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PITCH DRIFT IN *A CAPPELLA* CHORAL SINGING – WORK IN PROGRESS REPORT

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1 INTRODUCTION

This paper describes work in progress in the first six months' part-time research towards the award of a PhD from The Open University. The research subject considers why choirs are not able always to maintain the pitch of the piece of music when they are performing *a cappella*. That is to say when the performance requires no instrumental accompaniment or when the accompaniment is removed for musical effect and then, at some time later, reintroduced. In the case of the former, the drift from the intended pitch may not be so obvious to an audience other than to those with knowledge of, and the ability to recognize, the pitch. In the case of the latter, however, the reintroduction of instrumental accompaniment will make any drift in pitch very obvious. A literature review is ongoing and the findings so far are reported here. Further, a survey of choral conductors and directors is in hand, and the responses to a pilot survey are reflected upon.

2 INITIAL LITERATURE REVIEW

2.1 What is understood by pitch?

Simon Halsey is conductor of both the Berlin Radio Choir and the CBSO Chorus, which is the chorus of the City of Birmingham Symphony Orchestra. In a radio programme on BBC Radio 4 in October 2012 entitled *Key Matters*[1], he recalled:

"I was a choir boy in New College, Oxford, and for two years we had no organ as it was being rebuilt so sang every single day *a cappella*, and 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."

Evidence here then that even first league choirs struggle with pitch from time to time. Also an insight into why the problem may have occurred, with references to the end of the week and wintry conditions, something to consider in the research. However, an admission by Simon Halsey that he really does not know what causes problems with pitch reinforces the need for this research.

In the *Cambridge Companion to Singing*[2], John Potter suggests that pitch can be affected by all sorts of extraneous things including as examples, the weather, central heating and humidity. He goes on to say that performers should not worry too much as the overall performance may be more acceptable and the audience more settled by staying in the pitch to which the performers have slipped. This not only introduces additional evidence, albeit apocryphal, of physical conditions affecting pitch but that again, as with the previous example, the pitch has gone down. Also, Potter confirms that finding a more suitable initial pitch may lead to a more stable performance. There is a notion, supported by the recollections of Halsey and Potter, that pitch going down happens much more often than it does going up. This is explored in the survey which is discussed in Section 3.

Intonation is the term often used to describe the state of a performer's tuning in that it may be described as good or poor[3]. The terms intonation and pitch are sometimes used interchangeably. However, intonation is relative to the prevailing pitch of the performance which may or may not be correct as notated in the music. Pitch, on the other hand, is related to the absolute frequency of the note. It is a qualitative attribute[4] of a musical sound which defines its position within the musical scale and is established by the frequency of the sound waves which act as a sensory stimulus. Pitch is heard to change when the frequency is changed and the amplitude held constant. Thus pitch consists of two attributes – a name representing the note, and a frequency measured in Hertz (Hz). For example the note A above middle C may have a frequency of 440 Hz and be written as A-440 or A4. Unfortunately, nothing is that fixed when dealing with pitch. The note G above middle C could be defined as G-440 in which case A would be 494 Hz, a whole tone higher. Since 1939, and renewed and extended in 1960, 'concert pitch' has been defined as 440 Hertz for the note A4 but this has not always been the case. In early polyphonic choral music, written before c. 1450, the relative pitch and spectrum of each of the parts would be dictated by the differences of the human voice due to the physical attributes of the singers. Bowers[5] states that while clefs were employed in the notation of manuscripts they gave no help in determining the actual sounding pitch expected by the composer, leaving the particular group of singers to select a sounding pitch appropriate to their constituency, the extremities of the staff equating to the performer's highest and lowest usual notes. Ravens[6] suggests that the average human voice was higher in the 16th century than today but this, as with other historical evidence, does not easily tie frequency to pitch names – after all no sound recordings exist!

Attempts at standardizing pitch only became necessary when instrumentation for accompaniment became accepted. When existing period instruments can be identified to specific geographic areas, e.g. matching the music of J.S. Bach to instruments manufactured in Leipzig where he lived and worked, attempts can be made to gain an insight into the pitches used. The pipe organ was the only instrument found in most religious buildings. Given their size and cost coupled to detailed documentation maintained by religious communities, pipe organs can give evidence to the pitch used and changes made to the original installations. However, the pitch of organs was often set higher than normal to give a brighter sound and to save expense. (At higher pitches shorter pipes using less material could be employed!)

