In: Mattias Heldner (ed.):
Proceedings from Fonetik 2019
10-12 June 2019, Stockholm Sweden,
PERILUS XXVII, ISSN 0282-6690
ISBN 978-91-7797-984-5 (print version)
ISBN 978-91.7797-985-2 (web version)
DOI: 10.5281/zenodo.3246011

Polyphonic Overtone Singing: an acoustic and physiological (MRI) analysis and a first-person description of a unique mode of singing

Anna-Maria Hefele [1], Robert Eklund[2], Anita McAllister[3]
[1] http://www.anna-maria-hefele.com
[2] Department of Culture and Communication, Linköping University, Sweden
[3] Division of Speech and Language Pathology, Karolinska Institutet, Sweden
ama@anna-maria-hefele.com, robert@roberteklund.info, anita.mcallister@ki.se

Abstract

This paper describes a unique singing mode, tentatively labeled "polyphonic overtone singing". In overtone singing the vocal harmonics of a stabile fundamental frequency are filtered by the singer in such a way that specific upper harmonics are amplified, and heard clearly, as a second musical voice. In the "throat singing" of Tuva (Mongolia) moving overtones usually occur over a stable drone. In polyphonic overtone singing not only the pitch of the overtones are changed and moving, but also the fundamental which results in two-voice singing.

Introduction

The historical records of overtone singing (OTS) are fairly scarce. It is used in different ethnic traditions and musical styles. A well-known example is the "Tuvan throat-singing" (Levin & Edgerton, 1999), which mainly occurs in Mongolia and Tibetan temples (Smith, Stevens & Tomlinson, 1967). Singers in these regions employ a variety of throat-singing styles, referred to as *sygyt*, *chöömej* and *kargyraa* (Grawunder, 1999:22). *Chöömej* is also used as an umbrella term for all central Asian techniques.

In the west, the tradition of OT is not as strong, and the development of the technique began during the last century. The earliest existing recording of western OTS is from 1929, sung by an American country singer, Arthur Miles. However, Miles did not leave any marked traces in musical history, although he was a local celebrity and even released an album (Tongeren, 2004:161). Also in America, La Monte Young began to experiment with vocal overtones and started to use it as a musical parameter, although it was not yet mature overtone singing (Tongeren, 2004:166).

In 1968 Karlheinz Stockhausen published *Stimmung* for six vocalists, which can be considered the first composition in contemporary music with exact, notated vocal overtones, amplified through specific vowels (Saus, 2009:1).

Further, Michael Vetter (Germany), who collaborated with Stockhausen from 1969 (Tongeren, 2004:177), and David Hykes "laid the solid foundations for overtone singing as an independent vocal technique /…/ With their original examples, overtone singing became an art in itself" (Tongeren, 2004:175).

The Greek singer Demetrio Stratos (1945–1979) also belongs to the first generation of experimental western overtone singers, and before his early death he left his album *Cantare la Voce* (1978) with "vocal sounding overtone noises" (Tongeren, 2004:175).

Trân Quang Hai (1944–), a Vietnamese musician and researcher living in Paris, got in contact with Mongol overtone singing in 1969 and he "collaborated in one of the first compositions and public performances of OTS in Europe after Stockhausen /.../ Apart from

his activities as a performer, Trân's main contribution to the field of overtone singing are scientific and educational" (Tongeren, 2004:171).

From 1983 and on OTS became popular also outside the field of experimental music and the knowledge about the technique grew. Singing groups and overtone choirs were formed for *chanting*, singing mantras or practicing overtone singing together, so it was not only performed by professional musicians (Tongeren, 2004:185). So called "World Music" gained popularity in the west, which spurred an interested in overtone singing. Also enhanced by the Tuva Ensemble tours (Tongeren, 2004:187). Today western overtone singing is used in many different musical genres.

From a phonetic perspective, the formant tuning and the adjustments of the articulators during OTS, are of interest both with regard to aspects related to production and pedagogy.

