The relationship between laryngeal mechanism and vocal tract resonance in the music theatre voice: A pilot study.

Tracy Bourne[1], Maëva Garnier[2]

1) University of Ballarat, Victoria, Australia; University of Sydney, Australia. Email: t.bourne@ballarat.edu.au
2) Music Acoustics Group, School of Physics, UNSW, Sydney, Australia. Email: mgarnier@unsw.edu.au

Introduction

•Music Theatre a new area of vocal pedagogy and research.
•Singers, teachers and researchers not agreed on definitions of vocal qualities; especially 'belt', 'legit' and 'mix'.
•Previous research indicates that there is some agreement amongst elite music theatre teachers on registration for belt and legit in women, confusion about the male voice, and that there is more than one type of belt. (Bourne & Kenny, 2008)
•This study aims to clarify definitions by measuring differences at the larynx, and the vocal tract in chesty belt, twangy belt, legit and mix vocal qualities.

What are the differences between belt, legit & mix vocal qualities?
What laryngeal mechanisms/adjustments and resonance strategies characterise these vocal qualities?

Method

• 1 female music theatre singer
• 4 vocal qualities: 'chesty' belt, mix, legit, 'twangy' belt
• 3 vowels: [a:], [e], [ʊ]
• 4 pitches: A4, B4, C5, D5
• 5 samples for each vowel, pitch & quality

Measurements taken:
•Audio (at lips)
→Sound Pressure Level (SPL)
→Alpha Coefficient (α) = IdB>1kHz – IdB<1kHz (Sundberg & Nordenberg, 2006)
•Impedance of vocal tract (Epps et al, 1997)
→1st and 2nd Resonances (R1 & R2)
•Electroglottographic (EGG) signals;
→Amplitude of EGG signal (Amp) →Open Quotient (OQ)

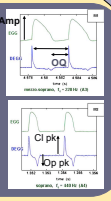
Results

Larynx

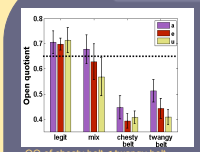
Background

Registration underlain by laryngeal mechanisms (Roubeau et al. 2009) corresponding to different muscle activity and different patterns of vocal fold vibration:
•Chest ~ laryngeal mechanism M1
•Head ~ laryngeal mechanism M2

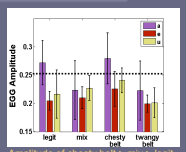
According to Henrich et al. (2005), EGG parameters can be indicators of laryngeal mechanisms:
• M1= OQ from 0.3-0.8, high EGG signal, high ratio of closed peak to open peak of glottal waveform
• M2 = OQ from 0.5-0.95. low EGG signal, low ratio of closed peak to open peak of glottal waveform



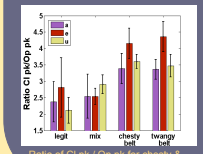
What are the EGG parameters?



OQ of chesty belt < twangy belt ≤ 0.60 < mix (except [u]) < legit



Amplitude of chesty belt > mix > legit (except [a]) > twangy belt

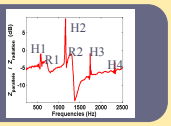


Ratio of Cl pk / Op pk for chesty & twangy belt > mix & legit

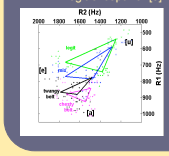
For this singer, the values of EGG parameters, suggest that:
•chesty belt appears to be produced in M1; low OQ, high EGG amp, high Ratio cl pk/op pk
•legit and mix appear to be produced in M2; high OQ, low EGG amp (except [a] in legit), low Ratio cl pk/op pk
•twangy belt appears to be produced in M1; low OQ, high Ratio cl pk/op pk, however EGG amp is relatively low. EGG amplitude does not appear to be a reliable indicator of mechanism in this case.

Vocal Tract

Acoustic resonances of the vocal tract measured to determine R1 & R2 frequency values in relation to harmonic frequencies and to determine tunings of vocal tract to harmonics



Twangy belt > chesty belt > mix > legit except for [e]

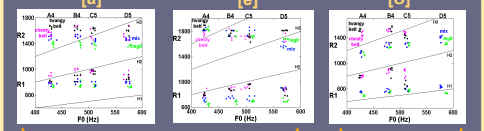


legit < mix < twangy belt ≤ chesty belt

How is articulation adjusted?

• High R1 related to more open lip and jaw position and higher larynx position; High R2 related to more forward placement of the tongue.
• Perceptual descriptions of 'forward' or 'backward' placement of the voice may relate to acoustic measurements of R1 and R2 in some singers, and to the movements of the tongue, jaw and lips. (Garnier et al. 2007)

Are there resonance tunings?



