A stratified study on hearing, respiration and voice in solosingers

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Introduction

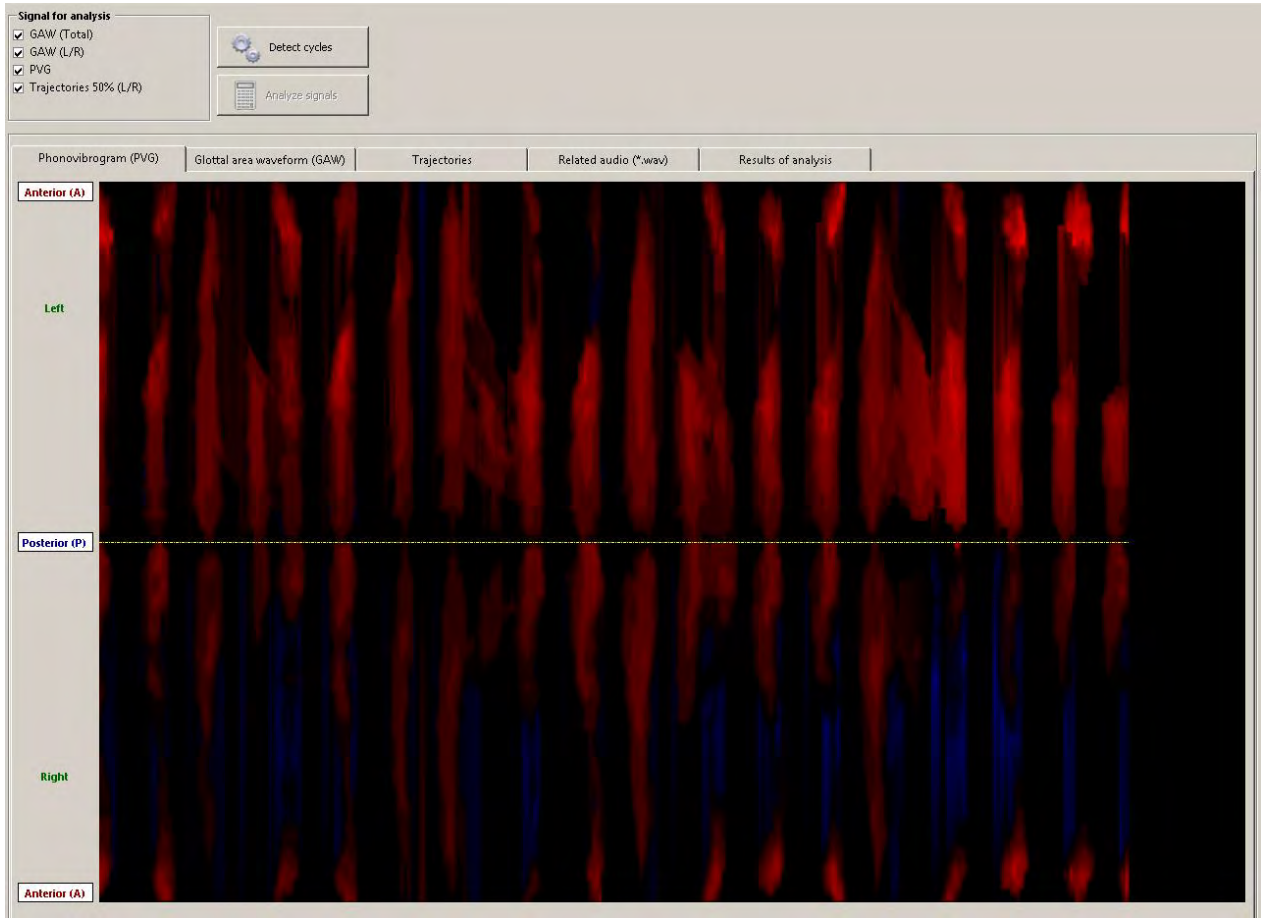
- Neuroscience is a new aspect for voice understanding and it seems there are many difficulties. One of the main problems is which measures to use, as basic references of the peripher laryngeal functions of the voice.

