

Nature or Nurture?

An investigation into the singing voices of untrained boys and girls with reference to the English choral tradition

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Abstract

In the thirty years since Salisbury became the first Cathedral to introduce girl choristers, debate about the merits of boys' voices compared to girls has continued apace. This paper attempts to give some clarity as to whether boys really do have a naturally 'special' voice, or whether the difference between boys' and girls' choirs (if, indeed, there is one at all) is a result of nurturing, and formal training. The investigation presented here attempted to measure the voice at a point where nurture will have had least impact, using untrained boys and girls in Key Stage 1, and asking them to produce simple steady-state vowels. The experiment found small differences in formants, with girls' voices producing slightly higher frequencies (depending on the vowel). However, with significant variation within each sex, and the difficulty perceiving this difference in a choir setting, the results are not considered grounds for the preferencing of choirboy over choirgirl. Subsequently, the discussion section of this paper assesses other reasons why the tradition may have excluded girls for so long, including consideration of the culture of choirboy and the early gendering of the singing voice.

Introduction

The debate between nature and nurture has been raging across the academic spectrum for centuries¹. In 1903, Thomas Edison described genius as "one per cent inspiration and ninety-nine per cent perspiration" (quoted in Newton 1987: 24), and yet the phrase '(s)he was born with it' remains a common reaction to extraordinary talent. It has become commonplace to view singing in these terms, as an activity one either can or cannot do, and this favouring of nature over nurture goes hand-in-hand with a reverence for tradition. Those who believe an activity is naturally imbued will perhaps inevitably oppose changes to tradition because it challenges their assertion that only a section of the population is up to the task.

The English Choral Tradition has been predominantly male for more than a millennium². The primary justification for this has always been natural quality; the organist Simon Lindley, for example, claims "The fact is that the sound of the singing boy has been felt for century upon century to be very special and particularly appropriate for worship"

¹ The term has been used in English since at least Shakespeare (*The Tempest* 4.1: *a born devil, on whose nature nurture can never stick*). For more information on the debate, see (McLeod, 2018)

² The tradition of boy trebles singing in the country's cathedrals dates back over a millennium to 909, when the first boys are recorded as singing at Wells Cathedral

(quoted in Wickham 2016). And yet, since Salisbury became the first cathedral to establish a choir of girl choristers in 1991, female treble lines have thrived to such an extent that there are now equal numbers of boy and girl choristers across the country (Burgess 2019).

The speed of this change forces us to question whether nature was ever the driving force of all-male choirs, or whether the “unique choral sound” (Eaglesham 2015) of boy trebles was simply the result of opportunity and training. The emotive nature of this debate has led to a number of polemical articles on each side,³ but the complicated nature of measuring young voices, particularly before the age of ten, has prevented a broad consensus from emerging (though the apparent recent dissolution of the Campaign for the Traditional Cathedral Choir,⁴ much quoted in such articles and for many years an outspoken critic of girl choristers, perhaps implies some movement in the debate).

This investigation attempts to give a clearer answer as to whether boys really do have a naturally special voice, or whether the difference between boys’ and girls’ choirs (if, indeed, there is one at all) is a result of nurturing, and formal training. In order to do this, this article will draw together the existing research, before conducting a new study into young voices, focusing on vocal formants. The discussion section then aims to understand what this research means for the choral tradition, as well as examining the role of gender expectations in shaping the musical landscape.

Timbre and the science of singing

The Oxford Dictionary of Music defines timbre as “tone-colour; that which distinguishes the quality of tone or voice of one instrument or singer from another” (Kennedy 2012). Likewise, Pratt and Doak, consider timbre “that attribute of auditory sensation whereby a listener can judge that two sounds are dissimilar using any criteria other than pitch, loudness, or duration.” (cited in Rossing 2014: 135). In essence, timbre is the particular *quality* of a sound that separates it from another sound.

Given it should be possible to train both boys and girls to the same basic level of vocal skill such that they are able to sustain a note at the same volume and duration with equal ability, we must focus on timbre, and what impacts it, to understand if there is any biological - or perceptual - difference between the voices of boys and girls at a young age. To do this we must understand the nature of musical sounds, and the mechanisms of the vocal organ.

Music, and indeed all sound, is created when a sound source vibrates, thereby causing the particles in the air to vibrate at the same frequencies. Once these vibrations are detected by the auditory system, they are decoded by a number of mechanisms within the ear, before being conveyed to the brain from the basilar membrane.

In singing, sound is created by the vocal folds in the larynx. These two small ligaments rapidly open and close, changing the rate of the flow of air from the lungs and producing

³ For example, see (Swift, 2015) and (Thomas, 2018)

⁴ The CTCC’s website was until recently available at <https://www.ctcc.org.uk/>. This has now been taken down and the only online reference to the organisation is at <https://www.oocities.org/~betapisces/academy/choir.htm>

a “pulse of energy into the vocal tract” (Howard 2008: 40). This creates a sound wave where each air particle vibrates at several different frequencies at the same time, meaning “an entire family or spectrum of tones is sounding simultaneously, almost as a chord consisting of many tones” (Sundberg 2012: 25).

Formants are pitches at which some of these tones, or harmonics, are emphasised in the sound. This happens where harmonics in the sound correspond to “resonant frequencies” in a “resonant cavity or space” in the vocal tract (Williams 2012, 204). In other words, the air within various sections of the vocal tract wants to vibrate at a certain frequency. If this frequency (the formant) matches a frequency in the sound, the harmonic is boosted.

