and Social Psychology, 58*, 487-498.

Johnson-Laird, P. N., & Oatley, K. (1989). The language of emotions: An analysis of a semantic field. *Cognition and Emotion, 3*(1), 81-123.

Juslin, P. (1997a). Emotional communication in music performance: A functionalist perspective and some data. *Music Perception, 14*, 383-418.

Juslin, P. N. (1997b). Perceived emotional expression in synthesized performances of a short melody. *Musicae Scientiae, 1*, 225-256.

Juslin, P. N. (2000). Cue utilization in communication of emotion in music performance: Relating performance to perception. *Journal of Experimental Psychology, 6*, 1797-1813.

Juslin, P. N. (2001). Communicating emotion in music performance: a review and a theoretical framework. In P. N. Juslin & J. A. Sloboda (Eds.), *Music and Emotion: Theory and Research (Series in Affective Science)* (pp. 309-337). New York: Oxford University Press.

Juslin, P. N., & Laukka, P. (2004). Expression, Perception, and Induction of Musical Emotions: A Review and a Questionnaire Study of Everyday Listening. *Journal of New Music Research, 33*(3), 217-238.

Kaemmer, J. E. (1993). *Music in Human Life: Anthropological Perspectives on Music (Texas Press Sourcebooks in Anthropology, No. 17)*. Austin, TX: University of Texas & Cassett. [978-0292743144]

Katz, B. (2002). *Mastering Audio: The Art and the Science*. Burlington, MA: Focal Press.

Kendall, R. A., & Carterette, E. C. (1990). The communication of musical expression. *Music Perception, 8*, 129-164.

Kenny, D. T., & Mitchell, H. F. (2006). Acoustic and Perceptual Appraisal of Vocal Gestures in the Female Classical Voice. *Journal of Voice, 20*(1), 55-70.

Krumhansl, C. L. (2004). The Cognition of Tonality - as We Know it Today. *Journal of New Music Research, 33*(3), 253-268.

Langer, S. (1942). *Philosophy in a new key*. Cambridge, MA: Harvard University Press.

Lavy, M. (2001). Emotion and the Experience of Listening to Music: A Framework for Empirical Research, *Unpublished Doctoral Dissertation* (pp. 232). Cambridge: Jesus College, University of Cambridge.

Lerdahl, F. (2001). *Tonal pitch space*. New York: Oxford University Press.

Lerdahl, F., & Jackendoff, R. (1996). *A generative theory of tonal music*. Cambridge, MA: MIT Press. [978-0262621076]

Levin, T. C., & Edgerton, M. E. (1999). The throat singers of Tuva. *Scientific American, 281*(3), 70-77.

Lindblom, B., & Sundberg, J. (1970). Towards a generative theory of melody. *Swedish Journal of Music, 52*, 71-88.

Lukasik, E. (2003). *AMATI: A multimedia database of violin sounds.* Paper presented at the Stockholm Music Acoustics Conference 2003, Stockholm, Sweden.

