Chapter 24
Singing and vocal development

Graham F. Welch

Singing and vocal development: Introduction

Despite the warmth in the room as they shook the snow off their winter coats and gathered around the kitchen table, there was a collective sense of nervousness and, in some cases, unease that was barely touched by the hostess' cheerful manner and greeting. Outside, the dark of a Newfoundland evening had already descended and the hostess wondered if some of the wind's icy chill was reflected in the body language. This gathering was to be the first of several sessions for the group when things usually unspoken, sometimes hidden for many decades, would be allowed to surface.

> My biggest recollection is school, of course. You went to school, the first thing the nuns would say, —Anybody can sing. You'd go and you were embarrassed to tears because you knew you couldn't sing, and there was no help… I can remember, at least a full row, if not two, in the classroom choirs or the singing choir, that you were told to pantomime. You had to go to music, and you had to listen to all the words and be able to mouth it or lip-sync it like everybody else, but you were not allowed to sing and you weren't allowed to turn it down. (Knight, 2010, pp. 108–9, interview with C., aged 50)

> I remember playing skipping and singing on the street. I can't remember the tunes now… I don't think I ever really thought I couldn't sing until Grade 7 and the teacher and all my friends and I were in glee club and that was a major time, she stopped and said —Somebody is tone deaf here. She said —It's you Vic, you're tone deaf. She said —You don't have any notes, you just can't sing along with the music at all… I can see the class, I was sitting second row back and there were kids behind me, you can imagine how embarrassed I felt. From then on I just assumed I was tone deaf… I guess obviously it was traumatic, to remember after 30 years. (Knight, 2010, p. 125, interview with V., aged 47)

> Then in Grade 6 [age 11] … I stood up to sing it and she told me to sit down, that I couldn't sing. Well, I was devastated … I'm sure I wanted to cry. Of course you came home, it was no good of telling your parents at the time that something like this had happened to you… And she was such a powerful person in the community… It stayed with me for so long. It was so degrading at the time. Even in high school, if there was anything to do with music, I hated music … I didn't learn it. I couldn't learn it, as I thought … I'm sure that [incident] affected it, in a lot of ways … maybe she just didn't have the knowledge and it didn't come to her—'I am doing something that's going to affect this child for most of her life.' That's probably the way it was. (Knight, 2010, p. 91, interview with L., aged 42)

Over the next few weeks and months, these adults shared many similar detailed, yet negative, memories, particularly associated with their former schooldays. Despite the passing of time, these episodes of childhood were vividly recalled. A sense of

embarrassment, shame, deep emotional upset, and humiliation were commonly evidenced, usually accompanied by reports of a life-long sense of musical inadequacy. For these particular Canadians, as for many other adults around the world in different cultural contexts, the associations between singing and childhood were not positive. Within the local Newfoundland culture, singing competency either as an individual or within a group has always had high status. Consequently, any perceived singing "failure" in childhood has often led to continued self-identify as a "non-singer" (see Knight, 1999) and has reinforced a cultural stereotype of a community that is divided in two: those who "can sing" and those who "cannot"—a status associated with emotional trauma, acceptance, and a sense of "irrevocability" (Knight, 1999, p. 144).

Similar findings have been reported from other studies of adults in North America, the UK, and Scandinavia. Yet, despite such experiences, there are some adults who never give up hope of improvement and there have been several successful examples of specialist choirs being started for adult "non-singers" (Mack, 1979; Richards & Durrant, 2003). These include a new community choir in St. John's, Newfoundland, four "beginners" choirs in one London college that have a 20-year history, various "Singing from Scratch" choirs in the Midlands and South-East of England, and similar initiatives in Sweden, the United States, Canada, Australia, and New Zealand.

The existence of such choirs for adult "non-singers" is one of a number of significant challenges to a bi-polar "can/cannot" categorization of singing behaviors. They are part of the evidence base for singing to be considered as a normal developmental behavior that can be enhanced or hindered, particularly by the

events and experiences of childhood. For example, other recent research suggests that such self-labeling in adulthood may be somewhat erroneous. An adult's perceived sense of singing inadequacy, based on their negative childhood experiences, is not necessarily born out empirically when their singing ability is actually assessed. Several studies have reported a mismatch between perceived and actual singing ability in adults, with the behavior often being more competent than the self-perception (Cuddy et al., 2005; Knight, 2010; Wise, 2009). One recent study of singing ability in the general adult population, for example, found that the majority of adult participants were much more pitch accurate when they performed a well-known target melody at slower tempi (Dalla Bella, Giguére, & Peretz, 2007).

Overall, the prime source of singing "failure" for an individual is often a particular moment in childhood and/or adolescence when there is a mismatch between developing singing competences and a set singing task (Cooksey & Welch, 1998; Welch, 1979, 1985, 2000a,b, 2005a). Erroneous adult expectation often creates the problem. This mismatch may then become further "objectified" by continuing inappropriate comments from adults or peers, which suggests that the singing problem is evidence of an underlying disability in music. Arguably, the number of singing "failures" that are socially generated in our communities would be reduced radically if there was a greater awareness of a) how singing mastery develops, b) how children of the same age can be in different phases of development (as is considered normal with other forms of culturally biased behavior, such as reading), and c) how best to provide suitable "developmentally sensitive" singing activities. The narrative that follows reviews the nature of singing development from early childhood through to (and including) adolescence.

Particular features are highlighted of how normal development may be fostered, shaped, and sometimes hindered.

Singing as a developmental behavior

Pre-birth and infancy

The foundations of singing development originate in the auditory and affective experiences of the developing fetus during the final months of gestation, particularly in relation to the earliest perception of melodic variations in the mother's voice. The amniotic fluid that surrounds the fetus is an effective transducer of the pitch contours of maternal voicing. As the mother speaks or sings, the prosodic features of her voice (melody and rhythm) are conveyed to the developing fetus by the sound waves that transfer through her body tissue and that also are reflected from surfaces in her immediate environment. At the same time, the mother's affective state as she speaks or sings is encoded hormonally in her bloodstream through neuroendocrine activity. This emotional state is believed to be experienced by the fetus relatively concomitantly with the sound of the mother's voice because of an interfacing of the fetal and maternal bloodstreams (see Welch, 2005a for a more detailed review). The outcome is an interweaving of acoustic (prosodic/melodic) and emotional experiences pre-birth that are likely to underpin the developing infant's subsequent interactions post-birth with the sounds of the maternal culture. For example, our ability to determine particularly strong emotions in vocal behaviors in speech and singing (Johnstone & Scherer, 2000; Loui et al., 2013; Nawrot, 2003; Sundberg, 2000) is likely to originate in these earliest dual-channel (acoustic-affect) experiences and, arguably, to create a certain bias toward the association of particular vocal timbres

with positive and negative feelings (termed "emotional capital"—Welch, 2005a). Six-month-olds, for example, exhibit endocrine (cortisol) changes after listening to their mothers singing (Trehub, 2001), becoming calmed when upset and more alert when sleepy.

The first year of life is characterized by a shaping of the infant's vocal production through an interaction with the acoustic characteristics of the maternal culture. Parents, for example, typically incorporate rich musical properties when interacting with infants: they speak and sing at higher pitch levels, use a wider pitch range and longer pauses, often at a slower rate, and use smooth, simple, but highly modulated intonation contours (see Thurman & Welch, 2000; Welch, 2005b; Trehub & Degé, Chapter 2). At birth, neonates continue to be particularly sensitive to the sound of the human voice, whilst demonstrating a certain initial perceptual plasticity toward any language (Eimas, 1985). Two-day-old neonates, for example, listen longer to women singing in a maternal style (Masataka, 1999). Adult singing (both male and female) appears to be especially significant, as demonstrated in its beneficial effects on premature infants' physiological functioning through changes in heart rate and oxygen saturation, alongside a reduction in stressful behaviors (Coleman et al., 1997).

The earliest vocal behavior is crying. It contains all of the ingredients of subsequent vocalization, including singing, with variations in intensity and pitch, as well as rhythmic patterning and phrasing (Vihman, 1996). At the age of 2 months, cooing and vowel-like sounds are already evidenced and being shaped by the maternal culture (Ruzza et al., 2003). Aspects of "musical babbling" that contain definite musical features, such as pitch and rhythmic patterns, are also evidenced

from 2 months onwards (Tafuri & Villa, 2002). Their incidence and quality appear to be related positively to the amount of time devoted to daily singing behaviors by the mother; the greater the amount of maternal singing, the increased likelihood of earlier musical babbling. Although maternal singing to infants is primarily a caregiving tool aimed at emotional regulation, it provides a rich musical context for mother–infant interaction where the young child is motivated to imitate and play with vocal sound (see Trehub & Gudmundsdottir, 2014, for a review).

By the age of 3 to 4 months, the infant is able to imitate their mother's exaggerated prosodic contours that characterize infant–mother interaction (Masataka, 1992). Vocal play emerges around the ages of 4 to 6 months (Papousek, 1996). By the age of 1 year, infants are sufficiently cued into the language of the maternal culture for elements to be reflected in their own vocalizations. As examples, French infants babble using French speech units, Russian infants babble using Russian, and Japanese infants using Japanese (Meltzoff, 2002). In general, the first year of life is characterized by increasingly diverse vocal activity. The first vocalizations of infancy, with their communication of affective state (discomfort and distress, then also comfort and eustress), are expanded to include quasi-melodic features (2–4 months), developing vocal control (4–7 months), with vocal pitch behaviors that are directly linked to the prosodic features of the mother tongue.

Early childhood and preschool

Singing development preschool is characterized by an increasing interaction with the sounds of the experienced maternal culture. This interaction is reflected in a mosaic of different singing behaviors that are evidenced between the ages of 1 and 5 years.