In singing and speech, “the vocal tract creates its formants (resonances) mainly by changing its cross-sectional area at various points of articulation along its length” (Rossing 2014: 377). It is the shape of this oral cavity, and the resulting pitch and strength of formants in combination with the harmonics of a sound, which determine vowel sounds and the timbre of our singing. The first three formants of a sound contribute about equally towards vowel sounds, but because the first formant has greater amplitude and lower frequency, closer to the fundamental, it contributes more to timbre. The higher formants “define other aspects of vocal quality, mostly concerned with the projection of the voice” (Williams 2012: 204).

Given the relationship between sung timbre and the shape of the vocal organ, we could expect any perceptual difference between the voices of boys and girls to be reflected in measurements of the vocal mechanism. However, the research suggests that there is little difference in the vocal tract morphology of boys and girls, with changes only arising “after the onset of the period of puberty” (Sergeant and Welch 2009: 321).

Indeed, Ingrisano et al. (1980) found little difference between the sexes in terms of vocal tract length, and Negus and Kirchner, cited in Napoles (2010, 217), stated “that larynxes are likely to be of the same size.” Comparably, Bennett and Weinberg (1979) found that the larynx only displayed gender cues in a small number of cases. Stathopoulos and Sapienza, (cited in Welch and Howard 2002) contended that, prior to the age of 10, the only possible difference between boys and girls is in lung capacity, which could be slightly higher for boys.

Vocal fold length is marginally different, with the tissue growing at 0.7mm per year for boys, rather than 0.4mm annually for girls (Titze 1994), but this disparity in growth only produces a meaningful deviation between the sexes after the age of 10. From 10 years old boys and girls diverge significantly, with girls undergoing a growth spurt between 10 and 13, before boys catch up, and eventually overtake, between 12 and 15. This period of puberty is also the point at which the vocal folds and the vocal tract grow in boys such that the fundamental of frequency of speaking becomes noticeable different from girls (Cooksey and Welch 1998).

Prior to the age of 10, studies suggest most differences between the voices of girls and boys are not biological in origin, but the result of gendered behaviour patterns within society. For example, Sachs et al., cited in Sergeant and Welch (2009, 321), have proposed

“that boys may habitually use smaller jaw opening, more rounding of lips, lower larynx positions, or head elevations, resulting in relatively small extensions of the vocal tract.” Similarly, Williams (2012, 14) suggests boys are more likely to round the lips, whereas girls are more likely to put “more of a smile in the sound,” thereby shortening the vocal tract slightly.

A number of other researchers have also pointed out the greater effect of culture, in comparison to sex, on singing and vocal timbre. Mecke and Sundberg’s experiment (2010, 3230), which analysed the voices of boys and girls from a school in Sweden, alongside boys from a German school, found, “Most of the investigated acoustic properties differed significantly between boys of the different choirs, whereas most differences between girls and boys of the same choir were not significant.”

As opposed to the sex of the singer being significant, the similar biology of young children suggests that it is in fact culture and training that is of most importance in vocal timbre. Indeed, it is likely that many of the claimed differences between boys and girls may be as a result of this gender stereotyping, rather than any true perceptual difference. Ashley (2009) summarises this, “The thin fold register is more likely to be perceived as girl-like whereas a richer, more colourful modal sound is perceived as masculine, even within the lower treble register” (63).

Ashely therefore argues that it is gender expectations which condition the listener’s perception of children’s voices, rather than the nature of the voice or the actual sex of the singer.

The rise of the girl chorister

The Director of Music at Salisbury, Richard Seal, initiated the influx of girls’ voices into the cathedrals of England in 1991. Rather than due to a shortfall of boy choristers, the new treble line was founded to provide girls with the same education as that open to boys (Mould 1991). Other than the mixed choir of Manchester Cathedral⁵, “the history of the English chorister for over fourteen hundred years had been the history of singing boys” (Mould 2007, 268) and so the decision at Salisbury provoked significant commentary.

In one such reaction to the admittance of girls’ voices, Roger Bowers (2000) branded girls’ choirs “superfluous,” and claimed the sound they produced was no more than “a watered-down version of the conventional adult chamber choir” (5). Similarly, the Campaign for the Traditional Cathedral Choir (CTCC), whilst seemingly now defunct, has been a significant contributor to this debate over the last three decades, consistently launching vociferous defences of boy treble lines.⁶

However, these arguments are undermined by the flourishing of girl choristers across the country since their inception and have been challenged by a number of academic studies. For example, Welch and Howard (2002) have argued that the initial years of choristers’

⁵ Since the 1970s, Manchester Cathedral has drawn choristers from an elite music school (Chetham’s) rather than a traditional choir school. Explaining this unique situation, Mackey posits, “If one thinks of evensong as the last lesson of the school day, and the trebles are the pupils, it is logical then to have a mixed gender top line just like any other class at school.”

⁶ For an archive example of the CTCC website, see <https://www.oocities.org/~betapisces/academy/choir.htm>

service should be comparable (up until the age of 10) and have disputed the CTCC claim “that there is a traditional and unique vocal timbre in a boy’s singing voice that is both generic to boys’ singing voices in general and perceivable” given lack of evidence (103).

To defend the view of CTCC, Sanders (2009), released a paper on behalf of CTCC entitled *‘The voices of boy and girl choristers - Is there a difference? And does it matter?’*. Sanders’ main intention, rather than offering any original research, was to critique Welch and Howard’s (2002) article, as well as a study conducted by Howard and Szymanski (2000), and to restate his defence of boy trebles, asserting, “The mindless insistence on equal opportunities, and political correctness in all its forms, should be opposed” (7).

In particular, he is critical of the methodology of the study completed by Howard and Szymanski. In this study, 20 excerpts of music (of 20 seconds each) were played to 189 listeners. These excerpts were taken from two CDs, both recorded in Wells Cathedral, with the same musical director, and with the same lay clerks, however with either boys or girls singing the top line. Participants were asked to identify the sex of the singers in each excerpt and achieved a success rating of 60.5% (though with significant variation between excerpts). Sanders claimed that results in this study could be affected by participants’ need to end up with 10 answers for each sex (implying participants may diverge from their instinctive to choose to maintain balance), and instead suggested an alternative system where recordings are blocked in pairs, with each pair consisting of a boy and a girl recording.