Maher, T. (1980). A rigorous test of the proposition that musical intervals have different psychological effects. *American Journal of Psychology, 93*(2), 309-327.
Malloch, S. N. (1999). Mothers and infants and communicative musicality. *Musicae Scientiae, Special Issue*, 29-57.
McPherson, G. (Ed.). (2006). *The Child As Musician: A Handbook of Musical Development*. New York: Oxford University Press. [978-0198530329]
Merriam, A. P., & Merriam, V. (1964). *The Anthropology of Music*. Evanston, IL: Northwestern University Press. [978-0810106079]
Merritt, L., Richards, A., & Davis, P. J. (2001). Performance anxiety: loss of the spoken edge. *Journal of Voice, 15*, 257-269.
Meyer, L. B. (1956). *Emotion and meaning in music*. Chicago: University of Chicago Press.
Miller, T. E., & Shahriari, A. C. (2008). *World Music: A Global Journey* (2nd ed.). London: Routledge. [978-0415988780]
Narmour, E. (1990). *The Analysis and Cognition of Basic Melodic Structures: the implication-realization model*. Chicago, IL: Chicago University Press.
Narmour, E. (1992). *The Analysis and Cognition of Melodic Complexity*. Chicago, IL: Chicago University Press.
Nattiez, J. J. (1990). *Music and Discourse: Toward a Semiology of Music* (C. Abbate, Trans.). New Jersey: Princeton University Press. [0691027145]
Nawrot, E., S. (2003). The perception of emotional expression in music: evidence from infants, children and adults. *Psychology of Music, 31*(1), 75-92.
Ockelford, A. (1999). *The Cognition of Order in Music: A Metacognitive Study*. London: The Centre for Advanced Studies in Music Education (ASME). [1-902-74306-7]
Ockelford, A. (2005). *Repetition in Music: Theoretical and Metatheoretical Perspectives*. London: Ashgate.
Olsson, B. (1997). The social psychology of music education. In D. J. Hargreaves & A. C. North (Eds.), *The social psychology of music* (pp. 290-305). Oxford: Oxford University Press.
Owsinski, B. (1999). *The Mixing Engineer's Handbook*. Vallejo, CA: Artistpro.
Owsinski, B. (2000). *The Mastering Engineer's Handbook*. Vallejo, CA: Artistpro.
Owsinski, B. (2004). *The Recording Engineer's Handbook*. Vallejo, CA: Artistpro.
Patel, A. D. (2007). *Music, Language and the Brain*. New York: Oxford University Press. [978-0195123753]
Patel, A. D., & Peretz, I. (1997). Is music autonomous from language? A neuropsychological appraisal. In I. Deliège & J. A. Sloboda (Eds.), *Perception and cognition of music*. Hove: Psychology Press.
Peretz, I. & Coltheart, M. (2003) Modularity of music processing. *Nature Neuroscience*, vol. 6(7), pp. 688-691
Peretz, I., Gagnon, L., Hébert, S., & Macoir, J. (2004). Singing in the brain: Insights from cognitive neuropsychology. *Music Perception, 21*(3), 373-390.
Potter, J. (1998). *Vocal authority*. Cambridge: Cambridge University Press.
Rigg, M. G. (1940). Speed as a determiner of musical mood. *Journal of Experimental Psychology, 27*, 566-571.
Rigg, M. G. (1964). The mood effects of music: A comparison of data from earlier investigations. *Journal of Psychology, 58*, 427-438.
Robazza, C., Macaluso, C., & C'Urso, V. (1994). Emotional Reactions to Music by Gender, Age, and Expertise. *Perceptual and Motor Skills, 79*, 939-944.
Roberts, D. (Ed.). (2004). *The Classical Good CD & DVD Guide 2005*. Teddington, Middlesex: Gramophone Publications Limited.