They relate to the young child's acquisitive, playful, creative, and spontaneous nature as they engage with and make sense of their "local" musical world (e.g., Barrett, 2011). The variety of vocalization includes: 2-year-olds' repetition of brief phrases with identifiable rhythmic and melodic contour patterns (Dowling, 1999); and 3-year-olds' vocal interplay between spontaneous improvisation and selected elements from the dominant song culture, termed "pot-pourri" songs (Moog, 1976) and "outline songs" (Hargreaves, 1996) in which the nature of the figurative shape of the sung melodic contour (its "schematic" contour) is thought to reflect the current level of the young child's understanding of tonal relationships (Davidson, 1994).

There is evidence of increasing sophistication and complexity in relation to the learning of songs from the dominant culture by young children (e.g., Mang, 2005; and see footnote 1 for developmental models by Rutkowski, 1997; Welch, 2002). However, the path of development is not necessarily linear for any particular individual. In a US study of the spontaneous singing of 2-year-olds' first songs, for example, there is evidence that "phrases are the initial musical units" (Davidson, 1994, p. 117). Such phrases are characterized by limited pitch range, a certain disjunction of key/tonality, and a descending contour. In contrast, recent Italian data of 2- to 3-year-old children indicate that some young children appear to be much better at imitating a complete melody modeled by their mother (and also by a specialist course tutor) than matching individual phrases of the same song (Tafuri & Welch, unpublished data, see Figure 24.1; see also Tafuri, 2008). These Italian children had been exposed to regular sessions of their mothers' singing since the final trimester of pregnancy, both at home and in a special infant–parent singing course organized in the local conservatoire. Yet for other children in the same Italian

group, with apparently the same levels of exposure to maternal singing, the opposite is the case. Their sung phrase accuracy is rated as better than their whole song accuracy (Figure 24.1), in line with data from the earlier US (Davidson, 1994) study.

<Insert Figure 24.1 here>

For the youngest children, the boundaries between singing and speaking may be blurred, or at least ambiguous to the adult listener, and are related to the dominance of a particular contour schema (Davidson, 1994) as well as to the influence of the mother tongue. For example, a longitudinal study in Canada of young girls aged 18 to 38 months from monolingual and bilingual backgrounds reported that "intermediate vocalisations" (a type of vocal behavior at the boundary between speech and song) were more prevalent in Mandarin- and Cantonese-speaking children than in English-speaking children (Mang, 2000/1). A follow-up study in Hong Kong with mono- and bilingual 3- and 4-year-olds confirmed these findings and revealed that, regardless of age, the manipulation of vocal pitch was used to distinguish between singing and speaking (Mang, 2002). The mean fundamental frequencies (F0) for songs were reported to be consistently higher than speech, but "own choice" songs were performed at a slightly lower pitch than a criterion song. In addition, the older English monolingual children demonstrated a wider mean F0 differentiation between their singing and speaking behaviors compared to their Cantonese monolingual and bilingual peers. Taken together, such examples from these diverse cultural settings remind us that singing behavior is subject to developmental processes, whilst also being sensitive to sociocultural context (including task). In these examples, context also includes the presence or absence of a pitch-based language as the mother tongue in which meaning is

explicitly conveyed by the shaping of melodic contour.

As might be expected from the interaction of enculturation with generative skill development in music (British Educational Research Association Music Education Review Group, 2001; Welch, 2005b), longitudinal data on singing development in early childhood confirm the importance of the prosodic features of the mother tongue. Spontaneous singing is characterized principally by the control of melodic–rhythmic contour patterns (Dowling, 1999; Sundin, 1997). Between the ages of 1 and 2 years, for example, a typically spontaneous infant song consists of repetitions of one brief melodic phrase at different pitch centers. By the age of 3 years, three different phrases are characteristically evidenced and one-phrase singing is rare (Dowling, 1988, 1999). Furthermore, recent case study research with 2- to 3-year-olds in a free-play daycare setting (Young, 2002) celebrates a wide diversity in young children's spontaneous singing that is linked to context and activity, whilst being mediated by age. This diversity includes "free-flow vocalizing" (a wordless vocal creation often associated with solitary play with no defined overall musical shape), "chanting" (often short, repeated phrases), "reworking of known songs" (the utilization of enculturated song fragments), "movement vocalizing" (either of self or objects), singing for "animation" (associated with dramatic play), and the imitation of actual sounds (defined as "comic-strip type noises," usually associated with object play). As children grow older (3 to 4 years) and more sociable, more speaking than singing may be evidenced.

Age is also a factor in young children's perception and expression of emotion in singing; 4- and 5-year-olds are able to express happiness and sadness in their invented songs. In one Canadian study, children used conventional musical devices,

such as a major modality and dotted or syncopated rhythms for "happy" songs, contrasted by a reduced pitch range and suppression of melodic contours in "sad" songs (Adachi & Trehub, 2000). Their song texts were also contraposed emotionally, with "happy" songs focused on "friends," "family," and "sweets," but "sad" songs focused more on a negative version of these (e.g., "no family"). In contrast, older children's "sad" songs were dominated by themes related to death (Adachi & Trehub, 1999). Data from Sweden (Gabrielsson & Örnkloo, 2002) confirm the growth of children's expertise with age in the recognition and expression of intended sung emotion, particularly between the ages of 4 and 7 years.

The first years of schooling

It is common for a diverse range of singing abilities to be exhibited by children on entry to compulsory schooling. Within this diversity, it is necessary to distinguish between i) children's (developing) skill in the performance of a taught song (Rutkowski, 1990, 1997; Welch, 1986, 1998, 2000b, 2002; Welch, Sergeant, & White, 1996, 1997, 1998) and ii) children's ability to invent songs (Davies, 1986, 1992, 1994). As with preschool singing behaviors, context and culture are also factors (Mang, 2003; Rutkowski & Chen-Haftek, 2000).

With regard to the first of these categories concerning the skilled performance of a taught song, two major US and UK studies have drawn on developmental theories to propose phased models of singing development (Rutkowski, 1997; Welch, 1998[1]). The US data (Rutkowski, 1997) was generated

[1] Rutkowski (1997), *Singing Voice Development Measure (SVDM)*

1 "Pre-singer" does not sing but chants the song text.

1.5 "Inconsistent Speaking Range Singer" sometimes chants, sometimes sustains tones and exhibits some sensitivity to pitch, but remains in the speaking voice range (usually a3 to c4 [note: the pitch labels have been altered to bring them in line with modern conventions in which middle C=c4, 256 Hz]).

2 "Speaking Range Singer" sustains tones and exhibits some sensitivity to pitch but remains in the speaking voice range (usually a3 to c4).

2.5 "Inconsistent Limited Range singer" wavers between speaking and singing voices and uses a limited range when in singing voice (usually up to f4).

3 "Limited Range Singer" exhibits consistent use of initial singing range (usually d4 to a4).

3.5 "Inconsistent Initial Range Singer" sometimes only exhibits use of limited singing range, but other times exhibits use of initial singing range (usually d4 to a4).

4 "Initial Range Singer" exhibits consistent use of initial singing range (usually d4 to a4).

4.5 "Inconsistent Singer" sometimes only exhibits use of initial singing range, but other times exhibits use of extended singing range (sings beyond the register lift: b^b4 and above).

5 "Singer" exhibits use of extended singing range (sings beyond the register lift: b^b4 and above).

Welch (1998) *A revised model of vocal pitch-matching development (VPMD)*

Phase 1 The words of the song appear to be the initial center of interest rather than the melody, singing is often described as "chant-like," employing a restricted pitch range and melodic phrases. In infant vocal pitch exploration, descending patterns predominate.

Phase 2 There is a growing awareness that vocal pitch can be a conscious process and that changes in vocal pitch are controllable. Sung melodic outline begins to follow the general (macro) contours of the target melody or key constituent phrases. Tonality is essentially phrase based. Self-invented and "schematic" songs "borrow" elements from the child's musical culture. Vocal pitch range used in "song" singing expands.

Phase 3 Melodic shape and intervals are mostly accurate, but some changes in tonality may occur, perhaps linked to inappropriate register usage. Overall, however, the number of different reference pitches is much reduced.

Phase 4 No significant melodic or pitch errors in relation to relatively simple songs from the singer's musical culture.

through systematic evaluation of children's singing behaviors across a period of over 15 years. The emergent nine-phase model (which went through several versions[2]) suggests that children progress from speech-like chanting of the song text, to singing within a limited range ("speaking range singer") to the demonstration of an expanded vocal pitch range that is allied to skilled competency in vocal pitch matching. This model has an affinity with that of another US-based longitudinal study (Davidson, 1994), which suggests that children's singing development is linked to a schematic processing of melodic contour. Data from Harvard University's six-year *Project Zero* study of children aged between the ages of 1 and 6 years indicated five specific levels of pitch development in young children's singing, expanding from an initial melodic contour scheme with a pitch interval of a third to one that embraced a complete octave.

