Findings from a survey of pitch drift

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Abstract

The phenomenon of pitch drifting while choirs perform a cappella *music is familiar to choral performers and directors, although there appears to be a lack of research into the reasons that it occurs. As part of a research project to investigate possible causes of pitch drift, when singing unaccompanied music, a survey of choral practitioners was undertaken. This paper presents the findings of the survey, which established that a majority of choirs suffer problems maintaining pitch and that varying beliefs about the cause are widespread. In general, anecdotal beliefs regarding pitch drift in* a cappella *choral singing are confirmed, but the causes remain unclear.*

Key words choirs, pitch, pitch drift, *a capella*, survey, tonal centre, intonation, beliefs,

Introduction

Pitch drift in *a cappella* singing is a well-known phenomenon for choral singers and musical directors alike. By 'pitch drift' we mean that a performance begins at the correct pitch but by the end has drifted to another tonal centre, even though the choir's intonation on chords might have been good throughout. Anecdotally at least, the drift is generally downwards.

The phenomenon is so widespread that it tends to be regarded as a fact of life, and the downward direction is taken as natural, possibly because keeping anything aloft seems to require special effort. But that analogy is surely false. There is no gravitational pull on voices; and if singers lose precision (for whatever reasons) we would expect pitch drift to be upwards as often as downwards. Thoughts such as these prompted a research project on pitch drift, of which this paper reports on a small part.

Background

The 'taken-for-grantedness' of pitch drift referred to above seems to have resulted in a lack of research and a dearth of publications. Instead there is a wealth of anecdote and lore around the subject. Although practitioners often have strong convictions about the causes of pitch drift, experimental evidence is scarce.

In a radio programme interview Simon Halsey (2012), the chorus director at the time of both the City of Birmingham Symphony Chorus and the Berlin Radio Choir, recalled his experience as a choirboy in Oxford. During a period when the choir sang *a cappella* daily:

> '... very often, on a Friday when it was snowy outside, and everyone was tired, we used to have intonation problems and the piece would begin in E flat and end down a semitone. I remember Sir David Lumsden getting rather cross about this and deciding he would try initially to sing all the pieces in E and A, a semitone higher than they looked, and interestingly the intonation stayed. Now the question was why did it stay, and I still can't tell you? But I think because it felt brighter, because we'd been told it was higher and because it required a great deal more connection of our diaphragm, our lungs to our vocal chords, because it was higher and a bit more effort we probably worked harder, brightened the sound, and the pitch stayed.'

A couple of points here are significant. First Halsey attributes the pitch drift to the boys' tiredness, and possibly also to the cold weather. Secondly, the remedy, as far as the conductor was concerned, lay in altering a feature of the music, specifically transposing it to a different key. The transposition forced the choir to make more physical effort. Underlying this strategy is a belief that if singing were too effortless, singers would neglect the physicality of singing (the connection of diaphragm, lungs and vocal folds) and pitch would drift downwards. There is also a suggestion that the quality of the sound itself (its 'brightness') played a role, possibly by affecting the audibility of the sound to the singers themselves.

Halsey's anecdote is not intended to be taken as a scientific exposition, of course, but it nicely illustrates some recurring themes in discussions of pitch drift. For example, it illustrates the puzzling nature of the phenomenon, despite practitioners' firm beliefs about its causes and remedies. Naturally we do not discount the views of the distinguished musicians referred to in the anecdote, but there seems to us to be a need for an empirically validated account of the phenomenon established through procedures in which the variables are controlled. This paper does not offer such an account, but by reporting the findings of a survey into the occurrence of pitch drift, it could be regarded as a contribution to further research.

Another point to notice from Halsey's anecdote is its suggestion of a multi-factorial basis to pitch drift. Tiredness, temperature, tonality (i.e. key), audibility and engagement with the physicalities of voice production are advanced, implicitly or explicitly, as relevant factors. It is not difficult to imagine that other factors could also be relevant, since the accuracy of pitching individual notes is thought to be affected by numerous external factors including, among others, the weather, central heating and humidity (Potter 2000). Similarly another external factor, auditory feedback (i.e. singers' ability to hear themselves), has been shown to affect singers' accuracy of pitching (Ternström and Sundberg, 1988; Tonkinson, 1990). By referring to these as 'external factors' we mean that they are external to the piece of music itself; in other words, they are factors which would be the same irrespective of the piece performed. Halsey's anecdote includes such external factors as temperature and the tiredness of the performers. External factors often relate to the environment of the venue in which the performances take place; for example, the acoustic properties of the room (such as reverberation time) and its size. Non-environmental external factors include the size of the choir, the relative sizes of the

SATB cohorts, and the presence or absence of particular members. The survey described below concentrated on external factors for reasons to be explained in a moment.

