HEARING AIDS AND MUSIC

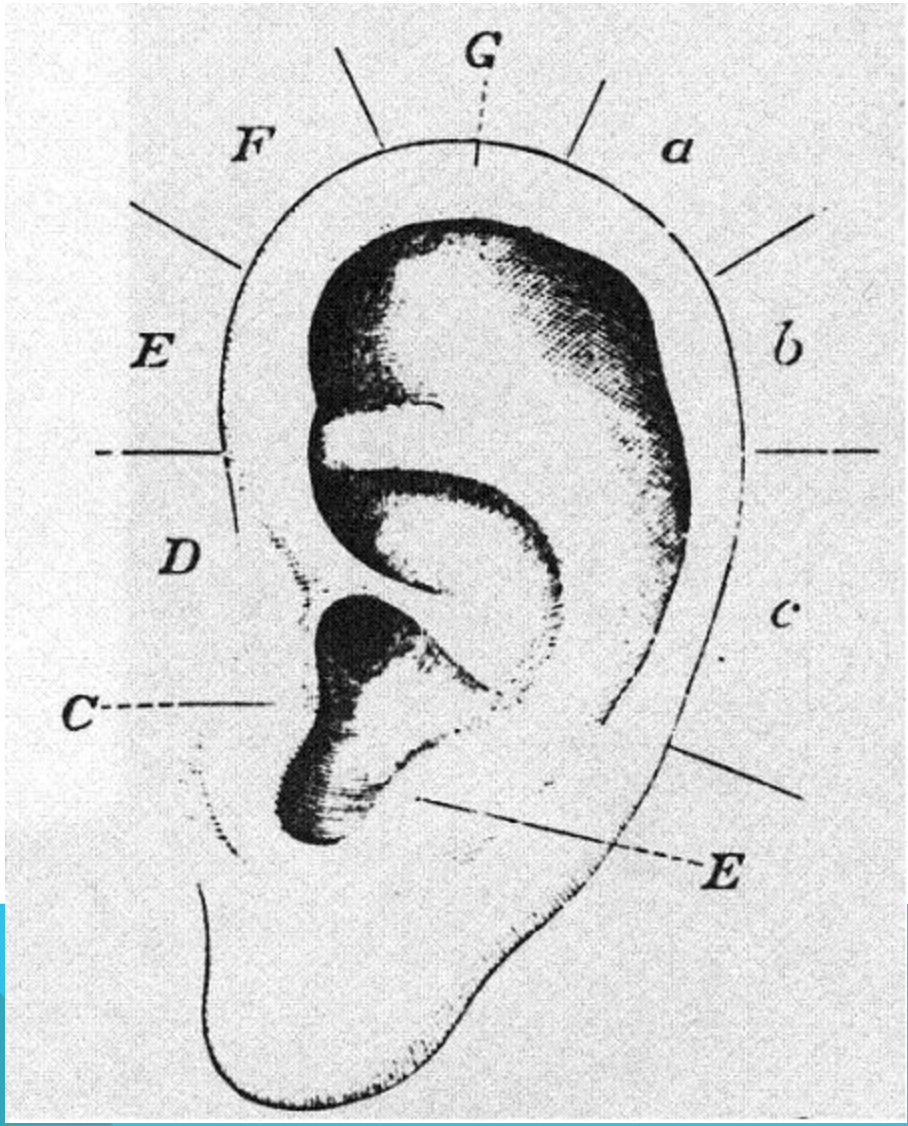
DR. MARSHALL CHASIN
AUDIOLOGIST
MUSICIANS' CLINICS OF CANADA

OR…

MUSIC AND HEARING AIDS

OR…

MUSIC AND HEARING AIDS IS NOT A SOFTWARE ISSUE…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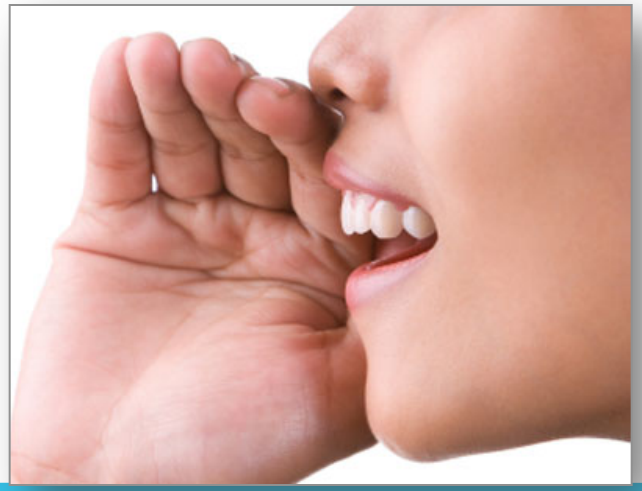
FOUR DIFFERENCES …