However, Sanders’ logic seems flawed. At no point in the experiment were participants told that the recordings were evenly split, so there is no reason for participants to try and ensure they have an equal number of answers. Moreover, Howard and Szymanski specifically designed their experiment such that listeners must respond to each stimulus independently with either ‘male’ or ‘female’, meaning each listener response in the investigation could be considered a Bernoulli trial (an independent event with a binary result). With 20 responses from each of 189 listeners, they have:

An overall total of 3780 success/fail Bernoulli trials available for statistical analysis. The resulting dataset is large enough to allow sensible analyses of sub-populations which can not only be grouped listener age and/or sex, but also by their relative success in recognising the voices of boys or girls within the stimuli.⁷

Howard and Szymanski recognise that, because of the range of stimuli (potentially with contrasting auditory cues), this approach is a “compromise between the limitations of pragmatic experimental logistics and the need to provide an adequate sample of the population of suitable stimuli.” However, their methodology is more robust than Sanders’ proposed system in that it treats each event as an independent event with consistent probability, allowing the listener’s response to be based primarily on the perception of the sound. In contrast, Sanders’ process of blocking recordings in pairs would force listeners to identify one recording as male and the other as female regardless of the sex they perceive the singer to be, meaning the responses are no longer independent and

⁷ This explanation of the study’s data analysis is presented in an earlier version of the article, now available here: <https://www.escom.org/proceedings/ICMPC2000/Sun/Howard.htm>

statistical analysis could not be completed on the set of 3780 responses as a whole, or on the relevant subpopulations.

The rise of the girl chorister has been perceived as a threat to the tradition of the all-male choir by a number of musicians and cathedral-goers, and that has led to an inundation of emotive, often anecdotal articles. However, if we move beyond gender stereotyping, a number of significant studies into the similarities and differences between the voices of young boys and girls have been undertaken, providing us with an insight into the scientific reality.

Can you hear the fourth formant?

A particular feature of the research into children's voices to this point has been the use of listening tests to examine the success of sex identification. A number of studies, using somewhat contrasting methodologies, have attempted to investigate whether listeners are in fact able to differentiate between the voices of boys and girls. While some of these studies have found that listeners are able to correctly identify the sex of the singer (Howard et al. 2000; Sergeant and Welch 1997; Sergeant et al. 2005; Bennett and Weinberg 1979; Mecke and Sundberg 2010), the contrasting findings of Napoles (2010) and, to an extent, Moore and Killian (2000) have prevented consensus.

Howard et al.'s (2000) study, described above (it is a later publication of the Howard and Szymanski study criticised by Sanders), found listeners had a mean accuracy rating 60.5%. However, this used commercially recorded extracts and each extract was a different work. As a result of this, there was significant variation in terms of accuracy of identification between the stimuli. For example, stimulus 15 returned a 77% accuracy rating, whereas stimulus 16 was only correctly identified 37% of the time. This suggests that sex identification was not based solely on the vocal timbre, but also on the content of the extract. Some works were more associated with either boys or girls, perhaps due to gender expectations of singing, and this affected the nature of the results.

Sergeant and Welch's (1997) study controlled this aspect of the experiment, with 15 trained children's choirs being asked to sing the first verse of Vaughan Williams' *This is the Truth Sent from Above*. The researchers report their result of 51% accurate identification as little better than chance, however, as Mecke and Sundberg point out in their study (2010), the chance level in this experiment was actually 33% due to the presence of three choir types – boys, girls, and mixed. Nonetheless, one finding of this experiment that is replicated in a number of the other studies listed is that there appears to be an archetypal 'boy' sound that listeners expect. This perhaps relates to the expectation of boys singing in cathedrals and so certain sacred music being more associated with that sex. The particular 'ethereal' sound associated with cathedral music may be an 'ideal' aspired to, but it is not one necessarily (indeed, not often) found to be representative in these studies.

As in the two studies above, Moore and Killian (2000) used extracts from commercial recordings (rather than single sounds). This experiment used Britten's *Ceremony of Carols* and included an extra level of research intended to differentiate between individual singers and groups. Whereas listeners were able to correctly identify the sex

of the singers on 62% of all occasions, this dropped significantly when limited to the recordings involving groups, rather than solo singers, with only 51% and 50% able to correctly identify girls' and boys' choirs respectively. This is perhaps not surprising. Welch and Howard (2002: 118), have noted, "Any individual differences between singers and sexes are likely to be minimised when singing as a collective within the large acoustic resonating space of the cathedral."

Moore and Killian's chosen repertoire – Britten's *Ceremony of Carols* – is interesting in this regard. Britten is said to have "regularly expressed his distaste for the pure, ethereal sound cultivated by many English cathedral choirs" (Wiebe 2012: 61), and the work was originally performed by adult women in 1942. However, two performances changed Britten's mind. In 1943, he heard a Welsh school choir sing the work, and wrote "I think the little boys were enchanting—the occasional roughness was easily outweighed by their freshness & naivety—something very special" (Cooke 2012). Then, in 1959, Britten heard the boy trebles of Westminster Cathedral sing *A Ceremony of Carols* under George Malcolm and was amazed by the sound they created: "The whole choir sang with a brilliance & authority which was staggering" (Kildea 2013: 96).