Method and material

The study includes acoustic analysis of OTS performed by the first author (AMH in the following). In all spectrograms the program Overtone Analyzer (https://www.sygyt.com/en) was used**.** The MRI recordings were made at Freiburg University Hospital, using a 3T Siemens Prisma Fit scanner. MRI recordings were completed in collaboration with professor Bernhard Richter, Dr Michael Burdumy and the singer at an earlier date. The MRI-llustrations are provided by the singer AMH.

The singer

AMH is a classically trained soprano with a wide frequency range of around ~100–2000 Hz. She started with overtone singing in 2005 and now cooperates with several musicians and composers to increase knowledge about the musical possibilities of the technique. AMH is also teaching overtone singing in masterclasses around the world.

The techniques

In the western style of overtone singing a distinction can be made between the so-called *one-cavity-technique*, where harmonics get amplified through specific vowel shapes and the so-called *two-cavity-technique*, where the tongue is raised and divides the oral cavity into two resonance chambers. This results in very clear, whistle-like harmonics. The differentiation between these two techniques was first performed by the ethnomusicologists Tran Quang Hai and Hugo Zemp, based on physiological research (Jentsch 2007:55).

The one-cavity technique enhances the harmonics through changing the vowel shapes, mostly over a stabile fundamental. This is usually the first technical stage to learn in OTS.

Results

Below different possibilities with OTS are explored. As seen in the spectrogram in Figure 1, overtones can be clearly visualized over a stabile fundamental. Note that a drone would have the same function. Below the spectrogram the simultaneous MRI registrations are shown. Also note the different and peculiar tongue shapes used to enhance the partials. This is especially apparent in the initial frames. The technique used for this analysis is the two-cavity technique.

Another possibility within the two-cavity technique is to move overtone and fundamental in parallel, or to leave the harmonics stabile and move the fundamental through the subharmonic series as shown in Figure 2.

By alternating the fundamental frequency different overtones can be enhanced as shown in Figure 3. Here two alternating fundamentals and their harmonics are combined using the two-cavity technique.

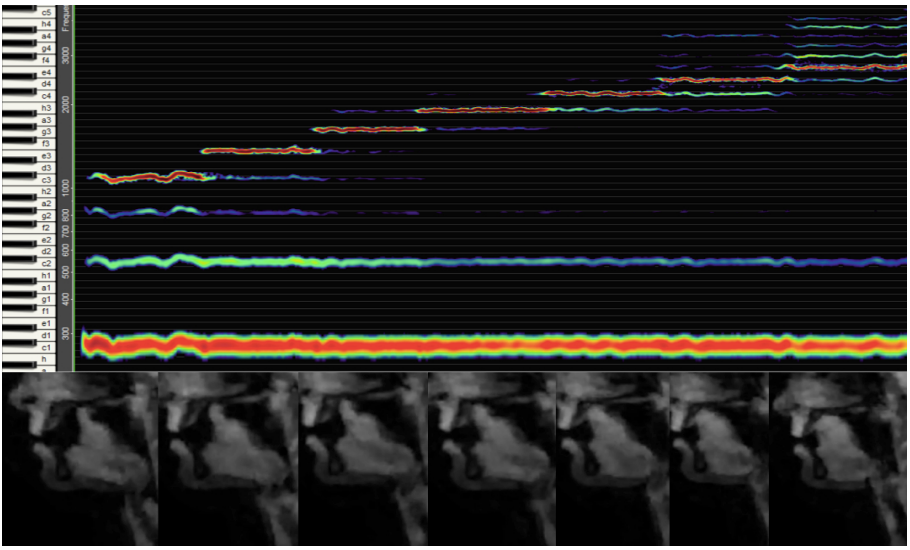

Figure 1. Harmonics 4-10 amplified in the two-cavity technique from fundamental C4.

