Cathedral Choirs in the United Kingdom: the professional boy chorister

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Introduction

This chapter reports on a study into the vocal behaviours of male choristers in the United Kingdom. It reflects on the challenge these boys face in giving performances of a professional standard on a daily basis, whilst also following a full school curriculum. Issues to be considered include the younger age of the onset of adolescent male voice mutation, the performance-related stress associated with participation in 'high profile' events, (such as live television broadcasts) and the academic pressure placed on boys in their school settings. In particular, this study enabled a comparative assessment of the influence of environment (boarding school) and activity (chorister training). The chapter explores how the intensive timetable of singing activity results in the boys performing at the peak of their vocal ability.

It should be pointed out why this chapter only concerns boy singers. It is a particular cultural artefact that the professional cathedral choirs in the UK, which require children to perform at the highest levels of performance, mostly have only male singers. The findings from the research could have wider implications for teachers and choral directors working with both boy and girl singers. If the specialist children assessed in this study were performing at their optimum in terms of vocal health, this suggests that intensive training with an emphasis on advanced vocal technique places children in an advantageous position. Voice researchers and clinicians may be interested in the findings related to assessment techniques. The question of appropriate use or otherwise of falsetto singing during voice change has implications for all boy singers, especially those attempting to sing in traditional SATB choirs.

Cultural background to the English Cathedral Chorister

Children have sung in the daily worship of cathedrals, abbeys and collegiate churches for fourteen hundred years; the fate of singing in the daily liturgy has been subject to much upheaval with invasions, reformation, civil war and neglect (Mould, 2007). This heritage itself arose from the Jewish practice of training Levite boys to sing psalms. In Canterbury from the start of the 7th Century, Augustine included boys from the age of seven in the

Episcopal *familia*. These boys were essentially in training for the clergy, but they would sing in the daily worship. In 680, Bede tells of a choral workshop at Wearmouth, where an expert musician gave instruction to the cantors in the "theory and practice of singing". Incidentally, for the first few hundred years of Christianity in Britain, girl oblates sang in nunneries. The re-introduction of girls into singing in modern cathedral foundations from the 1990s was controversial at the time but can be seen to have ancient roots. Child oblation would have been considered the highest honour for an Anglo-Saxon family. From the 12th Century, the practice of child oblation was dropped and boys were educated in secular cathedrals and collegiate churches where they were not bound for monastic life.

Between 1350 and 1550 there was a great flowering of church music with a huge expansion of the number of churches and chapels in which choristers could be heard. Monasteries reintroduced boys into their singing as lay-members. Adult (male) singers in the choirs were employed primarily for their musical skills and were increasingly lay clerks and not ordained clergy. Collegiate churches were established at Eton; Winchester; New College, Magdalen and Christ Church, Oxford; and King's College, Cambridge. The music itself was notated and complex; polyphony for five parts or more can be seen in the Old Hall Manuscript and in the Eton Choirbook. Little music survives from this period as much was destroyed during the following reformation of religious practice in England. We know that by the close of the 15th Century there were approaching two hundred professional liturgical choirs with boys in England. During the reformation in the 1530s, many monastic foundations were re-founded as secular cathedrals. In the final years of Henry VIII's reign, composers such as Tallis, Sheppard and Tye produced some of their finest music for cathedral choirs.

Some accounts suggest that choristers could be quite unruly; in Southwell in 1503 the choristers' vestments were 'disgracefully torn' and the boys themselves were known to 'rave and swear'. There are numerous accounts of lay clerks and organists in the late 16th and early 17th century as drunkards, gamblers, blasphemers and fornicators. There were, however, centres of excellence such as the Chapel Royal, and the sacred music of composers Purcell, Byrd, Mundy, Morley, Weelkes, Gibbons and Tomkins whose works are still central to cathedral music today. A sideline of some of the choristers in places such as Westminster, St Paul's and the Chapel Royal, was participating in dramatic performances. Some of these were at court and others were in public theatres. In the 1570s the choristers of St Paul's Cathedral had their own raised stage with seating for about a hundred people.

With the Restoration of the monarchy in 1660 following Cromwell, the destiny of cathedral music and the boy chorister went into slow decline. Between 1700 and 1850 secular music in England flourished. Opera was popular, music societies were common as were choral societies. Church music was, however, almost wholly neglected by the most able composers of the time. Chorister numbers dwindled, the boys suffered neglect and maltreatment in much the same way as other children employed in the mines and factories. A report of a Sunday evensong at St Paul's Cathedral in 1871 stated that 'at no time did there appear to be more than an irregular confused hum of children's voices, trying to sing something of which the majority seemed incapable'.

Reform of the choristers' welfare was initiated by Maria Hackett in 1811 and continued by her until the 1870s. She was an educated lady with some financial means, enabling her to devote her life to improving the welfare of choristers. This was in a small way resembling the work of Elizabeth Fry in the prisons and Florence Nightingale in nursing. By the middle of the century chorister numbers had begun to rise in many foundations.

The twentieth century has seen some changes in chorister education. Many choirs have seen the introduction, from the 1980s, of a specialist singing teacher to complement the work of the choirmaster in training the singers. From the 1990s many choral foundations have introduced girls, either to join the boys or to form a parallel choir. All but one of the designated choir schools (Westminster Abbey Choir School) have opened their classrooms to non-choristers. This means that the choristers have their daily school curriculum classes in a mixed environment of both choristers and non-choristers.

Boys are members of cathedral and collegiate choirs, of which there are a total of thirty-eight in the UK, from the age of eight to thirteen. UK chorister entry requirements are purely on musical and vocal aptitude, their education is often subsidised by the cathedral and choir school foundations. However, the socio-economic and cultural background of choristers is predominantly white (92%) and middle-class (95.6%) (2009).

Vocal loading and voice disorders

Vocal loading is defined as the stress inflicted on the vocal apparatus during periods of usage. This may be when speaking or singing. Factors known to increase levels of vocal loading are the proportion of time (within a given time frame) for which the voice is operating, the intensity (loudness) level at which the voice is operating and the level of psychological stress of the vocalist (Artkoski, Tommila, & Laukkanen, 2002; Sala et al., 2002; Titze, 1994).

If supranormal performance expectations are taken higher than is possible for the individual, the resulting collapse renders their performance level subnormal.

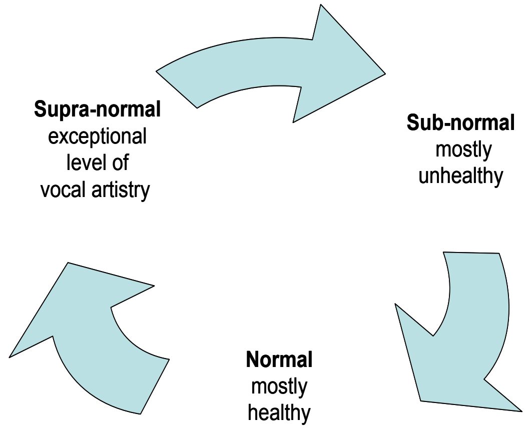

Figure 1 Schematic diagram of the cyclical relationship between vocal activity and vocal health

Any increase in pressure both in terms of academic attainment and the expectations of maturity and leadership can raise the anxiety levels of the boy and increase the possibility of vocal dysfunction. It could be suggested that these UK choristers are subject to greater vocal loading than any other professional child singer.

Some recent changes have, arguably, increased the pressure on the boys involved. They are expected to attain the same rigorous academic levels as their non-chorister peers, and to achieve a high level of performance on at least one other musical instrument. The potential for performance-related stress is greater with regular live television and radio broadcasts, these are inevitably compared with edited commercially available recordings. We have seen a drop in the age of onset of puberty in both boys and girls since the middle of the twentieth century. During the early and mid-twentieth century it was not uncommon for boys to remain on the soprano line for two or three years beyond the onset of voice change. It is now considered unwise to encourage this prolongation of exclusive soprano singing. Boys of 11 or 12 years old are now expected to exhibit leadership qualities such as prompt and accurate musical entries, advanced sight-reading skills, and exemplary discipline and behaviour both in public performances and also during choir practice.