Both these choirs produced sounds quite different from the archetypal 'boy'. Indeed, George Malcolm railed against the idea that boys' voices must be pure and trained the boys of Westminster Cathedral Choir in a harsher, more "continental" tone (Luff 1969), believing it was "precisely the dangerous and troublesome elements in a boy's voice that gave it character" (Kildea 2013: 94). This variation within choirs of boy trebles implies that the expected sound of young boy, at least in a choir setting, may be primarily a historical, cultural sound resulting from training provided by directors ensconced in the idiom, as opposed to a natural result of age and sex. This may explain why Jessica Napoles' (2010) cross-cultural study using Piccolo's *Preces and Responses*, which focused on listeners outside the English Cathedral tradition, recorded accurate identification of just 47.8% for Argentinian listeners, or 46.8% for American listeners – both below chance level. Alongside individual gender cues, it appears perception of choral sound is shaped by the training of the singers, the repertoire chosen, and the expectations of the listener.

Sergeant et al.'s (2005) study involved recording 320 children of different ages singing an unaccompanied, newly composed song. In contrast to Napoles, and Moore and Killian, this study recorded 71.57% accurate identifications. However, ratings were considerably lower for younger children, implying that, as expected, voices become more differentiated with age, particularly upon the commencement of puberty. In addition, Sergeant et al. do note that, whilst gender cues were present in these untrained singers' voices, they are most complex and could be sociological in origin, rather than physiological.

It seems likely that some of the perceived difference in young singers' voices has been induced by a combination of societal gender roles, training and gendered learning, and listener expectation. However, it is unlikely sociological cues alone account for the higher accuracy ratings for sex identification found in a number of studies. The common consensus among studies that carried out spectral and formant analysis is that, particularly from the age of 10 when the male vocal tract is somewhat longer than the

female, higher formant frequencies are consistently found in girls (Bennett and Weinberg 1979; White 1999; Busby and Plant 1995; Perry et al. 2001; Mecke and Sundberg 2010).

The precise nature of these formant frequency differences is still contentious. Perry et al. (2001), in their analysis of spoken vowels, found that all formants differed from the age of 8, but only *F3* was higher in girls than boys at age 4. Mecke and Sundberg (2010) instead found that *F4* was of the most importance in sex differentiation, whereas Busby and Plant (1995) contended that *F2* differed significantly between boys and girls, with *F1* also providing gender cues, but only for low vowels.

The research into children's voices undertaken thus far has had to correct many myths and inaccuracies present in choir training. For example, Lucy Hodges, in an article for the Times Education Supplement in 1995, claimed that girls' voices were "lighter and breathier" than boys', and this has been a common belief among musicians. However, as Mecke and Sundberg state,

In contrast to the idea that breathiness is a characteristic difference between boy and girl voices, our findings suggest that timbral effects produced by formant frequency characteristics may be more important perceptually (3230).

These timbral effects have been investigated at some length, however much focus has been on spoken vowels, on children around 10 years old, or on singing in the context of a song. In order to fully appreciate whether there is any perceptual difference in the core sound of boys' and girls' voices, it is important to look at children of young ages, and to focus solely on the sung, sustained vowel, allowing as few learned gender cues to infiltrate the sound as possible.

Method

Participants

31 children participated in this study, with an age range of 5-7 years (mean = 5.77 years, *SD* = 0.62 years). 48.39% of the children were boys (*n* = 15), and all children were selected from school years 1 and 2 at a school in Surrey. It was chosen to select children from a single area so as to minimise the effect of cultural differences, which were shown to be significant by Mecke and Sundberg (2010).

Children of this age were selected so as to minimise any formal musical or singing training they may have received. Whereas most such experiments have focused on choirs, or on trained singers, it was decided that training could have a significant effect on the vocal quality of children, as indicated by Welch and Howard (2002).

In addition, Sergeant et al. have intimated that trained singers are likely to mimic and be influenced by singers of their own sex. For example, whereas the oldest choir members in a boys' choir tend to be of 13 or 14 years of age, girls (due to the different nature of their voice change) often attend the same choir to the age of 18, at which point the voice is significantly more mature. Trained girls therefore may imitate this more adult sound from an early age, and such learned differences would likely disrupt the results. The core aim in choosing participants for this study was to record those least likely to have had

their voices affected by their environment, or at least to choose singers who will have been affected similarly, whether they were male or female.

Experiment

The experiment involved recording each child singing three vowel sounds, /o/, /i/, and /a/,⁸ on a constant, sustained pitch. This was repeated 4 times, if possible, in order to increase the number of recordings. Although Rinta and Welch (2009: 677) have contended, "Speaking and singing behaviours exploit the same voice as their main instrument," it was chosen to use sung vowels rather than spoken vowels so as to relate the experiment more closely to the cathedral music tradition.

It was decided to use single vowel sounds rather than songs, as have been in used in some of the studies cited above, because "vowels are associated with a steady-state articulatory configuration and a steady-state acoustic pattern," meaning they can be treated as if they have no finite duration (Kent 2002: 105). This allows us to take any instant of the recording as representative of the sung voice as a whole.

In choosing vowels, /o/ and /a/ were selected as they have the strongest second formants (Rossing 2014), whilst /i/ was chosen in order to have a contrasting vowel shape. The original aim of the experiment was to use a consistent pitch across all recordings, but the nature of untrained voices meant this proved unrealistic, and singers were instead encouraged to sing on a comfortable pitch. The pitch chosen was only questioned when a child was deliberately altering the pitch, with, for example, one boy intentionally trying to lower the pitch of his voice. These problems are consistent with those of Mecke and Sundberg (2010), though their subjects were trained and so were slightly more successful in pitch matching.

Analysis

While most children were able to produce 12 vowel sounds (4 of each chosen vowel), a few children produced fewer recordings due to nerves, while some snippets were discarded at the discretion of the researcher, as it was felt the child failed to reach the intended vowel sound. As a result, 114 recordings for both /a/ and /i/, and 112 for /o/ were included in the sample for analysis.

