

“Boys are apt to change their voice at about fourteene yeeres of age”: An historical background to the debate about longevity in boy treble singers

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Historical sources and longstanding custom suggest that boys’ voices “break” during their 15th year. This event, when experienced boys leave the treble sections of choirs, represents a significant musical loss to the choir and potentially significant disruption to the boy’s musical career. In recent decades, increasing attention has been paid to research that highlights more subtle staged changes to the voice rather than a sudden “break.” A pedagogical consequence has sometimes been for boys to leave treble sections at younger ages. Even more recently, concern with a trend toward earlier puberty, termed “secular” in the medical profession, has exerted further downward pressure, leading to expectations that age 12 rather than 14 might be the time choirs lose their most experienced trebles. Potential impacts include the need to simplify repertoire or commence the training of boys at younger ages. The paper reviews existing research in order to probe the unlikely scenario that the age of voice change has only recently dropped to as low as 12 after being consistently at 14 for over 2000 years. The conclusion is that a lack of conceptual clarity, wide variations in choral practice and inconsistent attempts at measurement in the past demand both skepticism and further research.

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The title of this paper is derived from Aristotle’s *Problems of Alexander Aphrodisias*, where the question “Why are boyes apt to change their voice about fourteen yeeres of age?” is answered (Aristotle, trans. 1683). Since Aristotle’s time (384–322 BC) the old and celebrated tradition of choral singing by boys’ choirs has become and remained significant across much of Europe, America, and Australia. In Germany, for example, the Regensburg Cathedral Choir (today Regensburger Domspatzen) was established in 975 CE, the famous Thomanerchor was founded in 1212 and includes among its former directors none less than the composer J. S. Bach. In the UK, a tradition of singing in cathedrals by professional choirs of boys and men can be traced back to the year 597 CE and has continued for some 1500 years with only one short break during the parliamentary rule of Cromwell. English

choral singing of this nature has followed emigration patterns across Atlantic and Pacific Oceans. For example, a visitor to St. Thomas Church, Fifth Avenue, New York, or the cathedral of St. John the Divine in Brisbane, Australia, would readily recognize the affinity with an English choral liturgy.

As the title of this paper suggests, the age of 14 has tended to serve as an approximate guide to the time when boys’ aptitude to sing the soprano or “treble” line ceases. Several ancient sources give us the baseline of 14 years of age for the principal impact of puberty upon the male voice to be felt. Aristotle’s world view (*Historia Animalia*) divided life into seven year portions. The age of “twice seven” thus provided a convenient timing for the event of voice change in boys familiar to Aristotle. Nevertheless, Flatau and Gutzmann (1905), in a study of boys and eunuchs claiming

a 4000 year span, give 14.5 as the “average age of mutation” in ancient times. Amundsen and Diers (1969) come to a similar result. Fascinating as they are, interpretation of such old sources is difficult. This is particularly so for the medieval period when many authors were more devoted to classical authorities than to their own observation (Amundsen & Diers, 1973).

Between 13 and 15 years of age boys have reached a stage of musical maturity that has traditionally allowed accomplished performance skills that are greatly valued by choir directors. The last two decades, however, have seen growing unease about the future of these traditions, less due to threats to admit girls than to the belief that the timing of puberty in boys has advanced. Recent newspaper reports have testified to the experiences of choir directors who report growing numbers of boys having to leave choirs earlier than expected. An English conductor expressed the view in a Sunday newspaper that this may result in the necessity of performing simpler music (Copping & Mole, 2010), whereas *The Washington Post* reported the steps of a German conductor to introduce younger-aged boys into the choir (Birnbäum, 2012).

In Germany, the assumption of an advanced voice change in choirs has been discussed since the 1970s in connection with questions of performance practice, especially concerning the vocal music of Johann Sebastian Bach (Daw, 1973; Mecke, 2007). Though some musicians and researchers argue that music written for ensembles of boys and men should be performed by boys and men today, others claim that the sound and quality of Bach’s boy sopranos and altos differed considerably from the sound of their modern counterparts because puberty occurred much later in 18th century boys. Additionally, questions regarding the musical and pedagogical standards of the traditional choirs, similar to those in the UK, have been raised in Germany by choir directors, conductors, and medical doctors. It has been stated that the time interval between boys reaching the high musical standard of the elite choirs and the onset of voice mutation has become too short (see comments by Nicolaus Harnoncourt in Schaufler, 2000), that discrepancies between psychological maturity and voice could lead to problems (Frank, 1969), that earlier puberty causes a shortage of new singers (Schmidt, 2000), or that the trend may lead to an imbalance between boys’ and men’s voices (Fuchs, 1997). Additionally there are complaints about the musical preparatory education in families and

nurseries (Eckart, 2010), also leading to a shortage of boys meeting the desired standards. Some choirs, such as the Thomanerchor Leipzig, have already reacted to these challenges by establishing choir classes for younger boys, thus beginning musical education at an earlier age. Similar discussions are known from Spain (Philipps, 2005) and Austria (Die Standard, 2002; Müller, 2008).

Aims of the present paper

In this paper we attempt an interdisciplinary literature analysis of the time at which boys have been “apt to change their voice.” Our review draws on history, voice science, and pediatrics and is directed mainly at those traditions in Europe and America that require boys to sing in the high treble register, usually in the high art or so-called “classical” tradition of choral singing. There are of course many more cultures of singing by boys (see Ashley, 2008, 2009; Harrison et al., 2012 for recent discussions). It is, however, the need for musically mature boys to perform in the high treble register in choirs rather than the music class where different voices can be more easily accommodated that justifies our review.

There is already a substantial literature on the process of voice change, many studies referring to the seminal work of John Cooksey (2000). Although this literature documents in depth the process of vocal metamorphosis from child to adult voice, it has yet to tackle in a similarly comprehensive way what is referred to in the medical literature as the *secular trend* in puberty. The term secular is applied in this field to a phenomenon that is not cyclical or seasonal but existing over a relatively long period (i.e., 100 years or more). Thus “secular trend in puberty” describes a slow drift toward earlier onset and completion of puberty with the likely consequence of earlier loss of treble voice.

A similar secular trend to greater stature has been well established in the literature. Although there is a general consensus that stature has increased, researchers disagree as to whether the trend has accelerated or peaked in recent years. For example, Vercauteren and Suzanne (1985) provide data to suggest that the trend in Belgium has now stopped and suggests that this is accounted for by the stabilization of nutritional status in an advanced Western democracy. Cameron (1979), however, concluded that the secular trend had ended in London during the 1960s for similar reasons. If this was so, it may have recommenced. Two studies by Juul, Magnusdottir, Scheike, Prytz, and

Skakkebaek note that more advanced stature development in the USA than Denmark may be particularly important. The study published in 2006 concluded that Danish boys were significantly taller than in 1964, but that their pubertal timing had not altered (Juil et al., 2006). However, the study published in 2007 did find a statistically significant downward trend in age at voice “break” of Danish boys (Juil, Magnusdottir, Scheike, Prytz, & Skakkebaek, 2007).

Karlberg (2002) is another researcher to have found that the trends of stature increase and pubertal onset are not always strongly correlated. Neither are height and weight; Loesch, Stokes, and Huggins (2000) note that in Australia, the secular trend for height has significantly slowed while that for weight has accelerated. Researchers have been unable to agree on the relative effects of these changes although it seems fairly clear that nutritional status is a significant variable. Tellingly, the Newsom Report of 1963 to the UK government showed a difference of seven pounds in the mean weight and one and a quarter inches in the mean height between middle and working class boys (DES, 1963). The two nutritional pathologies of malnutrition and obesity clearly have measurable consequences linked to changes over time that happen differently according to social class.