A comparison between the boys' choirs of two major German foundations (Williams, 2004) found that English choristers are potentially subject to greater vocal loading. The proportion of rehearsal to performance time in the German choirs was 10:1, whereas in the English choirs it was 3:1. The English choristers are also required to match a mature adult sound from the alto, tenor and bass sections; the German choirs have young voices (under 18 years) throughout the choir. The training of the German choral directors is as a singer, whereas, in general, the training of UK cathedral choral director is as an organist; it is not usual for the director of music to have had any formal training as a conductor or any specific training in vocal pedagogy.

A body of research exists into the health and growth of child athletes and dancers, relating the pressures of the training to the developmental outcomes. There is also research into the vocal health of adult professional singers. When considering environmental factors such as background noise, as well as performance stress on professional adult musicians, findings suggest that musicians are perhaps not as unhealthy as they should be. There may be an element of subconscious self-regulation which is reducing the impact of these factors on the health of professional musicians. This possibility of self-regulation is a key finding of this research on boy choristers.

Vocal abuse is common among children with up to 40% of children at any time suffering from some level of dysphonia (Arnoux-Sindt et al., 1993; Sederholm, 1995). Those at risk often are involved in shouting and loud activities in play, speaking over high levels of background noise, speaking on inappropriate pitch, prolonged talking, and coughing or harsh clearing of the throat. The speech habits and voice hygiene of family members and role models can play an important role. Children with allergies, asthma or chronic upper respiratory tract infections also are at risk. Additionally, abuse of the voice is common among those who demonstrate aggressive or emotionally unstable personality traits (Brandell, 1982; Green, 1989). Fortunately, because of the adaptability of the developing larynx children are more likely to recover spontaneously from voice disorders with vocal rest.

There are five characteristics that can be used to define a problem voice (Wilson, 1979):

1. Disturbed voice quality caused by laryngeal dysfunction,
2. Hypernasality or hyponasality,
3. Voice too soft to be heard or unpleasantly loud,
4. A speaking pitch too high or too low for the age, size and sex,
5. Inappropriate inflections of pitch and loudness,

Methods of data collection

The main participants were a cohort of choristers at a major London cathedral and aged eight to thirteen years. These boys lived on site as boarders in the choir school. They had a demanding daily schedule of rehearsals and performances as well as the usual classroom curricula, and sporting and leisure activities of schoolboys of this age. Each of the participant boys' voices was recorded at six-monthly intervals over a three-year period. A subgroup of the boys was recorded at six-monthly intervals over a period of three years. The participants followed a specially designed vocal behaviour assessment protocol that embraced speaking and singing activities. The resultant vocal behaviour was recorded digitally prior to (a) perceptual and (b) acoustic analyses. Voice source data were collected in parallel to the acoustic data via an electrolaryngograph (Lx) for subsequent analysis. The Lx data represent the activity of the opening/closing mechanism of the vocal folds in running speech or singing. Recorded data was supplemented with information from questionnaires and a junior personality profile.

In order to provide a perspective on whether the choristers were typical or untypical of boys of a similar age and background, other groups of participants were recruited to provide a comparative perspective.

There were four groups of participants:

1 Choristers (boarders) from a major UK cathedral in London;
2 Their non-chorister 'day pupil' peers in the same school;
3 Other choristers ('day pupils') who were from a provincial cathedral in South East England;
4 Groups of boys who boarded in two traditional (non-music specialist) preparatory schools in South East England.

Measurement of voice: perceptual and acoustic perspectives

There are two types of assessment which are conventionally used in both laboratory and clinical settings. The main type of assessment used in this study was perceptual. The expert listener hears any deviations from an accepted standard of 'healthy' or 'normal'; these are qualified and quantified in order to reach a conclusion (Carding, Carlson, Epstein, Mathieson, & Shewell, 2000). Acoustic measurements such as observation of the long term average spectrum, or analysis of electroglottogram data can be applied as a way of reinforcing and validating these perceptual judgements.

The perceptual analysis employed in this study was of two main types. The first was a detailed assessment of many aspects of vocal function, derived from Voice Profile Analysis Scheme (Laver, Wirz, MacKenzie, & Hiller, 1981; Shewell, 2009). This is a descriptive system that allows the listener both to describe and to analyse conversational or reading voice quality. The aspects of voice use are divided into categories and individual settings of the larynx and vocal tract. Each feature is compared with a neutral baseline setting. It is a comprehensive and detailed system of analysis and is a potentially more useful tool for analysing normal voice use. In this study, 36 parameters of voice use were evaluated.

The second type was a single-score evaluation of vocal efficiency, or perceived vocal dysfunction. Dysphonia is a general term referring to any unusual or unhealthy vocal behaviour. Hoarseness is a more common term. It has been defined as the presence of hyperfunction, breathiness or roughness and seemed to be reasonably well defined and unequivocal between judges (Sederholm, McAllister, Sundberg, & Dalkvist, 1993). The nature of the perceptual evaluation in these cases was to consider aspects of laryngeal behaviour, namely: breathiness, harshness and creak. These are all known to indicate dysfunctional voice.

Both types of perceptual assessment were carried out by a panel of expert judges. These judges were taken from various professional backgrounds: singing teaching, spoken voice teaching, voice research and clinical speech therapy. This was intended to represent the wide range of training and experience from professional practitioners involved in the assessment of children's voices in the UK.

Acoustic measures used included long-term average spectrum (LTAS) and electroglottogram analysis. The LTAS shows the distribution of sound energy at different frequencies within the signal, averaged over time. In the LTAS the spectral variation from the vowels is smoothed and the peaks and troughs show the overall characteristics of the sound. In speech the LTAS will show evidence of non-harmonic 'noise' at higher frequencies, generated by breathiness in the sound, or enhanced groups of harmonics or formants. These contribute to any 'ringing' quality in the voice (Howard & Williams, 2009). From the LTAS it was possible to infer aspects of vocal health in terms of vocal quality and implied efficiency.

The Portable Field Laryngograph uses a pair of electrodes to measure current flow across the larynx. When the vocal folds are together, the current flows between the electrodes. An increase in current flow between the electrodes is plotted as a positive change on the vertical axis; as the area of vocal fold contact becomes greater, the inter-electrode soft tissue contact increases (Abberton, Howard, & Fourcin, 1989). A display of this current against time gives an indication of the degree and duration of glottal closure with each cycle. Analysis of this signal using Speech Studio will give a quantifiable reading of cycle-by-cycle irregularity in amplitude, frequency or degree of glottal contact. This irregularity is evidence of vocal dysfunction.

Vocal behaviour of choristers – perceptual analyses

Analysis of the Voice Profile Analysis data illustrated patterns of vocal behaviour and general trends exhibited by the cohort as a whole. This analysis also clarified the relevance of the categories in the VPA using factor analysis; a revised VPA assessment form was generated.