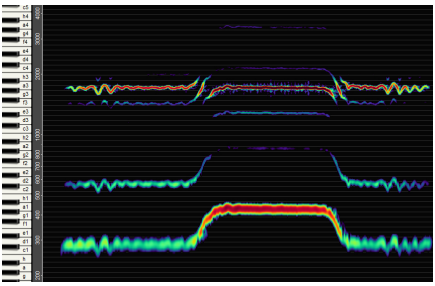

Figure 2. A stable harmonic and a moving fundamental.

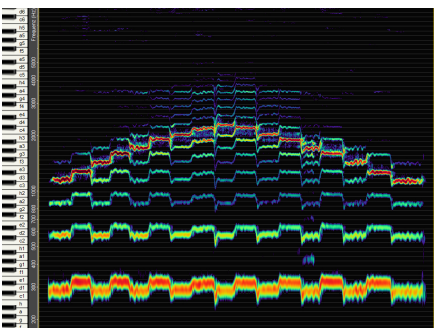

Figure 3. Overtones over two alternating fundamentals.

In Figure 4 AMH illustrates how overtones and fundamentals can be moved in opposite directions. This results in creating a musical counterpoint. Thus, simple classical songs or folk melodies can be easily arranged for OTS. In Figure 5 the spectrogram of the first phrase of "Sehnsucht nach dem Frühlinge" by W.A. Mozart is shown. The fundamental is not moved randomly but rather chosen within the overtone- and subharmonic series and within the singer's voice range. Within these options harmonics are chosen that deliver a harmony or create a counterpoint movement. This provides a harmonic context to the melody in OT.

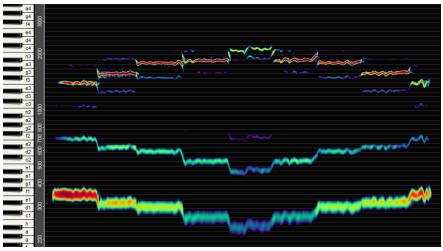

Figure 4. Fundamental and overtones moving in opposite directions, resulting in a musical counterpoint.

To result in polyphonic overtone singing, different combinations of movements for overtones and fundamentals are used. In the figure three combinations of movements for the overtones and the fundamentals are displayed.

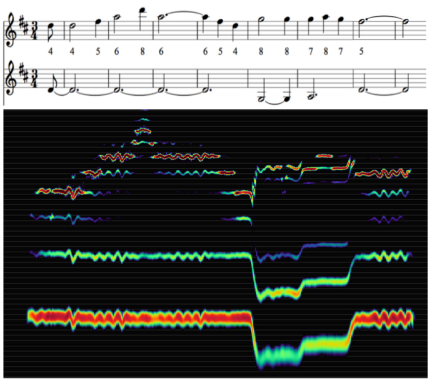

Figure 5. Three combinations of movements for overtones and fundamentals are shown. In this example it is the first phrase of "Sehnsucht nach dem Frühlinge" by W.A. Mozart.

The physiology of overtone singing

In the one-cavity-technique the vowel transition between /i/ and /u/ is used, as in the slowly spoken words "oui" and "you". Here only the movement of the second formant is enhancing harmonics, see Figure 6. In the second panel of the figure the same movement was executed but while whispering, to illustrate the effects of the vocal tract.

In the two-cavity technique the elevation and shape of the tongue creates two separate resonatory chambers. The tongue shape is similar to a /l/ or /ɪ /. The third formant is lowered and brought close to the second by a raised tongue. The 2nd and 3rd formant are coordinated and moved through the spectrum almost at the same frequency (Saus, 2016:450), amplifying the same harmonic. Also the impact of other formants is lowered.

In both techniques, the first formant is kept low to improve control and provide a larger range of options in the harmonic scale. In overtone singing melodies are created by formant tuning, primarily involving the second and third formant (F2, F3). The shape and elevation of the tongue, jaw position, lip rounding and spreading plays key roles in this process.