External factors are contrasted with internal factors, and a brief digression into internal factors is relevant here. Terasawa (2004) reports an investigation of pitch drift in Bruckner's unaccompanied motet *Os Justi*, which had been found to be particularly susceptible to pitch drift. At the heart of Terasawa's paper is the premise that compositional features of the music are the primary cause of the pitch drift. Teresawa undertook a series of experiments that compared chord sequences using both just intonation and equal temperament and indicated that the particular sequence of root notes for the chords in *Os Justi* may be the cause of the problem of pitch drift, although external factors are acknowledged to be relevant also. Tempo has also been found to affect pitch drift, with quick tempos being more susceptible than slow ones (Jers and Ternström, 2004).

Howard (2007) investigated the problems of *a cappella* intonation with experiments using his own chorale-style composition in which every chord has a note suspended from the preceding chord. The successive suspensions provide references from which the pitches of the other notes in new chords can be derived. For instance, if a new chord has the altos holding a D from the preceding chord, and if the basses, tenors and sopranos are required to find respectively G, B and G for the new chord, they can readily do so from the altos' D. Howard calculates that if singers use just intonation when deriving their pitches from the reference tone, the tonal centre of the piece will inevitably drift during the course of the performance; and his experiments with a vocal quartet of experienced singers confirmed this. However, whether this accounts for pitch drift in a typical amateur choir with multiple voices in each part, or even in quasi-professional choirs, such as Halsey's college chapel choir, is unclear. For example, starting a piece a semitone higher, the ruse used by Halsey's conductor, ought to offer no benefit if pitch drift results from repeated derivation of pitches through just intonation in the way described. Also, it is an open question whether singers in an amateur choir use any consistent system of reference notes or tempering to arrive at their typically somewhat variable pitches.

There is no reason why external and internal factors should not both be present and interact to cause pitch drift. For example, one could imagine harmonic complexity (an internal factor) and singers' tiredness or lack of ability (external factors) both contributing to a poor performance. Similarly, in Halsey's anecdote, key (an internal factor) is cited as contributory among a list of external factors. However, if internal factors were primarily responsible for pitch drift, we would expect pitch drift to be consistent from performance to performance and from choir to choir. On the other hand, if external factors were primarily responsible we would expect inconsistent amounts of pitch drift from performance to performance and from choir to choir, which is what is generally found. In fact the variability of pitch drift from one rehearsal to another is what primarily motivated this research, and hence the survey discussed below, which looks at the constitution of choirs, their rehearsal venues, the extent to which pitch drift occurs, and so on.

Online survey of choral practitioners

A survey was prepared using the well-regarded *Survey Monkey* online platform. Although using an online survey would exclude those practitioners without internet access (this was in 2013) the global reach offered was seen as an advantage.

The survey questionnaire, outlined below, was piloted with colleagues to iron-out any faults before publication in August 2013. Rather than publicise the survey through social media, which could have resulted in many time-wasting responses, it was decided to target the survey towards interested groups. The first opportunity to promote the survey was at the ABCD's Annual Conference held that year in Oxford and through their online newsletter. One visitor to the convention, the then executive director of the American Choral Directors Association (ACDA), kindly agreed to publicise the research in the association's *Choralnet* newsletter during September 2013. Contact was made with *Voice Moves*, Western Australia's major choral association, whose secretary posted details of the research to their members. Messages requesting participation from choral practitioners on two dedicated music e-forums, *Performance Studies Network (Perf-Stud-Net)* and the *Musicology-All Network* resulted in a doubling of responses overnight.

The survey closed in May 2014 with a total of 296 responses of which 216 were sufficiently complete to be used in the analysis described below.