Context	Type of measure	Category	Normal/ Neutral	Sub-categories perceived as *'non-normal'* features	1	2	3	4	5	Comments (e.g. singing *vs* speech)
Observations in performance ☐	**Measures of muscular tension in the vocal tract**	Phonation Type		Harshness						
				Whisper						
				Creak						
Observations in rehearsal ☐		Velo-pharyngeal		Nasal						
				Denasal						
		Excess tension		Pharyngeal constriction						
Observations in special test ☐				Jaw – minimised range						
		Tongue		Lisp						
				Backed						
Observations from recording of special test ☐	**Measures of vocal skill and maturity**	Vocal skill		Pitch stability						
				Wide range						
		Junior voice		High pitch mean						
				Narrow pitch range						
				Easy passaggio management						
		Voice change		Modal-falsetto in speech						
				Pitch instability						
				Low pitch mean						
				Upper passaggio obvious						
				Lower passaggio obvious						
Other comments										
Health										
Self rating of voice										
Vocal ability/progress in choir										

Figure 2 Revised Voice Profile Assessment form for use with children and especially trained child singers

Analysis of the single-score evaluation of vocal efficiency gave some interesting results. Figure 3 shows the perceived vocal health of non-chorister boys. The x-axis is the degree of perceived dysphonia with 1 being clear and 7 being voiceless. The y-axis shows the percentage of the whole sample. This chart showed that boarders had a higher incidence of perceived dysphonia at level 4 and a lower incidence of perceived dysphonia levels 2 and 3 than non-boarders. This suggested that the boarding environment may have caused a higher level of voice disorder. This agreed with the current literature (Casper, Abramson, & Forman-Franco, 1981; Sederholm, 1996) referring to the increased likelihood of voice disorder in children who spend a large part of each day in noisy environments.

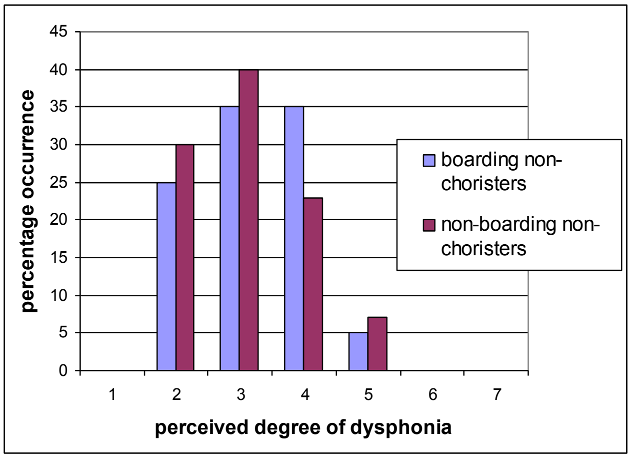

Figure 3 Non-choristers; a comparison between the perceived dysphonia of boys who are boarding and non-boarding

Anecdotally, anyone who has been into a school dining room will have observed that the level of background noise in the school environment is particularly high during mealtimes and playtimes. Individuals trying to make their voices heard above this noise will be using more vocal effort, higher intensity and a greater force of vocal fold collision. All of these factors are contributory to the development of vocal disorders. For children attending a day school, their environment changes when they leave school at the end of the day (normally between 3.30 and 4.30pm). They are more likely to go to homes which are quieter than school. In a boarding school, individuals may be in noisy environments for a much greater part of the day. These data in Figure 3 show a higher incidence of vocal dysphonia in the non-chorister boys attending boarding school, and suggest the possible effect of this environment on the level of perceived voice disorder.

Considering that the choristers not only boarded but also sang for many hours a week, resulting in an even greater vocal loading, we may have expected to have seen an even higher incidence of perceived vocal dysfunction. However, their underlying vocal health appeared to be significantly better than that of the non-choristers as shown in Figure 4. The choristers have a lower incidence of perceived dysphonia in level 4 and a higher incidence in levels 2 and 3. This would suggest that, although they have been exposed to an environment encouraging a greater vocal loading, they have learned vocal behaviours to reduce their level of dysphonia within this environment.

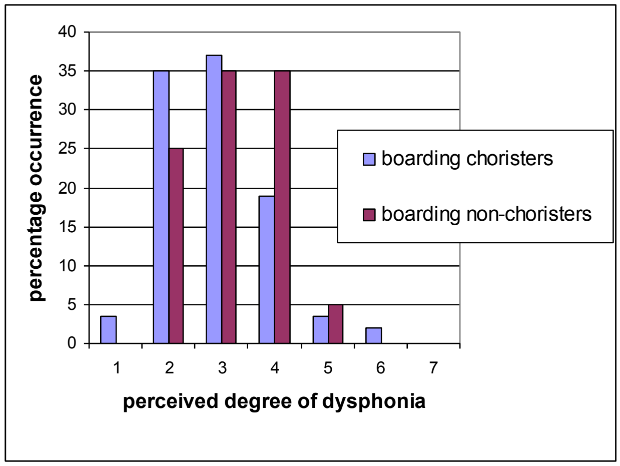

Figure 4 Boarders; a comparison between the perceived dysphonia of boys who are choristers and non-choristers

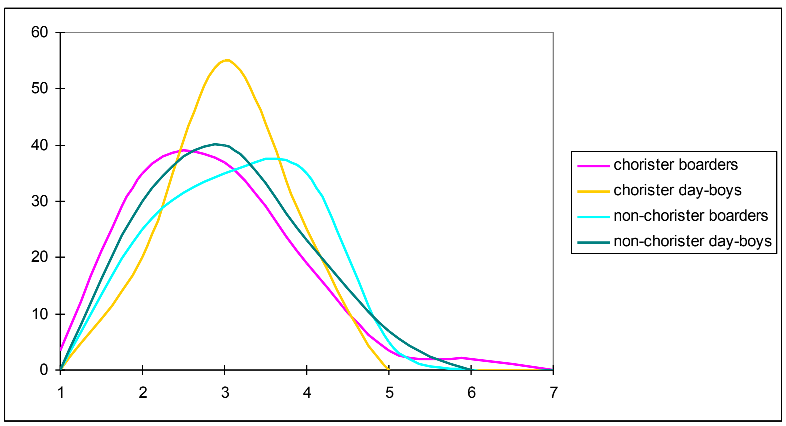

Figure 5 The distribution of perceived vocal dysfunction of all four groups. The x axis is the perceived level of dysfunction with 0 as healthy and 7 as voiceless. The y axis is the percentage frequency of occurrence of each level within the group.

The distribution of the perceived vocal dysfunction for all four groups can be seen in Figure 5. Figure 6 shows the box plots for the perceived vocal dysfunction of each activity group. There is a greater spread of scores for the non-chorister non-boarders. There is one outlier from the non-boarding non-chorister group; he has a particularly high score for perceived vocal dysfunction. He may have been suffering from an acute respiratory tract infection on the day of recording; this is itself is a totally normal occasional occurrence in every child. It was not possible to separate the cases of perceived dysphonia as a result of illness, from that as a result of poor habitual voice use. It was assumed that respiratory tract infections would be occurring to some degree in all of the groups of boys.

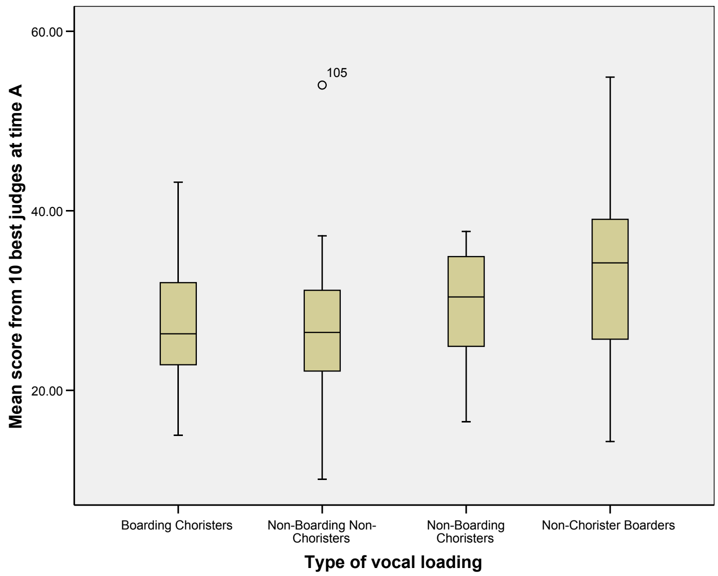

Figure 6 The median ratings (50th percentile) and standard deviation for the four different activity groups.