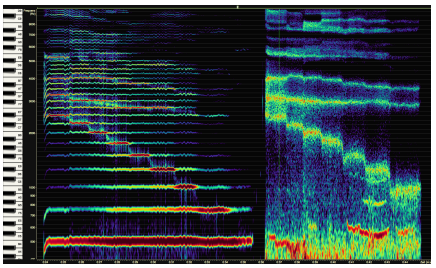

Figure 6. To the left overtones and f_0 is shown while moving from /i/ to /u/ in one-cavity technique. To the right the same movement from /i/ to /u/ while whispering, illustrating filtering of the vocal tract.

Discussion

In the present study OTS produced by one singer using two techniques was analysed. Previously the enhancement of harmonics has been attributed to a narrowing of pharynx and the velar constriction, adjusting the mouth opening and a tuning of F1 and F2 (Klingholz 1993). In this study we showed that the formant tuning mainly involves F2 and F3 and that several other alterations are involved, such as tongue elevation and shape, lips and jaw position. Also the alterations differ depending on whether a one- or a two-cavity technique was used. Thus, OTS requires precision and timing of the motor control of the articulators and a very accurate pitch perception.

OT singing: A first-person account

When learning OTS, one learns to perceive harmonics as musical notes or pitches, while they are usually perceived as timbre or different vowels. This also leads to a more detailed perception of timbre and vowels, which is useful while learning other singing techniques or working with other singers.

An improved perception and more precise control of your sound can lead to increased blending and enhanced intonation. Learning overtone singing increases the ability to control the first 3 formants precisely and autonomously. This could be a useful ability also in

other singing techniques in order to improve specific resonance strategies.

In polyphonic overtone singing not only the harmonics but also the fundamental is moved within the musical context to enlarge the musical possibilities of the technique.

When overtones and fundamentals are moved simultaneously a very specific coordination is required. The closest analogy for me (AMH) as a singer is that of "juggling".

On terminology – what to call it

On the note of terminology the term "polyphonic overtone singing" has been questioned, e.g. by Maxfield and Titze (2015:470), who write: "Ms. Hefele dubs her technique "polyphonic overtone singing." In reality, like most overtone singers, she selectively amplifies overtones to create a melody above a relatively stable fundamental frequency (F0). While her F0 does move, it may be questioned whether its movement rise to the level of an independent melody. As such, calling her technique "polyphony" – a musical style with its own rich history – might be a stretch. Stuart Hinds (2005) points out that he and other overtone singers are indeed capable of a style of overtone singing that could justifiably be called polyphonic, but this practice seems to be an extension of the style and not the most common practice". Ethnomusicologist Carole Pegg notes that English terms for the practice include "biphonic singing," "split-tone singing," "Jew's harp voice," and "throat singing." French terms are no less varied, including "chant diphonique," "voix dédoublée," and "voix guimbarde".

While it is (trivially) true that the set of upper harmonics are defined by the fundamental frequency, this does not completely rule out the use of the word "polyphony". Although composers such as Palestrina (c1525–1594) were free, in theory, to put in any note in the upper voices, he most surely would never had considered going outside of the "true harmony", making the end result similar to AMH's singing. Palestrina was considered the "golden standard" of polyphony during his lifetime.

This links to the second argument against the term, that the singing technique used by Hefele is not true polyphony, since "poly-" means "many", and OTS can only produce two separate voices (Maxfield and Titze 2015:470). This argument has more merit since many languages make use of a "one, two, many" (singular, dual, plural) grammar. However, the suggested terms "biphonic singing" or "chant diphonique", while technically accurate, might be somewhat misleading since "biphonic(al)" or the more commonly used term diplophonic phonation is well established in pathological voice production (e.g. Colton, Casper, Leonard, 2011) commonly referring to abnormal vocal fold vibrational patterns (Sveç, 2000) sometimes also including the ventricular folds (Maryn, De Bodt, Van Cauwenberge 2003). The term is also used to describe animal vocalizations (Wilden et al. 1998; Volodin & Volodina, 2012), where it is a common in e.g. African Wild Dogs (*Lycaon pictus*) and dholes (*Cuon alpinus*). Also, and perhaps more importantly, biphonation implies that the sound source are the vocal folds vibrating at different frequencies or irregularly. This, of course, is very far from the precise control of the fundamental and the harmonics Hefele, and other OT singers use to create their two-part singing.

