CASE STUDY OF VOICE QUALITY DIFFERENCES IN A SOPRANO SINGING IN DIFFERENT EARLY MUSIC PERFORMANCE STYLES

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Abstract:
This paper considers the characteristics of three differing styles of singing early music, as characterized by Richard Bethell [1] of the National Early Music Association, UK. In particular, the sung outputs from a postgraduate soprano who was practiced in singing all three styles are analysed along with the output from an electrolaryngograph which provides data on cycle-by-cycle fundamental variation as well as vocal fold contact area. The results are compared and contrasted with those from a group of early music and opera singers analysed previously.

Keywords: Singing, voice analysis, voice acoustics, electrolaryngography, closed quotient, opera, early music.

I. INTRODUCTION
Sung performances by modern-day singers of music composed between approximately 1600 to 1900 (referred to herein as early music) can vary considerably in terms of technique and vocal output. Details of the exact techniques that would have been used by the singers of that period are scarce, but known major differences between then and now include tuning systems (non-equal temperament then and equal temperament now), pitch reference (typically higher today note-for-note based on A4 (440Hz) rather than A4 (415Hz), but this does depend on whether the musical key of the piece has been changed in modern editions), the size of audiences (modest then and much larger today), the timbre of accompanying instruments (today’s instruments have developed considerably in terms of their timbral output, tuning stability and overall acoustic output power) and overall size of performance spaces (today’s spaces are much larger requiring a singing technique that achieves greater acoustic output power).

Singing fashion has changed over the years and the performance of early music has been subjected to these variations. Since the 1960’s revival of early music in the UK, many singers have become interested in performing early music and Potter [2, p3] notes that “One of the consequences of the stylistic fragmentation of classical music has been the proliferation of singing styles associated with early music”.

There continues to be much debate about appropriate singing styles and techniques for the performance of early music today. Recently Richard Bethell of the National Early Music Association, UK, [1] described three commonly used performance styles, the third being as yet less well established, that should be more widely considered for the performance of this repertoire.

A) Operatic: Institutionally/ academically trained singer’s formant voice, with fairly wide continuous vibrato, lower larynx development (producing a rich and plummy sound) and capable of high volume.

B) Early Music Mainstream. When compared to the operatic voice, higher larynx position (producing a sound midway between categories A and C), narrower amplitude (but more or less continuous) vibrato, and generally lower volume.

C) Clear Smooth Sweet Chaste. Fairly soft, straight tone, without vibrato except as an ornament. Little or no lower larynx development, producing a sound close to the speaking voice.

An initial analysis is conducted of vibrato samples from each style. An initial analysis is conducted of vibrato samples from each style and larynx closed quotient (the percentage of time for which the vocal folds remain in contact in each cycle) data is presented, for which differences have been shown for adult singers with training and experience [3].

These results are compared to those obtained for modern-day professional singers of early music and professional opera singers [4] to highlight similarities and differences.

II. METHOD
The experiment was carried out in a performance space in the Music Department at the University of York, UK. A young professional soprano sang ‘Lascia ch’io pianga’ from Rinaldo by Handel accompanied by a harpsichord in the three different styles identified above.

The singer was placed further away from the harpsichord than she would have been for a performance in order to keep the singer to harpsichord output ratio low on the audio recording, which was made with two closely positioned (~30cm off-axis) omnidirectional microphones (Sennheiser MKH20 and DPA 4060). In addition, the output from an electrolaryngograph was simultaneously recorded on an Audio Devices 744 4-channel digital recorder at 44.1 kHz sampling rate and 24 bit resolution. The harpsichord level was kept constant with the lid open...
with the short stick for all three performances so as not to influence the timbral or intensity output of the singer with the accompaniment (Daffern et al., 2006).

An analysis was made of the note C5 from bar 14 of the aria, sung to the final syllable of the word libertà in the three different styles.

![Figure 1: Fundamental frequency contours for the final syllable of the word libertà (C5) from bar 14 of ‘Lascia ch’io pianga’ from Rinaldo by Handel sung by a young professional soprano in the three styles A, B and C (see text).](image)

III. RESULTS

Fig. 1 shows the fundamental frequency contours of the analysed samples in styles A, B and C respectively. There are clear differences between the three styles. Style A (operatic) shows vibrato more or less continuously throughout the tone, whereas in style B (early music) a periodic vibrato is not apparent until nearly half-way through the tone. Style C shows no discernible periodic vibrato, although there is some natural fluctuation in the sung fundamental frequency.

There are further differences in the vibrato, when present, in the tones in styles A and B. Although the rate of the vibrato is the same, at 6 oscillations per second for each style, the average peak-to-peak extent of vibrato in Style A (123.8 cents) was larger than that found in Style B (87.4 cents).

![Figure 2: Fundamental frequency contours for individual notes sung by a professional opera singer and a professional Early Music singer (Data from [4]).](image)

The differences in the vibrato found here between styles A and B mirror those found by Daffern [4] when comparing opera and early music singers. Example data from Daffern’s study are shown in Fig. 2 for a a professional opera singer (adult female) and a professional early music singer (adult female). A comparison of the vibrato results of the style A sample here with the sample from a professional opera singer shown in Fig. 2, for which average peak-to-peak vibrato extent is 191.5 cents, indicates that the vibrato extent used by the current singer is not as extreme as that normally found in professional opera singers. Daffern also found for her opera singer group that they produced a more consistent vibrato from the very onset of the tone, whereas there is some delay in the onset of vibrato in style A produced by the singer in this study (compare plots in Figs. 1 and 2).