For each snippet ($n = 340$) the fundamental frequency (f_0) and the first two formants (F_1 , F_2) were measured, with measurements taken in the middle of the most consistent period of vowel production in the recording. Due to the high frequencies of children's formants, there are well-established difficulties in obtaining accurate results in a test such as this (Sergeant and Welch 2009) and so recordings were tested against White's measurements of formant frequencies for specific vowels in children (1999). Snippets that exceeded likely bounds, such as those that were particularly breathy, were discarded from the results.

⁸ Symbols from the International Phonetic Alphabet

Results

Figures i-iii show a summary of the means and standard deviations for each vowel, gender and formant whilst table 1 gives a breakdown of mean frequencies. The difference between the formants in each vowel is clear and is consistent with White and Rossing’s findings (2014) on formant position.

The results are consistent with those of previous researchers in that the formant frequencies were consistently higher for girls than boys. However, upon the completion of t-tests for each vowel, only the results for /a/ showed a statistically significant difference between boys and girls ($p < 0.005$). When the formant frequencies of all vowels were combined, the difference between the first formant of boys and girls was found to be significant ($p < 0.05$), and there was a clear trend with respect to the frequencies of the second formant. However, all results should be treated with caution due to the variable nature of the children’s chosen fundamental frequency.

Figures i - iii

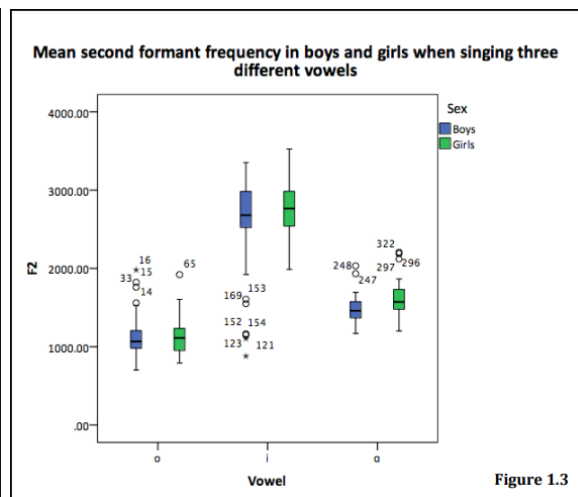
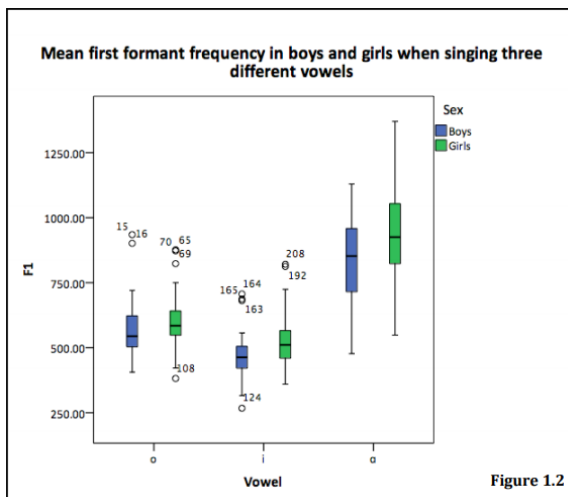
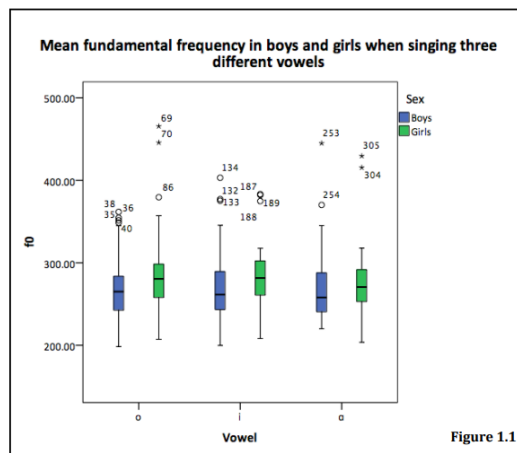


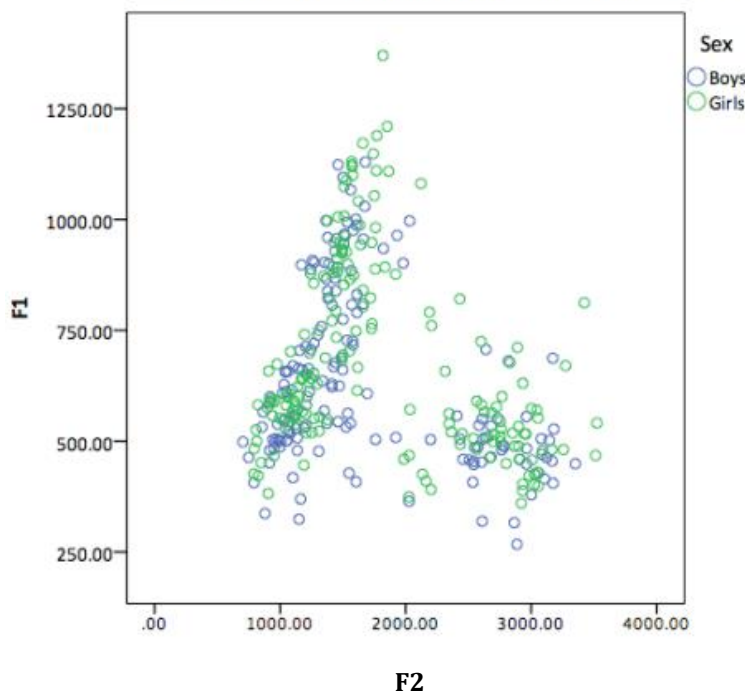
Table 1

	o		i		a	
	Boys	Girls	Boys	Girls	Boys	Girls
f0	271.09	286.83	273.81	284.37	271.77	276.89
F1	571.96	601.91	499.82	529.79	839.55	928.05
F2	1126.99	1143.77	2570.58	2756.92	1469.82	1602.50

Figure iv shows the standard *F1-F2* vowel space for all recordings. The three vowels are clearly separated, with the results for /a/ being toward the top of the chart (indicating an open vowel sound), the /i/ being toward the lower left corner, and the /o/ vowel being in the lower right corner. As can be seen, the results for boys and girls are somewhat scrambled.

