

ASPECTS OF RESONANCE: COMPARISON OF HIGH SPEED FILMS AND OVERTONE MEASUREMENTS

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Introduction

- There are new apparatuses on the market - based on voice research - where the patient can benefit from advanced diagnostics of overtones.
- A clinical routine with high speed films includes kymography, electroglottography and quantitative measures of the movement of the left and right vocal fold. – It showed that irregularity of the two vocal folds against each other hardly ever was the case.
- Therefore new approaches had to be made, especially not related to airflow.
- Documentation of overtones measures up to 20.000Hz (or more) with a stable and well established overtone analyzer leads to new clinical experiences –
- since it is made in a clinic friendly easy way – even cheep.
- What is next is to optimize larynx functions understanding into a position to be part of among others Optical coherence tomography to understand the mucosal function,
- which in most cases seems to be the problem..

Software for high speed films

- With high speed films combined with electroglottography, kymography, and overtones, nuanced evaluation of the voice is possible and to some extent evidence based.
- The software of high speed films includes quantitative measures of the closure of the vocal folds as well as stiffness, a calculation of maximal amplitude versus maximal speed of the vocal folds
- - in all 345 measurements of the voice can be made with the software that is on the market - "Glottal analyses tools" from Erlangen Germany.
- Acoustical analysis as well as glottal area waveforms calculations are made online on high speed films.

All measures in “Glottis Analysis Tools”

Source: Audio

- APF(%)
- APQ-11(%)
- APQ-3(%)
- APQ-5(%)
- AVI
- CHNR-v1(dB)
- CHNR-v2(dB)
- CPP(dB)
- Cycle-duration(ms)
- EPF(%)
- EPQ-11(%)
- EPQ-3(%)
- EPQ-5(%)
- Fundamental-Freq(Hz)
- GNE
- Harmonics-Intensity(%)
- HNR(dB)
- Jitt(%)
- Jitt-Factor
- Jitt-Ratio
- max-Harmonic(Hz)
- max-WMC
- mean-Jitt(ms)
- mean-Shim(dB)
- mean-WMC
- min-Subharmonic(Hz)
- NNE(dB)
- PPF(%)
- PPQ-11(%)
- PPQ-3(%)
- PPQ-5(%)
- PVI
- RAP-v1
- RAP-v2
- Shim(%)
- SNR-v1(dB)
- SNR-v2(dB)
- Spectral-Flatness(SFM)

Source: GAW

- Amplitude-Length-Ratio
- Amplitude-Periodicity
- Amplitude-Quotient

- Amplitude-Symmetry*
- Amplitude-Symmetry-Index
- APF(%)
- APQ-11(%)
- APQ-3(%)
- APQ-5(%)
- Asymmetrie-Quotient
- AVI
- CHNR-v1(dB)
- CHNR-v2(dB)
- Closing-Quotient(CIQ)
- CPP(dB)
- Cycle-duration(ms)
- DynamicRange-Symmetry*
- DynamicRange-Symmetry-Index
- EPF(%)
- EPQ-11(%)
- EPQ-3(%)
- EPQ-5(%)
- Fundamental-Freq(Hz)
- Glottal-Area-Index(AC/OQ)
- Glottis-Gap-Index(GGI)
- GNE
- Harmonics-Intensity(%)
- HNR(dB)
- Jitt(%)
- Jitt-Factor
- Jitt-Ratio
- max-Harmonic(Hz)
- Maximum-Area-Declination-Rate
- max-WMC
- mean-Jitt(ms)
- mean-Shim(dB)
- mean-WMC
- min-Subharmonic(Hz)
- NNE(dB)
- Open-Quotient(OQ)
- Peak-Acceleration
- Peak-Closing-Velocity
- Phase-Asymmetry*
- Phase-Asymmetry-Index
- Plateau-Quotient(PQ)
- PPF(%)
- PPQ-11(%)

- PPQ-3(%)
- PPQ-5(%)
- PVI
- RAP-v1
- RAP-v2
- Rate-Quotient(RQ)
- Shim(%)
- SNR-v1(dB)
- SNR-v2(dB)
- Spatial-Symmetry*
- Spatial-Symmetry-Index
- Spectral-Flatness(SFM)
- Speed-Index(SI)
- Speed-Quotient(SQ)
- Stiffness
- Time-Periodicity
- Waveform-Symmetry-Index