Speech vs. Music Spectra

Phonemic vs. phonetic requirements

Differing sound levels

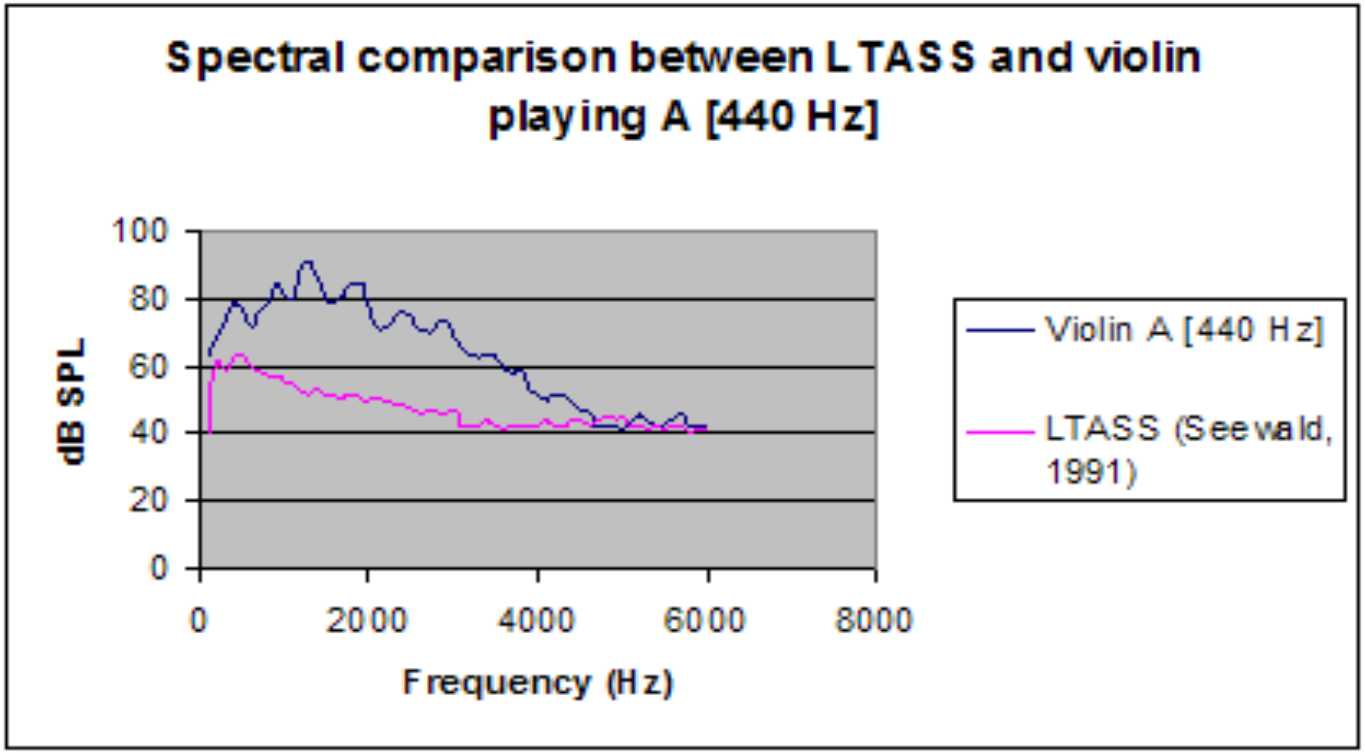
Crest factors

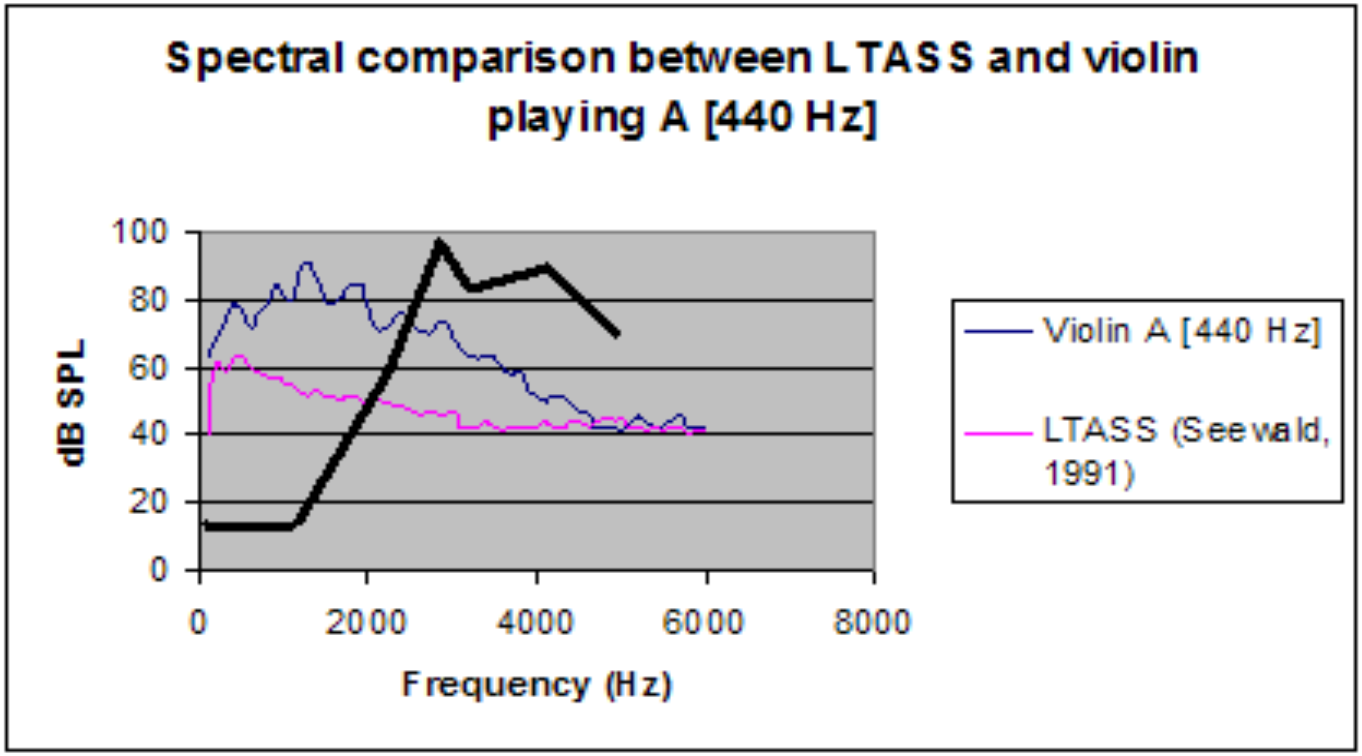


FOUR DIFFERENCES …

(1) Speech vs. Music Spectra:

- *Speech has a relatively uniform spectrum*
  - Human vocal tract source
  - Long-term speech spectrum “target”
- *Music has many sources*
  - Highly variable
  - No “music target”


Spectral comparison between LTASS and violin playing A [440 Hz]
dB SPL
100
80
60
40
20
0
0
2000
4000
6000
8000
Frequency (Hz)
Violin A [440 Hz]
LTASS (Seewald, 1991)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Frequency (Hz)
Violin A [440 Hz]
LTASS (Seewald, 1991)

FOUR DIFFERENCES …

(2) Phonemic vs. phonetic requirements:

- *Speech is mostly low-frequency energy and high frequency clarity* (SII).