Figure iv

The relationship between first and second formant frequencies in boys and girls when singing three different vowels



Therefore, though there seems to be a significant trend for formant frequencies to be higher in girls' voices than boys', supporting the results of previous researchers, the high standard deviations (as seen in the box plots of figures i-iii) point to notable within-sex differences between individuals' voices.

Discussion

Boy, girl, or child?

Consistent with the results of other studies (Bennett and Weinberg 1979; White 1999; Busby and Plant 1995; Perry et al. 2001; Mecke and Sundberg 2010) the results above indicate that formant frequencies are higher in girls' voices than in boys' voices. This however varies vowel to vowel, as suggested by Busby and Plant, and any trend should be treated with caution, due to the high standard deviation of each formant within the boys' or girls' groups. This variance suggests that any difference between the sexes would be masked in a large group where formant frequencies fluctuate extensively between individuals.

It is possible that it is these slight formant differences that allow some listeners to differentiate between boys and girls in listening tests, however the difficulties expressed by those to have taken part in such listening tests (see, for example, Mould 1991), suggest that any difference is only marginal. Given the significant overlap seen in Figure 2 between boys and girls, it appears likely that nurture is of more importance in the development of the voice prior to adolescence.

This apparent slight difference between the voices of boys and girls is not likely, therefore, to account for the resistance to girl choristers amongst some cathedral musicians. Bowers' polemical article in criticism of girls' choirs (2000: 5) relies on a tired cliché that proclaims, "The sound of the traditional English cathedral choir is universally recognised to be unique." Not only is this statement questionable, as we shall see, but it underestimates the importance of training in the creation of this sound. It seems unlikely that the slightly lower formants found in boys voices are entirely responsible for the 'ethereal, pure' sound so desired by cathedral musicians. It seems far more likely that this sound ideal is the result of significant daily training in choir schools.

Brenda Smith, in her work on choral pedagogy, states,

There is no difference in choral vocal exercises prescribed for boys and girls. In children's voices, the basic ranges, sound ideals [italics added], and agility rates are the same (2013, 180).

In other words, children of both sexes should be receiving similar training. There is no reason to train boys differently to girls, and no reason to expect different results (Mould 1991). As Napoles has suggested, perhaps the reservations of those with issues regarding girls' choirs in cathedrals "have less to do with tone quality and more to do with breaking with tradition" (2010: 223). For the most part, and certainly in day-to-day life, it seems more apt to consider not the boy's voice nor the girl's voice, but the child's voice.

The culture of choirboy

The English choral tradition in cathedrals has tended to be depicted as a single narrative, stretching back some fourteen hundred years. Indeed, Welch and Howard have claimed, anecdotally, that the weight of tradition has come to shape "the musical behaviours of its new entrants... towards an established acoustic model" (2002: 117). This is a popular view, with many critics of the advent of girl choristers referring to the desire to maintain the sound for which the music sung in cathedrals was composed.

Disregarding the suggestion that the introduction of girls would change the sound, as we now know this need not be the case, all these claims suggest that the output of cathedral musicians has remained unchanged for centuries. Day, in his survey of cathedral music, draws attention to the difficulties of this claim:

With English cathedral music there is a particular danger in extrapolating back into earlier decades of the nineteenth century for there is clear evidence that towards the end of the last century there were real changes in the music of cathedral and college chapels (2000, 123).

In examining the authentic sound of English Cathedrals Luff (1969) similarly argued that there is no single, unified sound palette in use across all English cathedrals. As discussed above, a number of directors, beginning with George Malcolm at Westminster Cathedral, and continuing with George Guest at St. John's College, Cambridge, trained their choristers to sing with a harsher, more 'continental' tone in contrast to the 'smooth, clear tone' traditionally expected. This divergence in sound between choirs and directors is audible in recordings. One need only listen to see "differences in the vocal timbre of the same choir over time," particularly when the musician in charge has changed (Welch and Howard 2002: 103).

Whatever society's archetypal expectation of choral sound, it is impossible to claim that there is one single choral tradition, and so it seems illogical to claim that the introduction of girl choristers, rather than adding a new strand to the many existing lines of this great tradition, could threaten the single English choral tradition.

This perhaps brings us to the crux of this gender debate in English cathedral choirs. Unable to rely on the claims of unique sound, or a single, uninterrupted tradition, there must be another aspect of the singing of boy trebles that is so important to supporters. Ashley (2009), in a chapter entitled 'Admiration of the Boy', suggests, "For some audiences girls will not do even if they, like boys, sing with the 'voice of an angel'... the boys who perform are admired by their supporters *because they are boys*" (73).

Ashley goes on, claiming the choirboy is

Uniquely attractive... he is not too good, for his catapult indicates a safe hint of masculinity that perversely renders him more attractive than a girl in the same position. The idealized mother-son relationship is a unique one in which the young boy, who can represent male eroticism without threat of sexual predation on women, is privileged in this relationship over the young girl (78).