Source: Phonovibrogram (PVG)

- ContourAngles-Symmetry*
- ContourAngles-Symmetry-Index
- Contour-Angle(DEG)

Source: Trajectories 50%

- Amplitude-Symmetry*
- Amplitude-Symmetry-Index
- DynamicRange-Symmetry*
- DynamicRange-Symmetry-Index
- Phase-Asymmetry*
- Phase-Asymmetry-Index
- Waveform-Symmetry-Index
- Amplitude-Length-Ratio
- Amplitude-Periodicity
- Amplitude-Quotient
- APF(%)
- APQ-11(%)
- APQ-3(%)
- APQ-5(%)
- Asymmetrie-Quotient
- AVI
- CHNR-v1(dB)
- CHNR-v2(dB)
- Closing-Quotient(CIQ)
- CPP(dB)

- Cycle-duration(ms)
- EPF(%)
- EPQ-11(%)
- EPQ-3(%)
- EPQ-5(%)
- Fundamental-Freq(Hz)
- Glottal-Area-Index(AC/OQ)
- Glottis-Gap-Index(GGI)
- GNE
- Harmonics-Intensity(%)
- HNR(dB)
- Jitt(%)
- Jitt-Factor
- Jitt-Ratio
- max-Harmonic(Hz)
- Maximum-Area-Declination-Rate
- max-WMC
- mean-Jitt(ms)
- mean-Shim(dB)
- mean-WMC
- min-Subharmonic(Hz)
- NNE(dB)
- Open-Quotient(OQ)
- Peak-Acceleration
- Peak-Closing-Velocity
- Plateau-Quotient(PQ)
- PPF(%)
- PPQ-11(%)
- PPQ-3(%)
- PPQ-5(%)
- PVI
- RAP-v1
- RAP-v2
- Rate-Quotient(RQ)
- Shim(%)
- SNR-v1(dB)
- SNR-v2(dB)
- Spectral-Flatness(SFM)
- Speed-Index(SI)
- Speed-Quotient(SQ)
- Stiffness
- Time-Periodicity

Voce Vista

Spectrograms

- Up to 5000 Hz

Fundamental frequency of speech was chosen to measure overtones:

- Males: 110 Hz
- Females: 220 Hz

Formants:

- A formant was defined as a bundle of harmonic overtones, which combined represented a maximum due to the resonance area of humans.
- The harmonic overtone with the highest point in dB, reflected in the formant, was selected for calculation.
- The amplitude of the selected harmonic overtones was read from the lowest to the highest point.
- The first three formants over 1000Hz were analysed with associated dB for each. Some formants under 1000Hz were noted in parentheses even if they are articulation related.

Sygyt (Ltd)

Spectrogram:

- Up to 20000 Hz

Fundamental frequency of speech as chosen for measures to be used in pathology

- Male: 110 Hz
- Female: 220 Hz

Formants:

- We have defined one formant as bundle of harmonic scale which combined represent the formant.
- The harmonic overtone with the highest point in dB reflected in the formant will be selected.
- The amplitude of the selected harmonic overtones will be read from the lowest to the highest point.
- The first three formants over 1000Hz were measured and the associated dB for each formant noted.