Questionnaire

The survey was in the form of a questionnaire with 20 questions in three sections, asking choral practitioners with current or past experience in directing, accompanying or singing in choirs for:

1. details of the choir – name, website, gender, age range and experience of singers, music genres sung (Questions 1–8);

2. features of the choir's rehearsals and venue – time of rehearsals, type of building, acoustic properties and the choirs' comportment (Questions 9–13);

3. opinions on pitch drift during unaccompanied singing – whether it happens, when and how it happens and if so does it matter, whether the drift is sharp or flat, whether public performances make a difference (Questions 14–20);

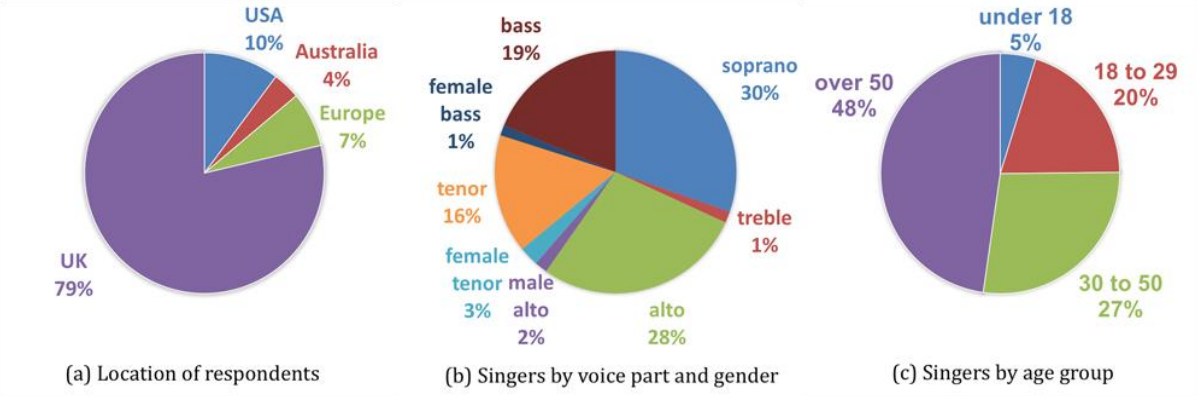
Respondents could leave their contact details at the end of the questionnaire.

The questions were mostly of the multiple-choice and list-answer form where one or more responses could be selected from a list of appropriate words or phrases. Several questions had a default 'other' choice as a catch-all in case the list, for whatever reason, did not apply or the respondent felt further explanation would be helpful. The questions which dealt with experiences of pitch drift were necessarily open-ended allowing for free-text replies in the hope that the respondents would volunteer as much information as they felt able. Any question could be skipped if the respondents so wished.

About the choirs

The first section of the survey focussed on the details of the respondents' choirs. Of the 216 valid responses received from choral practitioners around the world, 79% were from the UK, as may be seen in Figure i (a).

Figure I
Demographics from the survey

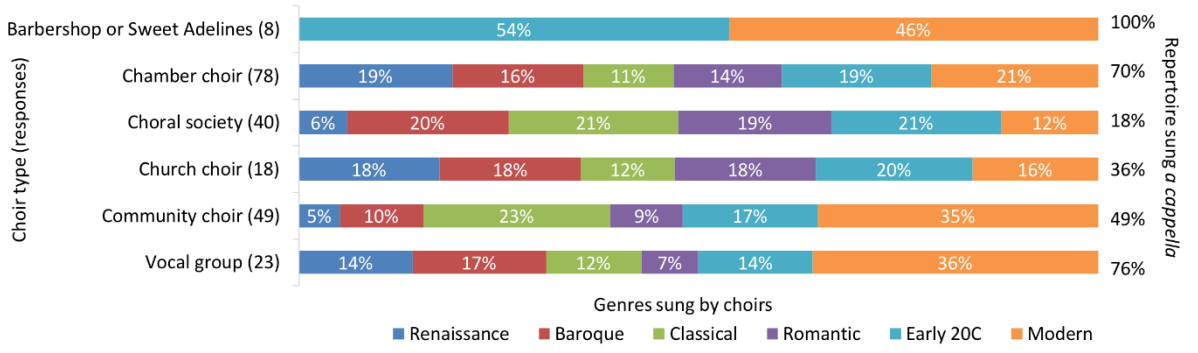


(a) Location of respondents (b) Singers by voice part and gender (c) Singers by age group

The demographic responses regarding the choirs revealed that from a total of 9,461 singers 62% were female and 38% male. Figure i (b) illustrates how the voice parts (SATB) were divided both by part and gender. Figure i (c) displays the combined age ranges of singers showing nearly half (48%) being over 50 years old!