The principal concern of this study is with the actual timing of puberty itself, rather than the sequence of events that occur once puberty has begun. It is the latter which has occupied by far the largest volume of writing about adolescent boys’ voices. However, a number of small studies summarized in Killian (1999) have made the case for a review such as we attempt here of normative expectations for the ages at which the various events of voice change occur. The literature we have prioritized for analysis therefore is that which deals with the timing of puberty rather than the processes of voice change, though there is naturally a significant overlap of the two areas.

We are confronted by the fact that reliable sources on the timing of puberty in boys are harder to find than might be imagined. Although a growing number of medical studies have provided fairly consistent evidence of a variable trend to earlier puberty in girls, the medical literature has so far been insufficient to establish a clear position for boys. A large-scale expert review of trends in boys’ puberty published in 2008 concluded that “... on the basis of few studies and reliability issues of some male puberty markers, the current data for boys are insufficient to evaluate secular trends in

male pubertal development” (Euling et al., 2008, p. S172). Other significant, large-scale reviews reporting broadly similar results include Parent et al. (2003) and Amselem et al. (2007).

We suspect that there are principally two reasons for this. First, the priority for medical research at least in the 19th and early 20th centuries has been girls’ reproductive health. Second, puberty in boys is difficult and inconvenient to measure. Conventional methods, which rely on inspection of the genitalia and pubic region, are highly invasive of boys’ privacy, potentially embarrassing for both subject and researcher and increasingly difficult ethically.

Paradoxically, new possibilities resulting from rapid developments in computerized voice analysis may render voice change to be a sufficiently reliable surrogate marker of puberty to allow for the first time large scale epidemiological data on the secular trend in boys’ puberty to be gathered. The possibilities are exciting, but the complexity of precise investigation of key components of voice quality such as jitter, shimmer, formant frequency distribution and additive noise component still render large scale study an aspiration rather than an achievement.

In looking backwards over the long time periods during which imperceptibly slow changes might take place, it is necessary to piece together studies that lack clear methodological description of how voice change status has been measured or inferred. This is what we attempt in this paper. In our attempt to make meaning from the disparate and inconsistent data on boys’ puberty and voices we have found it necessary to address three key problems first before presenting the results of different investigations. These are

- inconsistency in the concept of voice change;
- differences in choral practice;
- and inconsistency in the methodology of researchers.

Given the inter-disciplinary nature of the paper and the extent to which pubertal status has to be inferred from voice change literature, we feel it most helpful to address each of these difficulties in turn.

Key problems

Inconsistency in the concept of voice change

The term “voice change” is generally employed by phoniatricians, voice researchers, and singing coaches to describe the protracted period of vocal metamorphosis that young males undergo during adolescence. The term

“change” is also more established in the USA than the UK, where popular discourse as well as the everyday language of singers and choir directors is still more likely to employ the term “voice break.” Corresponding terms are used in Germany, Russia, Sweden, and Finland (Mecke, 2007), and European practice has sometimes been less concerned than US practice with the notion that a “broken” voice is a damaged one.

The perception of damage is perhaps enhanced by the characteristic “cracking,” or involuntary flips between high and low vocal registers during excited speech. This phenomenon has been studied in some depth by Killian (1997), Freer (2009), and Hesterman (2000). It is also possible that “break” refers to growing differences in register or vocal mechanism that are important and measurable features of change in the singing voice. Growing register differences were observed in 1895 by Francis Howard (Howard, 1895) and later in an influential work by Frederik Swanson (Swanson, 1977). Swanson assessed 82 8th-grade (13- and 14-year-old) boys four times over the course of a year and concluded that the rate of voice change differed across his sample. Between 30% and 40% of his sample experienced a quite rapid emergence of lower register, and it was these boys who were unable to sing any notes at all across the approximate range of C4–F4.

Willis and Kenny (2008) revived Swanson’s ideas when they described and mapped out the temporary emergence of this phonational gap in boys of mid-pubertal status. The inability of the boy to phonate or sing any notes across the range where his adult passagio is to occur can be seen as a voice that has literally “broken” into two temporarily disconnected registers. Typically, a boy who experiences this may still be able to access most or all of his soprano register from G-sharp upwards, and a new emergent baritone range from around D4 down to C3. Leck (2009), however, regards such a gap not as inevitable but as the result of faulty training.

Though there are justifications for the term “break,” there are methods, including those of Leck, for eliminating actual register breaks; thus a phonational gap would not seem to be inevitable. Almost all research, though, is now agreed that the change is not a sudden, overnight event. A particular difficulty in this respect concerns the difference between the singing voice and the speaking voice. Boys’ speaking voices fall almost continuously in pitch from an approximate range of 250–300 Hz at the onset of puberty at

around 10 to 11 years of age to the attainment of the settling adult pitch range of about 110 to 130 Hz at around 15 to 16 years of age (Hollien, Green, & Massey, 1994). Terms such as Habitual Speaking Pitch (HP) or Speaking Pitch Center (SPC) are employed to describe the modal points within the frequency ranges encountered in speech. For most boys most of the time, the Habitual Speaking Pitch is a subconscious function of the physical maturity of the larynx and therefore a relatively objective phenomenon.

Singing voices, however, conform to the pitch range or compass of the song. Boys who sing during the period of puberty make constant adjustments to their technique, often intuitively and without help or guidance, in order to maintain the voice within the compass of the song or vocal part. It is the considerable variation in correspondence between objective “change” of speaking voice and subjective “change” of singing voice that constitutes one chief difficulty in defining a certain age for the voice change.

In assessing any historical account of voice “change” or “break” it is thus essential to be clear about what possible meanings could be given to change as an event experienced by young male singers. Voice change might refer to

- a change in habitual speaking pitch;
- a change from one singing range to another;
- a change from one section of a choir to another;
- a change in voice production and the management of register break;
- a change in qualities such as timbre, agility, or acoustic properties such as jitter or shimmer;
- a change in singing style or repertoire (e.g., from “classical” treble to adolescent “rock”);
- or a change in identity (e.g., from chorister to ex-chorister, including voice “resting”).

The measurement of voice change may draw on one or more of the above qualities. At the simplest level, the measurement of “break” might amount to little more than recording the age of boys when they cease being choristers. More sophisticated studies, however, are likely to take account not only of pitch as in speaking voice fundamental frequency (SF₀), singing tessitura, and extreme range, but of measurable features of vocal timbre and functionality. Management of range and register breaks has concerned many practitioners and the measurement of this has concerned researchers.

Attempts to “stage” the change. For comparing the mutational status of different boys in different ages and circumstances, many researchers have found it helpful to establish certain stages or steps of the change. There is little doubt that the most comprehensive analysis of vocal metamorphosis during adolescence in the English speaking literature is still considered to be that of John Cooksey. One reason for the longevity of the Cooksey scheme, summarized in Table 1, is that subsequent researchers generally testify to its apparently definitive descriptive and analytical qualities (Harries, Walker, Williams, Hawkins & Hughes, 1997; Hesterman, 2000; Morris, 2011; Willis & Kenny, 2008; Williams, 2010). Cooksey based his scheme on range, tessitura, register development, voice quality, and the average fundamental frequency of the speaking voice (ASFF). Such critique as has been mounted tends to be based on over-prescriptiveness for practical use in the singing class (Barham & Nelson, 1991) or objections to Cooksey’s emphasis upon the range and development of the modal (“chest”) voice during change (Beet, personal communication, 2011; Brown, 2010; Leck, 2009; Sassi, 2009).