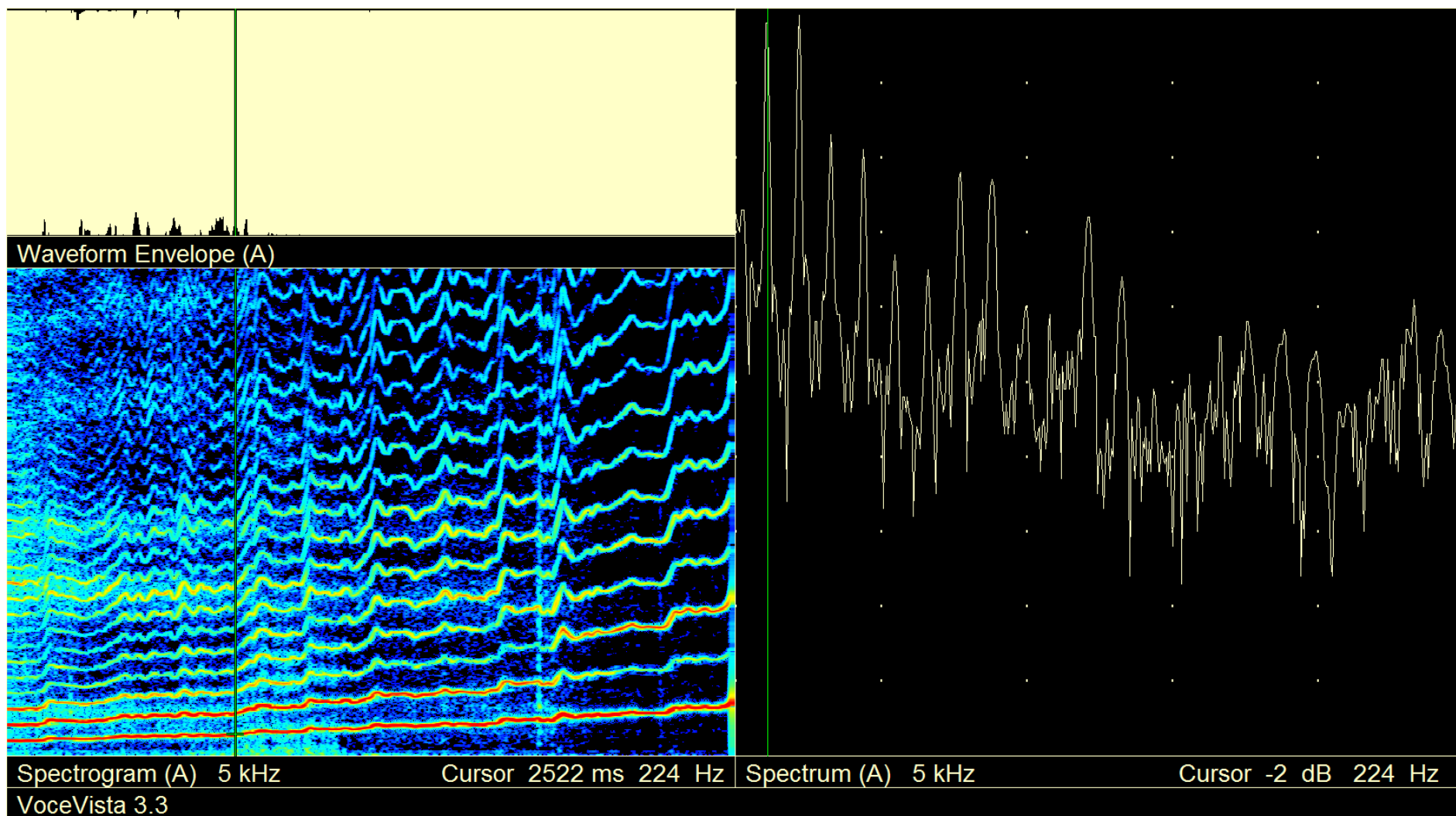
Methods

- We have compared 12 normal voices of persons without complaints with measures of "VoceVista" and "Sygyt Ltd" results of sound analysis of the overtones =, harmonics.
- 12 persons were statictically enough in a prospective cohort study to characterize a normal material and it was used to identify major differences between the two systems.
- As the voices of the patients are very different in nature, it is a problem to identify the vocal problems.
- In order to identify the pathological problem in the clinic, a sensitive and specific measurement is needed.
- In the litterature formant measurements over several seconds have been analysed of famous singers without discription of F0.
- If you have a clinical situation singing will vary extreemly much, and results can be understood in many ways.
- So to begin with, a clinical approach of the mean fundamental frequency in speech (F0) and the formants hereof as defined with "VoceVista" which measures to 5000 Hz compared with "Sygyt Ltd." that measures to 20.000 Hz was made, over 1000 Hz to exclude articulation related variations.