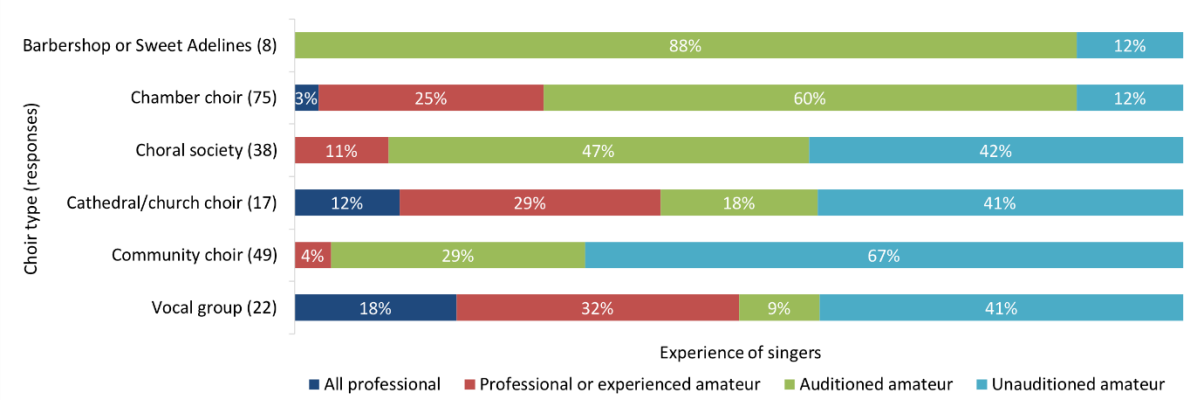
In a survey concentrating on *a cappella* singing it was thought useful to know the types of choirs involved and the musical genres in their repertoires. Figure ii shows the mix of genres sung by the six choir types into which the respondents placed their choirs. The percentage of *a cappella* music performed is shown on the right of Figure ii and demonstrates all of the respondents sang unaccompanied music to a greater or lesser extent giving authority to their experiences with pitch drift. Unfortunately, only eight Barbershop and Sweet Adelines choirs responded, which was a pity given that they reported always singing *a cappella*. Vocal groups and chamber choirs were both reported as singing a high percentage of unaccompanied repertoire but choral societies and to a lesser extent church choirs tended to sing a higher percentage of accompanied music.

Figure II
Respondents' repertoire by choir type and percentage sung *a cappella*



Singers' experience was thought a potentially useful factor to investigate. For example, it might be expected that choirs which auditioned singers would have more experienced members and might therefore not find pitch drift so severe as choirs with unauditioned members. Respondents were invited to grade the majority of the singers in their choir into one of four categories: all professional; professional (unpaid) and experienced amateur; auditioned amateur; and unauditioned amateur. (Note that it was assumed that choirs with all professional or experienced amateurs would audition their singers.) In Figure iii responses are shown by choir type according to these categories. The number of responses here is seven fewer than in the previous figure. Possibly respondents could not readily allocate their choir to one of the categories listed (except perhaps for the 'all professional' category). If so, it is a useful reminder of the wide range of abilities typically found in an amateur choir. Eight 'all professional' responses were received, comprising one chamber choir, three cathedral/church choirs, and four vocal groups.