There was a statistically significant difference between the perceived vocal health of boarding choristers and boarding non-choristers (Table 1).

Table 1 Comparisons of perceived levels of dysphonia between the four different activity groups; dependent variable: mean score for ten best judges

(I) Type of vocal loading	(J) Type of vocal loading	Mean difference (I–J)	Std. error	Sig.	95% Confidence interval	
					Lower bound	Upper bound
boarding choristers	non-boarding non-choristers	.413	2.102	.845	-3.751	4.577
	non-boarding choristers	-2.596	2.315	.265	-7.182	1.991
	boarding non-choristers	-6.555(*)	1.938	.001	-10.393	-2.717
non-boarding non-choristers	non-boarding choristers	-3.009	2.378	.208	-7.719	1.702
	boarding non-choristers	-6.968(*)	2.012	.001	-10.953	-2.982
non-boarding choristers	boarding non-choristers	-3.959	2.234	.079	-8.384	.466

* The mean difference is significant at the 0.05 level.

This suggests that the chorister factor is significant for ratings of vocal health. The position of Cathedral Organist and Director of Music was subject to a new appointment one-third of the way through this longitudinal study. This fact probably rules out the possibility for the data to be significantly influenced in the long-term by the training methods of one individual, although there may be a dominant culture in cathedral music that transcends the individual, given that the adults are often likely to be ex-choristers.

There was a significant statistical difference between the boarding non-choristers and the non-boarding non-choristers, which suggests that the boarding factor is significant for ratings of vocal health, as observed by the increase in the incidence of perceived vocal dysphonia in the boarders. There are still differences (although not statistically significant) between all of the groups except the boarding choristers and the non-boarding non-choristers. This is also illustrated in the distribution graph, Figure 5.

Looking at the distribution of the scores, one can observe that the choristers in fact have a higher incidence of low-level disorders. This suggests that they were indeed vocally fatigued, but that their vocal health tended not to degenerate beyond a certain level. It suggests that they are either athletically conditioned to support these activities, and/or that they are self-regulating their voice use at all times in order to maintain a healthy vocal system. One could hypothesise the reasons for this. It is possible that this is a result of education, persistent and regular reminders, but it is more likely that the boys will only modify their behaviour if there is a tangible pay-off for them. It would only take a few occasions on which they have missed an opportunity as a result of over-use of their voice for them to learn to self-regulate. This of course applies to all of their voice use, especially in sport and social contexts. Furthermore, the collective singing voice of the choristers as a group is presumably 'healthy', so it is likely that any one individual would have their own individual sound and underlying vocal behaviour shaped by the collective, i.e., there is convergence within the group towards sounds that are more healthy and, as part of a virtuous circle, such healthy sounds tend to condition the voices to sustain this type of production.

From informal discussions with the boys, it is evident that they are consciously aware of their voice use in the choral environment and make adjustments accordingly. A senior boy may give a strong lead at the start of a musical phrase in order to give confidence to the younger boys; he may then ease off vocally once the phrase is underway. In sport and social contexts it is much less likely that the boys will be consciously regulating their voice use. Listening to them in the playground would suggest that they are free and uninhibited with their voice use. The evidence from the distribution of ratings would suggest, however, that caution is being exercised at some level, conscious or subconscious, at all times. A similar caution can be observed when one is watching young pianists and string players from a specialist music school when they are playing competitive team sports. It is much less tactile and confrontational as a result of their self-regulatory care.

It is possible that the choristers in the London cathedral had healthier voices from the outset of their training as a result of the selection procedure. It was possible to assess the baseline vocal health of the London choristers before any training, as the first set of recordings were made in the first week of term. The boys new to the choir at this time (probationers) would not have been influenced by their training or by the increased vocal loading of the boarding chorister schedule. A statistical ANOVA test was made to compare the means of the vocal health scores from the London probationers with the equivalent age of boys from both the non-boarding non-chorister environment, and the boys from the non-boarding chorister environment. The analysis shows a significance of .690. For the probationer group to have a significantly healthier voice use than the other boys, this figure would need to be less than .05. From this it can be assumed that the boys selected as choristers in the London cathedral do not have healthier or unhealthier voices than their non-selected peers. Any subsequent significant difference in vocal health is likely to be as a result of experience and learned behaviour.

The results of the tests for personality type showed that the boys with the highest score for perceived vocal dysfunction also had unusually high scores in either extroversion or neuroticism. This has been shown to be the case in previous research on Swedish non-choristers (Sederholm, 1996). One final observation was that there was a striking similarity between the boys who are both boarders and choristers, and the boys who are neither boarders nor choristers. These two groups had very different activities, but happen to go to the same school between 8.45 and 3.30, Monday to Friday. Perhaps the influence of peer group on voice use is more powerful than either that of activity or voice education (Wiltermuth & Heath, 2009).

Vocal behaviour of choristers – acoustic and voice-source analyses

In order to make comparisons between recordings, it was important to calibrate the sound pressure level of each recording. All LTAS plots are calculated to absolute dB SPL values.
The LTAS graphs are shown with both a linear and a logarithmic frequency scale. The logarithmic scale represents our aural perception more closely and provides more detail regarding the lower frequencies. The upper frequencies (1000 to 10000Hz) show other timbral factors of the voice. These upper frequencies are more clearly observed in the linear frequency scale. The creaky, breathy and harsh voice examples were selected as samples which had been given a high score for these particular qualities on the VPA, but not high scores in other voice qualities. In most cases, however, these voice qualities occurred in various combinations.

Creaky voice

Figures 7 and 8 show the LTAS for two examples of creaky voice, alongside one example of healthy voice. The creaky voices have a lower intensity from 100 to 5000Hz; above this the intensity rises. This shows a level of higher frequency noise in the signal, possibly generated by 'noise' from air escaping through a constricted larynx.

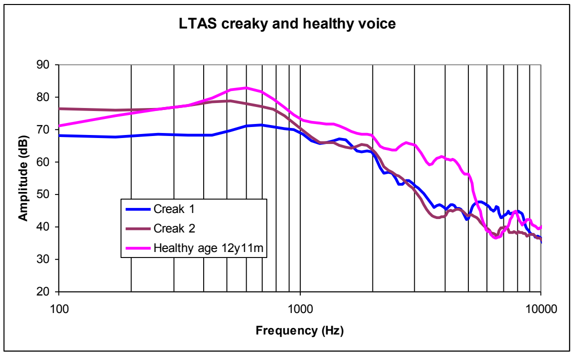

Figure 7 LTAS of two examples of creaky voice and one example of healthy voice (pink line), using a logarithmic frequency scale

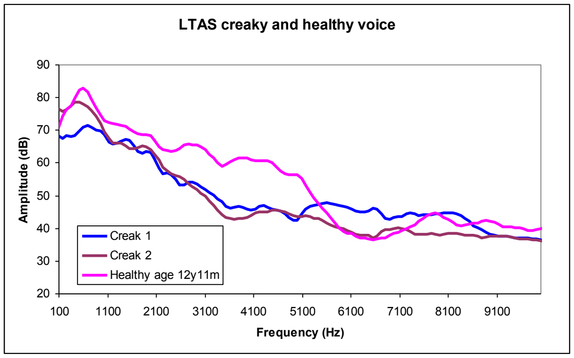

Figure 8 LTAS of two examples of creaky voice and one example of healthy voice (pink line), using a linear frequency scale

Breathy voice

Figures 9 and 10 show examples of breathy voice in a LTAS. They show a characteristic rise in intensity of the upper frequencies (above 10000Hz) created by 'noise' as air rushes through the glottis. The orange line is a particularly weak intensity; it is at least 10dB lower than the healthy voice signal. This difference makes the breathy voice half as loud as the normal one (Howard & Angus, 1996, second edition 2001). This boy is unable to project his voice effectively due to the inefficiency of the breathy phonation.