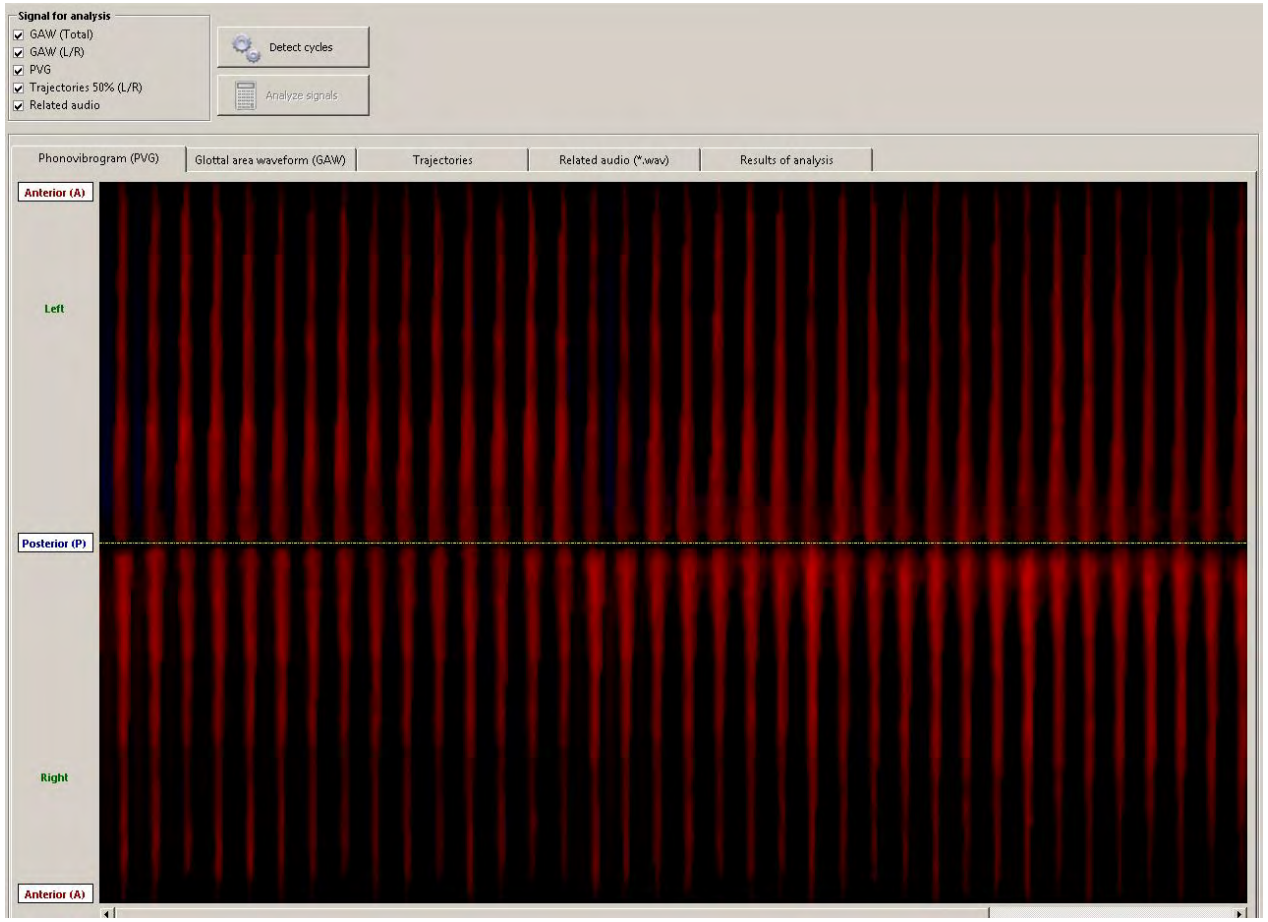
- For many years central brain understanding of hearing has been divided from clinical voice brain understanding and this has also been the case for respiration and central brain voice understanding.
- In this new central brain aspect of neuroscience we have no evidence of voice related to the larynx so we have to start over from the beginning:
- Till now our co workers from neuro science have only accepted glottal area waveform as a peripherical quantitative measurement, in high speed films.
- In this study we tried to finde out how the hearing and the respiration functions are in high quality singers compared with high speed films as a basis for further neuro science studies.