Figure III
Experience of singers in the respondents' choirs

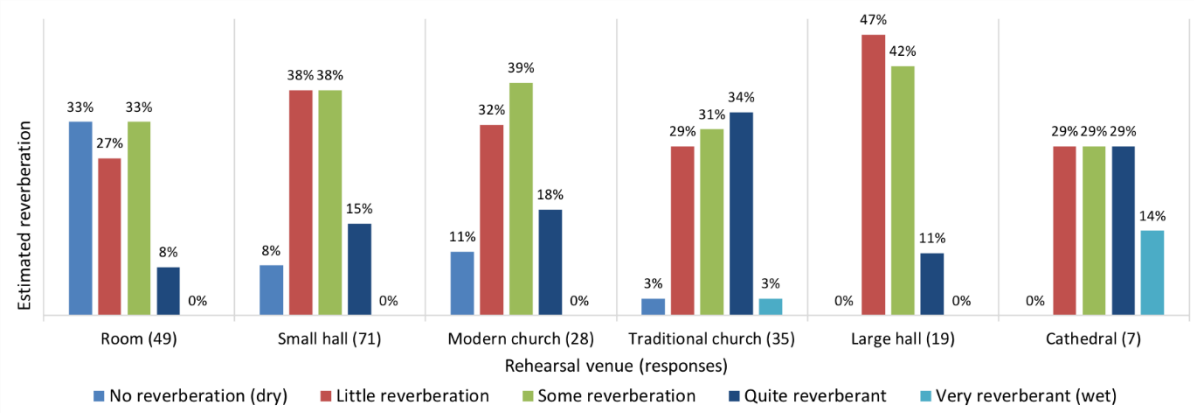


Concerning venues and rehearsals

The second section of the survey asked respondents about rehearsals. The acoustic characteristics of the venue, which are experienced by singers during performances, is germane to their ability to hear both themselves and each other – both crucial factors when singing *a cappella* music. Respondents were asked to estimate one of the acoustic characteristics of the venues in which they rehearse, namely reverberation. Although we cannot assume respondents were accurate or consistent in their responses, the research of Howard and Moretti (2009) found inexperienced listeners quite capable of estimating the acoustic characteristics of a number of churches in Venice. Respondents reported both the type of venue and their estimate of the reverberation from two given lists. The results are shown in Figure iv and barring one or two unexpected results appear to be sensible, i.e. no rooms being described as very reverberant or cathedrals as lacking reverberation.

A wide range of building types was used, from rooms in homes to cathedrals. However, there may have been some confusion with cathedrals as to whether the rehearsals take place in the nave and/or chancel or, as is more likely given the responses, a smaller rehearsal room (song school).

Figure IV
Estimated reverberation of the respondents' rehearsal venue by type



Rehearsal times and days were also requested to determine whether there was any correlation between the predominance of pitch drift and a presumed level of tiredness. Nearly three-quarters of the respondents (73%) reported starting rehearsals in the evening, i.e. after 6:00 pm. The remainder were spread fairly evenly throughout the day although no one reported starting at 11:00 am; perhaps that's coffee-time.

This section of the questionnaire concluded with respondents reporting on the positioning of their singers during performances. Again, this data was requested to test for a possible correlation with pitch drift. The results showed that in the majority of choirs (86%) singers are placed together in their appropriate voice parts. Furthermore, choirs were reported performing both sitting and standing as directed, or always standing, or always sitting, in roughly equal measures. Just over 20% sing from memory with just under 20% using choreography. Only one respondent reported using the tonic sol-fa notation.

Experiences of pitch drift

The third section of the survey concentrated on respondents' experience of pitch drift. From the replies received 48% reported their choirs suffering pitch drift occasionally with 39% stating that it was a regular occurrence. Only 13% replied that their choirs rarely or never drifted in pitch. Naturally we should be cautious about generalising the results of the survey to all choirs that sing *a cappella*. Nevertheless, this result is consistent with the anecdotal evidence, referred to above, that pitch drift is a real and important issue.

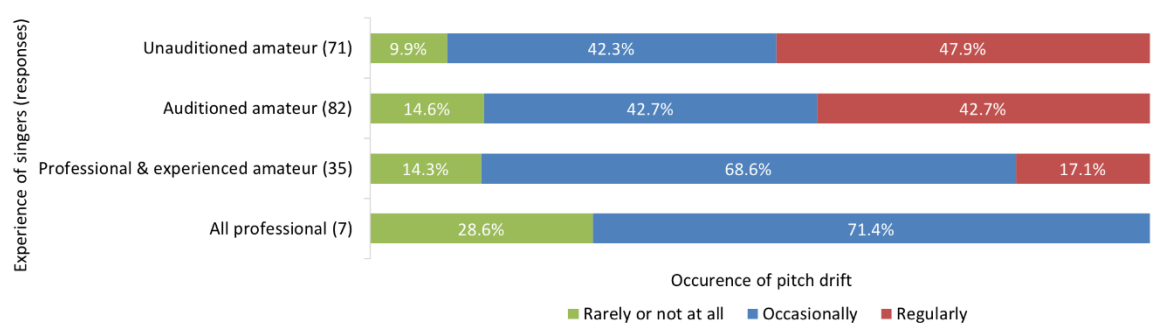
Of the respondents who stated that pitch drifted either occasionally or regularly, 91% reported it drifted down. Only two choirs (1%) were reported drifting upwards, with the remainder (8%) drifting in both directions. Anecdotal evidence, again referred to in the background to this paper, indicates that when choirs drift in pitch it will usually be down, and the survey results support this.