- *Music perceptual requirements depends on the instrument…. Highly variable*.
  - Violins need to hear the balance between low and high frequencies.
  - Clarinets only need to hear the lower frequencies.


ONTARIO
PHONETIC


LESLIE ABOVE EGLINTON
ONTARIO
PHONEMIC
Parkview BMW

FOUR DIFFERENCES …

(3) Differing sound levels:

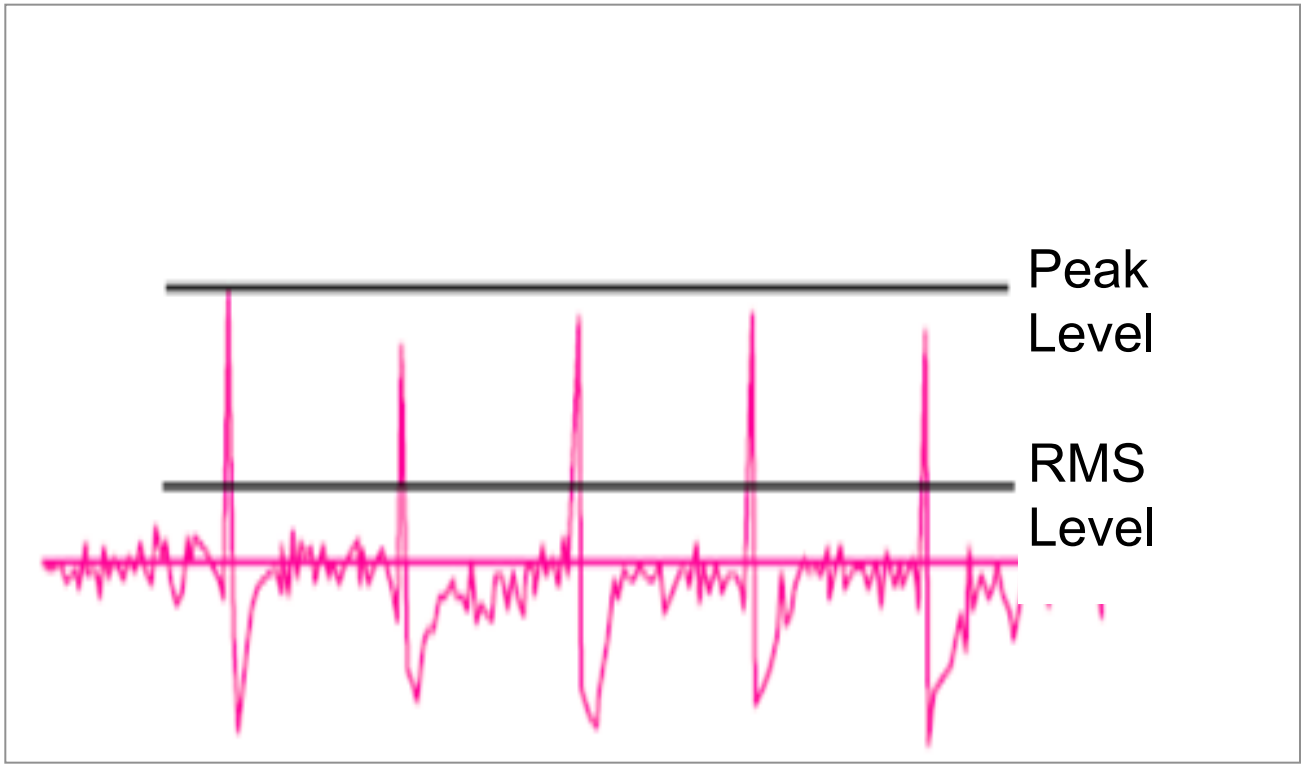
- *Speech is 65 dB SPL ± 12 dB*
  - (53 dB SPL to 77 dB SPL)
  - Shouted speech can be 82 dB SPL
- *Music can reach 105 dBA; peaks of 120 dBA*

FOUR DIFFERENCES …

(4) Crest factor: (peak – RMS)

- *Speech has a crest factor of 12 dB*
- *Music has a crest factor -up to 18 dB*
  - Less damping.

CREST FACTOR



SPEECH

65 dB SPL RMS

12 dB crest factor

-6 dB / octave

Well defined SII and target

Context and conversation

MUSIC

>100 dB SPL RMS

18 dB crest factor

Variable slopes

No “MII” and no target

No context

HEARING AIDS AND MUSICIANS

1. Peak input limiting level of most hearing aids limits sound above 85 dB SPL.

... 1980s: set to about 100 dB SPL.

... great for speech... bad for music.

- shouted [a] is about 82 dB SPL peak

- music can be >110 dB SPL

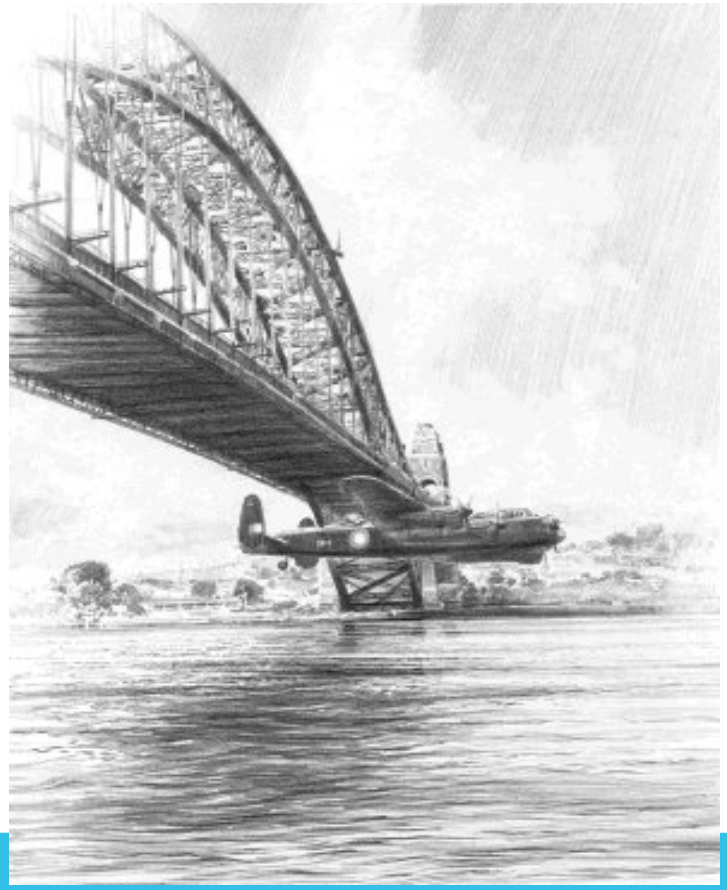
PEAK INPUT LIMITING LEVEL

This occurs just after the microphone, and is related to the A/D converter.