Sagen, D. P. (1983). The development and validity of a university band performance rating scale. *Journal of Band Research, 18*(1), 1-1.
Scheirer, E. D. (1996). *Bregman's Chimarae: Music Perception as Auditory Scene Analysis.* Paper presented at the Paper presented at the 4th International Conference in Music Perception and Cognition, Montreal, Canada.
Schellenberg, E. G., & Trehub, S. E. (1996). Natural Music Intervals: Evidence from Infant Listeners. *Psychological Science, 7*(5), 272-277.
Schenker, H. (1954). *Harmony (J. Oswald, Ed.)* (E. Mann Borgese, Trans.). Chicago: University of Chicago Press. [978-0-226-73734-8]
Scherer, K. R. (1992). What does facial expression express? In K. Strongman (Ed.), *International Review of Studies on Emotion* (Vol. 2, pp. 139-165). Chichester: Wiley.
Scherer, K. R. (2003). Why music does not produce basic emotions: a plea for a new approach to measuring emotional effects of music. In R. Bresin (Ed.), *Proceedings of the Stockholm Music Acoustics Conference 2003* (pp. 25-28). Stockholm, Sweden: Royal Institute of Technology.
Scherer, K. R. (2004). Which Emotions Can be Induced by Music? What Are the Underlying Mechanisms? And How Can We Measure Them? *Journal of New Music Research, 33*(3), 239-251.
Scherer, K. R., & Oshinsky, J. S. (1977). Cue utilization in emotion attribution from auditory stimuli. *Motivation and Emotion, I*, 331-346.
Scherer, K. R., & Zentner, M. R. (2001). Emotional effects of Music: Production Rules. In P. N. Juslin & J. A. Sloboda (Eds.), *Music and Emotion: Theory and Research* (pp. 361-392). Oxford: Oxford University Press.
Schneck, D. J., & Berger, D. S. (2006). *The Music Effect: Music Physiology And Clinical Applications*. London: Jessica Kingsley Publishers. [978-1843107712]
Schubert, E. (1999). Measuring emotion continuously: Validity and reliability of the two-dimensional emotion space. *Australian Journal of Psychology, 51*, 154-165.
Schubert, E. (2003). Update of the Hevner adjective checklist. *Perceptual and Motor Skills, 96*, 1117-1122.
Senju, M., & Ohgushi, K. (1987). How are the player's ideas conveyed to the audience? *Music Perception, 4*, 381-389.
Shaffer, L. H. (1992). How to interpret music. In M. R. Jones & S. Holleran (Eds.), *Cognitive bases of musical communication* (pp. 263-278). Washington: American Psychological Association.
Shatin, L. (1970). Alteration of mood via music: a study of the vectoring effect. *The Journal of Psychology, 3*(1), 81-86.
Sloboda, J. A. (1983). The communication of musical metre in piano performance. *Quarterly Journal of Experimental Psychology, 35*(A), 377-396.
Sloboda, J. A. (1991). Music structure and emotional response: Some empirical findings. *Psychology of Music, 19*(2), 110-120.
Sloboda, J. A., & Lehmann, A. C. (2001). Tracking performance correlates of changes in perceived intensity of emotion during different interpretations of a Chopin piano prelude. *Music Perception, 19*, 87-120.
Small, C. (1999). Musicking: The Meanings of Performing and Listening. A Lecture. *Music Education Research, 1*(1), 9-21.
Spender, N. (1987). Psychology of Music. In R. L. Gregory (Ed.), *The Oxford Companion to the Mind* (pp. 499-505). Oxford: Oxford University Press.
Stanley, M., Brooker, R., & Gilbert, R. (2002). Examiner perceptions of using criteria in music performance assessment. *Research Studies in Music Education, 18*, 43-52.
Steed, O. A. (1881). On Beauty of Touch and Tone: An Inquiry into the Physiological and Mechanical Principles Involved in Their Cultivation. Part II. The Piano and Organ. In W. H. Monk (Ed.),

Proceedings of the Musical Association, 7th Sess., (1880 - 1881) (pp. 53-74). London: Oxford University Press on Behalf of the Royal Musical Association.
Stone, R. E., Cleveland, T. F., Sundberg, J., & Prokop, J. (2002). Aerodynamic and Acoustical Measures of Speech, Operatic, and Broadway Vocal Styles in a Professional Female Singer. *TMH-QPSR, 43*, 17-29.
Subotnik, R. R. (1996). *Deconstructive Variations: Music and Reason in Western Society*. Minneapolis: University of Minnesota Press.
Sundberg, J. (1974). Articulatory interpretation of the "singing formant". *Journal of the Acoustical Society of America, 55*, 838-844.
Sundberg, J. (1975). Formant Technique in a Professional Female Singer. *Acustica, 32*, 89-96.
Sundberg, J. (1987). *The Science of the Singing Voice*. Decalb, Illinois: Northern Illinois University Press. [0-87580-542-6]
Sundberg, J. (2001). Level and Center Frequency of the Singer's Formant. *Journal of Voice, 15*(2), 176-186.
Sundberg, J. (2006). The KTH Synthesis of Singing. *Advances in Cognitive Psychology, 2*(2-3), 131-143.
Sundberg, J., Friberg, A., & Bresin, R. (2003). Attempts to Reproduce a Pianist's Expressive Timing with Director Musices Performance Rules. *Journal of New Music Research, 32*(3), 317-325.
Sundberg, J., Friberg, A., & Frydén, L. (1991). Common secrets of musicians and listeners: An analysis by synthesis study of musical performance. In R. Howell, R. West & I. Cross (Eds.), *Representing musical structure* (pp. 161-197). London: Academic Press.
Thomasson, M. (2003). *From Air to Aria: Relevance of Respiratory Behaviour to Voice Function in Classical Western Vocal Art.* . Stockholm: Royal Institute of Technology. [91-628-5703-7]
Thompson, S. (2005). Evaluating Evaluation: An Investigation of Quality Judgements in Musical Performance, *Unpublished Doctoral Dissertation* (pp. 288). London: Royal Holloway, University of London.
Thompson, S., & Williamon, A. (2003). Evaluating Evaluation: Musical Performance Assessment as a Research Tool. *Music Perception, 21*(1), 21-41.
Thompson, W. F., Diamond, P. C. T., & Balkwill, L.-L. (1998). The adjudication of six performances of a Chopin etude: a study of expert knowledge. *Psychology of Music, 26*, 154-174.
Thurman, L., Welch, G. F., Theimer, A., & Klitzke, C. (2004). *Addressing Vocal Register Discrepancies: An Alternative, Science-Based Theory of Register Phenomena.* Paper presented at the Second International Physiology and Acoustics of Singing Conference (PAS04), Denver, Colorado.
Titon, J. T. (2001). *Worlds of Music: An Introduction to the Music of the World's Peoples* (4th ed.). New York: Schirmer Books. [978-0534591038]
Titze, I. R. (2000). *Principles of Voice Production* (2nd ed.). Iowa City: National Center for Voice and Speech. [0-87414-122-2]
Titze, I. R., & Story, B. H. (2002). Voice quality: What is most characteristic about "you". *Echoes, 12*(4), 3-4.
Tomkins, S. S. (1962). *Affect, Imagery, Consciousness: Vol. 1. The Positive Affects*. New York: Springer.
Tschannen-Moran, M., Woolfolk Hoy, A., & Hoy, W. K. (1998). Teacher efficacy: its meaning and measure. *Review of Educational Research, 68*(2), 202-248.
Vurma, A., & Ross, J. (2003). The perception of 'forward' and 'backward placement' of the singing voice. *Logopedics Phoniatrics Vocology, 28*(1), 19-28.
Wadhams, W. (1990). *Sound Advice: The Musicians Guide to the Recording Studio*. New York: MacMillan Publishing Company. [0028726936]
Wapnick, J., & Ekholm, E. (1997). Expert consensus in solo voice performance evaluation. *Journal of Voice, 11*, 429-436.