2.2 What controls the voice

The array of sounds produced by the human voice originates from vibrations of the vocal folds (commonly known as the vocal cords). These vibrations are generated by an adequate airflow from the lungs. This airflow is interrupted by the vocal folds rapidly opening and closing causing an audible sound of varying pitch. Muscles in the larynx stretch or relax the vocal folds to fine tune the pitch to the desired frequency. Finally a combination of the tongue, palate, cheeks, lips, etc., collectively known as the articulators, filter the content of the harmonic-rich sound generated by the vocal folds to produce the array of sounds that we hear as the human voice. Choral singers can exhibit very fine control over the pitch through an ability to make micro adjustments to the fundamental frequency (f_0) of their vocal folds[7]. This is achieved by listening to their own voice and by allowing subtle changes in pitch through vowel colour and loudness[8] knowing automatically how to shape the vocal tract for a particular sound. Further, they must exhibit an ability to listen to those singers around them to ensure they each produce a melded sound which contributes to the most pleasing or consonant performance.

2.3 Evidence of pitch drift

Literature searches demonstrate the phenomenon of pitch drift both in individual and choral performances. Having stated that often in *a cappella* ensemble singing the overall pitch may sharpen or flatten during a performance. Vurma[9] describes how professional singers try to maintain pitch when paired together in *a cappella* performances. The research found that, as individuals, they prefer to maintain their own part and ignore any deviations by their co-singers, relying on inner standards and ignoring any mistuning of the accompanying voice. This may be seen as problematic in ensemble singing depending on the singer's relative position within the body of the choir to both their own and other parts, assuming polyphonic music is being sung. Ternström and Sundberg found the fundamental frequency precision of the choral singer deteriorated abruptly when the reference was too loud[10]. At first sight this may seem surprising but it is due to the sudden masking of the feedback of the performer's own voice, making comparison with the reference impossible. No actual measurement on pitch variation was made within choirs, but their experiments on individual singers under laboratory conditions found that pitch variation also occurred with changes to vowel quality and the presence or absence of certain partials and of vibrato. In further experiments on soloists[11] masking auditory feedback to the singer decreased the accuracy of the pitch. This error increased when singing fast staccato notes rather than slow legato ones. The importance of auditory feedback is further emphasized in Tonkinson[12] who considered how the 'Lombard Effect', whereby the sound level of the voice is raised subconsciously in relation to the intensity of the surrounding sound, affected choral singers. The suggestion is that this autonomous control could be overridden with training. Good practice should mean that choral singers do not raise their voices above a reasonable vocal intensity limit, but often this is not the case, and given the preceding evidence, could this be a contributing factor to pitch drift? So far there is no evidence of work in this area with choirs as a whole, but it provides an investigative lead into the research subject.

2.4 Pitch drift investigation

Much of the research so far revealed in the literature search has dealt with the results of experimentation on an individual's performance, and in laboratory conditions which at times involve anechoic chambers. The research here is to be based on ensemble performances by choirs in their usual surroundings, that is in their regular place for rehearsal. This being the case and in order to measure pitch drift it will be necessary to obtain information about and data on the performances both from the conductor and/or a choir representative and by making a digital sound recording for later analysis. The former is relatively straight forward, requiring the completion of an appropriate record sheet for that rehearsal, including environmental measurements. Precisely which data will be captured will be informed by the survey. Digital sound recordings of rehearsals are planned and while these may effect a change of behaviour on the choir, care will be taken to familiarize the choir members with its use before the recording. Agreement from all concerned will be sought before any experiments are undertaken or data recorded.