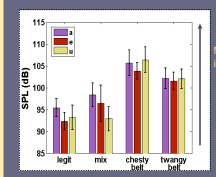
Tuning of R1 to H2 in chesty belt & twangy belt (up to C5 only). No adjustments observed in mix and legit.

R1 tends to follow H2 in chesty belt & twangy belt. R1 tends to follow H1 in mix and legit (to C5 only)

•Garnier et al (2008) suggest that raising R1 and hyper articulating in loud vocalisation may assist in tuning R1 to H1 or H2, thus increasing vocal intensity.

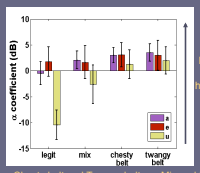
Radiated Sound

How do SPL and α relate?



More intense

Chesty belt > Twangy belt > Mix and Legit



Richer in high harmonics

α Chesty belt and Twangy belt > α Mix and Legit

• chesty and twangy belt show a brighter and more intense sound than legit and mix.
• α lower for [u]: R1 & R2 very low < 1kHz = 'dull' sound.

Conclusions

(1) **All observed qualities are different**:There appear to be two main groups :

• which differ not only in laryngeal mechanisms	twangy and chesty belt	mix and legit
• but also in global articulation (inferred for Ri values)	M1	M2
• And suggest different resonance strategies	wide open / forward	less open / backward
	R1 to H2 (up to C5)	R1 follows H1 for [ʊ] (up to C5)
	(similar to Henrich, Kiek, et al (2007)	(similar to Joliveau, 2004)

These findings support the argument that belt requires a different method of training from classical styles such as legit (Lovetri 2008).

(2) **Are there different types of belt?**
- SPL and α coefficient not signficantly different between twangy belt and chesty belt, and both seem to be produced in M1.
- Yet, OQ higher and EGG amplitude lower for twang. This supports the hypothesis that twangy belt may be a more efficient/safer type of belt than chesty belt.

(3) **What is mix quality?**
- For this singer, mix seems to be produced in M2, like legit. However, lower OQ values and global placement more open and forward. According to Castellengo et al. (2004) mix voice in Western lyrical singing is produced in one mechanism but with adjustments in the vocal tract so that the perceived sound is more like the other mechanism; (ie M1 more like M2 and vice versa).

Future Directions

➔ **New database with 12 subjects: both genders and different levels of expertise for further analysis**

➔ **Further examination of α: these results do not show much difference between qualities, especially chesty and twangy belt, even though there is some distinction perceptually. We will look at the 'singing formant' as another indicator of timbral difference.**

REFERENCES:

Bourne, T. & Kenny, D (2008). Perceptual descriptions of belt and legit voice qualities in music theatre (Conference paper). *Australian National Association of Teachers of Singing (ANATS), Sing into Spring*, Perth, W.A., Australia
Castellengo, M., Chuberre, B., Henrich, N. (2004). Is 'Voix Mixte', the Vocal Technique Used to Smooth the Transition across the Two Main Laryngeal Mechanisms, an Independent Mechanism? *Proceedings of ISMA, NARA, Japan.*
Epps, J., Smith, J., Wolfe, J., (1997). A novel instrument to measure acoustic resonances of the vocal tract during speech. *Measurement Science and Technology* **8**: 1112-1121.
Garnier, M., Wolfe, J., Henrich, N., Smith, J. (2008) Interrelationship between vocal effort and vocal tract acoustics: a pilot study. *Proceedings of ICSLP, Brisbane, Australia*
Henrich, N., d'Alessandro, C., Doval, B., Castellengo, M. (2005). Glottal open quotient in singing: Measurements and correlation with laryngeal mechanisms, vocal intensity, and fundamental frequency. *Journal of the Acoustical Society of America* **117**(3): 1417-1430.
Henrich, N., Kiek, M., Smith, J., Wolfe, J. (2007). Resonance strategies used in Bulgarian Women's singing style: a pilot study. *Logopedics, Phoniatrics, Vocology* **32**(4): 171-177.
Joliveau, E., Smith, J., Wolfe, J., (2004) Tuning of vocal tract resonance of sopranos. Nature **427**: 116.
Lovetri, J. (2008). Contemporary Commercial Music. Journal of Voice **22**(3): 260-262.
Roubeau, B., Henrich, N., & Castellengo, M. (2009). Laryngeal Vibratory Mechanisms: The notion of vocal register revisted. *Journal of Voice* **23**(4): 425-438.
Schutte, H., & Miller, D. (1993) Belting and Pop, Nonclassical Approaches to the Female Middle Voice: Some preliminary conclusions. Journal of Voice **7**(2): 142-150.
Sundberg, J., & Nordenberg, M. (2006). Effects of vocal loudness variation on spectral balance as reflected by the alpha measure of long-term-average spectra of speech. *J Acoust Soc Am* **120**(1): 453-457