Within the research literature, children are sometimes reported as being more skilled when copying a sung model if they used a neutral syllable rather than attempting the song with its text (e.g. Levinowitz, 1989). This finding has resonances with data from a three-year longitudinal study of 184 children in their first three years of formal education in ten UK primary schools (Welch et al., 1996, 1997, 1998). The research provided detailed evidence of how singing behaviors are age-, sex-, and task-sensitive. Over the three years, the participants as a collective appeared to

---

[2] The conceptualization of development as occurring in "phases" is a common outcome of research that is undertaken over a long period with time for researcher reflection and the evaluation of new data. For example, the current author has developed and reviewed a particular model of vocal pitch matching over the past two decades (1986, 2002), which reconceptualizes the evidence and reduces the number of developmental "phases" (rather than the originally labelled "stages") from five to four.

demonstrate little overall improvement when required to match the sung pitches of the criterion songs (two songs were specially taught and assessed each year) (see Figure 24.2). However, this singing behavior was in marked contrast to their ability to learn the words of the songs, which was extremely good, even in their first term of compulsory schooling at age 5 (Figure 24.2: Year 1, age 5 data). Furthermore, when the pitch elements of the target songs were deconstructed into simpler musical tasks in which the children were required to match individual pitches, echo melodic contours, or copy small melodic fragments, the children were significantly more pitch accurate, as demonstrated by year-on-year improvements. There were no sex differences in their singing of these three types of deconstructed tasks: boys and girls were equally successful and demonstrated similar improvements over time. In contrast, when the *same* boys were faced with the challenge of singing a complete song, their vocal pitch became less accurate and, as a group, they demonstrated little or no improvement in song-singing across the three years. Overall, singing competency appeared to be closely related to the nature of the task, with many boys negatively affected in the task of singing a "school" song.

This is a consistent finding across twentieth-century research literature. In general, girls as a group are reported to be more advanced in their singing development than boys, with recent research indicating that this gender difference gets larger as children get older from age 5 through to 12 (see Welch et al., 2012 for a review).

In line with these longitudinal findings, two recent studies suggest that gender stereotyping may be a factor in the lack of singing development in some young boys (Hall, 2005; Joyce, 2005). Australian research into 5-year-old boys'

singing (Hall, 2005) indicates that singing may be perceived as a "female" activity. UK research of 9- and 10-year-olds (Joyce, 2005) across three primary schools found that only one-third of boys enjoyed singing (compared with two-thirds of girls) and that boys believed that girls were better singers.

In addition to age, sex/gender, and task, there are also contextual factors that can affect children's singing behaviors. For example, the UK longitudinal study data demonstrated a clear "school effect" (Welch, 2000a). When comparing individual school data, *all* the children in one inner-city school improved their singing skills over the three years, notwithstanding their poor socio-economic environment and generally low academic attainment in other areas of the curriculum, whereas relatively few children made progress in another school, despite them having much higher socio-economic status and attainment levels. A major factor in these differences appears to have been teacher expectation. Progress was most marked where the class teacher expected and worked consistently for singing improvement with all their pupils over a sustained period. Similar findings concerning school effects on singing motivation perceived self-identity as a singer and overall enjoyment of singing as a school activity are also reported by Joyce (2005).

<Insert Figure 24.2 here>

Sociocultural differences have been exampled also in the more advanced singing skills demonstrated by a large class of first-grade Chinese (Hong Kong) children compared with their US peers (Rutkowski & Chen-Haftek, 2000). Similarly, an assessment of the singing behaviors of 120 Hong Kong children aged 7 to 9 years from various language groups (Mang, 2003, 2006), using both the Rutkowski and Welch developmental profiles, reported statistically significant effects for sex

(favoring girls) as well as mother-tongue. Chinese monolingual children performed consistently better than English bilingual children, even though the criterion song was in English. This was seen as a further indication (following Mang, 2006 Rutkowski & Chen-Haftek, 2000) that Cantonese-speaking children achieve singing mastery earlier than their English counterparts, perhaps because the pitch centers for speech and singing of the former are more closely aligned.

Both the US- and UK-based developmental models agree that different "phases" of singing competency are likely to be exampled within any group of children entering their first school class. Some children already will be extremely competent performers of complete songs from the experienced maternal culture (both words and music), whilst others will be less advanced and will be in one of the "earlier phases" of singing development. This does not mean that the latter group of "developing" singers will not gain singing mastery, particularly if they are provided with an appropriately nurturing environment in which singing tasks are designed to match, then to extend, current vocal behaviors. For such children, it is likely that their preschool interactions have provided fewer opportunities to fulfill their singing potential (as outlined in the "Early childhood and preschool" section earlier).

The effects of singing alone or with a group are equivocal in the research literature. Some research evidence suggests that children may become more accurate in reproducing the musical features of a criterion song when singing in a group compared to singing alone (e.g. Buckton, 1982; Greene, 1993). Other research (e.g. Goetze, 1985; Smale, 1988) reports the opposite in favor of increased reproductive accuracy if the young child is assessed when singing alone. It may be possible to reconcile these two positions by assuming that individual singing

behavior is likely to be framed by an interaction between current singing competency, the nature of the singing task, the competency of other singers in the group, and an individual's current ability to make sense of the available feedback. There is an internal psychological feedback monitoring system that is essentially outside conscious awareness, which is used for a moment-by-moment self-monitoring of the singing behavior. This system draws on information from internal sense receptors, as well as internal and external auditory information concerning the relative matching of vocal behavior with an external model (see Welch, 1985, 2005a). Where the individual is able to make sense of and use these different feedback channels in combination, then singing as a member of a skilled group may promote more competent behavior. Where the individual is less able to make sense of and use this feedback, such as when surrounded by a less skilled group of singers and/or when it is difficult to "hear" their own voice, then performing in a group context may be more disadvantageous. Data from studies of choral acoustics, for example, indicate that auditory feedback for one's own vocal output is reduced when i) other singers are in close proximity (self-to-other ratio) and ii) when nearby singers are singing, or attempting to sing, the same pitches (Daugherty, 2000; Ternström, 1994).

Nevertheless, it is likely that singing competency will be nurtured through exposure to frequent opportunities for vocal play within an environment that encourages vocal exploration and accurate imitation (Mang, 2003; Welch, 2005a; Young, 2002).

The data from various studies on early singing development were collated into a theoretical protocol "baseline assessment of singing" for use with children on

entry to school (Welch & Elsley, 1999). This was evaluated subsequently with a small class of children (n=19) aged from 3 years 8 months to 5 years 10 months (King, 2000). In general, the data supported key features of the model, namely that singing competence is likely to vary at an individual level with musical task, such as in the sung reproduction of melodic contour, pitch intervals, and song text. Any assessment of singing abilities in young children, therefore, should provide a mixture of tasks (such as pitch glides and pitch patterns, as well as song melodies) as a basis for diagnosis and curriculum planning. Furthermore, recent neuropsychobiological data on pitch-processing modules in the brain (Peretz & Coltheart, 2003) support a hierarchical model in which melodic contour (*pace* Davidson, 1994; Rutkowski, 1997; Welch, 1998) is analyzed before the processing of intervals and tonality (see Welch, 2005a for a review).

With regard to children's ability to invent songs, a series of studies (Davies, 1986, 1992, 1994) indicate that 5- to 7-year-olds have a range of song-making strategies; these include narrative songs (chant-like in nature, often with repeated figures), as well as songs that have more conventional features, such as an opening idea and a clear sense of closure, four-phrase structures, repetition, phrases that both "borrow" from the immediate musical culture and which also may be transformed (sequenced, inverted, augmented) in some way. Overall, children in the first years of schooling demonstrate a clear sense of musical form and of emotional expression in their invented songs.

Older childhood

The latter years of childhood are characterized by a general singing competency for

the majority. Relatively few children are reported as singing "out-of-tune" at the age of 11 years (Howard, Angus, & Welch, 1994; Welch, 1979, 2000b). For example, evidence from a wide range of studies indicates that approximately 30% of pupils aged 7 years are reported as being relatively "inaccurate" when vocally matching a melody within a Western cultural tradition. However, this proportion drops to around 4% of the same pupil population by the age of 11 (a proportion that is similar to that reported for the adult population—Dalla Bella et al., 2007). Within each of these and the intervening age groups, "out-of-tune" boys outnumber girls by a ratio of 2:1 or 3:1 (Welch, 1979). Culture, however, continues to be significant. Anthropological and ethnomusicological studies, for example, have suggested that young children from the Anang in Nigeria can sing "hundreds of songs, both individually and in choral groups" by the age of 5 (Messinger, 1958, p. 20), Venda children in South Africa were reported as both learning special children's songs and composing new songs for themselves (Blacking, 1967), whereas Herati children in Afghanistan tended to focus on the imitation of adult models, with the children (particularly boys) of professional musicians' families (*sazendeh*) being immersed in the local music culture and often expected to perform professionally by the age of 12 (Doubleday & Baily, 1995).

<Insert Figure 24.3 here>

A large-scale study of children's singing development was undertaken as part of an evaluation of the impact of the UK Government's National Singing Program "Sing Up," which ran in England from 2007 to 2012. Data on the singing ability of 11,258 children aged 5 to 12 years were collected over a period of four years as the program was rolled out across the country. Children's singing was assessed using a

protocol that combined the Rutkowski (1997) and Welch (1998) developmental profiles (mentioned previously) to create a normalized singing score (out of 100). Amongst other findings, data analyses revealed a) that older children tended to be more advanced in their singing ability compared to younger children, and b) that those children with experience of "Sing Up" were, on average, two years in advance developmentally compared to their peers outside the program, an impact that was even more marked for the youngest children (see Figure 24.3) (Welch et al., forthcoming). In general—and in line with the research reported earlier—singing ability normally develops with age and can be enhanced if children experience an appropriately rich educational program. Moreover, there are also other potential benefits of successful singing experience, in that children are more likely to have a positive self-concept and sense of being socially included (Welch et al., 2014). Amongst other potential benefits from singing are improved reading skills (Biggs et al., 2008; Welch et al., 2012).