This scheme does not identify a time at which the voice “breaks”—not least because its author objected quite strongly to that term on the grounds that this implied a “sudden rending asunder” or “destruction.” According to Cooksey, “the destructive concept of an adolescent broken voice is completely indefensible” (Cooksey, 2000, p. 47, emphasis in original). Similar views were held by earlier educators such as Duncan McKenzie and Herbert Wiseman, strong opponents of the idea that the boy’s voice should be “rested” after the “break” (McKenzie, 1956), although no empirical evidence is offered with regard to the numbers of young males actually lost to singing because of the use of the term “break.” The whole point of any staged scheme that is descriptive of singing and associated with a suitably adapted repertoire is nevertheless that a boy does not have to suffer a break in choir membership or singing activity.

An account dated 1888 shows that many of the features of voice change or mutation described by researchers working in the mid- to late-20th century were known some 100 years earlier. The writer in this case believed both that it is possible to sing throughout puberty without injury, and that this is nevertheless best avoided:

Mutation affects voices in various ways. Some boys change very gradually; the vocal bands and the parts

Table 1
Summary of Cooksey’s “Eclectic” Scheme

Stage	SF ₀		Tessitura	Full range	Qualities
	Mean	Range			
0	259	220–260	D4–C5 (seventh)	A3–>F5	Full, rich soprano. The “pinnacle of development.”
1	226	220–247	B3–G4 (sixth)	A3–D5	Breathy, strained upper range; little resonance or “body” in lower range
2	210	196–233	A3–F4 (sixth)	E3–C5	Loss of agility, falsetto emerges, uniquely beautiful and rich if in range
3	186	175–185	F3–D4 (sixth)	D3–A4	Evolution of modal register into baritone range, retention of stage 2 quality
4	151	131–165	D3–A3 (fifth)	A#2–D#4	Light and husky, approximating mid-baritone, difficulties with 4ths and 5ths
5	120	110–139	C3–B3 (seventh)	<A2–D4	Body, resonance and power increase, agility recovered, adult qualities emerge

affecting them developing slowly and evenly. In such cases the boy simply loses his top notes one by one, until his voice settles into tenor, baritone, or bass. Others lose their middle or lower notes first, and afterward the higher notes. There is no certainty about the matter, different voices changing in different ways. Although a skillful voice-trainer can at times so manage a boy’s voice that he can sing all through mutation without injury, nevertheless the rule “Stop singing when the change appears” should seldom, if ever, be disregarded. (Stubbs, 1888, p. 76)

Staged changes of puberty have been discussed in the medical literature since Greulich, Day, Lachman, Wolfe, and Shuttleworth (1938) were among the first to indicate the means by which pubertal development might be objectively assessed. Their methods were substantially developed by Marshall and Tanner during the 1960s (Marshall & Tanner, 1970) until a widely accepted view that there are five stages of male puberty was established by

Tanner and Whitehouse (1976) on publication of new clinical longitudinal standards for height, weight, height velocity, weight velocity, and stages of puberty.

Cooksey was by no means the originator of the corresponding five vocal stages. Finn (1939) in a treatise on choral conducting describes five stages and uses the term “register,” which probably implies in the quote below that a “well-trained soprano boy” is a boy some way into or even approaching the end of puberty. Management of the voice with its pubertal register breaks seems to have been part of at least some English conductors’ art in these pre-war years. More recent practice that relies on a child voice with less pronounced register breaks may contribute to the impression that puberty is later since conductors may have come to know less about the cultivation of different sections of the voice necessitated by pubertal onset (see Beet, 2005, and Brown, 2010 for related discussions). Finn placed particular value on the spiritual qualities of a boy voice that retained the soprano register during the processes of puberty:

The well-trained soprano-boy has not only an easy compass of two full octaves [c' to c''], he has also an effective middle register. If the principle of apposition has been carefully applied in his vocalizations after the purifying process of the Five Stages, his voice in this range [f' to f''] should be of rich, round, albeit spiritual timbre. This part of his soprano voice can be retained during the months when adolescence first attacks his childhood and begins stealthily to purloin his boyish attributes. Later, when the change into man’s estate has been completed and his natural voice will have become fixed in the lower octave, the former voice, with modifications of the original, may still function as high as [d''] and in many cases, higher." (Finn, 1939, pp. 136-137)

In Germany, Rudolph Schilling introduced the *Vormutation* (pre-mutation) stage characterized by a slow descent of the lower limit of the voice range, whereas the upper limit “flutters” or shows instability in some cases, with a loss or gain in highest register in others (Schilling, 1948). Similarly, a post-mutational phase was later defined (Frank, 1970). The process of descent in the lower register accompanied by instability in the upper is very similar to Cooksey’s descriptions (Cooksey, 1992). However, German researchers have sometimes preferred to talk of three phases

rather than five or six stages, as in the work of Fuchs, Behrendt, Keller, and Kratzsch (1999).

This work raises questions about the difference between what is heard purely through auditory perception and what can be shown through computer assisted measurement as used by Fuchs and colleagues of changes undetected by the ear. Intriguingly, prior to such technology in 1950, Weiss was referring to pre-mutational changes that occur in the majority of cases as early as 9 years of age. Schilling and Karthaus (1961) were similarly classifying some 9-year-old boys as pre-mutational (meaning early voice change had begun), thus conveying a possible impression of pubertal advance whereas what may have changed more was the definition and method of measurement.

Differences in choral practice

In the previous section we referred to the different events and stages that could be connected with the voice change. In this section, we consider the problems occurring even if two studies agree that by “voice change” they mean the moment a boy ceases to be a choirboy singing treble. Our contention is that few reliable or meaningful conclusions can be drawn from studies of the longevity of boy treble singers unless a reasonably comprehensive account of the associated choral practice is given.

Different “schools” of voice change guidance. Sassi (2009) summarizes three discrete schools or approaches to the changing voice:

- School A. Originating with the work of McKenzie (1956), this school believes that the voice changes slowly and predictably in a staged series of descending ranges, during which time tessitura contract. Cooksey, in latter years, has been the principal exponent of this school.
- School B. Originating with the work of Swanson (1961), this school believes that the voice may change quickly or slowly in a less predictable manner. The vocal history or ontogenesis is not the same for every boy. This assumption leads to a highly individual handling in choral practice, as reflected in Kennedy’s (2004) analysis of the American Boychoir (Sassi, 2009, pp. 9-10).

Schools A and B are both concerned more with boys’ needs for vocal development than choirs’ needs for singers to fit the established vocal ranges of soprano, alto, tenor bass. In contrast to school C below, their proponents have pressured music publishers for suitable arrangements.

- School C. Described by Phillips (1996) as the “English choirboy school,” this school believes that boys should sing in the “upper voice” for as long as possible and then stop completely for a period of rest and adjustment.