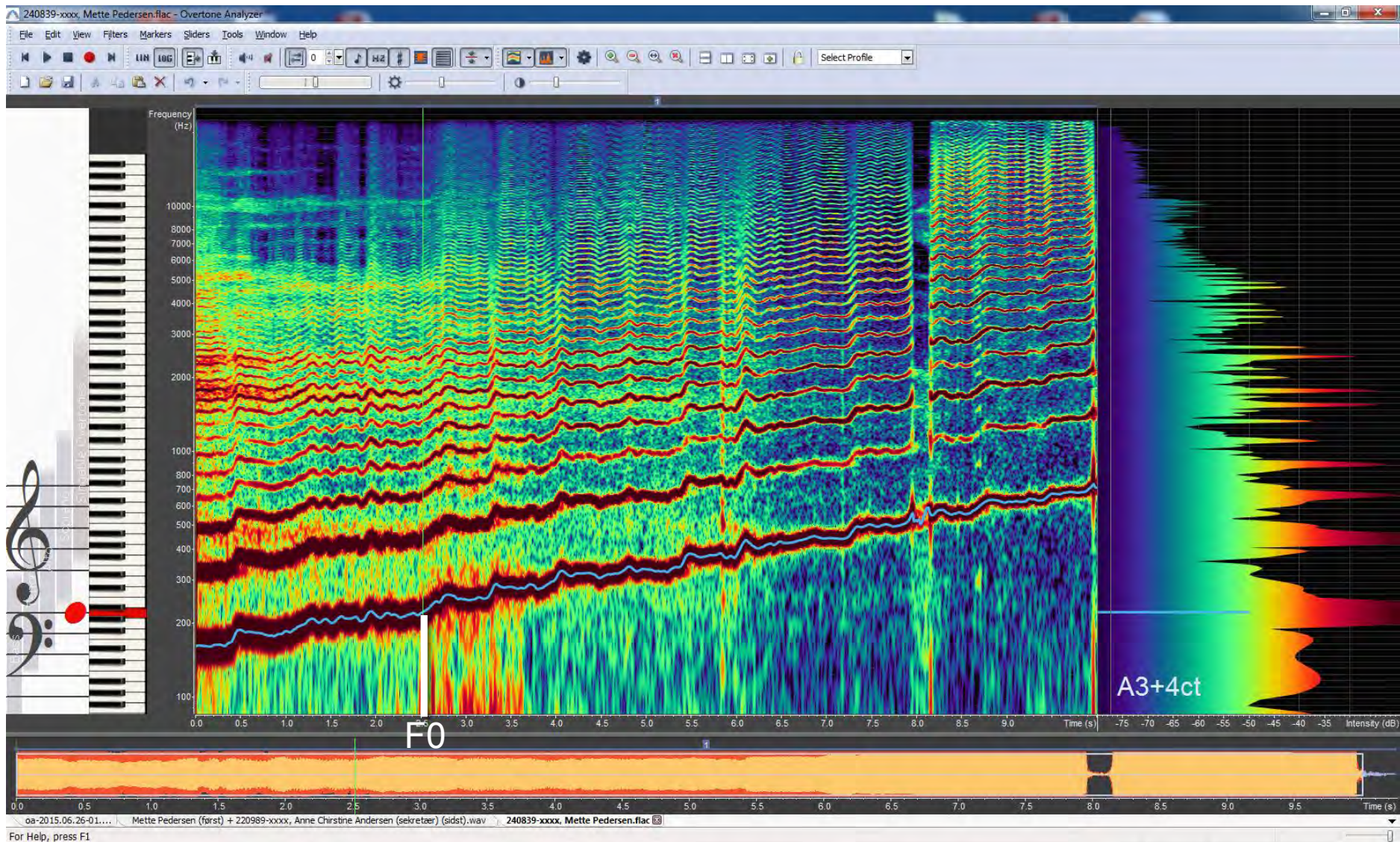
Methods

- Normal persons
- 6 males and 6 females were analysed.
- The fundamental frequency of speech (F0) during intonation of "ah" was defined.
- We have made a prospective cohort study of the formant placements of F0 with "VoceVista" up to 5000 Hz and "Sygyt Ltd." up to 20.000 Hz and there seems to be correspondence.
- From a statistical point of view the same ms (milisecond) measurements to compare the formants - was necessary in a test of intonation as suggested by our statistician.