Rather than being about the voice, or about the tradition, Ashley suggests the privileging of boy trebles in some parts of the cathedral tradition is due to a desire to see *boys* sing, over girls. It is down to their gender, not their singing. Indeed, Samuel Sebastian Wesley alludes to this, saying boys' voices,

At the best, are a poor substitute for the vastly superior quality and power of those of women; but as the introduction of the latter at Cathedrals is inadmissible, it is necessary to cultivate boys' voices with due diligence (1849: 73).

There are those that would see a performance of Wesley's music with female sopranos, or girl trebles, as 'inauthentic', and yet Wesley admits here that he composes for boys primarily because that is the tradition of the church. It is only the 'admiration of boy', or

perhaps more aptly, of 'choirboy', that kept the domain of cathedral music predominantly free of women until Seal's decision at Salisbury in 1991.

Curwen, writing in the nineteenth century, appreciated, and criticised this angelic view and privileged position of the choirboy, declaring,

The custom of throwing a halo of sentiment round choir-boys, and petting them, is much to be deprecated. It has become the custom to write tales and songs about them, in which they are made out to be little angels in disguise. All this is very foolish and harmful. Choirboys, as a rule, are no better and no worse than other boys (1891: 11).

No better than other boys, and no better than, if marginally different to, girls.

The English choral tradition and its fear of the feminine

One aspect of the Church's resistance to the introduction of girl choristers appears to have been a fear of the feminine. In the majority of schools, singing remains a feminine pastime. Often placed in competition with sport, boys tend to choose the more physical, more apparently masculine, pursuit where, Ashley claims, "conventional patriarchal power structures are still more likely to be found" (2009:77). In contrast, within cathedrals, "the very fact that girls were excluded legitimated boys' participation in high-art singing as a form of masculinity" (Ashley 2006: 198). There is a fear that the introduction of girl choristers will feminise church music departments, and lead to girls taking over.

The overwrought articles by Bowers (2000) and Neslund (2002) both foresee a future bereft of adequate altos, tenors, and basses due to an erroneously perceived reduction in boys' singing caused by girls' choirs. Mould's trenchant rejection of this claim asserts that there is "not a shred of evidence" to suggest the introduction of girls will reduce the supply of male altos, tenors, and basses (2007: 269), and he suggests the reduction in boys' performance time may actually help recruitment. Indeed, Mackey's reports, "not one director reported that girl choristers had a negative impact on [the recruitment of] boy choristers" (2015: 178). With brothers and sisters now able to access similar opportunities, families are more able, and willing, to commit.

Lindsay Gray, whilst being vociferous in his support of girls' choirs, does argue that "it is essential to ensure that singing is not perceived to be something that is done 'mainly by girls'" (2004: 25), for that would pose a threat to the future of boys' singing. The common consensus is that both boys and girls between the ages of 8 and 13 "are willing to sing with their own sex" but are less confident when placed in a group with the other sex (Hodges 1995: 15). Particularly in the case of boys, Ashley postulates that they "need a sense of male solidarity if they are to overcome their fears and inhibitions about singing" (2009: 98). Consequently, Salisbury created a whole new choir for girls, with the boy treble line and girl treble line running concurrently. Most cathedrals have followed this model, rather than Manchester's mixed choir route, with no Cathedrals in Mackey's study (2015) expressing "any intention of allowing the girls to sing more than the boys, nor to combine the two groups except for special occasions" (174).

However, this consensus brings us to the final key argument for those wishing to preserve the all-male choir: money. Further to the scholarships required to help the female singers attend the choir school, if it is co-educational, extra staff are normally required to direct

and administrate the additional choir and new robes will be needed. However, while introducing girls may require investment, there is ample evidence to suggest the benefits outweigh the costs, with almost every Cathedral in the country now offering flourishing female treble lines. With 30 years having passed since Salisbury made the leap, there has been sufficient time for this challenge to be examined and addressed.

Those Cathedrals that have overcome the fear of the feminine have reaped the rewards of running two treble lines, one of boys, one of girls. While allowing boys to retain a sense of male camaraderie, the slight reduction in workload as a result of having two choirs has allowed “the organist and choirmaster to be able to spend far more time on such areas as vocal technique, blend and other important aspect of choir training” (Gray 2004: 25). In other words, the choirs have improved.

Moreover, having two choirs allows for more outreach work, such as concerts and services elsewhere, as one choir is able to cover for the other. The introduction of two choirs even allows the boys to play sport in times they would otherwise have spent singing, thereby removing that boundary and allowing boys “to play football as well as singing in the choir” (Williams 2012: 14).

The introduction of girls into cathedrals and other places of worship has long been considered a threat, both to the English choral tradition, and to boys’ singing in general. However, not only has the advent of girl choristers allowed the girls the opportunity to experience the education afforded to the other half of the population for over fourteen hundred years, but music in cathedral has actually improved. Not only is the standard higher, due to increased rehearsal time, but also the number of singers is higher than ever. In his complete history of the English chorister, Mould suggested that, “by 2004 there were some 900 boys and 250 girls enrolled as choristers or probationers in cathedral and collegiate choirs,” around twice as many as in “the great choral decades of the early sixteenth century” (2007: 215). Latest statistics suggest this number has grown even further since, with around 1500 choristers (split equally between boys and girls) now singing in Cathedrals across the country (Burgess 2019). This is more than sufficient evidence to suggest that the influx of girls, rather than being a threat, has actually brought about a renaissance in singing across England.

The gendered singing voice

Before drawing this investigation into the voices of untrained boys and girls to a close, it is of benefit to explore the effect of societal gender expectations on young voices. Whilst it has been shown that training, and singing in a large group, is able to negate the impact of previous gendered learning, it clearly has an effect on children as young as 5.