Boys whose singing careers develop under such a regime may come to fear their impending dismissal from the choir, facing what can amount to a trauma of redundancy at the early age of 13 or 14, described by one parent as “bereavement” (Ashley, 2009, p. 114). Beliefs such as that held by the English cathedral organist Edmund Bairstow in the 1930s are revealing about attitudes. Practice in many English cathedrals has changed little since then:

My experience is that if a boy uses his voice naturally and without forcing it, he never goes through a period when he cannot sing at all but, while in such cases it does very little harm for him to sing, it is no use him trying, as his voice is gradually changing in compass and in timbre. (Bairstow, 1930, p. 14)

To these may be added at least two more not mentioned by Sassi:

- School D. The “expanding voice” principle of Henry Leck and the Indianapolis Children’s Choir. Leck believes that a three-octave range can be developed during voice change through the use of both the old high register and the new proto-bass voice through elimination of the “clunk” between the two (Leck, 2009).
- School E. The “Temple Tradition.” Associated with George Thalben Ball at London’s Temple Church and such notable boy sopranos as Ernest Lough, this tradition engineered a skillful choral blend of mature and less mature voices which resulted in boys remaining in the choir until the age of sixteen or seventeen (Lough, 2012). It is likely that an upper or mixed register intermediate between falsetto and modal voice was developed by older boys within this tradition (see Brown, 2010, pp. 11–19 for extended discussion). Beet (2005) refers to this as the old “head tone.”

The boys’ alto voice. Probably the most significant of all differences in choral practice, however, is the divide between the UK tradition and those of mainland Europe (principally the Germanic). In the majority of cases in the English tradition, as defined by practice in cathedral choirs, boys still sing only the top line, the other parts being taken by adult men. This is a practice that is beginning to change. For example, the American Boychoir School, influenced initially by the UK tradition, has come to pay more attention to lower voices. In the Germanic tradition the

preference has been for boys and young men to sing all four parts, with boys in the soprano and alto section and young men as tenors and basses. This practice sometimes allows boys experiencing first signs of mutation to change from the soprano to the alto section. Whether or not the alto voice is regarded as unchanged is an important consideration. German boy altos are generally regarded still as unchanged voices even if they have previously sung soprano. At least one English cathedral offers alto or treble positions to boys whose voices, though unchanged, are in a slightly lower range than boys selected for the soprano line. According to Martin Baker, Master of the Music at Westminster Cathedral in London, this practice is unusual (personal communication, 2012).

Psychological Factors. Psychological factors may also have an effect on the time a boy is dismissed from the choir. English boys have been shown to have divided loyalties (Ashley, 2009). In choir, they wish to retain their soprano voice, while in everyday life at school their wish is to be perceived as having a lower voice. Significant conflict exists between attachment to the choir and its repertoire and beliefs about masculinity (see also Freer, 2009). For English boys with singing talent, the former is often the more dominant, leading to the retention of soprano voice arguably for too long (Ashley, 2010, 2011). It might be more tolerable to leave the soprano or alto section if it is possible to sing again in the choir as tenor or bass. It might be even easier to accept if the change from the boys’ to the men’s voices is associated with a rise of social status as in many traditional German boys’ choirs.

Repertoire. Aside from the obvious case of music arranged specially for changing voices, genre and style can influence perceptions and practice with regard to choir dismissal. A non-demanding repertoire with a relatively low tessitura will allow the first stages of voice change to be ignored more easily than a challenging program with high tessitura. The considerable vocal agility called for by the music of J.S. Bach could become problematic for boys in Cooksey’s Stage 2, whereas the more floating, legato lines of Edwardian era Anglican composers may place less stress on voices in the first stage of change. Hook (2005) offers a comprehensive discussion of the important topic of vocal agility during puberty while Brown (2010) provides a valuable insight into the part writing and tessitura of vocal music across several

centuries that is revealing about the kind of voice the composer would have been familiar with.

The ideal tone and registers. Even within a choral tradition with a stable repertoire, differences in the ideals of tone production are possible. The Great War marks a convenient historical divide and there is evidence that prior to 1914 considerable attention was paid by English theorists and writers to the cultivation of what was then considered good tone in boys' choirs. John Curwen toured Great Britain and wrote up what he found about successful practice in a volume entitled *The Boy's Voice* (1899). Similar principles were elucidated by Francis Howard's *The Child Voice in Singing* (1895). The theories proposed by these authors (see also Behnke, 1880) were that only the so-called "head voice" should be used in boys' singing although it is increasingly clear that the understanding of what "head voice" was as referred to by such authors is no longer adequate and much work has subsequently been undertaken to understand register better (Brown, 2010). By 1928, however, it was being speculatively suggested that good singing was learned in the 16th century purely by imitation with "no pretence to scientific understanding" (Evetts & Worthington, 1928).

Such anti-scientific approaches have been found more and more wanting as choirs have come under increasing pressure in the early 21st century with regard to child protection and the vocal health of their singers. The status quo of the English tradition was also much disturbed from the 1950s onwards by a preference for a new kind of tone that was thought to be more youthful and undeniably "boyish." Beet (2011) traces this back to the Arthur Martin Boys' Choir of Belfast, said to have influenced Benjamin Britten in his preference for a more "boyish" tone than the sound that had become customary during the first part of the 20th century. It is more often attributed in the UK to George Malcolm who is often credited with introducing something that came to be known as "continental tone" at Westminster Cathedral in 1947. Continental tone was much popularized during a 1960s purge of emotional sacred music from the Victorian period. A degree of "shoutiness" and a "cutting" or "incisive" character that is said to be appropriate for the performance of polyphonic music from the 16th century is characteristic of this approach.

Upward forcing of the modal range is very different from the skilled training of vocal register control and there remains a need for detailed research on how what has been

called continental tone in England has subsequently developed and how it truly equates to practices on mainland Europe, such as the Germanic preference for a more robust lower register. The timing of choirboy dismissal as a result of changes in voice range may vary, reflecting differences between countries, musical periods, and in some cases the preferences of influential conductors. For example, a growing lower register with richer tones could be more acceptable if the choir director values and attends carefully to the properties of the boys' modal voice. On the other hand, where this is not considered important, older boys may just drift into a falsetto tone with very little power at the bottom of the range where there may be little or no development of the modal register. This may be more likely in English choirs with their preference for the lighter tone, and one result may have been the notorious "hoot" that dominated provincial English cathedral choirs during the mid-20th century and which choral revivalists such as George Thalben-Ball worked hard to eliminate (Lough, 2012).

Among the many unanswered questions remaining about how long a boy maintains a soprano or treble range during progress through the five stages of puberty, this question of register is probably the most pressing. The recent work of Henry Leck (2009) is reviving interest in the retention of a boy's upper register beyond the mutational point at which a new modal or "chest" voice develops. Leck questions whether the corpus of staged voice change schemes has over-emphasized the emerging modal voice and dispensed too quickly with the still usable upper register. A recent study by Ashley (in press) has found English boys to be able and willing to phonate clearly and without break across a full three-octave range at the time when the SF₀ was indicative of the mutational stage, much in the way Leck describes. These boys added new notes more quickly to the bottom of their range than lost notes at the top, calling into question the accuracy of Cooksey's "slinky spring" metaphor (Cooksey, 1992, p. 10).

Brown's (2010) recent discussion of the importance of register is also critical of the tendency in much writing about adolescent voices to stress range only. Understanding of register, he argues, is crucial to the development of control and the avoidance of needlessly limiting ranges. The extent to which retention of the upper register as suggested by Leck (2009) or earlier practitioners such as Thalben-Ball is

encouraged will certainly impact upon the time the singing voice is perceived to have changed.