“Sygyt Ltd.” 5000 Hz “Voce Vista”



“Sygyt Ltd.” Overtone analyzer to 20000 Hz



“VoceVista” results of formants from 1000 up to 5000 Hz in a prospective cohort study of 12 normal persons with the F0 nearest to 220 and 110 Hz

A: “VoceVista” Results														
Nr.	Name	Gender	Age	ms	F0 (Hz)	F0 (dB)	(Fa) (Hz)	Fa(dB)	Fx (Hz)	Fx (dB)	Fy(Hz)	Fy (dB)	Fz (dB)	Fz (dB)
1	MP-A	K	75	2522	224	62			1546	38	2430	36	4662	23
2	ACA-A	K	25	14154	224	46			1558	28	2906	24	3886	16
3	LTC-A	K	40	2335	224	43			1113	38	2304	25	3525	18
4	KJH-A	K	47	2668	224	60			1552	48	2220	35	3766	25
5	SM-A	K	24	308	224	49			1762	30	2864	23	4350	14
6	NBL-A	K	25	616	224	46			1762	29	2202	24	3929	24
7	AJ-A	M	24	2551	107	48			1768	19	3321	15	4247	17
8	MSM-A	M	23	567	107	40			1624	22	2430	30	3243	30
9	BHA-A	M	22	883	107	38			1576	28	2286	20	3122	20
10	MO-A	M	28	1063	107	52			1546	35	2151	18	3327	20
11	AH-A	M	16	2320	107	42			1251	20	2290	26	3868	22
12	JJ-B	M	33	847	107	46			1095	28	3303	26	4079	24

"Sygyt Ltd." results of sound formants from over 1000 Hz up to 5000 Hz with 110 and 220 Hz as basis of overtone measures in the same normal persons.

B: "Sygyt" Results																
															Total Range in Hz	
Nr.	Name	Gender	Age	ms	F0 (Hz)	F0 (dB)	(Fa) (Hz)	(Fa) (dB)	Fx (Hz)	Fx (dB)	Fy (Hz)	Fy (dB)	Fz (Hz)	Fz (dB)	Lowest	highest
1	MP-B	K	75	2520	220	58	436	55	1545	31	2433	35	4662	20	231	1126
2	ACA-B	K	25	14150	220	43	436	52	1555	24	2874	33	3881	13	174	610
3	LTC-B	K	40	2330	220	43	403	48	1114	40	2304	20	3526	16	190	874
4	KJH-B	K	47	2665	220	58	441	55	1539	42	2201	26	3762	19	151	760
5	SM-B	K	24	310	220	45	441	56	1765	25	2869	22	4333	12	211	491
6	NBL-B	K	25	620	220	51	441	49	1765	29	2201	21	3924	25	196	703
7	AJ-B	M	24	2560	110	48	333	47	1781	22	3321	23	4247	22	88	714
8	MSM-B	M	23	570	110	38	344	41	1625	21	2470	25	3246	19	98	615
9	BHA-B	M	22	880	110	44	452	59	1571	25	2255	22	3133	17	99	853
10	MO-B	M	28	1060	110	48	333	44	1550	27	2131	21	3332	22	102	538
11	AH-B	M	16	2320	110	48	333	38	1254	20	2217	24	3865	20	110	365
12	JJ-B	M	33	850	110	42	549	45	1098	24	3305	23	4107	21	107	683

Comparing "Sygyt Ltd." - "VoceVista"