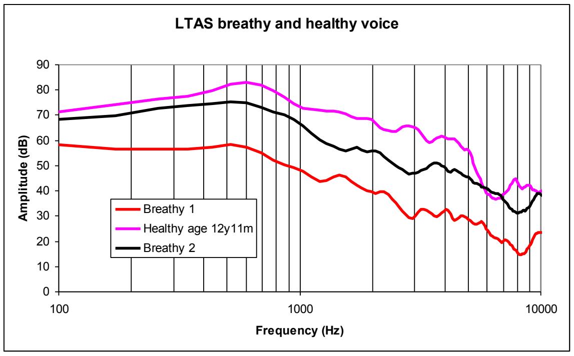

Figure 9 LTAS of two examples of breathy voice and one example of healthy voice, using a logarithmic frequency scale

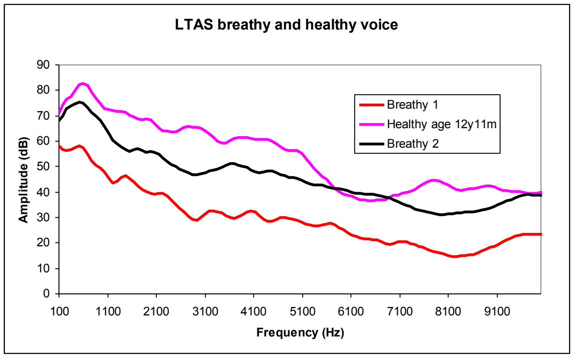

Figure 10 LTAS of two examples of breathy voice and one example of healthy voice, using a linear frequency scale

Harsh voice

Figures 11 and 12 show the LTAS of a harsh voice. This has a similar spectral profile to the healthy voice, but it is at a significantly lower amplitude; this voice quality is less efficient at projecting.

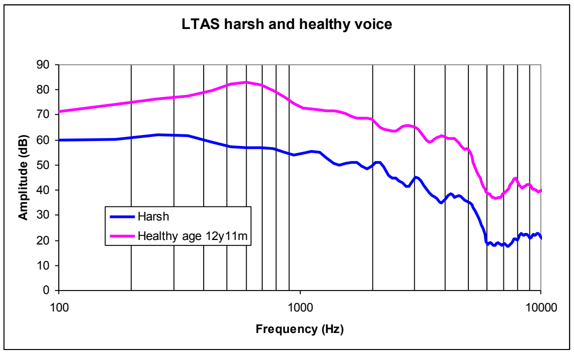

Figure 11 LTAS of an example of harsh voice and an example of healthy voice (pink line), using a logarithmic frequency scale

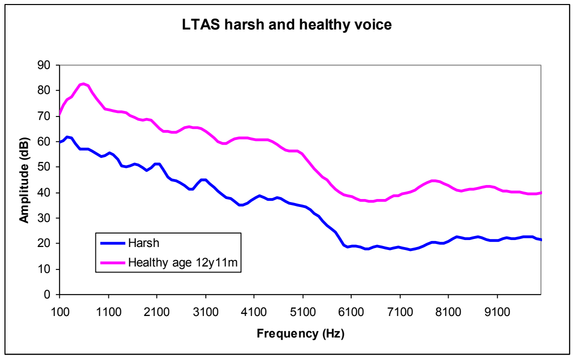

Figure 12 LTAS of an example of harsh voice and an example of healthy voice (pink line), using a linear frequency scale

The observation of the elements seen in the LTAS was unsurprising. Creaky voice had evidence of irregular vocal fold vibration; creaky, breathy and harsh voice showed a reduced ability for loud phonation. The analysis of the laryngographic waveform gave more detailed results. These showed evidence of irregularity in the vocal fold vibrations in all cases. Breathy voice showed a significant proportion of the vocal fold collisions to have inefficient closure (97%). Creaky voice had a marked irregularity in the degree of vocal fold closure with a small figure for coherence (17%). Harsh voice showed irregularity in the cycle by cycle amplitude measurement with a coherence of 23%.

Lx waveform of a voice in the early stages of voice change

The laryngographic (Lx) waveform gives information of the degree of vocal fold closure. This can be used to assess the efficiency of phonation (steeper closing slope, longer closed phase) and can show the changes in vocal fold closure patterns with the onset of adolescent voice change.

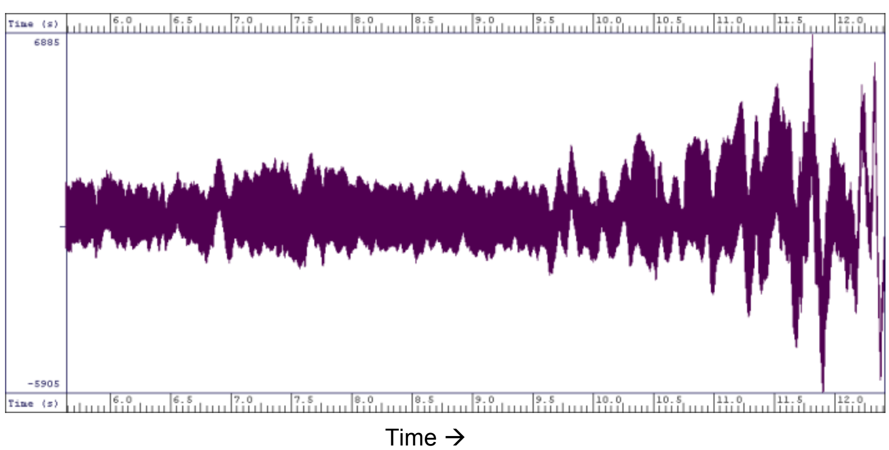

Figure 13 The Lx waveform of boy H aged 12 years, 0 months (pre-puberty), singing a descending slide from G5 to G3

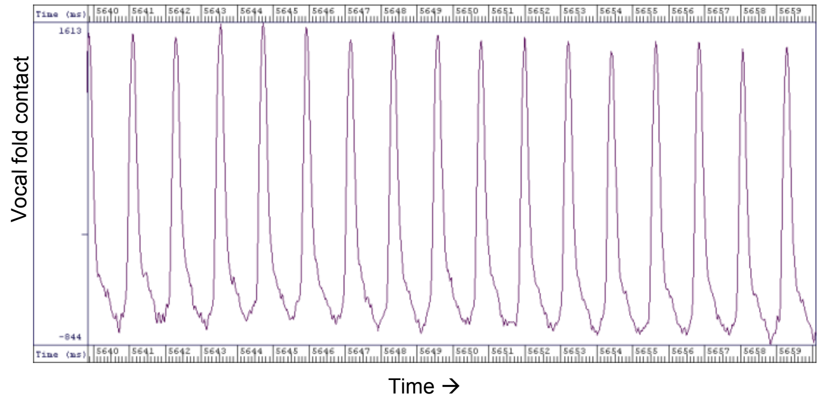

Figure 14 Selected portion of the Lx waveform of boy H aged 12 years, 0 months, singing G5 from a descending slide from G5 to G3

