

## Research Note

# VIBRATO FREQUENCY AND PHASE LOCK IN OPERATIC DUET QUALITY

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For a singer, trained in the 'bel canto' tradition, vibrato is defined as a periodic variation of the fundamental frequency of the sung note, accompanied by a periodic variation of intensity with the same period. The maximum of the intensity usually coincides with that of the pitch, but can be in antiphase in some singers. Tremolo is a periodic variation in intensity only.

The locking of vibrato frequencies in unison soprano choirs has been reported and studied by Sacerdote [1].

In a review article on the physics of the singing voice [2], published in 1982, the following surmise occurs: 'It may well be that the pleasing or less pleasing quality of harmony in a vocal duet, for example, depends on whether or not the vibratos of the singers synchronise. This does not appear to have been investigated.'

We are happy to report work in progress which agrees with this surmise: recordings of Dame Joan Sutherland singing the same duet with each of three different singers were used. The 'Flower Duet' from the opera 'Lakme' was the piece investigated: the other singers were Jane Berbie, Marilyn Horne, and Huguette Tourangeau. Naturally, in each case, Sutherland was the soprano! The duet has a number of unaccompanied passages, so that the voices can be analysed without interference from the orchestral music. The new and very powerful 'Spectra Pro' software, downloadable from the internet and free of cost for one month, was used for the analysis. In fact, 'Spectra Pro' proved so powerful that the work did not need to be restricted to the unaccompanied passages.

Our initial results show that Berbie is the closest to locking in phase in the vibrato frequency variation for most of the segments studied: Tourangeau tends to lock in antiphase, and Horne tends to wander without locking. It seems quite remarkable that such a complicatedly coupled system as two singers singing a duet (and therefore

often with different fundamental frequencies) behaves so like a classical coupled 2-oscillator system as far as the vibrato is concerned (presumably the coupling is psychophysical as well as physical). In the simple classical system, depending on the coupling and the natural frequency of each oscillator, we can get an in-phase mode, or an out-of-phase mode, or no joint mode at all (wandering). The analysis of the pairs of singers shows these characteristics.

It should be clear that, for the vibrato, the in-phase mode will give maximum consonance (or minimum dissonance), while the out-of-phase mode will, on the average, give maximum dissonance. Wandering, or lack of lock, will produce noise, and therefore increase the perceived dissonance above the minimum dissonance of an in phase lock. Clearly, a number of factors can affect phase lock, and more clarifying work is under way.

The vibrato frequency of each singer lies in the range 5 to 6 Hz., so the locking failure is not due to the frequencies being too far apart. It manifests itself as a change in frequency with time, as if 'hunting' is occurring.

Rumour has it that the Sutherland-Berbie recording is regarded as the 'definitive' version. A carefully prepared questionnaire has been sent to noted singers and teachers about this. Of the nine replies so far received, seven agree with 'rumour'. Again, a pleasing result.

The next project is the male duet 'In the depths of the temple', from 'The Pearl Fishers'. The Jussi Bjorling-Robert Merrill version is regarded as the 'definitive' one, but there are problems. It appears that Bjorling recorded this with no other baritone, and we have had difficulty tracing a Merrill recording with another tenor. Any assistance in this regard would be most welcome!

- [1] Sacerdote, G.G., Researches on the singing voice, *Acustica* 7, 61-68 (1957).
- [2] Troup, G.J., The physics of the singing voice, *Physics Reports* 74, 379-401 (1981).

## Letter...

The following two researchers are employed until the end of August as Teaching and Research Assistants at the University of Le Mans and are interested in positions in Australia.

Helen Bailliet (28) has experience in musical acoustics, thermoacoustics, physical acoustics, speech, and nonlinear acoustics. She has 5 published papers plus 11 conference papers. Her thesis (on thermoacoustic engines) received "les felicitations du jury". She also has a masters degree in musical acoustics from the University of Wales and a graduate diploma in solid-state physics engineering.

Vincent Valeau (28) has experience in signal processing, musical acoustics, laser Doppler anemometry, metrology, aeroacoustics, and fluid mechanics. He has 1 published paper (2 in preparation), 7 conference papers and 3 reports. He also has an engineering diploma in sea hydrodynamics and spent a year at the University of Ireland in Dublin.

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