Wapnick, J., Flowers, P., Alegant, M., & Jasinkas, L. (1993). Consistency in piano performance evaluation. *Journal of Research in Music Education, 41*, 282-292.
Watkins, J. G. (1942). *Objective Measurement of Instrumental Music*. New York: Teachers College Bureau of Publications, Columbia University.
Wedin, L. (1972). Multi-dimensional study of perceptualemotional qualities in music. *Scandinavian Journal of Psychology, 13*, 241-257.
Weekley, J. A., & Gier, J. A. (1989). Ceilings in the reliability and validity of performance ratings: The case of expert raters. *Academy of Management Journal, 32*, 213-222.
Welch, G. F. (1998). Early Childhood Musical Development. *Research Studies in Music Education, 11*, 27-41.
Welch, G. F. (2005). Singing as Communication. In D. Miell, R. A. R. MacDonald & D. J. Hargreaves (Eds.), *Musical Communication* (pp. 239-259). New York: Oxford University Press.
Welch, G. F., & Sundberg, J. (2002). Solo Voice. In R. Parncutt & G. McPherson (Eds.), *The Science and Psychology of Music Performance: Creative Strategies for Teaching and Learning* (pp. 253-268). New York: Oxford University Press.
Welch, G. F., Himonides, E., Howard, D. M., & Brereton, J. (2004). *VOXed: Technology as a meaningful teaching aid in the singing studio.* Paper presented at the CIM04 Conference on Interdisciplinary Musicology, Graz, Austria.
Widmer, G., & Goebl, W. (2004). Computational Models of Expressive Music Performance: The State of the Art. *Journal of New Music Research, 33*(3), 203-216.
Witvliet, C. V. (1996). The emotional impact of instrumental music on affect ratings, facial EMG, autonomic response, and the startle reflex: Effects of valence and arousal. *Psychophysiology, 33*(Suppl. 1), 91.
Wundt, W. M. (1904). *Principles of Physiological Psychology* (E. B. Titchener, Trans.). New York: MacMillan Publishing Company.
Zatorre, R. J., & Peretz, I. (Eds.). (2001). *The Biological Foundations of Music (Annals of the New York Academy of Sciences, V. 930)*. New York: New York Academy of Sciences. [978-1573313070]