Phillips (1996) gives comprehensive advice on the blending of registers in boys' changing voices. In spite of this, there is little doubt that in a good number of choirs, particularly ecclesiastical ones, boys mask the fact that their voice has changed by cultivating an untutored falsetto phonation, which is not the same as learned control of register. This has been greatly discouraged for some time by some of the more well-known singing teachers and voice specialists (Janice Chapman, personal communication, 2008; Titze, 1993; Trundle, 2005; Vennard, 1967; Ware, 1998), although choir directors tend to value the boy's maturity and leadership qualities, even if he has lost the top of his upper register and resorts to miming some of the notes (Ashley, in press). Striny (2007), Phillips (1996), Miller (1986), and Roe (1983) are among others who have provided good discussions of the management of register and falsetto in boys' changing voices.

The matter is of considerable significance, not only from the vocal health aspect, but also because of Wayman's demonstration that it is harder than is often imagined for listeners to distinguish between a boy singing falsetto and a boy with a genuinely unchanged voice (Killian & Wayman, 2010; Wayman, 2009). Moreover, according to Striny (2007), once voices are blended in chorus it becomes almost impossible to distinguish perceptually between a choir with some falsetto voices and a choir with none. Even with regard to falsetto the issue is not as straightforward as it can appear in schemes such as that of Cooksey. Ongoing research continues to throw up further complications. Williams (2010) found a boy chorister aged two months short of 14 and with a changing voice, but singing a full treble range with the non-falsetto phonation "of a child or adult woman" (p. 235).

To the problem of defining what is meant by voice "change" or "break" discussed in the first section are thus now added many uncertainties occasioned by disparate choral practices which impact upon the longevity of the treble voice. In the next section we add to this the problem of researchers' failure to agree on methods and criteria for what counts as the beginning of voice change. We consider first the contribution of musicological and biographical studies and then dispensation studies (those that have looked at the time boys are dismissed as trebles from choirs) before looking at more scientific, statistical studies and

concluding with a section on studies that have used John Cooksey's work as a particular reference point.

Inconsistency in the methodology of researchers

Musicological and biographical studies. Some authors working in fields such as musicology have tried to identify the age at mutation onset in past centuries from historical records. Often a single biographical event like the voice change of Henry Purcell, Wolfgang Mozart, or Joseph Haydn, or a single statement in written sources is taken to be representative. David Wulstan (1985) mixes approaches, resulting in the unlikely conclusion that mutation occurred at age 18 in 1475, at 16 in 1550, at 15 in 1600, and again at 18 in 1850. Bowers (1987) disagrees sharply. Bowers has investigated biographies of 100 singers of St. Georges Chapel and concludes that mutation occurred at the age of 14 or 15 around 1500 in England. He also mentions choir records from 1545 and 1547. All boys in those records are younger than 15 years old.

Daw (1973) investigated choir records of the Thomanerchor and came to the result that mutation occurred at the age of 17 or 18 during Bach's time. However, Daw starts his investigation with highly questionable assumptions and omits that the choir records are erroneous regarding the leaving dates of the pupils. It is possible that he overestimates the mutation age by approximately two years (see Mecke, 2007).

Beet (2005) has conducted extensive interviews with former British boy sopranos, now in their 70s, 80s, or 90s. These significant and thorough oral histories generally point toward a mutational age of around 15, 16, or 17, rather than 13 or 14. This was confirmed by the late Denis Barthel, a contemporary of world famous boy soprano Ernest Lough, in a personal communication to one of the present authors:

...the fact that the Temple chorister's voices often did not break early was due to the "Temple tone" and the manner in which Dr. Sir George Thalben-Ball (whom we all loved very much) taught us to project our voices. For example, my voice and that of Ernest Lough did not break until we were both seventeen. (Barthel, personal communication, 2006)

Unfortunately, it is not really clear in accounts such as this what is meant by "break," and the reference to the "Temple tone" re-opens the debate of the previous section about widely differing choral practices.

Studies from dispensation records. Two studies have tried specifically to identify a secular trend using dispensation records. Pfützner (2001) used exclusion data from the Kreuzchor Dresden for the period 1956–1993. Between these points he found an advance of about one year. The mean grade level for voice change onset was at the end of German Grade 8 in 1956 and in the middle of Grade 7 in 1993. At the middle of Grade 7 pupils in Germany are usually around 12.5 years old, and by the end of Grade 8 approximately 14.0 years. However, the exact age of the singer is not recorded, and it is possible that the apparent advance in the timing of voice change might equally be the result of changes in the structural organization. Pfützner also found that the duration of mutation had extended—which might be a sign of greater care for the developing voice or an attempt to deal with the problem of balance (because the choir would contain too many tenors and basses if voice change occurs earlier and the boys came back too soon.)

The second study was conducted by Juul et al. on the Copenhagen Royal Boys' Choir of Denmark (Juul et al., 2007). This found a mutational age of 14.2 years for the boys joining the choir at the age of 8 between 1993 and 1994. However, for the boys joining the choir between 1997 and 1999, this had fallen to 13.7 years. Two other cohorts were examined. For the 1990–1992 cohort the age was 14.0 years and for the 1995–1996 cohort, 14.2 years. In this study, a clear description of the criterion of exclusion was given. This was “unintentional falsetto notes and changes in singing tone” as observed by the conductor of the choir in weekly voice assessments of the boys. A statistically significant downward trend was found between 1994 and 2003 ($p = 0.0146$). The overall median for the 10 year period was 14.0 years. Also important in this category was the extensive study of the pre-mutational voice within the Thomanerchor by Fuchs, Behrendt, Keller, and Kratzsch (Fuchs, Behrendt, Keller, and Kratzsch, 1999; Fuchs, Behrendt, Kratzsch, and Keller 1997). This study recorded the age of 14.2 years as the mean determined by the choir director for boys' dismissal in 1997.

Scientific, statistical studies—longitudinal and cross-sectional. Different authors have investigated the mean or median age for the voice change onset, but there is little agreement among practitioners about the onset of voice change in singing and speaking voice. Historical documentary studies

and oral histories are possibly even less clear about what is actually being measured. Contrary to what might be hoped, however, those studies presented as scientific are also often confusing and do not generally synthesize to a coherent picture. Some concentrate on the singing voice, others on the speaking voice. Some assume three states (pre-mutational, mutational, and post-mutational voices); others just distinguish between “unbroken” and “broken” voices. Some researchers checked the range of the singing voice, some asked for self-assessment, but many estimated whether mutation has started just by listening to the sound of the voice (either singing or speaking). Data were obtained through longitudinal, cross-sectional or retrospective studies.

Confounding incompatibilities in specific criteria may occur even where studies agree on broad objectives and methodological approaches. For example, Schilling and Karthaus (1961) tried to replicate an earlier investigation by Paulsen (1900). As had Paulsen, these authors used three categories and investigated the singing voice of their subjects before classifying them by their perceptual judgment. However, the researchers obviously differed with regard to this. Though Paulsen's data suggest a median age of 14.8 years for the onset of mutation, in their 1961 study Schilling and Karthaus classified 20% of the 9-year-olds as already having a “mutational” voice, and found the median age for onset of mutation to be 11 years old. These findings reflect a shift of nearly four years in the age of voice change onset within the 60-year period between the studies.