- Overloading the “front end”.

If distortion occurs this early in the circuitry, then nothing later (e.g. software adjustments) can improve things.

MAX HEADROOM



THE OVERPASS ANALOGY

80 dB dynamic range

IF WE DON'T HAVE ENOUGH HEADROOM

AN EXPERIMENT:

A hearing aid was constructed where the peak input limiting level can be successively reduced from 115 dB SPL, to 105 dB SPL, to 96 dB SPL to 92 dB SPL, … and back to 115 dB SPL.

Acknowledgments: Mead Killion, Russ Tomas, Norm Matzen, Mark Schmidt, Steve Aiken.

p

..... PEAK INPUT LIMITING LEVEL SHOULD BE AT LEAST 105 DB SPL .....

SOFTWARE CHANGES?

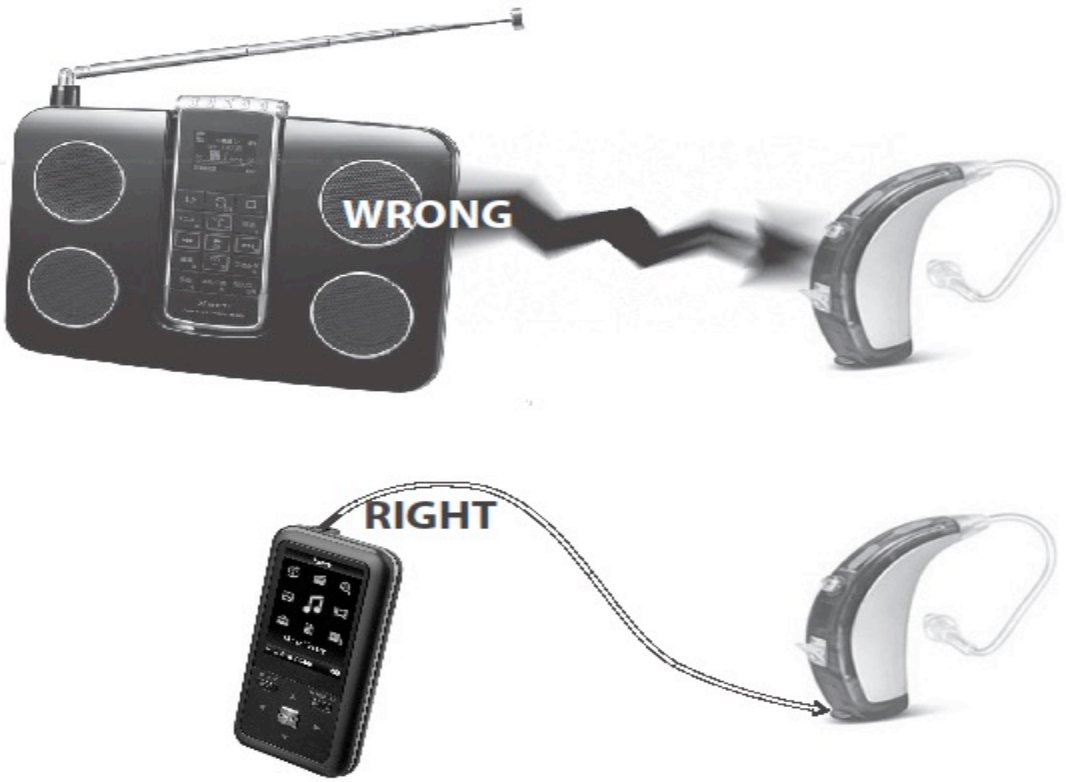
Many manufacturers have tried frequency response changes. This may take the effect of a low cut, a low frequency boost, a high cut, a high frequency boost, or alterations to the mid-frequencies.

None work well, and are of minimal use in real life situations.

FOUR STRATEGIES…

1. Lower volume on stereo or other input and increase gain on aid.
2. You can use an FM (or ALD) system as input.
3. Use (creative) microphone attenuators such as Scotch tape. Tape will provide 10-12 dB of flat attenuation up to 4000 Hz.
4. Take off the hearing aids

1. LOWER THE VOLUME OF THE INPUT (AND RAISE THE VOLUME CONTROL IF NECESSARY)…



2. YOU CAN USE AN FM SYSTEM AS INPUT.

And turn down the volume on the FM or other assistive listening device. ("1 kohm resistor in series and 10 kohm to ground")