Material & method

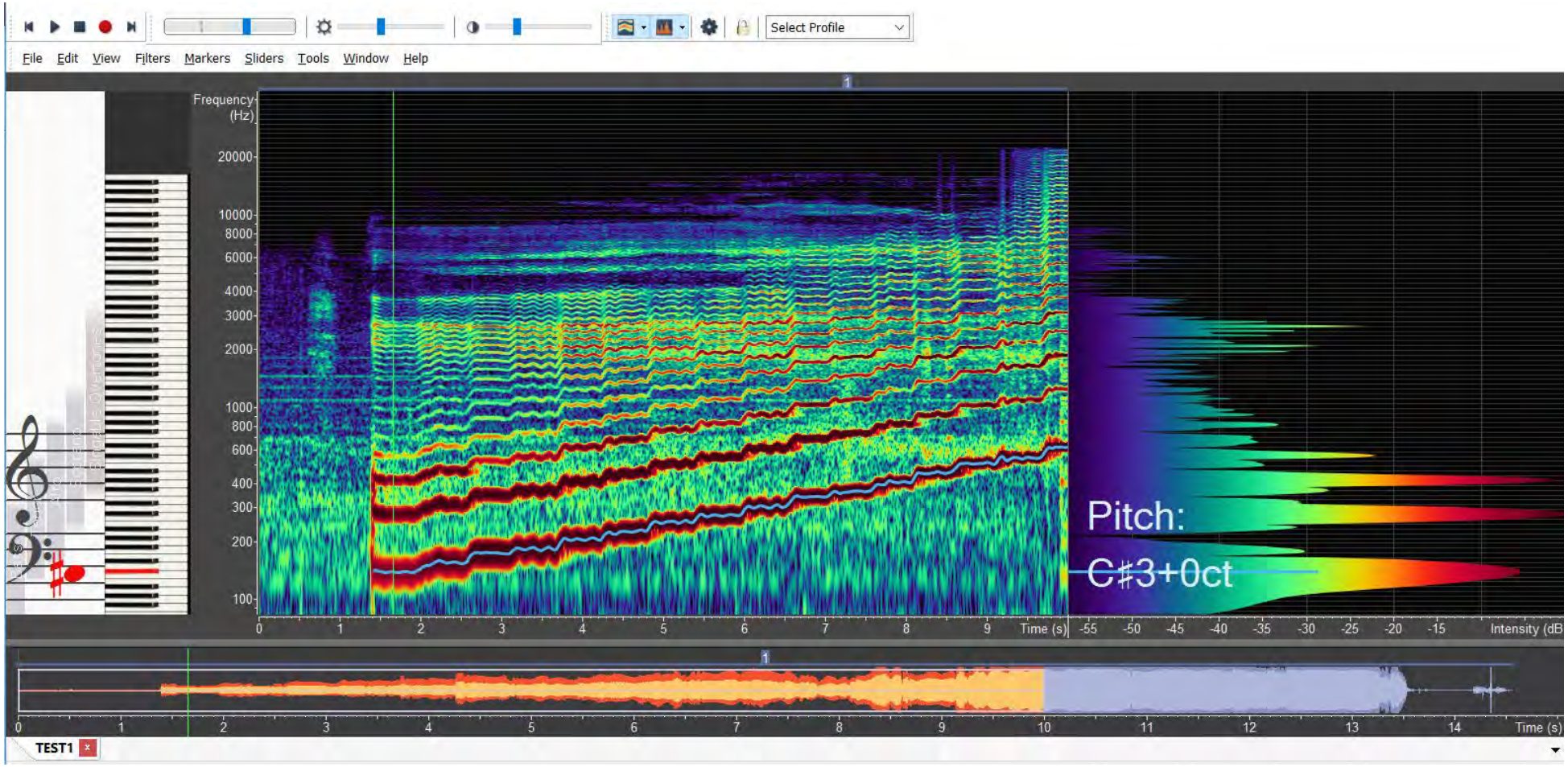
- 12 subjects (7 male and 5 female)
- All soloists were selected based on their subjective musical skill.
- 6 experiments were carried out:
- Hearing:
  - Audiometry (Hz, dB)
  - DPOAE = Distortion Product Oto Acoustic Emissions (dB SPL)
- Respiration:
  - Phonation time (seconds)
  - Peakflow (Liters/min)
- Voice production:
  - High speed film recording of the vibrating vocal folds (jitter%, shimmer% based on audio, glottal area wave form, kymography)
  - Overtone analysis (Hz, dB)