Given that pitch drift occurs then consideration should be given as to whether it matters. If a choir is singing an *a cappella* piece, does the choir or the audience really worry about a drop in pitch during the performance? The responses to a question as to concerns about pitch drift indicated that just over half (51%) were worried. However, 29% expressed no

concern and 20% chose not to comment. This lack of concern may well demonstrate a pragmatic view by the respondents, in line with Potter (2000) who suggests that the majority of any audience may not be overly concerned or even appreciated that pitch drift had occurred in an *a cappella* performance. Certainly, small deviations in pitch need not worry choirs. Research has demonstrated that changes in pitch of up to a quarter of a semitone are acceptable to trained musicians (Siegal and Siegal, 1977). However, this is not the case with larger changes in pitch which may be noticed even by untrained ears. Interestingly, anecdote suggests that pitch is better maintained in public performances than in rehearsal. This was borne out by 48% of the respondents who, when asked about pitch drift in performance, reported it to be less obvious. A further 16% reported that pitch drift would be unlikely and 29% indicated there was no difference in pitch drift between rehearsals and public performances. The remainder made no comment.

One possible cause of pitch drift could be the inexperience of the singers. As mentioned above, respondents were asked to categorize their choir into one of four types. The reported occurrence of pitch drift for these four types is shown in Figure V.

Figure V
Occurrence of pitch drift against the experience of singers in the choirs

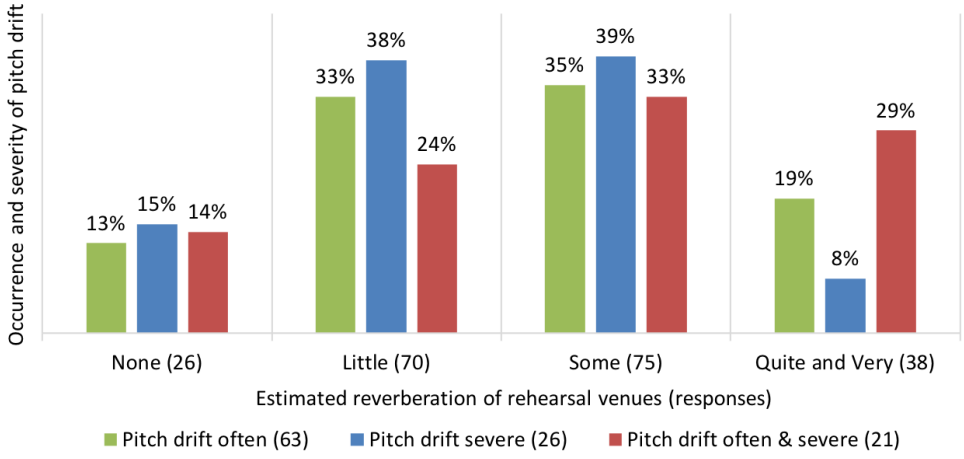


While not unexpected, these results demonstrate an approximately inverse correlation between the experience of singers and pitch drift. Choirs with professional singers did not report the occurrence of regular pitch drift but did admit that the pitch may drift occasionally, which agrees with Halsey's comments. Similarly, choirs with experienced singers are less likely to drift regularly than choirs consisting of amateur singers. Surprisingly, there is little to choose between the choirs which audition singers and those which do not, although there is a slightly greater occurrence of regular pitch drift in the unauditioned choirs. However, in regard to a choir's audition process, experience may well be only one of several qualities sought from the prospective singers.