3. USE MICROPHONE ATTENUATORS SUCH AS SCOTCH TAPE.

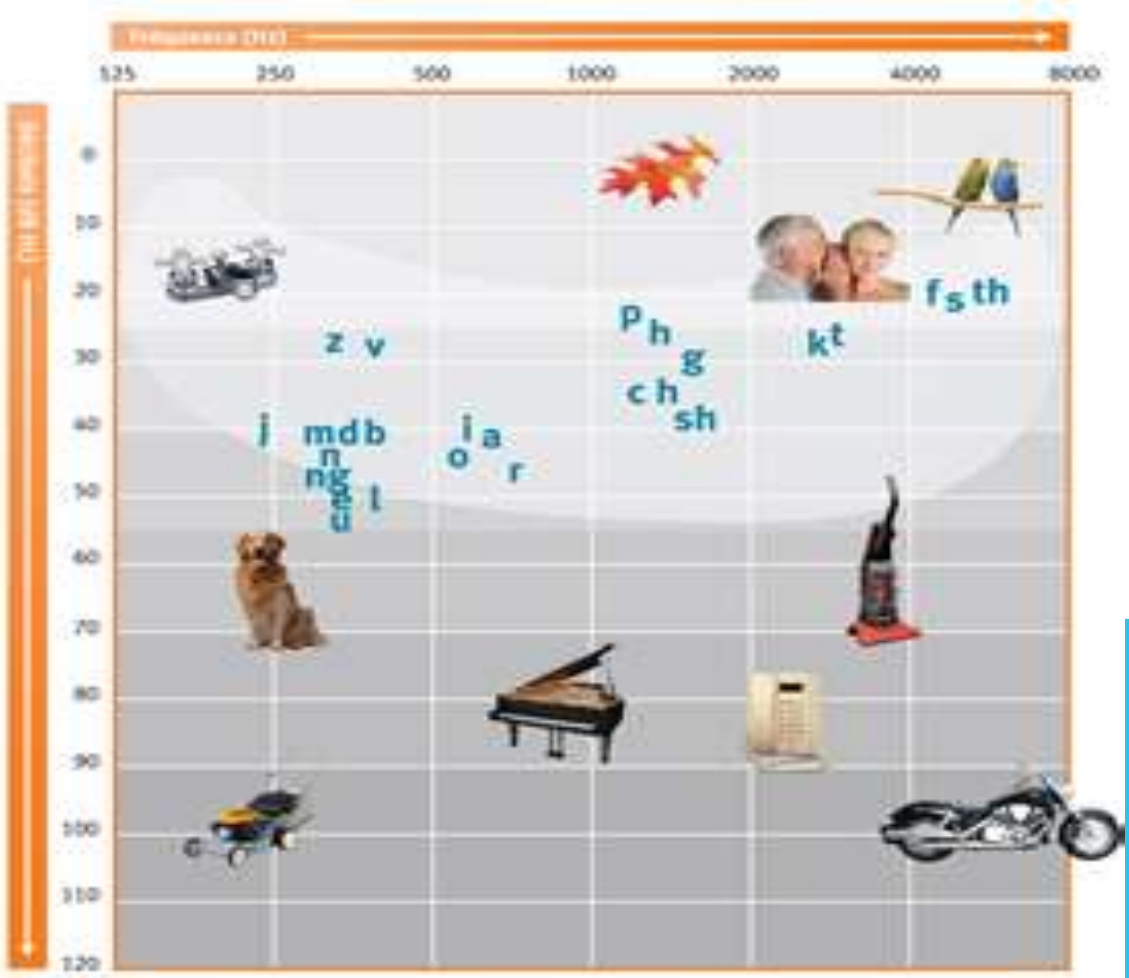
3-4 layers of Scotch tape will attenuate the input by 10-12 decibels…

4. TAKE OFF THE HEARING AIDS

Since music has a higher sound level than speech, maybe removing the hearing aids may be

the best

thing?



4. TAKE OFF THE HEARING AIDS

dB HL at 1000 Hz	*65 dB input*	*80 dB input*	*95 dB input*
15	0	0	0
25	2	1	0
35	8	4	0
45	14	7	0
55	20	10	1
65	28	15	2
75	36	20	3
85	44	24	4

FOUR TECHNICAL INNOVATIONS…

1. -6 dB/octave low cut microphone
2. Shifting the dynamic range upwards
3. Front end compression prior to the A/D converter
4. Post 16 bit architecture

1. -6 DB/OCTAVE LOW CUT MICROPHONE

Non-occluding BTE provide gain above 1000 Hz and do not occlude the ear canal.