High speed films





Overtone Analyzer



Statistics for Audiometry (by gender) and Distortion Product Otoacoustic Emission measurement

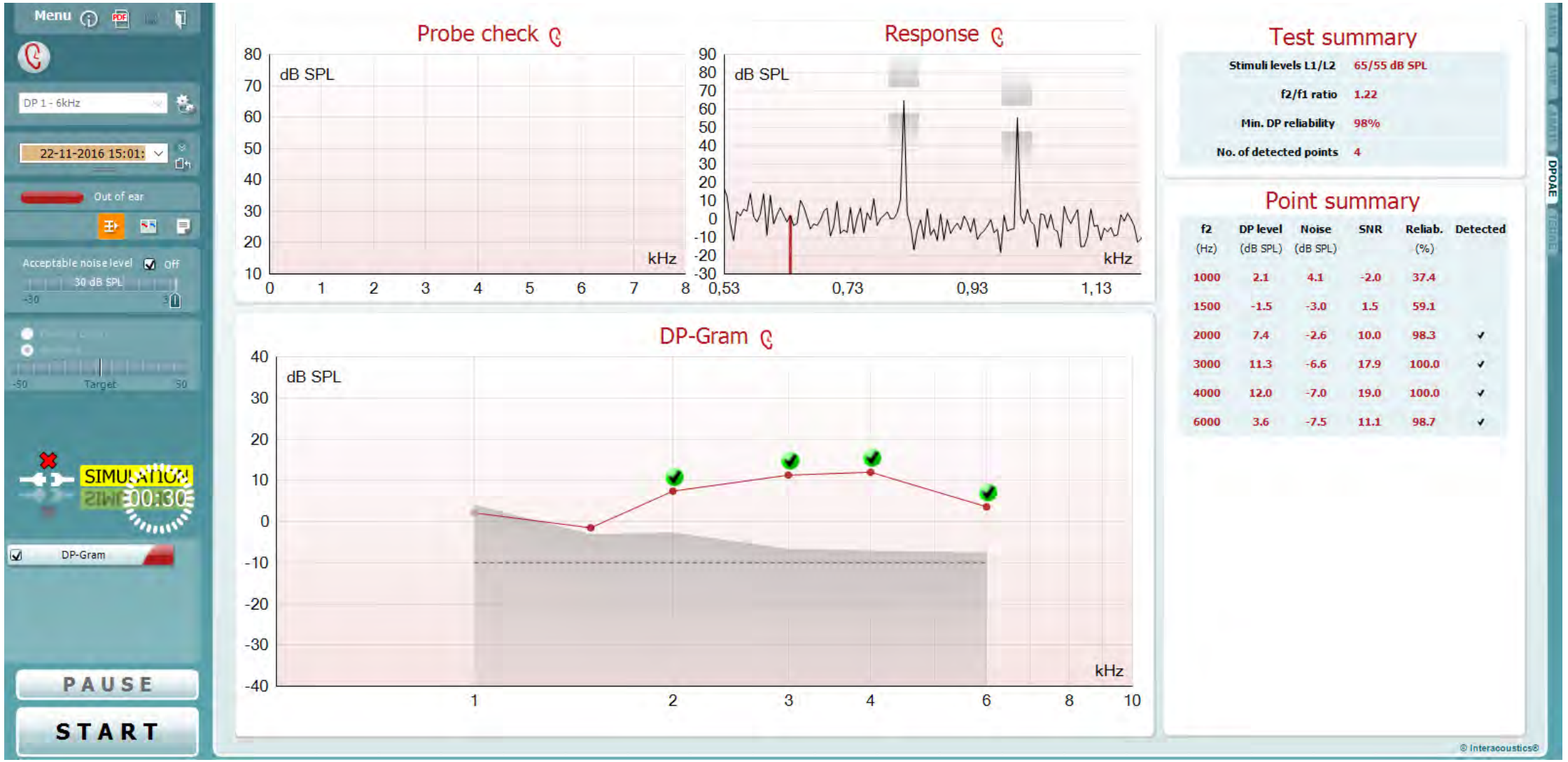
A		dB SPL	mean	std	min	max
gender	Parameter					
Female	Age		38.8	3.962	34	44
	Audiometry R500Hz		18.33	2.887	15	20
	Audiometry R1000Hz		13.33	2.887	10	15
	Audiometry R2000Hz		11.67	2.887	10	15
	Audiometry R4000Hz		8.333	2.887	5	10
	Audiometry R8000Hz		27.5	31.82	5	50
	Audiometry L500Hz		20	0	20	20
	Audiometry L1000Hz		15	5	10	20
	Audiometry L2000Hz		10	5	5	15
	Audiometry L4000Hz		5	5	0	10
	Audiometry L8000Hz		5	5	0	10
Male	Age		37.14	7.358	28	49
	Audiometry R500Hz		17.14	2.673	15	20
	Audiometry R1000Hz		12.86	5.669	5	20
	Audiometry R2000Hz		8.571	4.756	0	15
	Audiometry R4000Hz		9.286	8.381	0	20
	Audiometry R8000Hz		6.429	8.522	0	25
	Audiometry L500Hz		16.43	9.88	5	35
	Audiometry L1000Hz		14.29	7.868	5	25
	Audiometry L2000Hz		10	5	5	20
	Audiometry L4000Hz		11.43	12.15	0	30
	Audiometry L8000Hz		7.857	13.18	-5	35

