Blend in Singing Ensemble Performance: Vibrato Production in a Vocal Quartet

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Summary: Objectives. "Blend" is a defining characteristic of good vocal ensemble performance. To achieve this, directors often consider vibrato as a feature to be controlled and consequently restrict its use. Analysis of individual voices in ensemble situations presents several challenges, including the isolation of voices for analysis from recordings. This study considers vibrato production as a feature that contributes to blend through an ecological study of a vocal quartet.

Methods. A vocal ensemble was recorded using head-worn microphones and electrolaryngograph electrodes to enable fundamental frequency analysis of the individual voices. The same four-part material was recorded over several weeks of rehearsal to allow analysis of conscious and subconscious changes to vibrato production over time. Alongside the recording of their rehearsal discussions, singers were also asked for opinions on vibrato production in connection with blend.

Results and Conclusions. The results indicate that vibrato is adjusted to some extent by individual singers to improve blend, with some instances of synchrony between voice parts. Some conscious alterations to vibrato were made to improve blend; however, these are not always evident in the data, suggesting that singers' own perceptions of their performance may be influenced by other factors. These findings indicate a need for further studies of vibrato as a feature of blend, particularly in terms of the synergies between expectation and actual production, and potential synchronicity between singers; increased understanding of vibrato in an ensemble setting will lead to more efficient rehearsal techniques and vocal training, and could prevent vocal misuse leading to pathology in the future.

Key Words: Vibrato–Singing–Blend–Ensemble singing–Choral.

INTRODUCTION

Blend is a key objective in a cappella solo voice ensemble performance, often being used as a main descriptor in the assessment of performance quality and is of particular importance in the performance of Renaissance and Baroque repertoire.[1] With the increased interest and understanding in the science of solo voice performance, research has begun to consider features of the singing voice that are representative of singing in a group, rather than as a soloist, with particular interest in the concept of blend (Ternström[2]). However, analysis of multiple voices in ensembles poses a number of additional challenges to solo voice analysis.

In the simultaneous recording of several voices, even using individual microphones situated close to the mouth, a certain amount of bleed from other voices is inevitable, and is likely to interfere with robust analysis of the individual voices. Various techniques have been employed to account for this issue and allow assessment of the ensemble singing voice, including polyphonic acoustic analysis toolkits such as *AMPACT* for *MATLAB*.[3]

Studies are therefore often based on the perception of choral blend, rather than on empirical analysis of the singing production and include, for example, consideration of singer position.[4,5] In consideration of tuning ensembles, we used electrolaryngographs to allow analysis of the voice source, including fundamental frequency (F0), without interference from other singers.[6,7]

Empirical studies concerning voice production in choral singing often involve experiments that control the environment, so that an individual is recorded in isolation, usually being tasked with blending his or her voice to a prerecorded track of an ensemble, which is delivered via headphones to the singer. The first significant study employing this type of protocol to investigate voice quality in choral blend is that undertaken by Goodwin,[8] whose study analyzed sustained tones in solo and blend techniques and found differences in formant production, with stronger fundamental frequencies in the blended mode. Using binaural recordings from singer positions within a choir, Rossing et al[9] analyzed formants alongside sound pressure level, alongside observing a wider vibrato in solo voice production compared with choir singing by the same singers. A later study employing the same method found increased relative energy in the spectrum between 2 and 4 kHz when sopranos sang in a solo mode rather than in a chorus mode.[10] Ternström and Sundberg[11] found clear differences in formant frequencies between singing and speech in choir singers, with agreement between the singers in the lower formants when singing.

With a particular focus on vibrato, Mann[12] more recently studied undergraduate female singers, again singing with a prerecorded track relayed via an earphone, and found a significant difference in the rate and extent of vibrato, alongside the duration of vibrato tones between choral and solo singing modes. However, Reid et al[13] found no difference between solo and chorus modes in professional opera chorus singers when analyzing vibrato rate and extent, long-term average spectra, singing power ratio, or energy ratio from close microphone recordings, concluding that opera chorus singers require a timbre similar to opera soloists. Close microphone recordings in a real choir situation were also used by Jers and Ternström,[14] whose study analyzed

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TABLE 1.
The Recording Sessions of the Vocal Quartet During the 10-Week Module

Week/ Session Number	Quality of Lx Data	Number of Takes	Take Chosen
1/1	Good	3	2
3/2	Good	2	2
5/3	Poor (all parts not used)	2	NA
9/4	Good (poor bass in places)	2	2

Abbreviation: NA, not applicable.

long tones within a choral piece and found evidence of synchronization of vibrato between singers.