Useful for those with a high frequency loss

BUT still has a front end limiting problem…

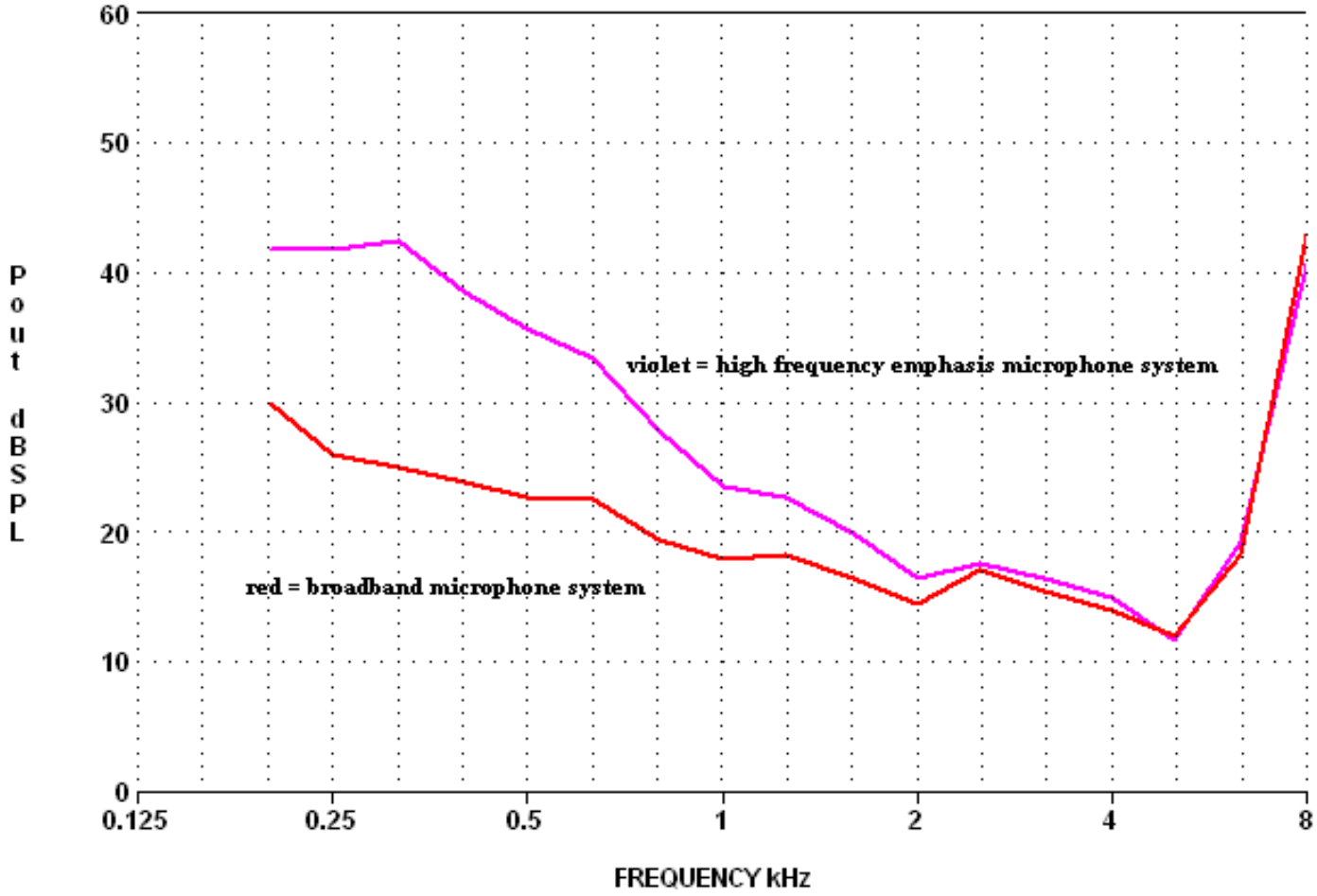
1. -6 DB/OCTAVE LOW CUT MICROPHONE

SO…. We can use a desensitized microphone.

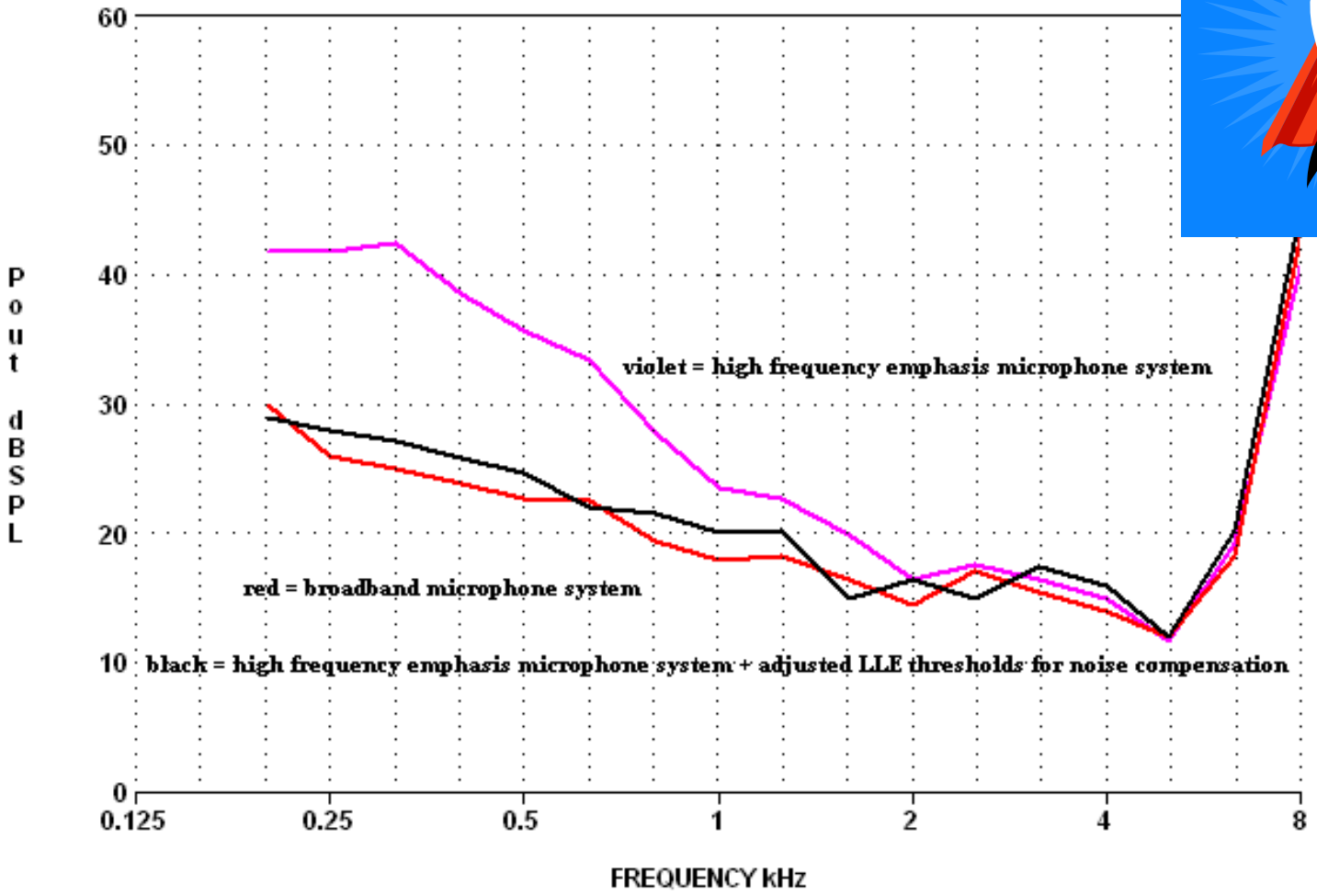
Use a high frequency emphasis (-6 dB low frequency roll-off) microphone.

Same frequency response but less front end distortion. (Unitron has done this).