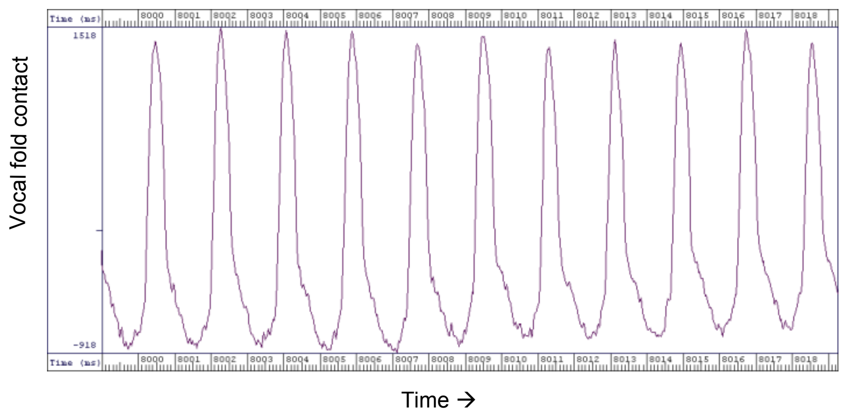

Figure 15 Selected portion of the Lx waveform of boy H aged 12 years, 0 months, from a descending slide from G5 to G3

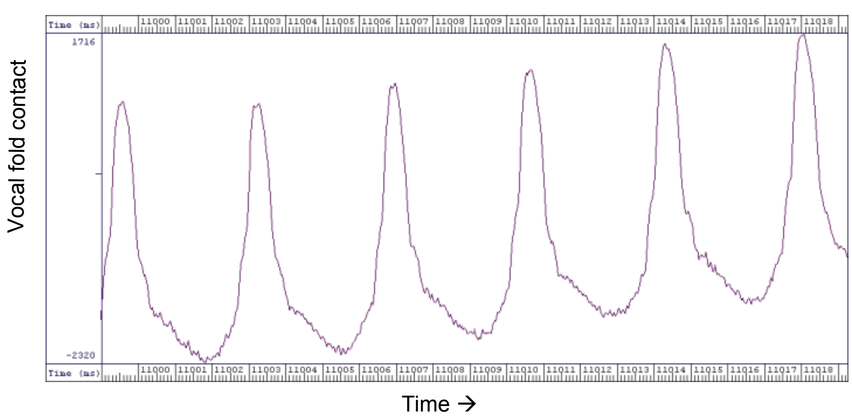

Figure 16 Selected portion of the Lx waveform of boy H aged 12 years, 0 months, from a descending slide from G5 to G3

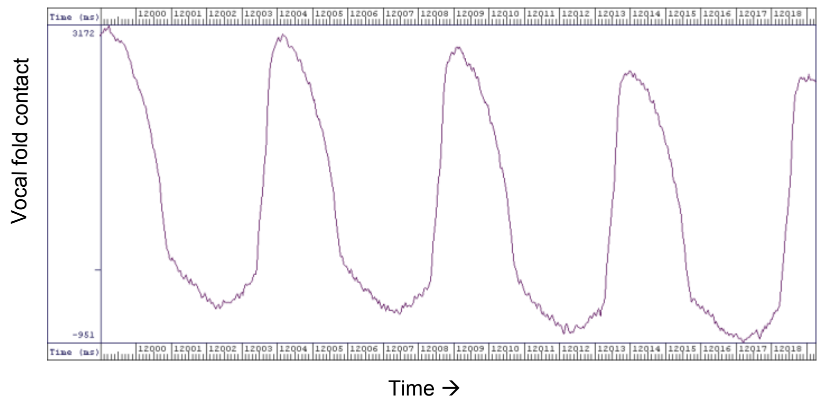

Figure 17 Selected portion of the Lx waveform of boy H aged 12 years, 0 months, singing G3 from a descending slide from G5 to G3

Figures 13 to 17 show the vocal fold closure pattern over a two-octave pitch range in an unchanged voice. Each window showing a selected portion of the waveform is of 20ms duration; there are fewer cycles at the lower pitches as the frequency is lower. This boy shows a fairly consistent pattern of closure over the pitch range. Figure 18 shows the whole two-octave pitch range; pitches where the larynx is functioning with a degree of instability are seen as disturbances to the overall pattern of the waveform. These are the passaggio points between vocal registers and are circled.

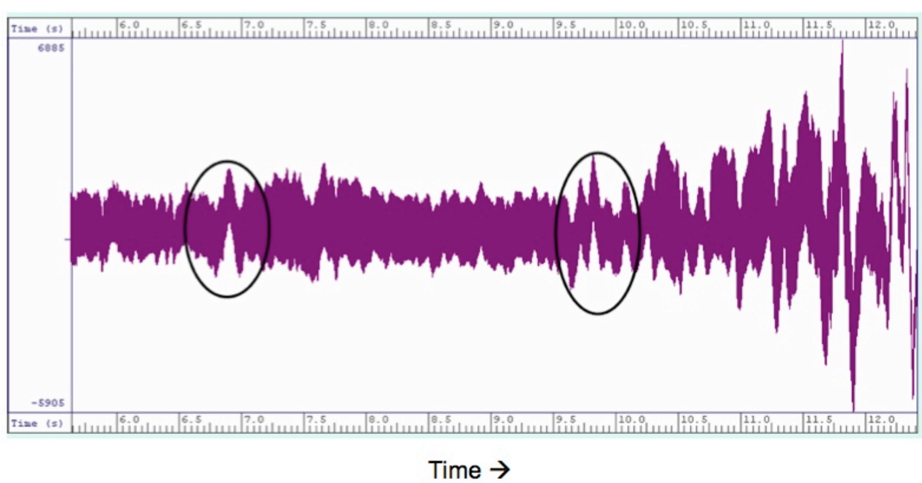

Figure 18 The laryngographic waveform of a two-octave slide showing the two passaggio points marked

Lx waveform of a voice at the mid-point of voice change

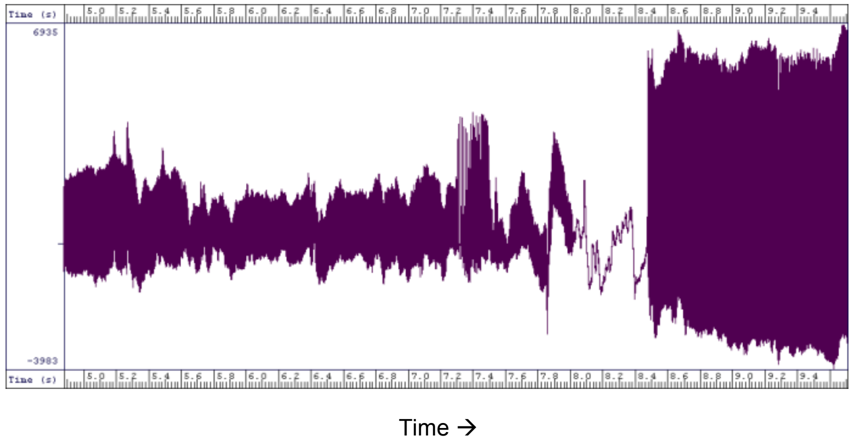

Figure 19 The Lx waveform of boy H aged 13 years 10 months, singing a descending slide from G5 to G3

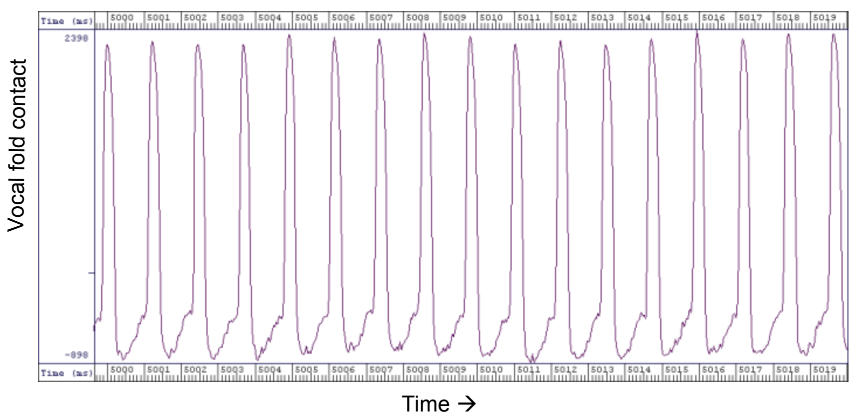

Figure 20 Selected portion of the Lx waveform of boy H aged 13 years 10 months, singing G5 from a descending slide from G5 to G3