Although previous research into group singing has focused on blend in choirs, in practice, blend remains a key objective in the performance of solo-voice ensemble singing, although the context is somewhat different: the singers are blending different notes as the parts of a chord, rather than unison notes within their own part. This study investigates vibrato as a factor contributing to blend in a vocal quartet through an ecological experiment, whereby a new vocal quartet rehearses and performs a piece live over a 10-week period.

METHOD

A newly formed soprano, alto, tenor, bass (female, female, male, male, respectively) student vocal quartet at the University of York took part in the study. All participants were first study undergraduate singers aged between 19 and 21 years and were undertaking a 10-week module in ensemble singing, which was assessed by recital as part of their final degree grade. As part of the module, they had formal coached rehearsals twice a week, with expected additional rehearsals (usually daily) throughout the 10 weeks.

The singers were recorded during specific coaching rehearsals throughout the module, illustrated in Table 1.

Recording setup

Singers wore a head-worn DPA 4066 omnidirectional microphone (DPA Microphones A/S Gydevang, Alleroed, Denmark) and electrolaryngograph electrodes held in place with an elastic strap. The DPA and Lx signals were recorded using two synced eight-channel TASCAM DR680 recorders (Montebello, CA) set to 16-bit 48.2 Hz sampling frequency. A separate stereo recording was also made. The singers were positioned in their usual rehearsal and performance configuration, in a semicircle in descending range order of voice part. All recording sessions took place in the same large rehearsal room in the Department of Music at the University of York. A reference pitch C4 was given on a piano before each take. The quartet set their own tempo.

Material

The singers performed two pieces from their recital repertoire as well as a bespoke piece (exercise 3, Figure 1) written by Howard[6] primarily for the investigation of choral tuning. They were asked to focus on blending, but were given no further instruction when singing the exercise.

A minimum of two takes were obtained from exercise 3 in each session, unless more were requested; the singers were asked which take they would "use" (Table 1). The singers were also asked about their opinion on each take in view of their performance and perception of the blend. Prior ethical approval was obtained from the Physical Sciences Ethics Committee.

ANALYSIS

The best takes of exercise 3, as determined by the participants, were extracted for analysis. F0 values were obtained from the Lx signals using *PRAAT* (http://www.praat.org/). When Lx data were not available because of poor contact of the electrodes, extraction of F0 was obtained from the DPA recordings for the bass. It was not possible to analyze two notes in session 4, which are noted in Table 2 in the Results section. The data from session 3 were too poor for accurate analysis and were removed from the study.

F0 data were exported to Microsoft Excel (Microsoft Corporation, Redmond, WA) for analysis, and plots were created for each beat of the piece. The onset of the next beat was determined by the introduction of any voice part after a rest. The vibrato tones were then extracted by eye from F0 contours of each beat, ensuring complete vibrato cycles were selected and the average peak-to-peak extent was calculated. Tones were classed as non-vibrato tones where no complete cycles of vibrato could be identified.

RESULTS

Table 2 shows the mean peak-to-peak vibrato extent of each beat sung by each singer in the three sessions that were analyzed. The mean vibrato extent of all four beats of the final bar is included in the final row.

Vibrato was present in most sung tones across all sessions in the soprano, the alto, and the tenor, although the notes lasting

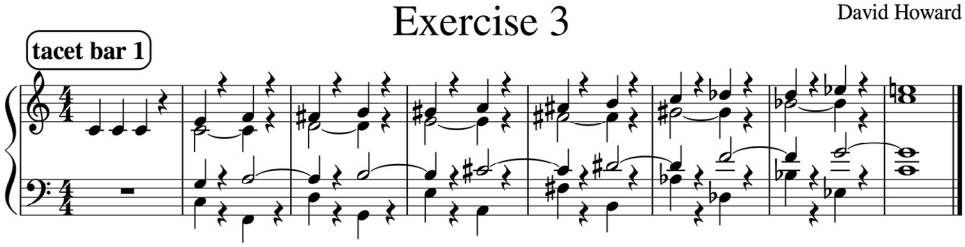

FIGURE 1. The piece performed by the quartet for analysis reproduced after Ref. 6 analyzed in each session.