Nr.	Name	Gender	Age	F0 (Hz)	F0 (dB)	(Fa) (Hz)	(Fa) (dB)	Fx (Hz)	Fx (dB)	Fy (Hz)	Fy (dB)	Fz (Hz)	Fz (dB)
1	MP-B	K	75	220	3			-19	-4	-21	2	862	-10
2	ACA-B	K	25	220	-20			-75	-11	74	10	-90	-7
3	LTC-B	K	40	220	-7			-29	-8	-884	-5	-1323	-9
4	KJH-B	K	47	220	-2			-73	9	-326	-17	-136	-9
5	SM-B	K	24	220	1			-88	-9	-115	-5	188	-5
6	NBL-B	K	25	220	1			-271	-1	-1228	1	-143	8
7	AJ-B	M	24	110	13			-42	-6	909	-7	932	2
8	MSM-B	M	23	110	8			-348	-4	-1001	5	-1152	-3
9	BHA-B	M	22	110	-6			-11	-5	-801	-3	-898	-8
10	MO-B	M	28	110	6			-610	2	-1244	1	-1523	-6
11	AH-B	M	16	110	3			-851	0	-592	5	141	3
12	JJ-B	M	33	110	-18			-3	-12	-4	-2	28	-3
mean								1513.5	27.5	2548.9	24.33	3834.3	18.417
sd								273.796	5.9461	639.65	6.995	803.97	5.6159
cv								<u>18.0903</u>	21.622	<u>25.095</u>	28.75	<u>20.968</u>	30.493

The same sound recording was analysed for the two different softwares.

The comparison is based on varying time points of F0 for the "Sygyt Ltd." and the "VoceVista".
 Notice that the coefficient of variation is 20-30%.

The fundamental frequency changes over time during the sound recording, as seen on the next slide it was essential that the results of the "Sygyt Ltd." and "VoceVista" was evaluated at the exact same millisecond for the sound recording.

Comparing "Sygyt Ltd." - "VoceVista"

Nr.	Name	Gender	Age	F0 (Hz)	F0 (dB)	(Fa) (Hz)	(Fa) (dB)	Fx (Hz)	Fx (dB)	Fy (Hz)	Fy (dB)	Fz (Hz)	Fz (dB)	Fz (dB)
1	MP-B	K	75	220	-4			-1	-7	3	-1	862	0	-3
2	ACA-B	K	25	220	-3			-3	-4	-32	9	-90	-5	-3
3	LTC-B	K	40	220	0			1	2	0	-5	-1323	1	-2
4	KJH-B	K	47	220	-2			-13	-6	-19	-9	-136	-4	-6
5	SM-B	K	24	220	-4			3	-5	5	-1	188	-17	-2
6	NBL-B	K	25	220	5			3	0	-1	-3	-143	-5	1
7	AJ-B	M	24	110	0			13	3	0	8	932	0	5
8	MSM ₅ -B	M	23	110	-2			1	-1	40	-5	-1152	3	-11
9	BHA ₅ -B	M	22	110	6			-5	-3	-31	2	-898	11	-3
10	MO-B	M	28	110	-4			4	-8	-20	3	-1523	5	2
11	AH-B	M	16	110	6			3	0	-73	-2	141	-3	-2
12	JJ-B	M	33	110	-4			3	-4	2	-3	28	28	-3
mean								1513.5	27.5	2548.42	24.5833	3834.33	3834.83	18.8333
sd								6.18098	3.54516	27.6192	5.29937	803.968	10.8195	3.98006
cv								0.40839	12.8915	1.08378	21.5568	20.9676	0.28214	21.1331
								0.75	-2.75	-10.5	-0.58333	-259.5	1.16667	-2.25
Difference in percent of mean								<u>0%</u>	-10%	<u>0%</u>	-2%	<u>-7%</u>	0%	-12%

The same sound recording was analysed for the two different softwares. As the fundamental frequency (F0) changes over time during the sound recording, it was essential that the results of the "Sygyt Ltd." and "VoceVista" were evaluated at the exact same millisecond for the sound recording.

The table shows the difference in formants of F0 between the "Sygyt Ltd." and the "VoceVista" sound analysis software over 1000Hz. As can be seen for the Fx, Fy and Fz, the mean Hz were 1513, 2548 and 3834, respectively with a difference between the softwares of 0.75, -10.5 and -259.5 Hz.

The difference in percentage of mean shows that the difference is 0, 0 and -7%, corresponding to almost identical assessment of the formants around 1500 Hz and 2550 Hz.