As noted earlier, boys’ and girls’ voices tend to be described in terms used “to characterize the genders in general” (Mecke and Sundberg 2010: 3223), and, as asserted by Welch and Howard, there appear to be “perceptual stereotypes” of boys’ and girls’ voices (2002: 111). While we have shown that these portrayals of children’s voices are scientifically inaccurate, it is possible that children “adopt gender-specific articulatory behaviours from childhood” (White 1999: 579). Williams proposes that, though there is little difference between the vocal apparatus of boys and girls, it is likely that “boys and girls

will adopt a manner of speaking which identifies with the male and female adults around them” (2012: 13).

This gendered learning is engrained in society and is a key aspect in the formation of identity – which Ashley claims is the “fundamental task” of childhood (2009: 8). For example, in Curwen’s book about *boys’* voices from the nineteenth century, he encourages choir trainers to ensure boys use their higher register, “that voice which is most like a girl’s” (1891: 50). Singing is equated with the feminine from an early age in our society, as can be seen in the frequently used derogatory phrase ‘you sing like a girl’, which tends to be used to imply that men don’t sing. If our environment encourages a situation where the high-pitched is equated with the female, and is subsequently derided, we manage to both marginalise women and eschew any form of young male singing.

This rejection of male singing, combined with the ostensibly masculine trait of suppressing emotion, has a significant impact on speech, which is transferred at a young age to male children. Research has found that female speech shows “more numerous changes of inflection, and higher rates of change than for males” (Sergeant and Welch 2009: 320), with monotonal speech being identified as male far more often in listening tests.

Moreover, with singing seen as feminine, boys “will often say that they are less good at singing than girls,” regardless of true ability (Williams 2012: 47). Green (1997) surveyed the music teachers of 78 different schools in England for their views on gender differences and found that 64 of 78 viewed girls as more successful when it came to singing, and none viewed boys as more successful. Green postulates this reluctance to sing in school may be caused by boys’ developing understanding of masculinity, and of society’s expectations of men.

Singing and speech are clearly affected by gendered learning at an early age. Even when being taught to sing, research has found that “the sex of the regular choir trainer was significantly related to the choir’s perceived sex,” suggesting that gender cues are being taught (Welch & Howard 2002: 111). In his article on boys’ choirs (2002), Neslund stipulates, without any convincing evidence, that any leader of male singing should themselves be male. In fact, it may be of more benefit to be taught by a leader of the opposite sex. Not only has research found that children do not actually see “teacher gender as an issue” (Ashley 2003: 129), but having a teacher of the opposite could assist in impeding the development of a gendered voice.

However, surely the most important aspect of a music leader is that they are inspiring, encouraging, and charismatic. Boys’ and girls’ voices are strikingly similar at a young age, and it is vital that they are motivated to express themselves through these voices.

Conclusion

Whilst not presenting an entirely united picture, the currently available research on children’s singing suggests that the voices of young boys and girls, while very similar, are marginally different. A number of researchers have shown that the formants in girls’ voices are at slightly higher frequencies than those in boys’ voices, and there may be some

differences between boys and girls in terms of pitch matching and pitch jitter, though these are not within the scope of this article. No differentiation in terms of fundamental frequency, or in terms of ability or aptitude has been discovered.

The experiment conducted here aimed to investigate the frequencies of the first and second formants in children's voices when a sung vowel was sustained. This was in contrast to a number of previous experiments, which have either used spoken vowels, or sung melodic lines. There were a few drawbacks to this investigation. A future project should perhaps spend more time attempting to record results with the same fundamental pitch, rather than allowing the child to choose their own pitch, as happened here. This would allow a more convincing comparison between formant frequencies. Moreover, a future experiment may find it useful to look at higher formants, to see whether the trend found in $F1$ and $F2$ remains in $F3$, $F4$, and so on, as well as looking at difference in vocal phonation, for example breathiness.

Despite this, the experiment did find some evidence of higher formant frequencies in girls' voices, particularly with reference to the /a/ vowel. It was noted, however, that there was great variation between individual children, and even within the repeats of a single child, and so any result should be treated with caution. Though the trend for higher formants in girls in this age group emerged, the variety in children's voices at this age (5-7) means sex identification through voice quality alone remains difficult and deceptive.

The results of this experiment, along with results from previous research, make the all-male position of some cathedral music virtually untenable. Though there appears to be a small difference in the voices of young boys and girls, this is likely to be subsumed by any acoustic, and will most likely be negated by formal training. It may also be masked in a choir of differing ages and sizes, such is the impact of these factors on vocal quality. Of course, it should be noted that many cathedral choirs now do take girl choristers, however a significant minority of the principal Cathedral choirs in England, such as St. Paul's and Westminster Abbey in London, remain all male. Whilst there are clearly practical difficulties in maintaining a girls' treble line, more needs to be done to overcome them.

It was noted that some of the resistance to taking girl choristers may be due to non-music reasons. Edward Wickham, for example, suggests

We should regard the sound of the English boy treble more like an aesthetic brand, cultivated during the middle decades of the 20th century, than as an expression of an inherent, pristine vocal quality exclusive to boys (2016).

This is in contrast to music outside of cathedrals, where boys are frequently still derided for singing in a masculine society. With gendered learning occurring at a young age, particularly in speech and other traits differentiated by sex, it is important that music educators attempt to counteract societal expectations in ensuring all can sing and do so without missing out on sport or other contrasting activities.

This research has aimed to answer the question of whether there are natural differences between the voices of boys and girls. Whilst there is reasonable evidence to suggest there is some natural differences between the prepubescent voices of boys and girls, it is also

likely gendered learning from a young age significantly exacerbates these and ensures that nurture is often primary in the differentiation of young singers by sex. Through formal training there is no reason that, prior to adolescence, a choir of boys and a choir of girls cannot sound identical, and, therefore, the introduction of girls into cathedral music is to be greatly encouraged.

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