Longitudinal studies of voice change are relatively rare. However, cross-sectional and retrospective studies may not be appropriate for the investigation of mutation onset. Significant critique of the cross-sectional approach began to appear with papers such as that of Bennett (1983). Bennett conducted a longitudinal study of boys and girls ($n = 25$) between the ages of 8.2 and 11.2 years. She found an average decrease in SF_0 of 12 Hz per annum ($SD = 8$ Hz). Although this was indicative of voice change not having commenced by the age of 11.1 years, Bennett concluded that a cross-sectional sampling would not reflect accurately any individual developmental course because the between-subject standard deviations are larger than the age-related changes that occur in children's voices at this stage of development. In retrospective studies, memory errors may be involved. In a study by Killian (1997) related to the psychological implications of voice change, 17 of 71 subjects

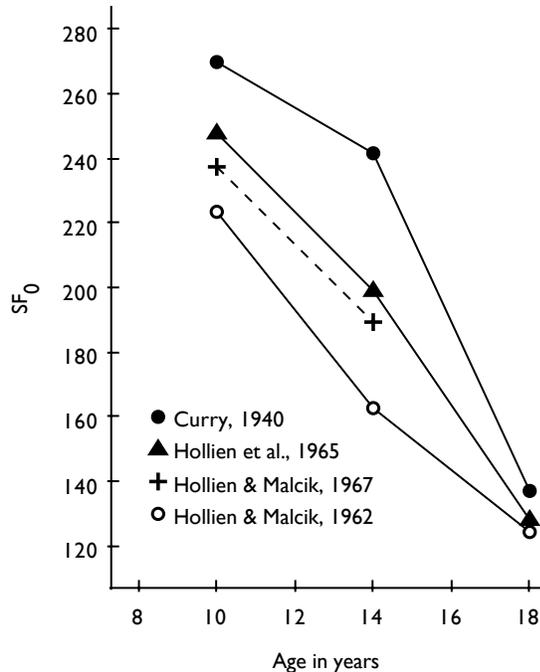


Figure 1. Median SF₀ of six representative boys of the indicated age from studies by Curry (1940), Hollien and Malcik (1962), Hollien et al. (1965), and Hollien and Malcik (1967).

could not remember their voice change at all. It is possible that subjects asked to recall their age at voice change onset just report the age they consider as normal for this change to occur.

Attempts at consistent comparison across time. The methodology of E. Thayer Curry allowed a form of consistent comparison over time to be made. Curry (1940) investigated the SF₀ of 10-, 14-, and 18-year-old boys from Iowa using a relatively small sample of six representative boys for each age group. He assumed that the first sample would represent the pre-pubescent boys, the second the adolescent and the last the post-pubescent category. This method was replicated 20 years later by Hollien and Malcik (1962) with African-American boys in Texas. The researchers were surprised to find much lower SF₀ for all age groups, especially for the 14-year-olds. To eliminate factors such as genetic or climatic differences between the subject groups, Hollien repeated the study with only Caucasian boys from Texas (Hollien, H., Malcik, & Hollien, B., 1965) and again (without the 18-year-olds) with Caucasian boys from Iowa (Hollien & Malcik, 1967). Although there were differences between Caucasian and African-American boys and between Texas and Iowa,

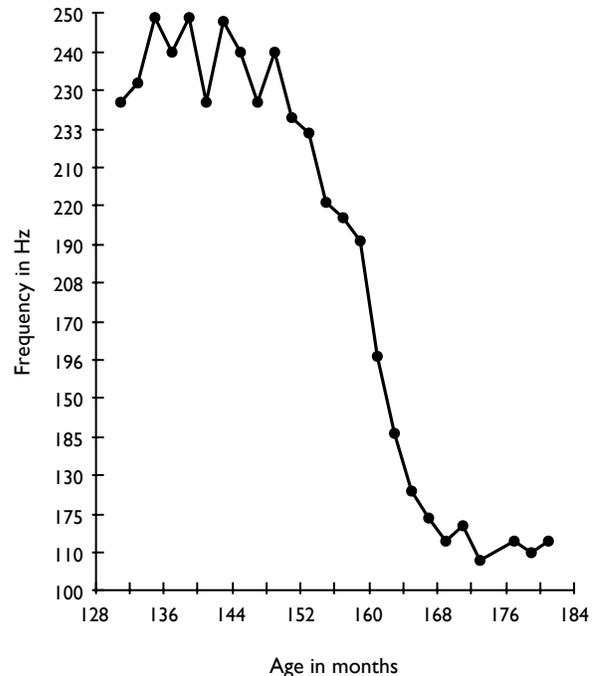


Figure 2. SF₀ for one boy in the study of Hollien et al. (1994). Adapted from “On Pubescent Voice Change in Males,” by H. Hollien, 2012, *Journal of Voice*, 26, p. e36. Copyright 2012 by Elsevier.

the difference between the studies from 1940 and the 1960s was striking (see Figure 1). It could be argued that the samples were too small and that social and cultural differences might have biased the results—this would explain the lower measurement for all age groups. However, these studies are a strong indication that the onset of voice mutation had advanced between 1940 and 1967.

Only one of the few longitudinal studies we found, that of Hollien et al. (1994), defined a relative criterion for the onset of voice change (i.e., a substantial change from an earlier state). In earlier longitudinal studies of puberty, the researchers just noted whether mutation had begun according to the actual sound of the voice, thereby using a criterion similar to a cross-sectional study. Hollien et al.’s method allows them to give a clear definition of voice change onset:

The SFF peak which was preceded by a generally varying pattern of at least four months and succeeded by a decreasing SFF slope at a minimum rate of one semitone per month for at least six months. (p. 2649)

Figure 2, taken from Hollien et al. (2012), illustrates the

process well for one individual boy who commenced the mutational stage at age 12.8 and completed it at age 14.2.

These authors give a mean age of onset in 1994 for White, Midwestern-American, middle-class boys of 13.4 years ($SD = 10.4$ months). The earliest onset was found to be 11.6 years, with 6% of the sample ($n = 65$) not having reached this stage by the age of 15.5 years. These data are probably among the most significant investigations of voice change onset, and it is clear from Figure 2 what the authors intend as the meaning of “onset.” Care is required in ensuring meaningful comparability with other studies claiming to have produced similar data.

Studies associated with John Cooksey’s work

An important symposium on the adolescent voice attended by many leading researchers was held at Buffalo State University in 1982. Cooksey himself contributed to this and a considerable degree of interest was aroused at the time. Cooksey was throughout his career cautious about ascribing age norms to events. Indeed, he stressed the unsuitability of chronological age as an indicator of voice part. Nevertheless he indicates, based on his considerable experience, when the majority of boys in his studies were at the various stages of development. Table 2 has been compiled from the appendices in Cooksey (1992).

Table 2
Indicative age norms from Cooksey (1992)

No.	Stage	Grade levels		Age (yrs)		
		Name	US	UK	Range	Mean
0	Unchanged		5–7	6–8	10–11	–
1	Midvoice I		6–8	7–9	12–13	–
2	Midvoice II		5–9	6–10	13–14	–
3	Midvoice IIA		7–9	8–10	13–14	13.6
4	New baritone		7–9	8–10	13–15	~14
5	Developing baritone		9	10	14–15	–

Note. Mean age data represented with dashes (–) were not provided in the original source.

Although mean ages for Stages 0–2 and 5 are not given, Cooksey’s (1992) designations of the age of 13.6 years for the “climactic period of puberty” and 14 years as the “end of

the most dramatic stage of voice change” (p. 59) are important.

Cooksey’s research was extensive, but not all of his discoveries were published, leaving the volume of actual academic output surprisingly small. Through the Buffalo State Symposium we find three comparable figures by Cooksey for different times: 14.25 years in 1939, 13.8 in 1972 and 13.5 in 1978. These data are collected from two unpublished theses (Sturdy, 1939 and Friesen, 1972) and from Mary Danker Groom’s presentation of her doctoral thesis at the Buffalo State Symposium in 1982. As Killian (1999) explains, it remains unclear how the onset of voice change was defined in these studies. Additionally, Cooksey does not explain why he chose these three studies out of the possible range of statistical investigations.