One effective means of fostering singing development is by the use of "imitation," which is a core reciprocal feature of early mother–child vocal interactions (Trehub & Gudmundsdottir, 2014). This approach is also evidenced pedagogically as part of an enculturated induction into the skilled practices of expert singers in many different musical cultures, such as exampled in the cathedrals where European sacred music is practiced, as well as in the choral communities of sub-Saharan Africa and Scandinavia. Cathedrals in the UK, for example, typically induct their choristers at the age of 8, so that by the age of 13 they will have had five years' immersion into a weekly (usually daily) ritual of rehearsals, performances, choral singing, and solos, embracing a wide range of compositional styles and musical

genres that span over 500 years of Western classical music. Within the cathedral choir, performance skill level is signaled by singer nomenclature (such as "head chorister," "senior corner boy," "probationer") and variations in the dress code, as well as by the degree of performance involvement in particular repertoire. Novices are deliberately placed in between more skilled, older choristers and normally are required to sing only certain items during the cathedral services while they deepen and develop their performance skills through listening and observing their more accomplished peers (see Welch, 2011).

Although the tradition of highly skilled boy singers in the UK may be traced back to the first foundations of English cathedrals in Canterbury (AD 597), Rochester (AD 604), and St. Paul's, London (AD 604), the "all-male" hegemony of cathedral music experienced a major challenge in 1991 with the admittance of girls to Salisbury Cathedral in the West of England. Since then, by 2009, the potential for equally skilled performance by girl choristers has been recognized through the creation of separate girls' choirs in 31 cathedrals and minsters (Welch, 2011),[3] with a small number of others added since. Girl choristers are usually admitted using the same audition criteria as their male counterparts and are expected to perform the same repertoire to the same professional standard.

Evidence of the power of the musical culture in cathedrals in fostering specialist singing skills may be found both in the quality of choral outputs (such as national and international broadcasts by the BBC, commercial recordings,

[3] The data for 2009 on the numbers of cathedrals with female choristers in UK cathedrals has been collated by Claire Stewart as part of her ongoing doctoral studies at the Institute of Education into their impact on the all-male choral tradition.

international tours, and concerts) and also in the regular media-fuelled controversies over whether it is possible or not to perceive differences between the singing of older female and male children (Sergeant, Sjölander, & Welch, 2005; Welch & Howard, 2002). With regard to perceived singer gender, a summary of recent research data (Figure 24.4) indicates that, whilst it is possible for an untrained solo singer's sex to be identified relatively accurately from around the age of 8 onwards, it is also equally possible for trained female choristers from the age of 8 to be systematically mistaken as male, depending on the particular piece of music being performed. However, once the female chorister moves into her mid-teens, the voice quality becomes more characteristically identifiable as "female" ("womanly").[4]

A key component of our ability to assign gender accurately to children's sung products relates to changes in vocal timbre as part of the aging process. A recent study of n=320 children aged 4–11 years revealed that, as children get older, there were significant shifts in spectral energy in their singing of the same target song. For the youngest age group (4–5 years), no gender differences were evidenced in the vocal spectrum. In contrast, significant differences emerged between genders for children aged 9–11 years, with spectral energy levels above 5.75 kHz decreasing with age and energies below 5.75 kHz increasing. However, this spectral shift occurred up to two years earlier for girls compared to boys of the same age (Sergeant & Welch, 2009).

In general, children's voices tend to be higher in pitch and have a less

[4] For a detailed review of the literature on gender and chorister voice, including similarities and differences in the underlying anatomy and physiology for singing, see Welch & Howard (2002). For data on the perceived gender of untrained children's voices, see Sergeant et al. (2005).

complex acoustic make-up than those of adults. Also, there are increases in vocal pitch range, both upwards and downwards, that are closely correlated with advancing chronological age (Sergeant & Welch, 2009). Nevertheless, children are able to achieve similar loudness levels as adults by using relatively more breath until the age of 12, when adult-like breathing patterns are observed (Stathopoulos, 2000).

<Insert Figure 24.4 here>

Puberty and adolescence

The onset of puberty heralds fundamental changes to the nature and quality of the singing voice for both females and males. Whereas the actual dimensions and growth of the vocal instrument are similar across sexes during childhood (Titze, 1994), during puberty the male vocal tract becomes significantly longer and develops a greater circumference. In contrast, the growth of the female vocal tract is less marked, being about 15% to 20% shorter than in the male and with a different internal ratio of resonating spaces, mainly because the female neck (pharynx) is relatively shorter compared to that of the male (Story, Titze, & Hoffman, 1997). Growth typically lasts from 10 to 18 years in females (and can begin at age 7—Herman-Giddens et al., 1997), compared with 12 to 20 years in males (Thurman & Klitzke, 2000). At the turn of the century, the highpoint of pubertal voice change was reported to be around the age of 12 to 14 years in both females and males (Cooksey, 2000; Gackle, 2000), a finding subsequently generally supported in more recent studies (Juul et al., 2006; Willis & Kenny, 2008). Nevertheless, there is also some evidence of a trend for voice change to happen earlier than previously (Ashley & Mecke, 2013; Killian & Wayman, 2010). The mean average onset of voice change is

likely to be between 10 and 12 years (e.g., Fisher, 2010), with one study reporting 80% of 11-year-olds showing evidence of voice change (Killian & Wayman, 2010). However, ethnicity is not reported to be a significant factor in voice change (Fisher, 2010).

There are relatively few major empirical studies of singing voice transformation during adolescence reported in the literature, particularly with regard to the female changing voice. Those that are available draw primarily on data from populations in the United States (e.g., Cooksey, 2000; Gackle, 2000; Killian & Wayman, 2010; Williams, Larson, & Price, 1996), the UK (e.g., Cooksey & Welch, 1998; Geddye, personal communication; Harries et al., 1996; Williams, 2010), Japan (Norioka, 1994), and Germany (Ashley & Mecke, 2013; Heidelbach, 1996). The data are consistent about the presence and characteristics of adolescent voice change.

Gackle (2000, updated and revised 2014) reports the outcome of her doctoral studies in Florida (during 1987), allied to almost 30 years' professional observation, to suggest that there are four distinct "phases" in female adolescent voice change (see ♀ in Figure 24.5a). In the first phase (termed "pre-pubertal: unchanged") the voice has a "clear/light, flute-like quality" with no apparent register changes. The comfortable singing range is between D4 and D5, within a wider singing range of Bb3 to F5 (and up to A5). The next phase ("pre-menarchial: beginning of mutation"—Phase IIA) is characteristic of the beginnings of female voice mutation around the ages of 11 to 13. The comfortable range is approximately the same as previously (D4 to D5), within a slightly expanded overall range (A3 to G5). However, there is often breathiness in the tone due to inadequate closure of the vocal folds as a result of growth occurring in the laryngeal area. A singing register transition typically appears

between F#4 and A#4, and some girls may have difficulties in singing lower pitches; others will experience a loss of upper range. Singing often becomes uncomfortable and effortful and a breathy voice quality is characteristic across the range. The next phase is the peak of female voice mutation ("post-menarchial: pubertal—high point of mutation"—Phase IIb). Singing is characterized by a limited comfortable range (B3 to C5), discomfort (particularly at upper pitches), distinct voice qualities for each sung register, and with the lower part of the voice often taking on a more "alto" and often husky quality. Register changes appear between F4 and A#4 and also at D5 to F#5. The final phase ("young adult female"—Phase III) has a much-expanded comfortable singing range (A3 to G5), less breathiness, greater consistency in tone quality and registers, and greater singing flexibility and agility. Vibrato often appears at this stage and the voice has a more adult, womanly quality. Ongoing research (Welch, 2004; Welch & Howard, 2002) indicates that adolescent voice change is the same for relatively untrained female singers as for those who have been involved in sustained vocal performance, such as through membership of a female cathedral choir. However, as with adult female singers (Lã & Davidson, 2005), there is always some individual variation in the impact of puberty on the singer's voice related to slight differences in the underlying endocrinological metabolism and physiological functioning.

Male adolescent voice change has a more extensive literature, both in Europe and the United States. One major and influential longitudinal study was conducted by Cooksey (2000), initially based on fieldwork in California in the late 1970s, then drawing on further studies in the United States during the following decade, as well as a London-based cross-cultural investigation in the 1990s (Cooksey

& Welch, 1998). Overall, Cooksey reports six "stages" of adolescent male singing voice change (see ♂ in Figure 24.5a) that are characterized by an overall lowering of the sung pitch range. Whilst the rate of voice change is unpredictable for any given individual, it is reliably sequential for all.

In the first male adolescent stage ("unchanged"), the mean sung vocal pitch range is A3 to F5, with the tessitura pitch boundaries C$^{\#}$4 to A$^{\#}$4. The voice quality is perceived as "clear," with relatively little evidence of breathiness in the tone. The beginnings of voice change (termed by Cooksey as Stage I, "Midvoice I") are marked by a reduced vocal range (Ab3 to C5) and instability of sung pitch, particularly for the upper frequencies, which tend to be produced with increased effort, as well as tone quality that is perceived as more effortful, strained, and breathy. The sung range then descends approximately in thirds across the next three stages (see Figure 24.5a), with each stage being characterized by a reduced mean range and relative continuing instability in the production of upper pitches, but contrasted by relative stability for the lower pitches. The pitch ranges are: Stage II ("Midvoice II"), F3 to A4; Stage III ("Midvoice IIa"), D3 to F$^{\#}$4; followed by Stage IV ("New Baritone," also termed "New Voice"), B2 to D$^{\#}$4. Within these, Stage II may be regarded as the mid-point of voice change, and this is when a falsetto register (C5 to B5) first appears and (for some) a whistle register (C6 to C7). Stage III ("Midvoice IIa") is characterized by the greatest vocal instability and the least clear vocal quality. It is only in the final stage of voice change (Stage V, "Settling Baritone," also termed "Emerging Adult Voice" G2 to D4) that the mean sung pitch range opens out again and the voice timbre begins to adopt a clearer, less breathy quality. However, the number and intensity of harmonics do not yet approximate normal adult characteristics.