The Audiometry measures suggests an above average hearing for most soloists.

B	dB SPL	mean	std	min	max
DPOAE Parameter					
Outer haircells H1000		7.25	8.394	-7.9	18.2
Outer haircells H1500		7.786	5.505	-1.5	13.1
Outer haircells H2000		5.613	3.531	0	9.6
Outer haircells H3000		3.55	6.829	-10	11.3
Outer haircells H4000		6.563	7.314	-10	12
Outer haircells H6000		6.975	9.002	-8	22.6
Outer haircells V1000		9.175	6.143	-3.4	17
Outer haircells V1500		9.571	6.228	-3	15.4
Outer haircells V2000		8.125	7.167	-2	16.2
Outer haircells V3000		2.588	6.296	-10	11.3
Outer haircells V4000		6.393	9.212	-12	15.3
Outer haircells V6000		5.075	9.477	-13.6	18.6

The DPOAE shows sound emitted in response to 2 simultanous tones of different frequencies.
DP level is measured in dB SPL, which is the absolute value of DPOAE.
(Otoacoustic emission (OAE) is a sound produced by cochlear outer hair cells).

DPOAE measurements



Statistics for Peakflow and Phonation time, by gender

			mean	std	min	max
gender	**Parameter**					
Female	Age		38.8	3.962	34	44
	Phonation time 220 (s)		18.2	5.357	10	23
	Phonation time 440 (s)		25.6	11.67	18	46
	Peakflow (L/min)		490	97.64	350	570
Male	Age		37.14	7.358	28	49
	Phonation time 110 (s)		17.83	5.037	12	25
	Phonation time 220 (s)		20.17	8.931	10	35
	Peakflow (L/min)		571.4	73.81	450	680

The phonation time correlates to jitt% and shim%: **The higher phonation time the smaller jitter and shimmer. (spearmann correlation P<0.001)**
The peakflow measurements show normal lung capacity, statistical analysis suggests no correlation to voice or hearing.