Two authors have investigated a possible secular trend in voice change using the Cooksey stages. Table 3 shows the results of a small study by Rutkowski (1984). Rutkowski attempted to replicate Cooksey’s work in a small study of 10 boys passing from US Grade 6 into Grade 7 and believed that she had found evidence of earlier progression, particularly in the case of one boy who reached the new baritone stage more rapidly than expected, before turning 13. Boys in Grade 6 (UK Year 7) were between 11 and 12 years old, and in Grade 7 (UK Year 8) between 12 and 13 years old.

Table 3
Changes in the progression of ten boys from G6 to G7

Grade	Stage					
	0	1	2	3	4	5
6	1	5	2	1	1	0
7	0	2	5	0	3	0

Rutkowski reported her findings as percentages, which is potentially misleading for such a small sample, and the data are insufficient to generalize into a trend. Thus, in Table 3 we present these data as raw figures. Rutkowski appears to contradict her own findings in a later symposium paper (Rutkowski, Miller, & Campbell, 2001). In this, the authors concluded that most boys at the end of 6th-grade (i.e., aged 12) “still exhibited ease of use of a treble range,” a finding which she acknowledged was inconsistent with her earlier work as well as that of Killian published in 1999.

Subsequently, Moore (1995) set out to discover whether there was an ongoing trend relative to Rutkowski's baseline. Moore's sample was larger and consisted of 60 7th-grade (UK Year 8) boys. Two sampling points were taken during this year when the mean age was 12.7 years old and 13.0 years old, respectively. The raw figures are shown below in Table 4.

According to this, there were almost no boys with unchanged voices in Grade 7 (UK Year 8). The greatest number are at Stage 2 by the age of 12.7 years, but this shifts

Table 4
Changes in the progression of sixty boys from G6 to G7

Age	Stage					
	0	1	2	3	4	5
12.7	0	10	29	14	5	2
13.0	1	0	18	20	17	4

quite rapidly over a three-month period, with 17 boys (28%) having reached the critical Stage 4 by the age of 13.0 years. Moore claimed, on the basis of this work, that there had been a downward trend between 1984 and 1995. It is unfortunate that the sample sizes are insufficient to permit generalization. It is also unfortunate that comparable data are not available for English or German boys, given that recent studies have reported earlier puberty in US boys than European boys (Sørensen, Aksglaede, Petersen, & Juul, 2010).

Synthesizing the studies to look for a trend

Reconciliation of medical and vocal studies. Some of the studies we have reviewed are by vocal pedagogues and choral researchers. Others are by medical investigators. Some have looked at the speaking voice, some the singing voice, yet others both. As we move toward a final synthesis, we need to have this in mind. Figure 3 below is a whisker plot of all the data found in a search of German language literature undertaken by Mecke (2007). The data points are not actual mean values; this plot gives an impression of the age that was considered normal for the beginning of voice change. It is possible to see that for the time between approximately 1850 and 1950 there is a clear trend toward voice change onset occurring at a younger age, possibly a result of changes in stature and nutritional status across the industrialized world during this era. The studies of Krawczynski,

Walkowiak, and Krzyzaniak (2003) of the secular trend in Poland over eight different periods from 1880 to the present are significant here. During the 20th century the 1950s and 1970s saw the greatest trend, and the 1940s, when wartime rationing was prominent, the least. Compared to changes of a 2 to 3 year magnitude, the more recent secular trend under discussion seems relatively small. However, the age of 17 or 18 years for voice change onset, as stated by musicological sources such as Daw (1973) for Bach's era, has never been considered as normal in written sources.

Is a regression trend possible? Although the idea of combining statistics from different times seems promising, the "key problems" mentioned in the previous section render a clear picture almost unattainable. The Appendix and Figure 4 provide a summary of studies undertaken across Europe and America between 1866 and 1994, referring specifically to the age of voice change and puberty (for more information see Mecke, 2007, or the indicated studies directly).

The wide range of methods and criteria makes it impossible to establish or refute a development toward an earlier mutation, even if one is actually occurring. Indeed, by choosing selectively from this table, different and contradictory "secular trends" could be illustrated. The data collected in the Appendix are shown as a diagram in Figure 4. A linear regression shows only a near-zero correlation ($r^2 = 0.08$) and a subtle trend toward earlier voice change (9 months in 100 years).

Conclusion

Much of the present paper has been concerned with difficulties defining a time of voice change onset in the more or less continuous change of the different voice parameters. It has been shown that a range of criteria and measurement methods are possible and that choir traditions and structures may influence the time at which a boy is considered to have a changed or "broken" voice. It is frustrating that the statistical investigations reviewed regarding the voice change have used criteria and methods too inconsistently across studies to permit completely reliable comparison or the confident identification of a trend. This literature review cannot therefore lend unqualified support to the beliefs of choir directors that a sudden lowering of the age of puberty has impacted on their work in the current era. However, taking into account all the studies reviewed, including historical and musicological

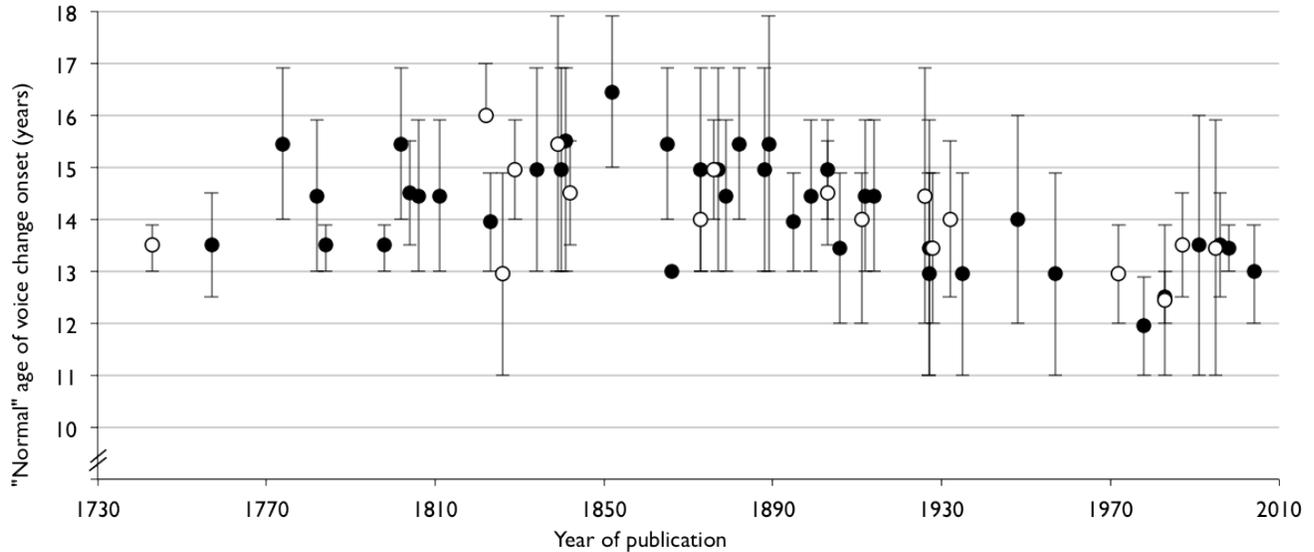


Figure 3. Age data for the onset of voice change from statements found in German singing texts (filled dots) and German medical books (unfilled dots). The extended lines, or whiskers, indicate the range considered normal for mutation onset age by the various authors.