When singing we are not aware of the vibrations of the vocal folds as such for we perceive them as musical pitch, placing them within the continuum we know as the musical scale. The ability to hear small differences is termed pitch discrimination and is individualistic in nature. Experiments undertaken by Seashore[13] demonstrated that while, for an unselected group of adults the average is five cents (a cent being one hundredth of a semitone), a sensitive ear could detect a variation of just one cent. Rarely, individuals display the phenomenon of 'absolute pitch' whereby, for example, on seeing a note on a score the individual can immediately sing the exact concert pitch frequency for that note. Conversely, some were unable to detect a difference of a semitone or even a whole tone. In any survey it will be necessary to rely on the ability of the conductors to recognize when pitch drift has occurred. However, digitally recording the sounds of performance for later analysis with software will allow a far greater insight into the performance than was available to earlier researchers.

In an edition of the BBC Radio 3 programme *The Choir*[14] in April 2013, record producer Adrian Peacock spoke about how the quality of reverberation differs between buildings and that buildings with a linear tail (reverberation), where the response falls off at a uniform rate, pitch is maintained. He went on to say: "In other buildings, for all sorts of bizarre reasons, some tails go flat and that does not sound good." Evidence then that the acoustics of buildings, even when reverberant, may not necessarily be supportive to singers in maintaining pitch.

3 SURVEY OF CHORAL DIRECTORS AND CONDUCTORS

3.1 Pilot questionnaire

A national and possibly international survey to illicit the opinions of choral directors and conductors is to be carried out. The questionnaire will be offered online. In order to ensure the questions are fit for purpose prior to publication a paper-based pilot survey was sent to five choral directors. The results from and issues arising from that pilot study are presented here.

The survey consists of three sections covering; choir details, rehearsals and venues, and maintenance of pitch during *a cappella* rehearsals. The aim is to find out not just about the possible causes of pitch drift in the opinion of a wide range of choral practitioners but to investigate whether particular choral genres are affected more than others. It will not be possible to experiment on every genre so gaining evidence through a survey will be valuable in reaching any possible conclusions as to the reasons for pitch drifting.

3.1.1 Choir details

This section of the survey is about the choir. Details of the members, the type of choir and whether prospective members are auditioned were asked. Finally, an estimation of the proportion of *a cappella* music sung was requested. The aim here is to see if there is any correlation between the choir's membership and any problems experienced with pitch.

Five choirs were surveyed. They were all mixed groups ranging in size from six, which are more or less individual voices, to 95 members. Members' details, in terms of age and parts, are shown in Figures 1 and 2 averaged across the choirs. Interestingly, despite their differences in size, the split between ages and parts in all the choirs were remarkably similar.

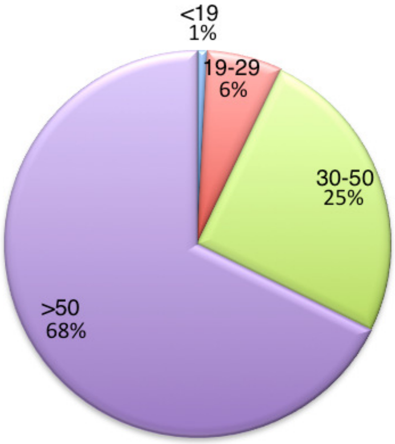

Figure 1 Choir profile by age

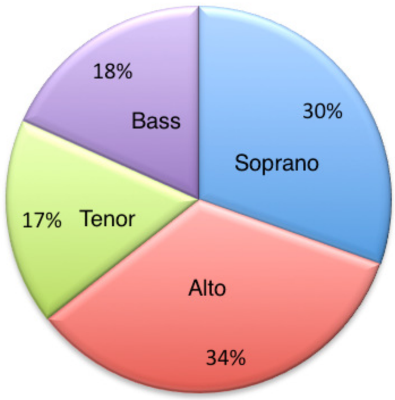

Figure 2 Choir profile by voice part

Only choir 1, shown in Figure 3, has auditions and they happen to sing mostly unaccompanied music. It will be instructive to see if there is a correlation between auditions and the amount of unaccompanied singing performed. An audition allows those with good voices and skills to be selected, whilst the less able can still sing in choirs without auditions.