Nevertheless, for each stage of voice change the adolescent male has a (limited) number of pitches that can be produced comfortably and musically (see the darker shaded elements in the ranges for male voices in Figure 24.5a) and it has been possible in recent years to find a greater awareness by publishers to produce repertoire that is specially written as being suitable for these changing voices.

In general, age is a poor predictor for establishing voice change stages, with any given age group likely to encompass several stages. It is possible for an individual to pass through all stages of adolescent voice change in twelve months, but it is also possible for this process to be much slower and to last several years. Nevertheless, a summation of selected UK and Japanese data for over 3,000 males, aged 9 to 14 years, provides some indication of the possible proportions of different categories of voice change by age group (Figure 24.5b), whilst noting that other, more recent research suggests that voice-change onset may be getting younger (Ashley & Mecke, 2013; Killian & Wayman, 2010). As can be seen, the ages of 12 to 14 have significant proportions of males whose voices are perceived to have already "changed," or in the process of "changing," whilst embracing a reducing number that are still "unchanged." Ideally, choral groups of adolescent male singers in this age range are best suited, therefore, to music that has been arranged specifically for them in three parts, using the Cooksey classification guidelines (Unchanged and Stage I on a top line, Stages II and III on a middle line, and Stages IV and V on the bottom line), rather than to attempt traditional four-part music in which the tessiturae often are likely to be mismatched with current singing abilities.

<Insert Figures 24.5a and 24.5b here>

Factors influencing singing development and the realization of potential

As can be seen from the previous text, singing in one form or another is an essential feature of our musical development and behavior. In each age phase (infancy, early childhood, older childhood, adolescence), the human voice has a distinctive underlying anatomy and physiology that is capable of producing a diversity of "singing" behaviors. These increasingly explore and approximate to the particular sonic features of models that are available in the soundworlds of the experienced maternal and global cultures. In the first months of life, these "sung" products are driven by basic human needs, before becoming more exploratory and melodic in nature as vocal skills develop in the acquisition and mastery of musical elements. Throughout childhood and adolescence, singing development is a product of neuropsychobiological activity, potential, and change, interfaced with, and shaped by, particular sociocultural environments in which certain patterns of sound characterize the dominant musical genres. At any age, development can be supported or hindered by a number of factors, such as the appropriateness of a given singing task set by an adult in relation to current singing capabilities, the expectations of peers, and/or the value placed on singing (and certain types of singing behavior) within the immediate culture. Opportunities to engage in vocal play and exploration, to share in singing games with peers and "experts," as well as to improvise and compose their own songs are essential features of musical cultures that foster singing development. Children who exceed the "norms" reported in the research literature are likely to have been provided with a nurturing environment that is designed to match, celebrate, enable, and extend individual singing expertise (such as evidenced in the "Sing Up" evaluation data (Welch et al., in press). Others,

whose singing is perceived to be “lacking” in some way, will not have had such appropriate opportunities. For some, entry to adolescence can confirm their perceived identity as a “non-singer,” as someone for whom music is seen as an area of “failure.” Yet, everyone has the potential to learn to sing—and indeed, studies of singing in adults suggest that “singing in the general population is more accurate and widespread than currently believed” (Dalla Bella et al., 2007, p. 1188; see also Cuddy et al., 2005). We need, therefore, to continue to seek optimal ways to allow children and adolescents to explore and extend their singing (and musical) birthright. In this, we will reduce the need for “remedial” action in adulthood, such as the establishment of adult choirs for “non-singers.” The stories of a life-long sense of singing “disability” should be confined to history.

Reference list

Adachi, M., & Trehub, S. E. (1999). Children's communication of emotion in song. In S. W. Yi (Ed.), *Music, mind and science* (pp. 454–65). Seoul: Seoul National University Press.

Adachi, M., & Trehub, S. E. (2000, April). *Preschoolers' expression of emotion through invented songs*. Paper presented at the meeting of the Society for Research in the Psychology of Music and Music Education, University of Leicester, England.

Ashley, M., & Mecke, A.-C. (2013). "Boys are apt to change their voice at about fourteene yeeres of age": An historical background to the debate about longevity in boy treble singers. *Reviews of Research in Human Learning and Music*, 1(epub2013001), doi: 10.6022/journal.rrhlm.2013001.

Barrett, M. S. (2011). Musical narratives: A study of a young child's identity work in and through music-making. *Psychology of Music*, *39*(4), 403–23, doi: 10.1177/0305735610373054.

Biggs, M. C., Homan, S. P., Dedrick, R., Minick, V., & Rasinski, T. (2008). Using an interactive singing software program: A comparative study of struggling middle school readers. *Reading Psychology*, *29*(3), 195–213.

Blacking, J. (1967). *Venda children's songs*. Johannesburg: University of Witwatersrand Press.

British Educational Research Association Music Education Review Group. (2001). *Mapping music education research in the UK*. Southwell, UK: British Educational Research Association.

Buckton, R. (1982). *Sing a song of six-year-olds*. Wellington, New Zealand: Council for Educational Research.

Coleman, J. M., Pratt, R. R., Stoddard, R. A., Gerstmann, D. R., & Abel, H.-H. (1997). The effects of the male and female singing behaviours and speaking voices on selected physiological and behavioural measures of premature infants in the intensive care unit. *International Journal of Arts Medicine*, *5*(2), 4–11.

Cooksey, J. (2000). Voice transformation in male adolescents. In L. Thurman, & G. F. Welch (Eds.), *Bodymind and voice: Foundations of voice education* (revised ed., pp. 718–38). Iowa City, Iowa: National Center for Voice and Speech.

Cooksey, J., & Welch, G. F. (1998). Adolescence, singing development and National Curricula design. *British Journal of Music Education*, *15*(1), 99–119.

Cuddy, L. L., Balkwill, L.-L., Peretz, I., & Holden, R. R. (2005). Musical difficulties are rare. A study of "tone deafness" amongst university students. *New York: Annals of the New York Academy of Sciences*, *1060*, 311–24, doi: 10.1196/annals.1360.026.

Dalla Bella, S., Giguére, J.-F. & Peretz, I. (2007). Singing proficiency in the general population. *Journal of the Acoustical Society of America*, *121*(2), 1182–9.

Daugherty, J. F. (2000). Choir spacing and choral sound: Physical, pedagogical, and philosophical dimensions. In B. A. Roberts & A. Rose (Eds.), *Conference proceedings of the international symposium, sharing the voices: The phenomenon of singing II* (pp. 77–88). St. Johns, Newfoundland, Canada: Memorial University of Newfoundland Press.

Davidson, L. (1994). Songsinging by young and old: A developmental approach to music. In R. Aiello and J. Sloboda (Eds.), *Musical perceptions* (pp. 99–130). New York: Oxford University Press.

Davies, C. (1986). Say it till a song comes: Reflections on songs invented by children 3–13. *British Journal of Music Education*, *3*(3), 279–93.

Davies, C. (1992). Listen to my song: A study of songs invented by children aged 5 to 7 years. *British Journal of Music Education*, *9*(1), 19–48.

Davies, C. (1994). The listening teacher: An approach to the collection and study of invented songs of children aged 5 to 7. In H. Lees (Ed.), *Musical connections: Tradition and change* (pp. 120–7). Auckland, NZ: International Society for Music Education.

Doubleday, V., & Baily, J. (1995). Patterns of musical development among children in Afghanistan. In E. J. Fernea (Ed.), *Children in the Muslim Middle East* (pp. 431–44). Austin: University of Texas Press.

Dowling, W. J. (1988). Tonal structure and children's early learning of music. In J. Sloboda (Ed.), *Generative processes in music* (pp. 113–28). Oxford: Oxford University Press.

Dowling, W. J. (1999). The development of music perception and cognition. In D. Deutsch (Ed.), *The Psychology of Music* (2nd ed., pp. 603–25). London: Academic Press.

Eimas, P. D. (1985). The perception of speech in early infancy. *Scientific American*, *252*(1), 34–40.

Fisher, R. A. (2010). Effect of ethnicity on the age of onset of the male voice change. *Journal of Research in Music Education*, *58*(2), 116–30, doi: 10.1177/0022429410371376.

Gabrielsson, A., & Örnkloo, H. (2002, August). *Children's perception and performance of emotion in singing and speech*. Paper presented at the ISME Early Childhood Conference, Copenhagen, Denmark.

Gackle, L. (2000). Understanding voice transformation in female adolescents. In L. Thurman, & G. F. Welch (Eds.), *Bodymind and Voice: Foundations of Voice Education* (revised ed., pp. 739–44). Iowa City, Iowa: National Center for Voice and Speech.

Gackle, L. (2014). Adolescent girls' singing development. In G. F. Welch, D. M. Howard, & J. Nix (Eds.), *Oxford handbook of singing*. New York: Oxford University Press, doi: 10.1093/oxfordhb/9780199660773.013.22.

Goetze, M. (1985). *Factors affecting accuracy in children's singing* (Unpublished doctoral dissertation). University of Colorado.

Greene, G. A. (1993). *The effects of unison singing versus individual singing on the vocal pitch accuracy of elementary school children*. Paper presented at the Southern Division of the Music Educators' National Conference.

Hall, C. (2005). Gender and boys' singing in early childhood. *British Journal of Music Education*, *22*(1), 5–20.

Hargreaves, D. J. (1996). The development of artistic and musical competence. In I. Deliege & J. Sloboda (Eds.), *Musical beginnings* (pp. 145–70). Oxford: Oxford University Press.

Harries, M. L. L., Griffin, M., Walker, J., & Hawkins, S. (1996). Changes in the male voice during puberty: Speaking and singing voice parameters. *Logopedics Phoniatrics Vocology*, *21*(2), 95–100.

Heidelbach, U. (1996). *Die entwicklung der knabenstimme zur mannerstimme bei chorsangern dargestellt am singstimmfeld* (Unpublished MD thesis). Technischen Universität Dresden, Dresden, BRD.