Venues are often stigmatised by singers for their poor or difficult acoustics, although the characteristics favoured by singers are likely to differ from those preferred by audiences. Performers need to hear singers in the other voice parts (Gade, 1986) whilst still being able to hear themselves (Ternström and Sundberg 1983; Howard, 2015). Audiences too need to hear all the voice parts; but an acoustic with good audibility across all parts for the audience might not be so for the performers. In an earlier question respondents were asked to rate the acoustic properties of their rehearsal venue. Since no knowledge of acoustic parameters could be assumed, five simple categories were provided to describe the venues. The five categories referred to the amount of reverberation, namely: none

(dry); little; some; quite; very (wet). The results were compared to the degree of pitch drift reported by choirs to produce Figure vi. Note that, for simplicity, the single response in the very reverberant category has been added to the quite reverberant category.

Figure VI
Rehearsal acoustic against the occurrence and severity of pitch drift



The results in Figure vi demonstrate that the acoustic properties of the rehearsal venues make little significant difference to the reported occurrence or severity of pitch drift. There is just a tendency for the often and severe category to rise as the acoustic becomes more reverberant but there is too little data to be sure of a significant result. However, with regular use singers will become accustomed to the acoustic in their rehearsal venue and devise strategies to overcome problematic acoustics. This may have had an effect on the results presented here.

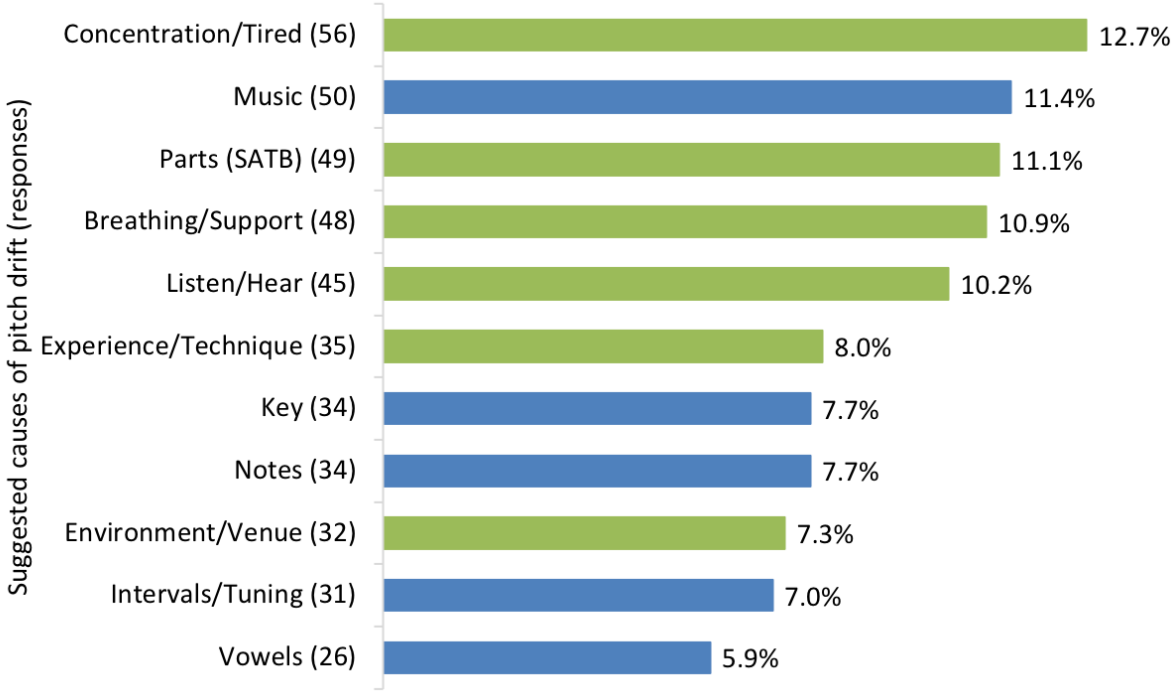
Possible causes of pitch drift

The word cloud illustrated in Figure VII distinguishes the frequency with which putative causes of pitch drift were cited. The more often a cause was cited, the larger it appears in the figure. The words were taken from the free-text responses to the question asking respondents to give their opinions as to why pitch drift occurs.