Statistics for Jitter, Shimmer, Stiffness and Amplitude Normal material

					mean	std	min	max
Parameter_label	**Source**	**Type**			**Value**	**Value**	**Value**	**Value**
Jitt(%)	[Audio]				6.5	10.3	0.3	27.9
	[GAW]				5.78	3.66	1.17	11.8
		[Left]			5.52	3.65	1.17	11.8
		[Right]			7.78	9.1	1.17	31.6
	[Traj-50%]	[Left]			9.9	6.19	2.21	23.2
		[Right]			10.7	5.05	2.34	19.4
Shim(%)	[GAW]				0.73	0.51	0.19	1.65
		[Left]			2.51	2.03	0.55	7.03
		[Right]			2.21	1.84	0.51	6.27

The Jitter% show a negative correlation to phonation time.

GAW = Glottal Area Waveform
Traj-50% = Quantified Kymography

Statistics for Overtone analysis measures

		n	mean	std	min	max
gender	**Parameter**					
Female	Age	5	38.8	3.962	34	44
	Formant 220Hz1 (1000-5000)	4	1897	135.4	1767	2041
	Formant 220Hz2 (1000-5000)	4	2866	460.9	2438	3507
	Formant 220Hz3 (1000-5000)	3	3839	114.1	3754	3969
	Formant 220Hz4 (~10.000Hz)	4	8481	1879	6368	10781
	Formant 440Hz1 (1000-5000)	4	1557	266	1318	1814
	Formant 440Hz2 (1000-5000)	4	2108	405.6	1780	2646
	Formant 440Hz3 (1000-5000)	4	3874	1829	2645	6596
	Formant 440Hz4 (~10.000Hz)	4	7452	1305	6378	9234
Male	Age	7	37.14	7.358	28	49
	Formant 110Hz1 (1000-5000)	6	1568	137	1430	1793
	Formant 110Hz2 (1000-5000)	6	2560	399.2	2117	3242
	Formant 110Hz3 (1000-5000)	6	3492	606.9	2981	4308
	Formant 110Hz4 (~10.000Hz)	4	6663	1028	5627	8074
	Formant 220Hz1 (1000-5000)	6	1392	104.9	1313	1551
	Formant 220Hz2 (1000-5000)	6	2751	545.7	2201	3548
	Formant 220Hz3 (1000-5000)	5	4046	1089	2876	5552
	Formant 220Hz4 (~10.000Hz)	2	9035	1917	7680	10391

The Overtone analysis shows no statistical correlation to other measures in this study.

Results

- The population used in the stratified material was defined as being soloist singers.
- Hearing:
  - It was very clear that their subjective audiometry (blinded) were extremely good also for the lowest as well as the highest frequency from 500 to 8000Hz.
  - Some had a small reduction in their hearing around 4000 Hz due to noise damage.
  - The objective distortion product of oto acoustic emission was extremely small in variation.
- Respiration:
  - The phonation times, at 110+220Hz for male and 220+440Hz for female, were mostly interesting for their upper registers as they were longer than for their lower registers (male/female measures)
  - The peakflows were very good, but without deviations from their age, 37-38 Years
- Voice production:
  - As for the high speed films the most interesting factor was the small standard deviation of the glottal area waveform measures significantly related to the phonation time
  - The formants maxima in Hz and dB were calculated at 220 and 440 Hz (female) and 110 Hz and 220 Hz (male) due to the register shift clearly seeen in the spectrum. There is correspondence with earlier measurements in clients without soloist qualifications.

Conclusion

- To examine soloist singers has always been interesting in our clinic.
- We have for a long time had this suspicion that the hearings were better than the average population, which certainly seem to be the case. The distortion product otoacoustic emissions responded to the audiometry in the way that that there were small variations.

  The longer the phonation time the smaller jitter% was based on the glottal area waveform.
- We want to compare hearing and respiration of qualified singers and laryngeal, and voice analysis with neuroscience measures in the future.
- The distortion product otoacoustical emission can be used together with usual audiometry. Phonation time is usable for jitter measure.
- As for voice production methods, the glottal area wave form is statistically valuable.
- Formants maxima in the overtone analysis have to be focused more upon in the future.

Thank you for your attention