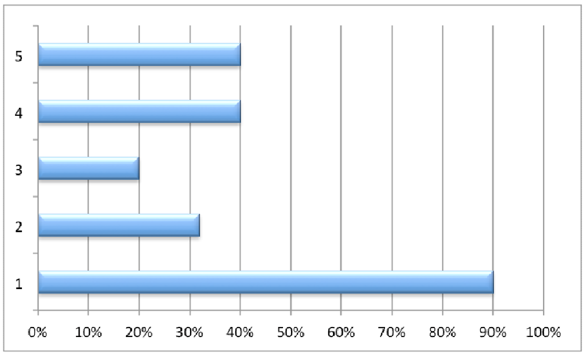

Figure 3 Percentage of music sung *a cappella*

3.1.2 Rehearsals and venues

This section of the survey is devoted to discovering more about where, when and how the choir rehearses. The concentration on the rehearsal rather than the performance is because any experiments will have to be undertaken in rehearsal, since this will allow the gathering of most data. Many amateur choirs only perform three or four times a year which would limit opportunities for experimentation. However this is not to say that performance data will ignored, indeed it may prove very useful. The questions ask the type of venue used, including an estimation of the acoustics, the day, time of day and length of the rehearsal, how the choir members are placed and whether the choir normally performs in the place of rehearsal.

In the pilot survey three choirs reported using rehearsal rooms, one a converted church and the final choir a small hall. Most venues were considered acoustically dry, with little reverberation, only the small hall was considered as having a moderate reverberation. None performed where they rehearsed. An additional question will be added to the survey to establish the acoustics of typical performance venues. All choirs rehearsed in parts and mostly sitting down. There is an opportunity here for experimentation as choirs nearly always stand during a performance.

The evening was the favoured time for rehearsal and the length varied between one and two-and-a-quarter hours. The days tended to vary but three choirs rehearsed on a Thursday. There was a suggestion that tiredness may be a contributory factor, but again performances are usually in the evening so this may or may not be the case. Gaining a response from a large number of choirs may give an insight into this aspect.

3.1.3 Maintenance of pitch during *a cappella* rehearsals

The final section of the survey is devoted to pitch drift and requires subjective responses. The questions ask whether pitch drift occurs during rehearsal and if so in which direction. Further questions are to discover how often and when in the rehearsal pitch drift occurs and if it also occurs in performance. Finally an open question asks for opinions as to why pitch drift happens.

In the pilot survey the two larger choirs reported pitch drift occurring regularly, while the remainder reported an occasional occurrence. All choirs reported concern that pitch drift happens and that in all cases the pitch goes down. Three choirs reported that drift can happen at any time whereas two stated it happens early on in rehearsal.

As expected there were several differing reasons given as to why pitch drift may happen:

- one voice or more tries too hard
- insufficient breath
- poor vowels and in particular diphthongs
- lazy basses(!)

- when the music is being learned
- acoustic conditions in rehearsal room
- less of a problem when the rehearsal venue was changed.

From the list it can be seen that two responses mention the acoustic conditions in the venue having a worsening affect on the choir's ability to maintain the pitch of the work. One did suggest the old adage of smiling when singing as a possible help, along with just maintaining hope!

The final question asked about pitch drift in performance. Three choirs reported that this was less problematic; the other two reported it as about the same. This is a well-known phenomenon and there may be several reasons why this occurs. The research will look at the differences between rehearsal and performance, because should the pitch be improved in rehearsal the performance may also be better, something all choirs would appreciated.

3.2 Survey conclusions

The choirs in the pilot survey were all similar in terms of age, configuration and types of music performed, so the outcomes of all choirs are similar. However, the fact that all the directors of these choirs had different opinions as to why pitch drift occurs strengthens the case for a national survey to try to achieve some agreement as to which possible reasons require detailed investigation through carefully designed experimentation. It is proposed that small scale experiments involving a self-selected choral ensemble will take place over the next six months to begin to test experimental measurements and data.

4 CONCLUSIONS

Pitch drift exists, as this paper has demonstrated both with anecdote and through literature. The latter confirms this phenomenon but tends to concentrate experiments on soloists. There is little covering the choral ensemble as a whole. The opportunity afforded by this research is to design appropriate experiments, once possible causes have been established, to conduct(!) with choirs. The national survey will attempt to quantify possible causes, which will lead to the design of appropriate experiments. It is expected that the analysis of the resulting data will lead to recommendations as to how pitch drift in *a cappella* performance may be eliminated, or at least reduced or controlled.

5 ACKNOWLEDGEMENTS

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