Figure VII
Word cloud showing possible causes of pitch drift

A more detailed examination of the possible causes is illustrated in Figure VIII, which displays eleven of the most frequently cited causes. Note that some grouping has been employed where similarities in cause exist. For example, tiredness and concentration are grouped as are breathing and support, etc. 'Parts' includes the separate SATB voices where mentioned by the respondents. In this figure the colours (shading) represent the internal and external causes. The blue (dark shade) bars are internal (Teresawa, 2004; Howard, 2007, 2013), i.e. appertaining to the characteristics of the music. The green (light shade) bars are external, i.e. singers, environment, etc. Totalling the number of responses for internal influences against the external ones gives a 40:60 split, thus 40% of cited causes are internal and 60% are external. Given that over half the respondents cite external influences indicates the need for additional research in this area.

Figure VIII
Most popular suggested causes of pitch drift



Consideration of external influences on pitch drift

Concentration and tiredness are the most likely causes of pitch drift. Given that 73% of the choirs rehearse in the evening tiredness may be a contributory factor. No research has been found to date into this concern. Moreover, a related question asking when, within the rehearsal, pitch drift occurred resulted in 86% of the respondents suggesting that it could be at any time, with only 4% stating pitch was more likely to drift towards the end of the rehearsal.

Parts were stated to be being problematic. Where a voice part was named sopranos and to a lesser extent basses were held responsible for pitch drift with altos mentioned only once and tenors twice. Most choirs reported performing with segregated voice parts

rather than in a mixed format (where singers from different voice parts are placed together). Anecdotal evidence from musical directors suggests a mixed layout offers an improved sound. Certainly this format allows singers to hear the other parts, something that may not be so easy when singers are grouped into their voice parts (Ternström, Jers and Nix, 2012). However, a mixed format choir needs experienced singers who, as has been stated previously, would be expected to maintain the required pitch better than less experienced singers.

Breath fuels singing and both breathing and support are allied to concentration and experience. Not having sufficient fuel in the power source (air in the lungs) may lead to variation in pitch on sustained notes. Thus knowledge of when and where to breath within the music, plus remembering to support the pitch for sufficient time in held notes, requires careful breath control. Here, singers need to listen to their own voice to ensure the pitch does not drift, which may be challenging particularly in venues with reverberant acoustics.

Despite being suggested as potential causes by respondents, subsequent research has concluded that environmental factors, which include temperature, humidity and atmospheric pressure along with the acoustic properties of the venue, do not appear to be responsible for irregular changes in pitch (Seaton, 2019).

Conclusion

Many members of the ABCD generously gave their time to take part in the survey. For this we are very grateful. It seems only fair that we should repay our debt, if only partly, by reporting the findings of the survey in the journal of the ABCD.

We began by commenting on the large amount of anecdotal evidence and lore around the question of pitch drift in *a cappella* choral performances. One purpose of the survey discussed here was to establish a firmer base of evidence for the concerns about pitch drift. In so far as the results of the survey largely confirm anecdotal evidence, namely that pitch occurs often and is generally downwards, it could be said that the survey has revealed little that is new. However, it would have been wrong for us to take anecdotal evidence, no matter how prevalent, at face value, and not to question it. That the survey largely confirms anecdotal evidence therefore seems to us a significant finding, as also is the infrequent but not negligible occurrence of upward drift.

In our discussion of pitch drift in *a cappella* singing, we have made a distinction between internal and external factors that could be responsible. We find this distinction useful, and we have not seen it made in the literature – at least not explicitly. Nevertheless, we do not feel able to state definitively on the basis of the survey what causes pitch drift in the types of choir we have been concerned with. However, we do feel confident about discounting or downgrading the effect of room acoustics, certainly in regard of the rehearsal, venues which are familiar to the choirs.

Readers could reasonably demur over findings from a survey where so much is based on self-reporting by respondents. After all, respondents themselves decided whether pitch drift had occurred, whether it was significant, and whether the performance space was highly reverberant or otherwise, etc. Would not objective measures of these phenomena

have been more rigorous? Our response would be to stress that this survey was simply the initial phase of a bigger research project. Other parts of the project did indeed use more objective techniques, although these sometimes proved unexpectedly problematic in their own way. (To give just one example: How does one gauge the amount of pitch drift if it is inconsistent across the voice parts because the chords themselves are not in tune at the measurement points?) We will report on other parts of the project in due course. In the meantime, the authors would again like to thank ABCD members who participated in the survey.

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