Herman-Giddens, M. E., Slora, E. J. Wasserman, R. C., Bourdony, C. J., Bhapkar, M. V., Kock, G. G., & Hasemeier, C. M. (1997). Secondary sexual characteristics and menses in young girls seen in office practice: A study from the Pediatric Research in Office Settings Network. *Pediatrics*, *99*(4), 505–12.

Howard, D. M., Angus, J. A., & Welch, G. F. (1994). Singing pitching accuracy from years 3 to 6 in a primary school. *Proceedings of the institute of acoustics*, *16*(5), 223–30.

Johnstone, T., & Scherer, K. R. (2000). Vocal communication of emotion. In M. Lewis & J. M. Haviland-Jones (Eds.), *Handbook of emotions* (pp. 220–35). New York: The Guildford Press.

Joyce, H. (2005). *The effects of sex, age and environment on attitudes to singing in Key Stage 2* (Unpublished master's dissertation). Institute of Education, University of London.

Juul, A., Teilmann, G., Scheike, T., Hertel, N. T., Holm, K., Laursen, E. M., Main, K. M., & Skakkebaek, N. E. (2006). Pubertal development in Danish children: Comparison of recent European and US data. *International Journal of Andrology*, *29*(1), 247–55, doi: 10.1111/j.1365–2605.2005.00556.x.

Killian, J. N., & Wayman, J. B. (2010). A descriptive study of vocal maturation among male adolescent vocalists and instrumentalists. *Journal of Research in Music Education*, *58*(1), 5–19, doi: 10.1177/0022429409359941.

King, R. (2000). *An investigation into the effectiveness of a baseline assessment in singing and some influential home-environmental factors* (Unpublished master's dissertation). Roehampton Institute London, London.

Knight, S. (1999). Exploring a cultural myth: What adult non-singers may reveal about the nature of singing. In B. A. Roberts & A. Rose (Eds.), *The phenomenon of singing II* (pp. 144–54). St. John's, NF: Memorial University Press.

Knight, S. (2010). *A study of adult "non-singers" in Newfoundland* (Unpublished doctoral dissertation). Institute of Education, University of London.

Lã, F., & Davidson, J. (2005). Investigating the relationship between sexual hormones and female Western classical singing. *Research Studies in Music Education*, *25*, 75–87.

Levinowitz, L. (1989). An investigation of preschool children's comparative capability to sing songs with and without words. *Bulletin of the Council for Research in Music Education*, *100*, 14–19.

Loui, P., Bachorik, J. P., Li, H. C., & Schlaug, G. (2013). Effects of voice on emotional arousal. *Frontiers in Psychology*, 4:675. doi: 10.3389/fpsyg.2013.00675.

Mack, L. (1979). *A descriptive study of a community chorus made up of "non-singers"* (Unpublished EdD dissertation). University of Illinois at Urbana-Champaign.

Mang, E. (2000/1). Intermediate vocalisations: An investigation of the boundary between speech and songs in young children's vocalisations. *Bulletin of the Council for Research in Music Education*, *147*, 116–21.

Mang, E. (2002). An investigation of vocal pitch behaviours of Hong Kong children. *Bulletin of the Council for Research in Music Education*, *153*(4), 128–34.

Mang, E. (2003). Singing competency of monolingual and bilingual children in Hong Kong. In L. C. R. Yip, C. C. Leung, & W. T. Lau (Eds.), *Curriculum innovation in music* (pp. 237–42). Hong Kong: Hong Kong Institute of Education.

Mang, E. (2005). The referent of children's early songs. *Music Education Research*, *7*(1), 3–20, doi: 10.1080/14613800500041796.

Mang, E. (2006). The effects of age, gender and language on children's singing competency. *British Journal of Music Education*, *23*(2), 161–74, doi: 10.1017/S0265051706006905.

Masataka, N. (1992). Pitch characteristics of Japanese maternal speech to infants. *Journal of Child Language*, *19*(2), 213–23.

Masataka, N. (1999). Preference for infant-directed singing in 2-day-old hearing infants of deaf parents. *Developmental Psychology*, *35*(4), 1001–5.

Meltzoff, A. N. (2002). Elements of a developmental theory of imitation. In A. N. Meltzoff & W. Prinz, (Eds.), *The Imitative Mind* (pp. 19–41). Cambridge: Cambridge University Press.

Messinger, J. (1958). Overseas report. *Basic College Quarterly*, *4* Fall, 20–4.

Moog, H. (1976). *The musical experience of the pre-school child* (trans. C. Clarke). London: Schott.

Nawrot, E. S. (2003). The perception of emotional expression in music: Evidence from infants, children and adults. *Psychology of Music*, *31*(1), 75–92.

Norioka, Y. (1994). A survey of Japanese school aged poor pitch singers. In G. F. Welch & T. Murao (Eds.), *Onchi and singing development* (pp. 49–62). London: David Fulton Publishers.

Papousek, M. (1996). Intuitive parenting: A hidden source of musical stimulation in infancy. In I. Deliege & J. Sloboda (Eds.), *Musical beginnings* (pp. 88–112). Oxford: Oxford University Press.

Peretz, I., & Coltheart, M. (2003). Modularity and music processing. *Nature Neuroscience*, *6*(7), 688–91.

Richards, H., & Durrant, C. (2003). To sing or not to sing: A study on the development of "non-singers" in choral activity. *Research Studies in Music Education*, *20*(1), 78–89.

Rutkowski, J. (1990). The measurement and evaluation of children's singing voice development. *The Quarterly*, *1*(1–2), 81–95.

Rutkowski, J. (1997). The nature of children's singing voices: Characteristics and assessment. In B. A. Roberts (Ed.), *The phenomenon of singing* (pp. 201–9). St. John's, NF: Memorial University Press.

Rutkowski, J., & Chen-Haftek, L. (2000, July). *The singing voice within every child: A cross-cultural comparison of first graders' use of singing voice*. Paper presented to the ISME Early Childhood Conference, Kingston, Canada.

Ruzza, B., Rocca, F., Boero, D. L., & Lenti, C. (2003). Investigating the musical qualities of early infant sounds. In G. Avanzini, C. Faienza, D. Minciacchi, L. Lopez, & M. Majno (Eds.), *The neurosciences and music* (Vol. 999, pp. 527–9). New York: Annals of the New York Academy of Sciences.

Sergeant, D. C., Sjölander, P., & Welch, G. F. (2005). Listeners' identification of gender differences in children's singing. *Research Studies in Music Education*, *24*(1) 28–39.

Sergeant, D. C., & Welch, G. F. (2009). Gender differences in Long-Term-Average Spectra of children's singing voices. *Journal of Voice*, *23*(3), 319–36, doi: 10.1016/j.jvoice.2007.10.010.

Smale, M. J. (1988). An investigation of pitch accuracy of four- and five-year-old singers. *Dissertation Abstracts International*, AAT—8723851.

Stathopoulos, E. T. (2000). A review of the development of the child voice: An anatomical and functional perspective. In P. J. White (Ed.), *Child Voice* (pp. 1–12). Stockholm: Royal Institute of Technology, Voice Research Centre.

Story, B. H., Titze, I. R., & Hoffman, E. A. (1997). Volumetric image-based comparison of male and female vocal tract shapes. *National Center for Voice and Speech Status and Progress Report*, *11*, 153–61.

Sundberg, J. (2000). Emotive transforms. *Phonetica*, *57*(2-4), 95–112.

Sundin, B. (1997). Musical creativity in childhood: A research project in retrospect. *Research Studies in Music Education*, *9*(1), 48–57.

Tafuri, J. (2008). *Infant musicality*. Farnham, UK: Ashgate.

Tafuri, J., & Villa, D. (2002). Musical elements in the vocalisations of infants aged 2 to 8 months. *British Journal of Music Education*, *19*(1), 73–88.

Ternström, S. (1994). Hearing myself with others: Sound levels in choral performance measured with separation of one's own voice from the rest of the choir. *Journal of Voice*, *8*(4), 293–302.

Thurman, L., & Klitzke, C. (2000). Highlights of physical growth and function of voices from prebirth to age 21. In L. Thurman, & G. F. Welch (Eds.), *Bodymind and Voice: Foundations of Voice Education* (revised ed., pp. 696–703). Iowa City, Iowa: National Center for Voice and Speech.

Thurman, L., & Welch, G. F. (Eds.) (2000). *Bodymind and Voice: Foundations of Voice Education* (revised ed.). Iowa City, Iowa: National Center for Voice and Speech.

Titze, I. (1994). *Principles of voice production*. Englewood Cliffs, NJ: Prentice-Hall.

Trehub, S. E. (2001). Musical predispositions in infancy. In R. J. Zatorre & I. Peretz (Eds.), *The biological foundations of music* (Vol. 930, pp. 1–16). New York: Annals of the New York Academy of Sciences.

Trehub, S. E., & Gudmundsdottir, H. R. (2014). Mothers as singing mentors for infants. In G. F. Welch, D. M. Howard, & J. Nix. (Eds.), *Oxford handbook of singing*. New York: Oxford University Press.

Vihman, M. M. (1996). *Phonological development*. Oxford: Blackwell.

Welch, G. F. (1979). Poor pitch singing: A review of the literature. *Psychology of Music*, *7*(1), 50–8.

Welch, G. F. (1985). A schema theory of how children learn to sing in tune. *Psychology of Music*, *13*(1), 3–18.

Welch, G. F. (1986). A developmental view of children's singing. *British Journal of Music Education*, *3*(3), 295–303.

Welch, G. F. (1998). Early childhood musical development. *Research Studies in Music Education*, *11*(1), 27–41.