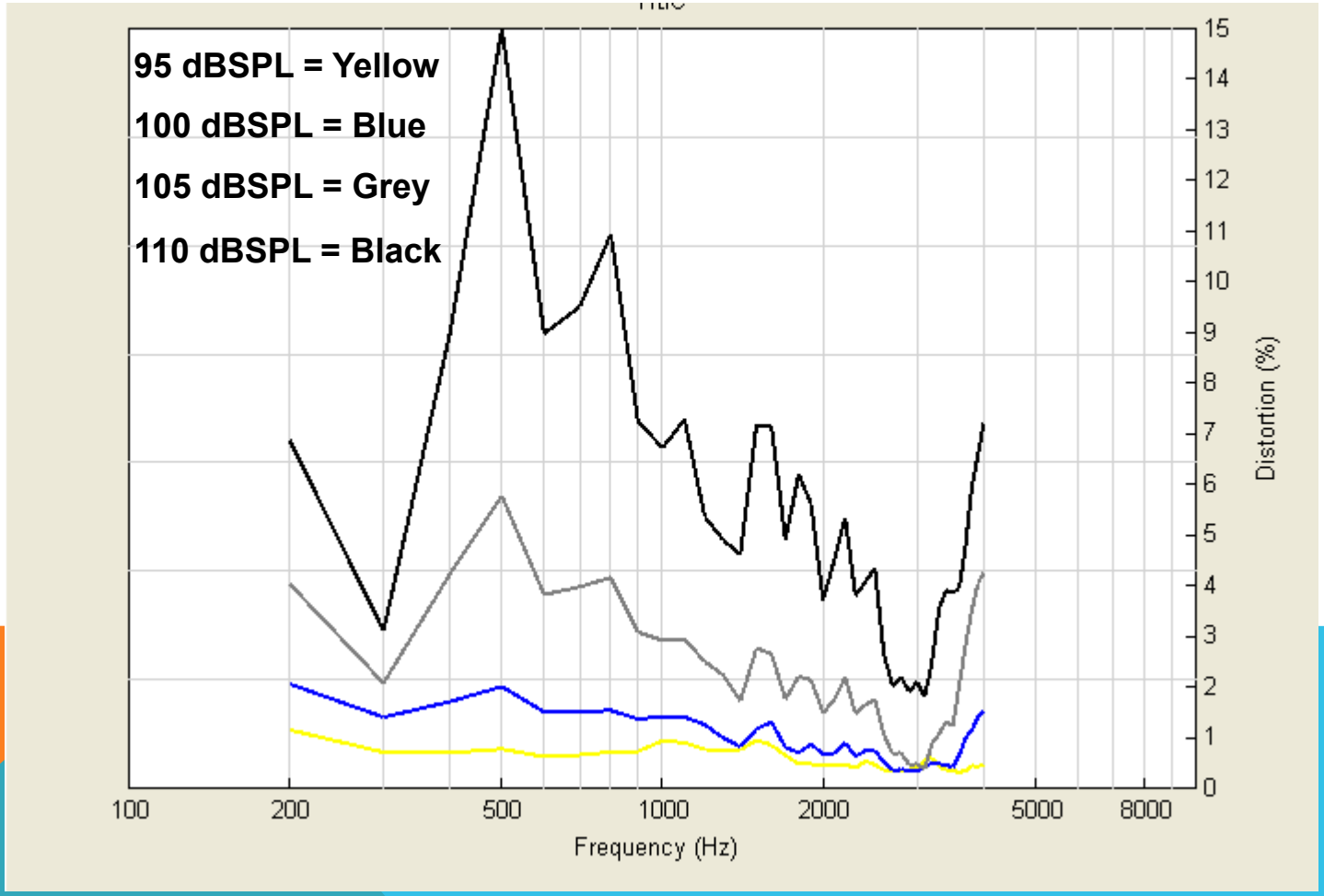
MICROPHONE NOISE…
YOU WILL NEED EXPANSION…