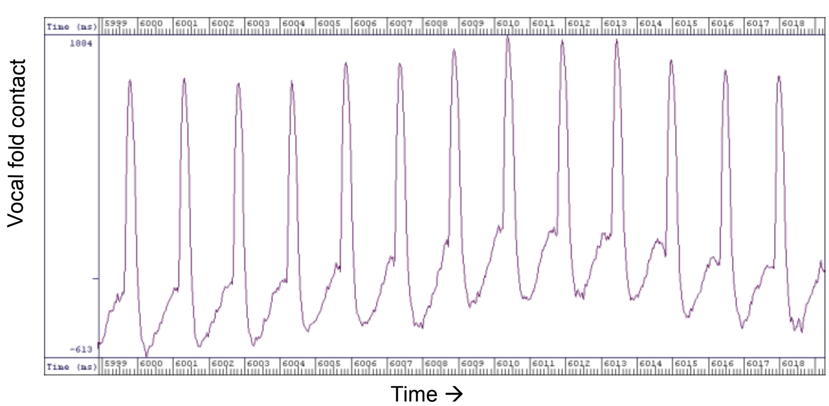

Figure 21 Selected portions of the Lx waveform of boy H aged 13 years 10 months, from a descending slide from G5 to G3

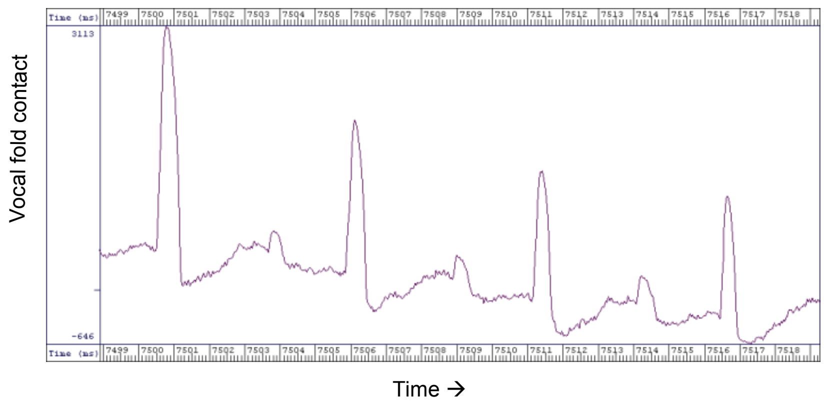

Figure 22 Selected portions of the Lx waveform of boy H aged 13 years 10 months, from a descending slide from G5 to G3

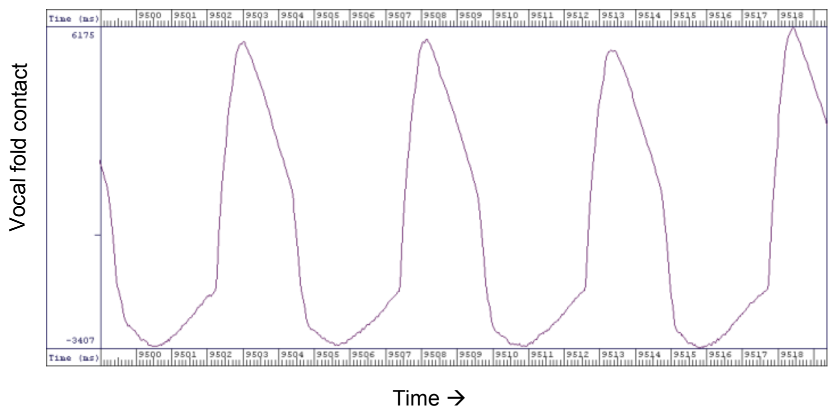

Figure 23 Selected portion of the Lx waveform of boy H aged 13 years 10 months, singing G3 from a descending slide from G5 to G3

These Figures (19 to 23) show a noticeable difference in vocal fold contact patterns over the two-octave pitch range. At the lower pitch (G3) the closed phase is longer and the opening slope has a 'knee'. This is typical for thick-fold phonation of the adult voice; the 'peel apart' of the lower edges of the vocal folds is at a slower rate than the mid to upper edges.

The second-lowest pitch in figure 22 shows extreme instability in the waveform. There appear to be two peaks, one strong and one weak. This is caused by an irregular vibratory pattern leading to weakness in alternate vocal fold collisions. Aurally, this is heard as diplophonia, or two pitches sounding simultaneously. The stronger collisions are heard as a pitch an octave lower than that of the combined collisions; these two pitches are heard at the same time giving rise to the phenomenon of diplophonia. This irregularity occurs at the main register transition point between thick-fold (speech quality) and thin-fold (upper range).

The upper pitches in the recordings of boy H at the mid-point of voice change are surprisingly close to those of the same boy when unchanged. The waveform is not that of falsetto singing, which would typically be a sinusoidal pattern. It appears to be closer to the phonation used by children and adult females at this pitch. It is possible that, as the larynx grows, the boy retains the ability to sing with the soprano sound. Although this has not been longitudinally assessed in boys undergoing voice change, it is known that trained male alto singers use a similar phonation, rather than the pure falsetto used by untrained adult male singers in their upper range.

Analysis of the rate of vocal fold closure over time

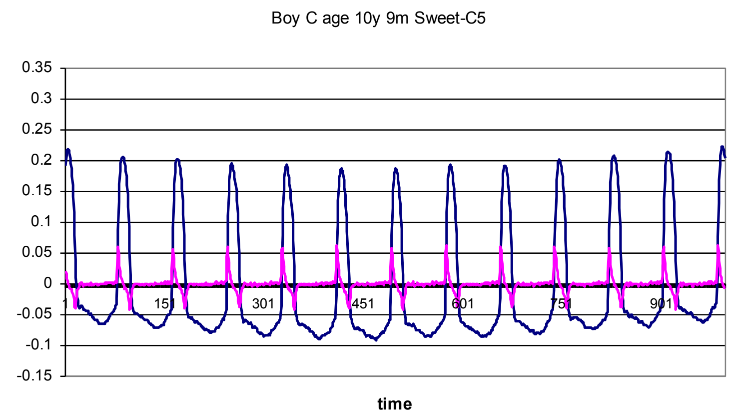

Figure 24 Efficiency of vocal fold closure in boy C at C5, aged 10 years 9 months

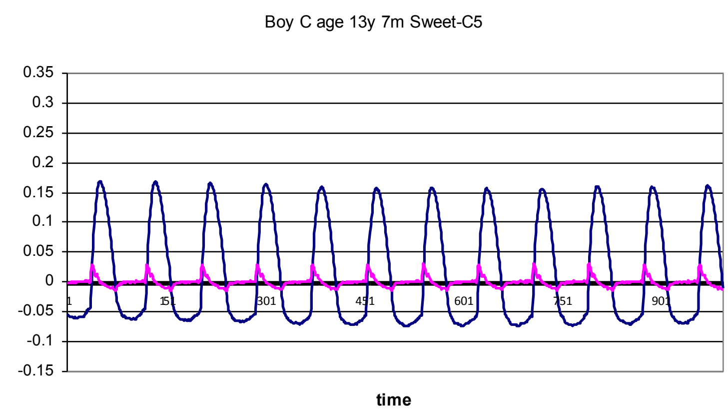

Figure 25 Efficiency of vocal fold closure in boy C at C5, aged 13 years 7 months

Figures 24 and 25 show the Lx waveform of the upper pitch range of another boy, Boy C. The superimposed line in pink shows the steepness of the rising part of the curve; this indicates the rate of closure of the vocal folds. The earlier recording, Figure 26, shows a more rapid vocal fold closure. This not only produces a stronger excitation impulse but also boosts the higher frequency spectral component (Howard & Murphy, 2008). This can be seen in the LTAS in Figures 26 and 27. The earlier recording with the more rapid closing phase of the vocal folds has a boost of frequencies in the upper range (4000–5000Hz) which is not seen on the later recording. The voice use of the boy when older was perceived to be more constricted, evidence of this can be seen by the longer closed phase on Figure 27, but it is less acoustically efficient.