"Sygyt Ltd." results over 5000 Hz are extremely interesting – here we show the overtones/harmonics and intensity variable around 10000 Hz in the 12 normal persons

				Register Change and formant around 10000 Hz in 12 normal persons		↓	
Nr.	Name	Gender	Age	RC (Hz)	RC (dB)		F 10k (dB)
1	MP-B	F	75	363	58	10125	14
2	ACA-B	F	25	365	52	10615	27
3	LTC-B	F	40	523	71	10325	21
4	KJH-B	F	47	457	41	10142	16
5	SM-B	F	24	415	49	9727	11
6	NBL-B	F	25	410	63	11138	24
7	AJ-B	M	24	205	63	10750	14
8	MSM-B	M	23	201	46	10448	15
9	BHA-B	M	22	224	49	10136	11
10	MO-B	M	28	231	48	9576	21
11	AH-B	M	16	180	14	10571	17
12	JJ-B	M	33	206	49	9969	15

F 10k = Sum of harmonics and formants around 10000 Hz at the fundamental frequency, F0, measured up till 20000 Hz to show the possibility of this new software.

As "Sygyt Ltd." results of up to 20.000 Hz can be measured, we tried to study the normal persons for a start - for variation of the formants near 10.000 Hz. The variation was 4,3% with SAS program 9,4 Spearman Rank correlation coefficient test.

Nr.	Name	Gender	Age	RC (Hz)	RC (dB)	F 10k (Hz)	F 10k (dB)
1	MP-B	F	75	363	58	10125	14
2	ACA-B	F	25	365	52	10615	27
3	LTC-B	F	40	523	71	10325	21
4	KJH-B	F	47	457	41	10142	16
5	SM-B	F	24	415	49	9727	11
6	NBL-B	F	25	410	63	11138	24
7	AJ-B	M	24	205	63	10750	14
8	MSM-B	M	23	201	46	10448	15
9	BHA-B	M	22	224	49	10136	11
10	MO-B	M	28	231	48	9576	21
11	AH-B	M	16	180	14	10571	17
12	JJ-B	M	33	206	49	9969	15

STD 441.4833

MEAN 10293.5

Coefficient of
Variation
(CV) 4.3%

Fundamental Frequency, F0, and intensity variations measured with the acoustic set up of high speed films of the 12 normal persons, using Wolf Ltd. High speed films apparatus

Nr.	Name	Gender	Age	Fundamental Frequency (Hz)	Max dB	Min dB
1	MP-A	F	75	327	95	89
2	ACA-A	F	25	251	80	73
3	LTC-A	F	40	329	85	74
4	KJH-A	F	47	142	84	84
5	SM-A	F	24	100	80	70
6	NBL-A	F	25	377	82	78
7	AJ-A	M	24	216	88	81
8	MSM-A	M	23	158	82	80
9	BHA-A	M	22	266	81	80
10	MO-A	M	28	211	93	85
11	AH-A	M	16	139	74	68
12	JJ-B	M	33	178	86	86

High speed films on line, the acoustical measures here from, analyzed with “Sygyt Ltd.” of a prospective cohort study of 12 normal persons, the results of formant variation are on the same level as “VoceVista” due to the variation of F0.

Variation of 3 formants 1000-5000Hz from high speed films

Nr.	Name	Gender	Age	ms	F0 (Hz)	F0 (dB)	(Fa) (Hz)	(Fa) (dB)	Fx (Hz)	Fx (dB)	Fy (Hz)	Fy (dB)	Fz (Hz)	Fz (dB)
1	MP-A	K	75	520	327	64			1320	35	2312	34	3271	18
2	ACA-A	K	25	70	251	48			1261	33	2241	30	4025	28
3	LTC-A	K	40	1130	329	45			1401	28	2295	20	3357	9
4	KJH-A	K	47	850	142	15			1293	39	2328	24	3028	27
5	SM-A	K	24	900	307	38			1606	38	3206	25	4004	26
6	NBL-A	K	25	640	377	64			1131	23	2258	22	3411	14
7	AJ-A	M	24	120	216	56			1293	48	2371	40	3449	40
8	MSM-A	M	23	1060	158	38			1115	38	2549	29	3341	21
9	BHA-A	M	22	1210	266	47			1320	51	2904	30	4230	20
10	MO-A	M	28	440	211	49			1077	42	2373	28	4694	19
11	AH-A	M	16	430	139	42			1385	23	2500	28	3336	16
12	JJ-B	M	33	160	196	20			1040	12	1697	12	2204	19