The early music singers in Daffern’s study typically produced vibrato as a stylistic component in the context of the music, producing appropriate notes as straight tones with a late introduction of vibrato with an average peak-to-peak vibrato extent of 69.8 cents. This is illustrated in the graphs below.

The average peak to peak extent of the vibrato tones produced by the early music singers in Daffern’s study was also generally lower than observed for the opera singers, which is a characteristic also observed in the results of the current study.

Larynx closed quotient (CQ) is measured with an electrolaryngograph [5] and it shows the percentage of each cycle for which the vocal folds are in contact. It is important to note that when the folds are in contact, it does not necessarily mean that they are closed, since they can be partly open. The output from the electrolaryngograph cannot show the difference between partly and fully closed.
Figure 3: Eleven point median smoothed larynx closed quotient (CQ) plots against time for the final syllable of the word libertà (C5) from bar 14 of ‘Lascia ch’io pianga’ from Rinaldo by Handel sung by a young professional soprano in the three styles A, B and C (see text).

Fig. 3 shows the CQ variation with time for the sung notes shown in Fig. 1; these values have been 11 point median smoothed due to the break-up that occurs around the midpoint of the type C plot. It can be seen that during the vibrato portions of the output during the type A and type B productions (compare the plot with Fig. 1), the CQ values are closely matched. However, the type A performance starts with relatively high CQ values during the early part of the note and then drops to around 23% as it meets the type B CQ output. The type C plot starts around 30% and then rises to nearly 40% before dropping again towards the end of the note.

To provide a different view of CQ values, the overall range of CQ values used during this note is shown in Fig. 4 in the form of a second order histogram, which serves to remove non smooth values [5], for each of the types A, B and C. It is clear that the CQ used for types B occupies its own range but that the CQ distributions used for types A and C are bimodal. The nature of this bimodality can be seen in the time plots (Fig. 3) for the type A output which starts high and then drops at the point where the vibrato starts (see Fig. 1). The type C version starts and ends around 30% and has a portion around the centre which is closer to 40%.

Figure 4: Larynx closed quotient (CQ) histograms for the final syllable of the word libertà (C5) from bar 14 of ‘Lascia ch’io pianga’ from Rinaldo by Handel sung by a young professional soprano in the three styles A, B and C (see text).

Fig. 5 shows the acoustic pressure waveforms for the three types. These waveforms are plotted with the correct amplitudes relative to each other so that comparisons can be made. It can be seen that the output for type A has the greatest amplitude, followed by type B and then type C. The type C output becomes quieter during its mid portion, and it turns out that this is where the vocal fold contact variation is both quite low in amplitude and close to being sinusoidal (n.b. because of the algorithm used to calculate CQ, a sinusoidal electrolaryngograph output waveform will have a value around 40%).

Figure 5: Sound pressure waveforms for the final syllable of the word libertà (C5) from bar 14 of ‘Lascia ch’io pianga’ from Rinaldo by Handel sung by a young professional soprano in the three styles A, B and C (see text).

Fig. 6: Sound pressure (uncalibrated hence no reference level and only dB given) output for the final syllable of the word libertà (C5) from bar 14 of ‘Lascia ch’io pianga’ from Rinaldo by Handel sung by a young professional soprano in the three styles A, B and C (see text).
Fig. 6 shows histograms of the output sound pressure amplitude for each type and it can be seen that type C is the quietest and that type A is the loudest, with around 17 dB difference between their modal values. The output for type B sits in between with its mode around 10 dB higher than that for type C and 7 dB lower than that for type A. However, it should also be noted that the type A note is clearly bimodal; this occurs between the early part (soft) and the later part (loud) of the note (see Fig. 5).

IV. DISCUSSION

The differences observed between the three styles, as produced by the current singer, appear to reflect the observations made by Bethell [1] and the previous research conducted by Daffern [4]. Whilst Daffern found the vibrato rate varied within the two groups she compared, the extent to which the vibrato changed between styles A and B was not as great as Daffern found for the two groups overall. This is especially true of the peak-to-peak extent and the use of vibrato throughout tones as discussed above. This could be due to the training and age of the singer in this study, allowing for a freedom of vocal technique to execute the different styles but without the intensive opera training or regular specialised performance of one style, does not produce the characteristics to the same extent. This would also support the findings of Daffern which suggest that the early music singers and opera singers have vocal techniques which thrive in their own environment.

Larynx CQ values do vary between the three types, indicating that CQ is available to the singer for modification when singing in different styles. This has been noted previously [6] for a professional tenor singing in three different styles: opera, Elizabethan and conventional early music for which the opera CQ values were higher than the conventional early music which in turn were higher than the Elizabethan style. These findings support those from this singer if the Elizabethan style can be approximately equated to the type C style herein.

V. CONCLUSION

The singer produced three differing singing styles which reflected the characteristics observed by Bethell [1], however styles A and B did not produce differences in vibrato as drastic as those found by Daffern [4] for professional singers specializing in those styles. In addition, the comparative distributions of CQ values between the three styles for this soprano confirm those found for a professional tenor by Howard [6].

Singing is a precious form of communication with many underlying facets. Understanding some of the subtleties of voice production strategies employed when singing in different styles will lead to a greater understanding and knowledge of the range of possible human vocal outputs and how best to achieve them in practice, whether pedagogically or clinically.

Knowledge of such differences has the potential to influence both performance practice and vocal coaching for both singing and speech. It has been shown that it lends itself well to implementation in real-time visual feedback systems for voice training such as WinSingad [7], SingandSee [8] and VoceVista [9]. In the future, there is the potential for enhancing such systems with additional displays, thus moving such work closer to being more “complete” for the professional voice user.

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REFERENCES