Welch, G. F. (2000a). Singing development in early childhood: The effects of culture and education on the realisation of potential. In P. J. White (Ed.), *Child voice* (pp. 27–44). Stockholm: Royal Institute of Technology.

Welch, G. F. (2000b). The developing voice. In L. Thurman, & G. F. Welch (Eds.), *Bodymind and Voice: Foundations of Voice Education* (pp. 704–17). Iowa: National Center for Voice and Speech.

Welch, G. F. (2002). Early childhood musical development. In L. Bresler & C. Thompson (Eds.), *The arts in children's lives: Context, culture and curriculum* (pp. 113–28). Dordrecht, NL: Kluwer.

Welch, G. F. (2004). Developing young professional singers in UK cathedrals. *Proceedings, 2nd International Physiology and Acoustics of Singing Conference, Denver, USA*. Retrieved 3 June, 2005 from <http://www.ncvs.org/pas/2004/pres/welch/welch.htm>.

Welch, G. F. (2005a). Singing as communication. In D. Miell, R. MacDonald, & D. J. Hargreaves (Eds.), *Musical communication* (pp. 239–59). New York: Oxford University Press.

Welch, G. F. (2005b). The musical development and education of young children. In B. Spodek & O. Saracho (Eds.), *Handbook of research on the education of young children* (pp. 251–67). Mahwah, NJ: Lawrence Erlbaum Associates Inc.

Welch, G. F. (2011). Culture and gender in a cathedral music context: An activity theory exploration. In M. Barrett (Ed.), *A cultural psychology of music education* (pp. 225–58). New York: Oxford University Press.

Welch, G. F., & Elsley, J. (1999). Baseline assessment in singing. *Australian Voice*, *5*, 60–6.

Welch, G. F., Himonides, E., Saunders, J., Papageorgi, I., & Sarazin, M. (2014). Singing and social inclusion. *Frontiers in Psychology*, *5*:803, doi: 10.3389/fpsyg.2014.00803.

Welch, G. F., Himonides, E., Saunders, J., Papageorgi, I., Vraka, M., Preti, C., & Sarazin, M. (forthcoming). Children's singing behaviour and development in the context of *Sing Up*, a national program in England.

Welch, G. F., & Howard, D. (2002). Gendered voice in the cathedral choir. *Psychology of Music*, *30*(1), 102–20.

Welch, G. F., Saunders, J., Hobsbaum, A., & Himonides, E. (2012). *Literacy through music: A research evaluation of the New London Orchestra's Literacy through Music programme*. London: International Music Education Research Centre, Institute of Education, University of London.

Welch, G. F., Saunders, J., Papageorgi, I., & Himonides, E. (2012). Sex, gender and singing development: Making a positive difference to boys' singing through a national programme in England. In S. Harrison, G. F. Welch, & A. Adler (Eds.), *Perspectives on males and singing* (pp. 37–54). London: Springer.

Welch, G. F., Sergeant, D. C., & White, P. (1996). The singing competences of five-year-old developing singers. *Bulletin of the Council for Research in Music Education*, *127*, 155–62.

Welch, G. F., Sergeant, D. C., & White, P. (1997). Age, sex and vocal task as factors in singing "in-tune" during the first years of schooling. *Bulletin of the Council for Research in Music Education*, *133*, 153–60.

Welch, G. F., Sergeant, D. C., & White, P. (1998). The role of linguistic dominance in the acquisition of song. *Research Studies in Music Education*, *10*(1), 67–74.

Williams, J. (2010). *The implications of intensive singing training on the vocal health and development of boy choristers in an English cathedral choir* (Unpublished doctoral dissertation). Institute of Education, University of London.

Williams, B., Larson, G., & Price, D. (1996). An investigation of selected female singing- and speaking-voice characteristics through comparison of a group of pre-menarchial girls to a group of post-menarchial girls. *Journal of Singing*, *52*(3), 33–40.

Willis, E., & Kenny, D. T. (2008). Relationship between weight, speaking fundamental frequency, and the appearance of phonational gaps in the adolescent male changing voice. *Journal of Voice*, *22*(4), 451–71, doi: http://dx.doi.org/10.1016/j.jvoice.2006.11.007.

Wise, K. (2009). *Understanding tone deafness: A multi-componential analysis of perception, cognition, singing and self-perceptions in adults reporting musical difficulties* (Unpublished doctoral dissertation). Keele University.

Young, S. (2002). Young children's spontaneous vocalizations in free play: Observations of two- to three-year-olds in a day care setting. *Bulletin of the Council for Research in Music Education*, *152*, 43–53.

Figure 24.1 Accuracy ratings of Italian children (n=28) aged 2.6 to 3.3 years in imitating song phrases and complete songs modeled by their mothers. Ratings are based on a 7-point scale of perceived accuracy

Data from Tafuri, J., *Infant Musicality*, 2008

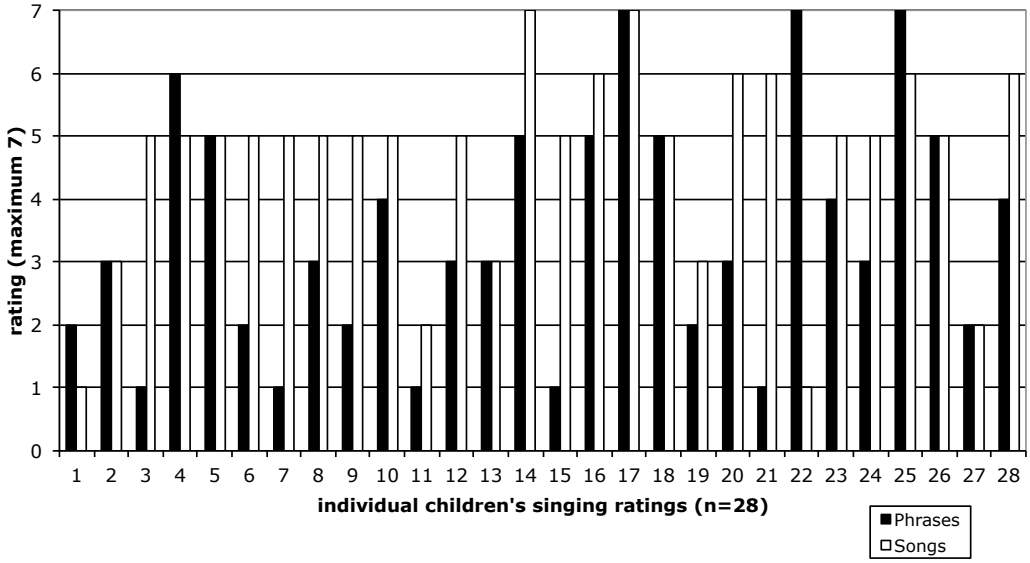

Figure 24.2 Longitudinal data on 5- to 7-year-old children's (n=184) rated singing abilities (maximum accuracy rating=7) for a) words of target songs (two songs were assessed each year); b) sung pitches of same complete songs; c) deconstructed pitch elements of the same songs (single pitches, simple melodic contours (glides), and simple melodic fragments)

Data from Welch, G. F., Sergeant, D. C., & White, P., The singing competences of five-year-old developing singers. *Bulletin of the Council for Research in Music Education, 127*, pp. 155–162, 1996, Welch, G. F., Sergeant, D. C., & White, P., Age, sex and vocal task as factors in singing "in-tune" during the first years of schooling. *Bulletin of the Council for Research in Music Education, 133*, pp. 153–160, 1997, and Welch, G. F., Sergeant, D. C., & White, P., The role of linguistic dominance in the acquisition of song. *Research Studies in Music Education, 10,* pp. 67–74, 1998.

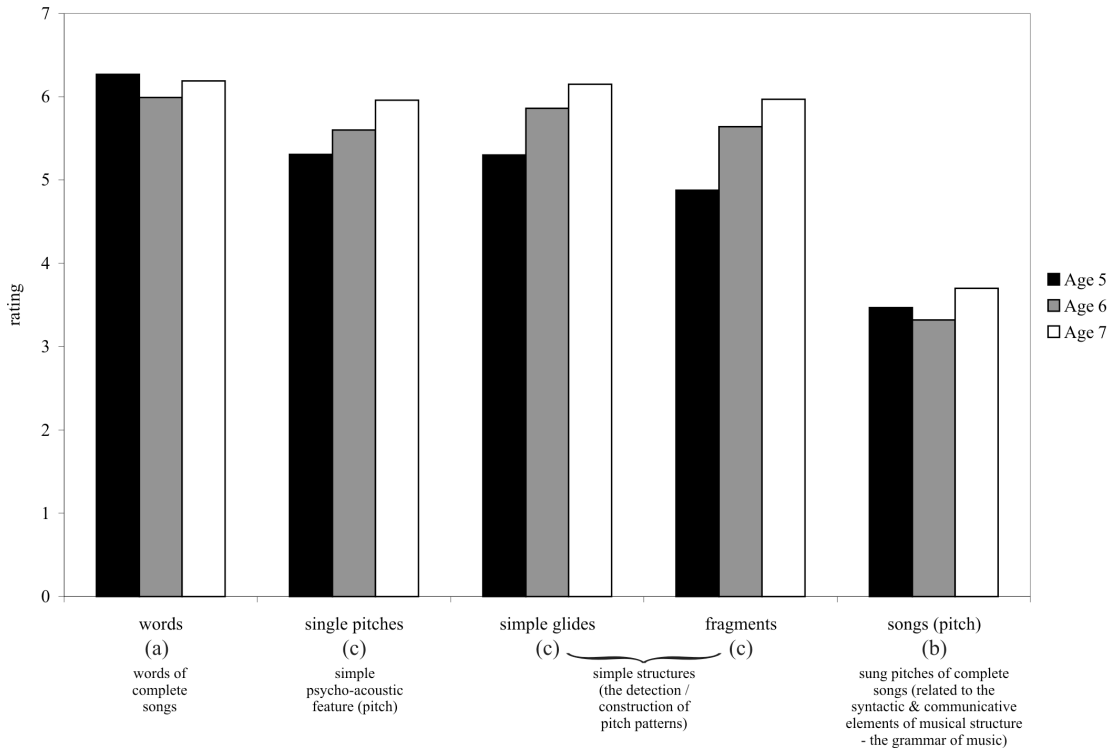

Figure 24.3 Mean normalized singing scores averages by decimal age and intervention ("Sing Up" versus Non "Sing Up")