Difference to sygyt sound analysis of 12 normal persons

Coefficient of variation (cv)	mean					1513.5			2548.4			3834.8
	change											
	mean					243.3			128.9			305.7
	std					270.0			632.7			923.4
	cv					18%			25%			24%

High speed films softwares, "VoceVista" and "Sygyt Ltd." compared: (SAS 9.4, Spearman rank correlation coefficients)

- A statistical difference of the following parameters was seen in a prospective cohort study between 12 healthy and 12 hoarse patients both left and right
 Glottal Area Wave form included:

Cepstral Harmonics- to-Noise Ratio-v2(dB) Cepstral Peak Prominence(dB) Harmonics-Intensity(%)	Normalized Noise Energy (dB) Period Perturbation Quotient-11(%) Signal-to-Noise Ratio-v1(dB)	Spectral-Flatness(SFM) min-Subharmonic(Hz)
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- out of 345 parameters in 12 healthy and 12 hoarse persons only
- Strong statistically significant ($p < 0.01$) correlation could be seen between:

Parameter	Source	Type	Method	Sound analysis parameter
Cepstral Harmonics-to-Noise Ratio version 2(dB)	[GAW]	[Right]	VoceVista	Fz (Hz)
Harmonics-Intensity(%)	[GAW]		VoceVista	Fz (dB)
Harmonics-Intensity(%)	[GAW]	[Right]	VoceVista	Fz (dB)
Spectral-Flatness(SFM)	[GAW]		VoceVista	Fx (dB)
Spectral-Flatness(SFM)	[GAW]	[Right]	VoceVista	Fx (dB)
min-Subharmonic(Hz)	[GAW]		sygyt	Fx (dB)
min-Subharmonic(Hz)	[GAW]	[Right]	VoceVista	F0 (Hz)
min-Subharmonic(Hz)	[GAW]	[Right]	sygyt	F0 (Hz)

**”Sygyt Ltd.” parameters with statistical significant correlations to the high speed film parameters - with p values down to 0,05. were not related to the acoustical parameters but to the high speed films glottal area waveforms.
(SAS 9.4, Spearman Rank Correlation Coefficient).**



Parameter_label	Source	Type	Item	klang	Parameter_klang	Variable	spearman	Pmean
Harmonics-Intensity(%)	[GAW]	[Right]		Sygyt	Fz (dB)	value	0.62215	0.0308
Period Perturbation Quotient-11(%)	[GAW]	[Left]		Sygyt	Fz (dB)	value	-0.64026	0.0461
Signal-to-Noise Ratio-v1(dB)	[GAW]	[Right]		Sygyt	Fy (dB)	value	0.63621	0.0261
Spectral-Flatness(SFM)	[GAW]			Sygyt	Fx (dB)	value	0.61404	0.0337
Spectral-Flatness(SFM)	[GAW]	[Left]		Sygyt	Fx (dB)	value	0.65245	0.0409
Spectral-Flatness(SFM)	[GAW]	[Right]		Sygyt	Fx (dB)	value	0.70527	0.0104
min-Subharmonic(Hz)	[GAW]			Sygyt	F0 (Hz)	value	0.62765	0.0289
min-Subharmonic(Hz)	[GAW]			Sygyt	Fx (dB)	value	0.7579	0.0043
min-Subharmonic(Hz)	[GAW]	[Left]		Sygyt	F0 (Hz)	value	0.73113	0.0163
min-Subharmonic(Hz)	[GAW]	[Right]		Sygyt	F0 (Hz)	value	0.77249	0.0032
min-Subharmonic(Hz)	[GAW]	[Right]		Sygyt	Fx (dB)	value	0.67018	0.0171

What we presented was an attempt to

- Measure high speed films combined with overtones/harmonics with “Voce Vista” and “Sygyt Ltd”.
- Show that “Sygyt Ltd” can be used in clinical praxis for formant analysis.
- Prove that the approach in clinical praxis must be simple - as using F0 as a basis for formant analysis for comparison of treatment effect in pathology together with high speed films.
- To evaluate if a patient gets better after treatment comparison at the same mili second is probably necessary.

Find the slides on: <http://www.mpedersen.org>

Thank you for your attention!