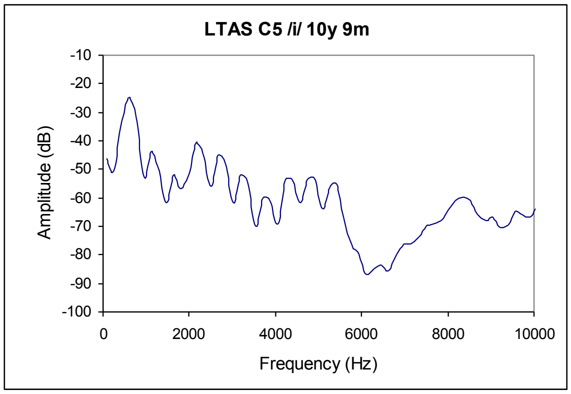

Figure 26 LTAS of /i/ vowel on C5,

Boy C aged 10 years 9 months

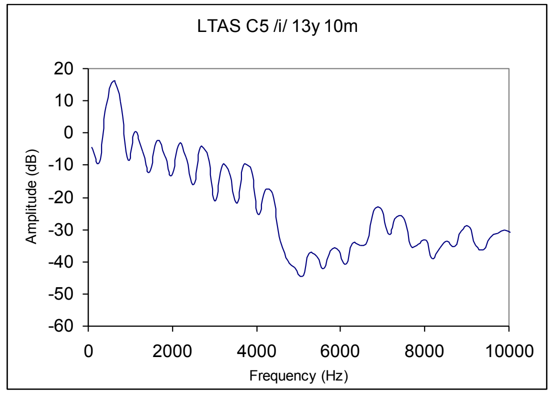

Figure 27 LTAS of /i/ vowel on C5,

Boy C aged 13 years 10 months

The comparisons of the Lx waveform before and during adolescent voice change did not necessarily show any evidence of the emergence of a falsetto phonation in the upper pitch range at this stage of development. Cooksey states, however, that in Stage lll of voice change, falsetto phonation is evident in the upper pitch range (Cooksey, 2000). It is possible that the technical skills exemplified by the boys at this stage of their chorister careers enable them to undergo the transition with greater continuity. This may give some insight into the way in which professional male altos use a type of hybrid phonation (Harris, Harris, Rubin, & Howard, 1998), using both falsetto and the thin-fold which tends to be associated with the upper pitch range of children and adult females (Doscher, 1994). This is presumably a learned skill, assuming that the individual has some physical aptitude for this thin-fold phonation. Due to the relatively small number of highly-trained choristers assessed in this study, there were only four who were undergoing voice change during the research period. The Lx waveform for each of these four boys was analysed and the same pattern of upper voice phonation was observed. This may not necessarily be the case in all trained choristers, and is unlikely to be the case in less experienced singers.

These findings could inform the practice of singing teachers and choir trainers. The current advice to boys during voice change tends to be to sing in the lowest comfortable pitch range for the duration of this time. These results may suggest that it is possible to maintain a singing voice with a high tessitura, at least for some of the time, during the early stages of voice change, and that the generally given advice may not necessarily apply to skilled boy choristers. This is integral to an ongoing debate between advocates of Cooksey's advice and that of Phillips and Leck. They represent two schools of thought regarding the stages of voice change for males. The first, or "limited range" school believes that boys' voices change predictably, lowering gradually according to a rather prescribed pattern. Irvin Cooper was the originator of this theory (the "Cambiata" concept); two of his students continue to advocate this approach: Don Collins (founder of Cambiata Press) and John Cooksey (the "Eclectic" theory). Cooksey (1992) expands upon Cooper's work and now includes five stages for the male pubertal voice during change. The second, or "extended range" school believes that boys' voices can change slowly or quickly and may not be limited to a midvoice comfort range of an octave or less during puberty. Frederick Swanson was the originator of this school and contemporary advocates include Henry Leck (2009) and Kenneth Phillips (2004). The Cooksey system of five stages may be a useful guide for less experienced teachers and singers. It is relatively simple to grasp, and it is unlikely to be misinterpreted. The 'extended range' school may be more applicable to experienced boy singers, who may have a larger accessible pitch range. This would need further research before it could be assumed to be sound pedagogical recommendation.

It is also interesting when cultural and historical perspectives are considered. There are a number of early recordings of boy singers using their upper (soprano) pitch range with a high level of vocal artistry and skill (Beet, 1998). Some of these boys were mid- or post-puberty: this can be heard on the one or two rare spoken interviews with them and it can be seen from photographs. As observed from the Lx data, some boys are able to retain their soprano voices whilst their larynx is growing in power and stamina, especially if these early phases happen relatively fast. The boys on these recordings were reported to have stopped singing when their voices 'broke' (often at the age of 17 or 18). As this event came some time after they had undergone adolescent voice change (probably at the age of 13 or 14 years), it is only possible to conjecture what may have precipitated this 'breaking' and what was happening physically. It is conceivable that the reported 'breaking' was a sudden inability of the laryngeal structures to sustain this thin-fold phonation as the larynx became less pliable in early adulthood. At the time of writing, maintaining the practice of singing in the soprano range after the onset of voice change is not generally popular amongst boys. There is no evidence to suggest whether or not this could be potentially harmful physically in terms of vocal habits persisting into adult singing.

Conclusion

This study set out to investigate the vocal health and development of intensively trained boy choristers. This was in the context of a relative paucity of scientific research on the singing voices of healthy or 'normal' children and no published research, at the time, in the field of acoustics and psychoacoustics relating to the vocal health or behaviour of children trained in choral singing to a professional level.

Some of the outcomes from the study are:

- Intensively trained boy choristers, despite high levels of vocal loading, have healthier voices than their non-chorister counterparts. Choristers have a higher incidence of low-level vocal dysfunction, suggesting that their voices are slightly fatigued most of the time. They rarely exceed these levels to exhibit higher levels of vocal dysfunction. Choristers probably employ self-regulatory caution with their voice use at all times in order to ensure that they do not exceed certain levels of vocal fatigue. They may also athletically condition their voices to cope with the high vocal loading.

- When measuring detailed voice use of the individual, the Voice Profile Assessment form is the most appropriate; a revised version of this has been suggested in the light of statistical analysis of the data.

- When measuring broad comparisons between groups of this sort, a single-score evaluation of vocal health is most appropriate as the resulting data has sufficient specificity for analysis using SPSS.

- When entering voice change, trained boy singers do not use falsetto phonation in the upper pitch ranges; they use a form of phonation more commonly observed in adult male countertenor and adult female singers – this has implications for voice training during this period of development. When they are actually capable of singing both parts, should they sing soprano or baritone?

- When entering voice change, boys may exhibit attributes of less healthy phonation as a consequence of the rapid growth of the larynx, and not as a result of unhealthy voice use. This has implications for voice assessment practices of voice health professionals and singing teachers.

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