It is evident that OTS, as performed by AMH, is distinct from Tuva throat-singing but what term best describes it is not entirely clear.

Overtone singing as a pedagogical tool

Although interesting in and by itself, OTS can also be used in the teaching of general phonetics and acoustic analysis, as tested for years by the second author (RE). Very often it is difficult to make students understand both that there are

upper partials to voiced sounds (although students with musical experience normally have no problem here), and that these upper partials can be both strengthened and weakened by the resonances (formants) created by the shape of the vocal tract. RE has found that if you let a student record three vowels, e.g. [i, a, u], at a stable frequency in Overtone Analyzer (the software used here), then applying a bandpass filter, it will show students that vowel identification does not occur at the level of the fundamental, but rather "higher up" in the spectrum. This seems to help most students grasp what is going on.

Conclusions

In the present study OTS produced by one singer using two techniques was analysed. The stability of our findings needs to be further investigated.

Acknowledgements

The fruitful collaboration with Professor Bernhard Richter, Institute for musician's medicine and Dr Michael Burdumy, University Clinic, Freiburg, during the MRI registrations are kindly acknowledged.

References

Colton, RH., Casper, JK., Leonard, RJ. (2011). *Understanding voice problems. A physiological perspective for diagnosis and treatment: Fourth ed.* Wolters Kluwer Health Adis (ESP).

Grawunder, Sven (1999). Obertongesang versus Kehlgesang – Die Erforschung eines besonderen Stimmgebrauchs. *Diplomarbeit am Institut für Sprechwissenschaft und Phonetik der Martin-Luther-Universität Halle-Wittenberg.*

Jentsch, Alexander (2007). Obertongesang in Mitteleuropa. *GRIN Verlag.*

Levin, T.C., Edgerton, M.E. 1999. The Throat Singers of Tuva. *Scientific American*, September 1999, 70–77.

Maryn, Y., De Bodt, M., & Van Cauwenberge, P. (2003). Ventricular Dysphonia: Clinical Aspects and Therapeutic Options. *Laryngoscope 113*: 859–66

Maxfield, L., & Titze, I. (2015). Overtone Singing: In The News Again. *Journal of Singing 71(4):*469-471..

Miles, Arthur, Lonely Cowboy. *https://www.discogs.com/Arthur-Miles-Lonely-Cowboy/release/9417772*

Mecke, A., Pfleiderer, M., Richter, B., Seedorf, T. (2016). Lexikon der Gesangsstimme: Geschichte - Wissenschaftliche Grundlagen - Gesangstechniken - Interpreten. *Laaber-Verlag*

Saus, W., 2009. Karlheinz Stockhausen's STIMMUNG and Vowel Overtone Singing. *The Annual of Texts by Foreign Guest Professors.* FF UK Praha, ISBN 978-80-7308-290-1, S 471–478.

Smith, H., Stevens, K., Tomlinson, R. 1967. On an unsual mode of singing by certain Tibetan lamas. *Journal of the Acoustical Society of America* 41:1262–1264.

Svec, J. (2000). *On Vibration Properties of Human Vocal Folds.* Groningen: Rijksuniversiteit Gronin-gen. PhD thesis, 67, 93.

Tongeren, Marc van (2004). Overtone Singing: Physics and Metaphysics of Harmonics in East and West. *Centraal Boekhuis.*

Wilden, I., Herzel, H., Peters, G., & Tembrock, G. (1998). Subharmonics, Biphonation, and Deterministic Chaos in Mammal Vocalization. *Bioacoustics 9:*171–196.

Volodin, I.A & Volodina, E.V. (2012). Biphonation as a prominent feature of dhole Cuon alpiunus sounds. *Bioacoustics 13:*105–120.