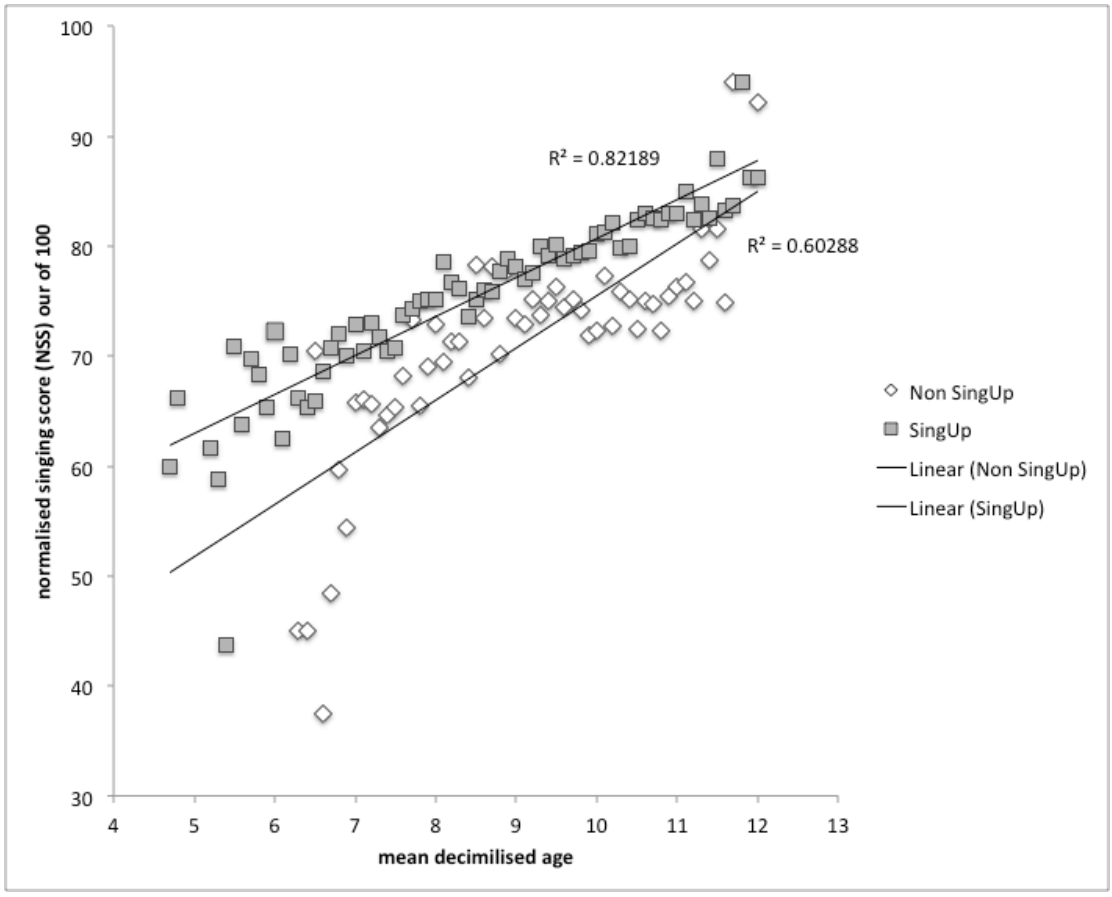

Figure 24.4 Confusability by age and gender of children and adolescents aged 4 to 16 years. The figure is extrapolated from measured data of perceived confusability for untrained singers (Sergeant et al., 2005) and measured data of perceived confusability for trained singers (Welch & Howard, 2002). Initially, untrained young boys are confused as girls. Then, the sexes become more readily distinguishable from the age of 8/9 years. However, singing training can enable girls from 8/9 years to 14 years to sound "boy-like" in certain pieces from the repertoire. From 14 years onward, singer sex becomes more readily identifiable

Data from Sergeant, D. C., Sjölander, P., & Welch, G. F., Listeners' identification of gender differences in children's singing. *Research Studies in Music Education, 25*, pp. 28–39, 2005 and Welch, G. F., & Howard, D., Gendered voice in the cathedral choir. *Psychology of Music, 30*(1), pp. 102–120, 2002.

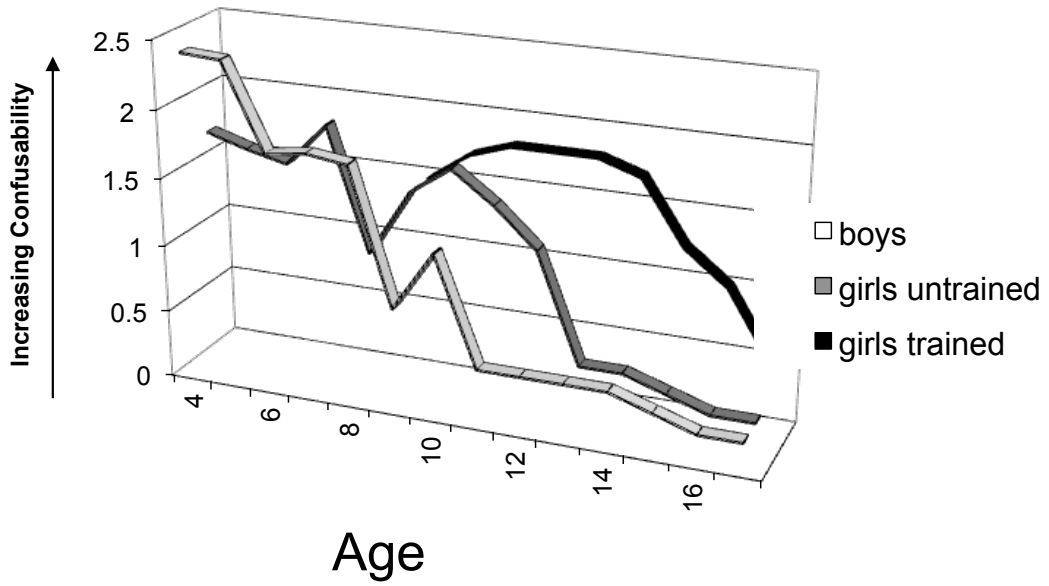

Figure 24.5a Stages of singing voice change for females (based on Gackle, 2000) and males (based on Cooksey, 2000)

Data from Gackle, L., "Understanding voice transformation in female adolescents," in: L. Thurman, & G. F. Welch (Eds.), *Bodymind and Voice: Foundations of Voice Education*. Revised Edition, pp. 739–744, 2000 and Cooksey, J., "Voice transformation in male adolescents," in: L. Thurman, & G. F. Welch (Eds.), *Bodymind and Voice: Foundations of Voice Education*. Revised Edition, pp. 718–738, 2000.

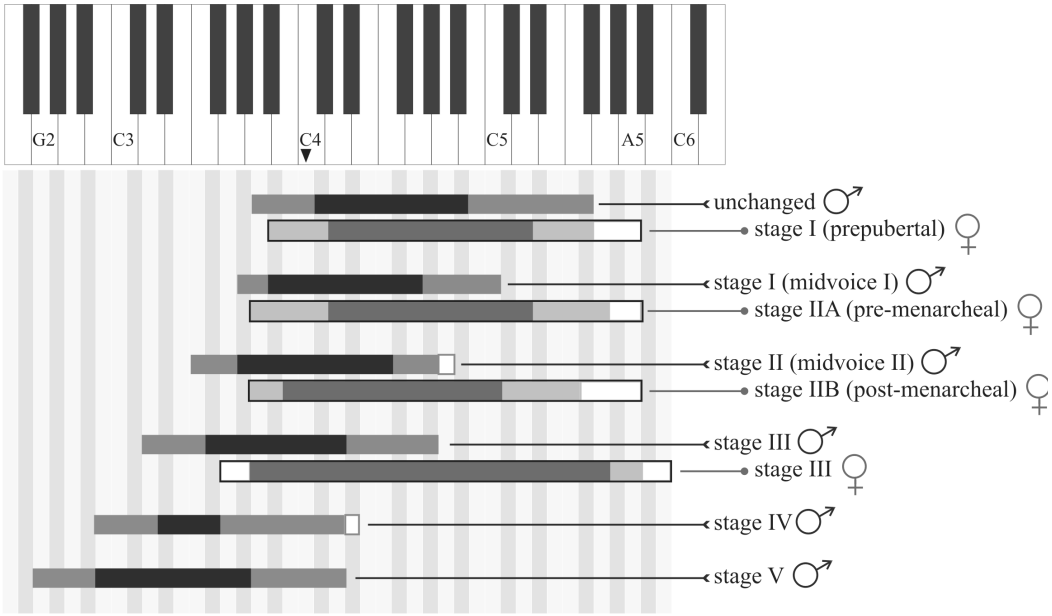

Figure 24.5b Extrapolated model of adolescent male voice change by age, based on UK (Geddye, personal communication) and Japanese data (Norioka, 1994), total n=3,188

Includes data from Norioka, Y., "A survey of Japanese school aged poor pitch singers," in: G. F. Welch, & T. Murao (Eds.), *Onchi and singing development*, pp. 49–62, 1994.