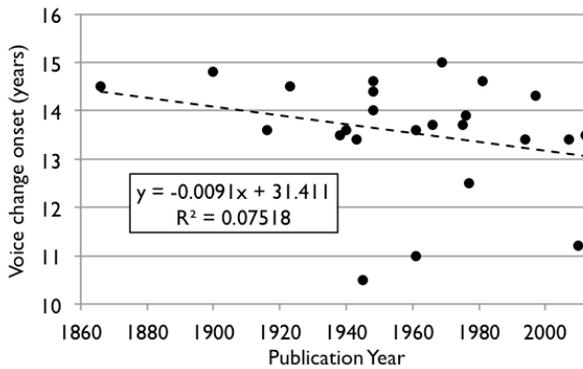


Figure 4. Regression plot of the Appendix data with the dates of publication as time coordinates. The dots represent mean or median values found in the indicated statistical surveys.

sources, a trend is revealed and some support is lent to the belief that the onset of voice change has occurred successively earlier over the last 150 years. Moreover, some studies investigating the SF₀ of boys or recording the dismissal ages of choirboys also support the contention that this trend may have accelerated during the last 50 years. The plausibility that the measured acceleration of puberty for girls could be in some way reflected in boys lends support to the belief, although the relative imbalance of work on girls and boys must be reiterated.

A significant question remains unanswered: Will the historical average for onset of boys' voice change continue to

trend earlier? If the trend does continue, will it speed up, slow down or even go into reverse as some research has shown is possible? Given this considerable uncertainty, we have one major conclusion for researchers: A reliable baseline should be established for the present time, and the methods used need to be properly scientific and clearly described. As far as possible, these methods should anticipate future replication across decades and even centuries, given what might be anticipated about further advances in computerized voice measurement.

There are potentially major implications for choral practice, which could arguably be at a historical turning point. It is wrong to conceive that the age at which boys are "apt to change their voice" is purely biologically determined. This review has shown that there are significant social and cultural dimensions that can influence the timing of voice change. Different choral practices clearly have a major impact, and boys' own desires to present their emergent masculine selves through voice render the use of the term "apt" quite appropriate. Boys' puberty is a socio-cultural event as well as a biological one.

We have the following recommendations. First, for those working with traditional high-art or "classical" choirs, it will be prudent to plan for a lower age demographic. Boys need to be recruited at younger ages and more attention needs to be given to high quality kindergarten work and the creation of junior training choirs from which the main choir

membership is subsequently drawn. Traditional structures of schooling such as the transfer at the end of Year 8 in the UK (US Grade 7) may need to be reappraised with the expectation that boys will be lost as treble singers once the age of thirteen has been attained. Some choirs are already making these adaptations.

Second, those working with such choirs should hear boys individually at regular intervals beginning at the age of twelve. Again, this is already practiced in some choirs but by no means all. Boys should be prepared psychologically for the changes ahead and encouraged to take an interest in their own voice, informed by an appropriate education about the physical and social aspects of puberty. We would recommend significantly improved training and education for conductors working with boys' choirs. Although work such as John Cooksey's should be thoroughly understood, so should alternative approaches such as Henry Leck's. The singing styles engendered in the boys should be based on an improved understanding of how register is to be managed during voice mutation and a better insight into those issues of masculinity and self-presentation that are so important to young adolescent boys. In short, young singers should be better treated than has sometimes been the case.

The biggest challenge of all, however, concerns how the choral world is to conceive boys' choirs in the future. What is their purpose? Is it primarily pedagogical—to capture young interest and develop sufficient musicianship to ensure a supply of adult tenor and bass singers? Alternatively, is the boys' choir still to be seen as a unique, cultural artifact in its own right? Is the expectation still to be that the performance of a demanding repertoire by an exclusively male choir reliant on competent, musically mature boys able to sustain a high treble line will remain as a primary objective of choral culture? Such questions have to be considered against the background that there are alternatives, such as “cambiata” choirs for boys in the first phase of voice change. Europe has perhaps been slower than the US to realize the potential value of these opportunities, but there is still a long way to go across the world to establish that the sound of boys' voices in early change is as worthwhile as the sound of boys' high treble voices. Composers and arrangers have yet properly to exploit this resource, and concert promoters have a big task in educating the musical public. The commercial music industry may need to be convinced that there are viable alternatives. We recommend significantly more attention to all these matters.

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APPENDIX
Summaries of Studies of Voice Change: 1866–2012

Author, Year	Place	Type	Method	Sample	Onset
Fournié, 1866	France (Paris)	Cross-sectional	Sound of singing voice, laryngoscopy exam	57	Mdn = 14.5
Paulsen, 1900	Germany (Kiel)	Cross-sectional	Sound of singing voice	1787	Mdn = 14.8
Weinberg, 1916	Sweden (Stockholm)	Cross-sectional	*Sound of singing voice	327	Mdn = 13.6
Scheidt, 1923	Germany (Munich)	Cross-sectional	Sound of speaking voice	350	Mdn = 14.5
Zeller, 1938	Germany (Munich)	Cross-sectional	Sound of speaking voice	≈400	Mdn = 13.5
Schmidt-Voigt, 1940	Germany (Frankfurt)	Cross-sectional	*Sound of speaking voice	1380	Mdn = 13.6
Ramsey, 1943	USA	Cross-sectional	Self-assessment, sound of speaking voice	291	Mdn = 13.4
Pedrey, 1945	USA (South)	Cross-sectional	Sound of speaking voice	1014	M = <11
Kinsey et al., 1948	USA	Retrospective	Self-assessment	2279	M = 14.4
Schilling, 1948	Germany (Freiburg)	Retrospective	Self-assessment	≈100	M = 14.6
Hogben, 1948	UK (Tottenham)	Cross-sectional	*Sound of speaking voice	850	Mdn = 14.0
Preu, 1961	Germany (Halle)	Longitudinal	Voice range, SF ₀	14	M = 13.6
Schilling & Karthaus, 1961	Germany (Marburg)	Cross-sectional	Sound of singing voice	640	Mdn = ~11
Chang, 1966	Hong Kong	Cross-sectional	Sound of speaking voice, self-assessment	3658	Mdn = 13.7
Andersen, 1969	Denmark (Copenhagen)	Cross-sectional	*Sound of speaking voice	477	Mdn = 15
Neyzi, 1975	Turkey (Istanbul)	Cross-sectional	*Sound of speaking voice	1530	M = 13.7
Taranger et al., 1976	Sweden	Longitudinal	Sound of speaking voice	103	M = 13.9
Billewicz et al., 1981	UK (Newcastle)	Longitudinal	Sound of speaking voice	669	M = 14.6
Cooksey, 1993	USA	Longitudinal	Cooksey stages	86	M = 12-13
Hollien et al., 1994	USA (Kansas)	Longitudinal	Speech frequency	65	M = 13.4
Fuchs, 1997	Germany (Leipzig)	Longitudinal	Dispensation from choir	28	M = 14.3
Kahl, 2007	Germany	Cross-sectional	Self-assessment	3950	Mdn = 13.4
Fisher, 2010	USA	Cross-sectional	Cooksey stages, Onset: Stage 1	197	M = 11.2
Ashley, 2012	UK	Cross-sectional	Cooksey stages in the UK: commencement of high mutation	843	M = 13.2