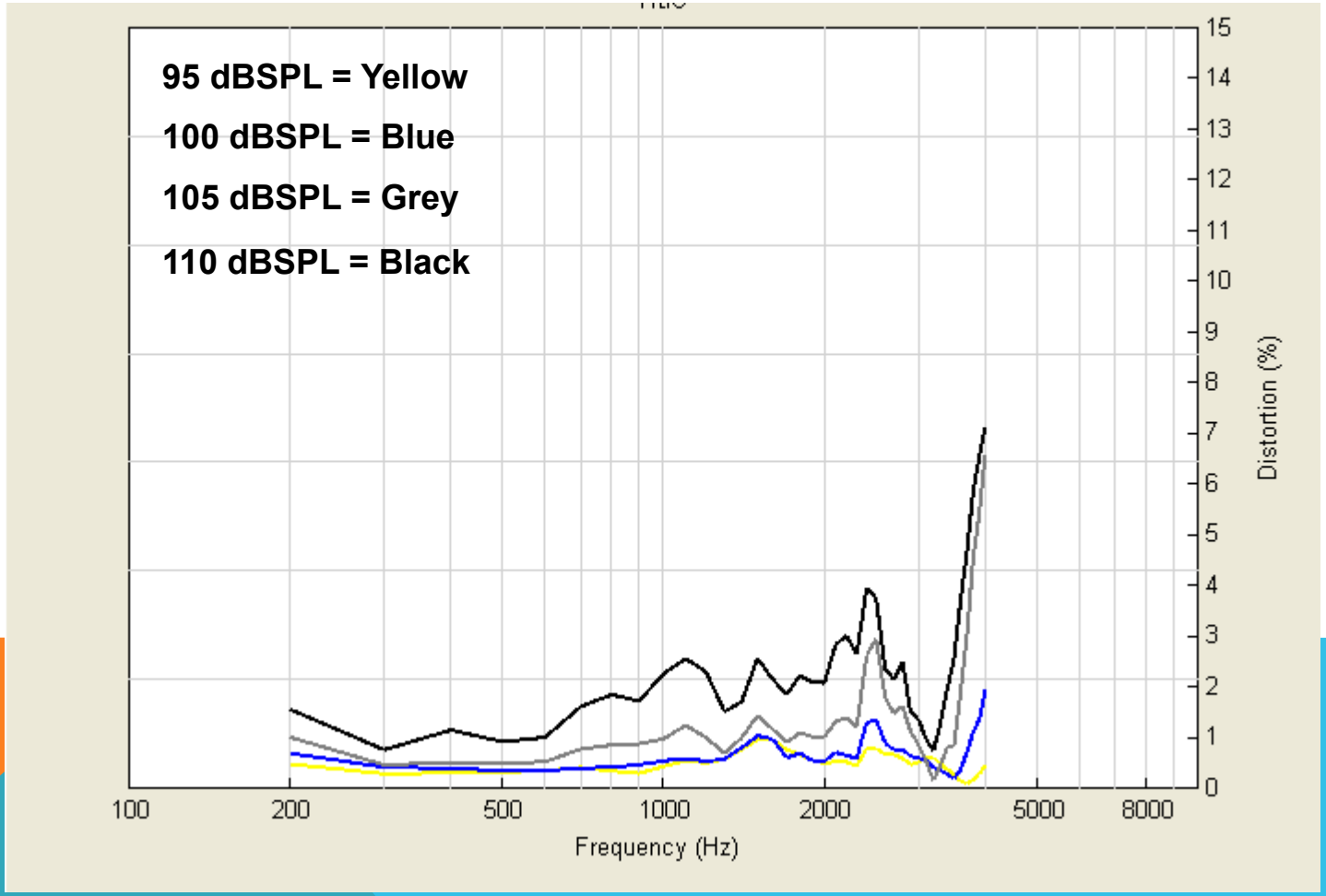
EXPANSION COMES TO THE RESCUE



THD RESULTS WITH BB MIC FOR 95, 100, 105 & 110 DB SPL INPUTS



THD RESULTS WITH HF MIC FOR 95, 100, 105 & 110 DB SPL INPUTS



2A. SHIFTING THE DYNAMIC RANGE UPWARDS

Bernafon Live Music Plus (111 dB SPL)

has shifted the dynamic range up

from 0- 96 dB SPL

to 15 dB – 111 dB SPL

2A. SHIFTING THE DYNAMIC RANGE UPWARDS

Bernafon 9 series on Live Music Plus function:

<3% distortion

Bernafon 9 series with function disabled:

20- 24% distortion

2B. SHIFTING THE DYNAMIC RANGE UPWARDS

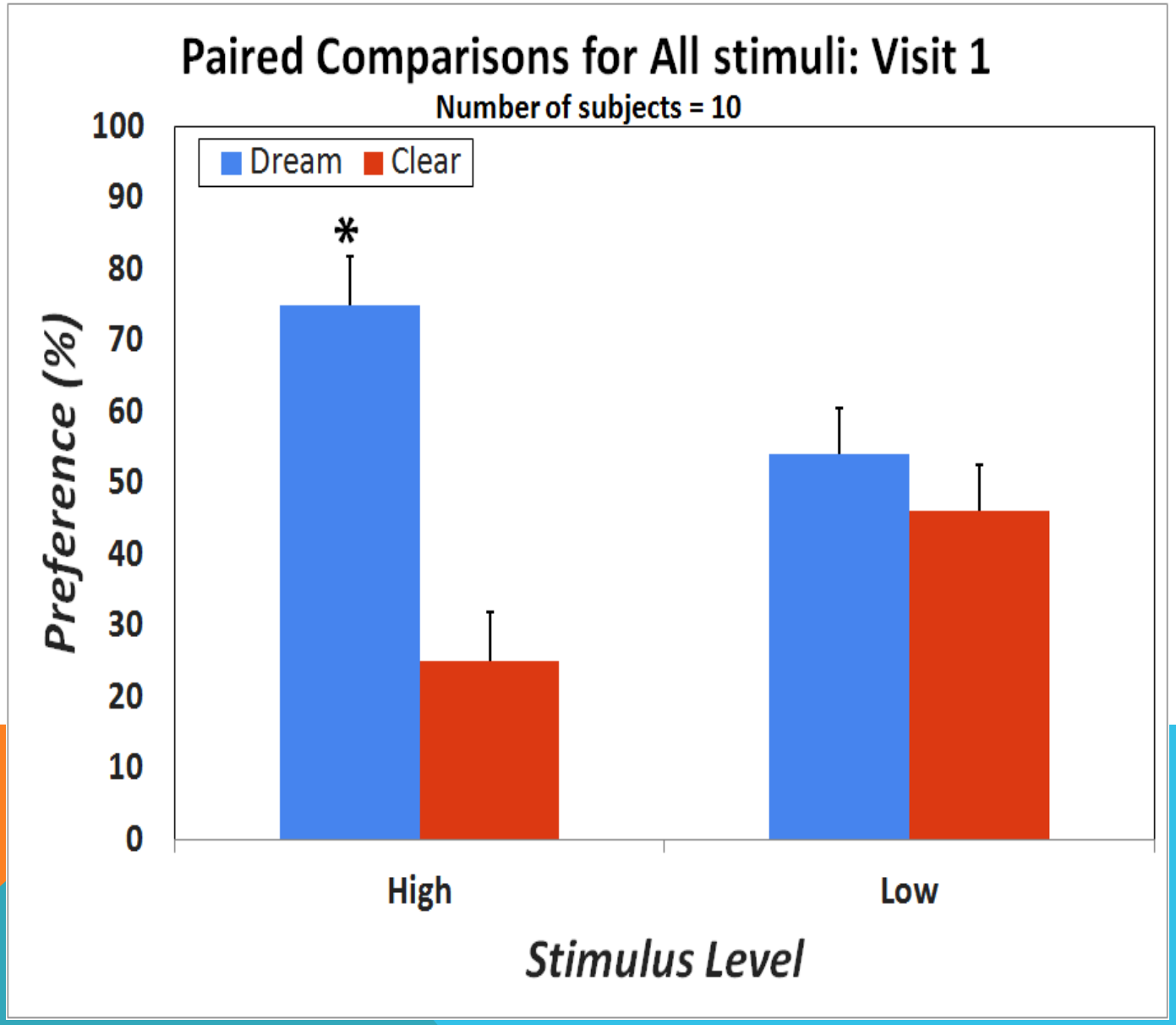
Another approach

(Widex Dream, 113 dB SPL)

Transformer effect by doubling the voltage

Different than amplification because it increases top end while keeping the noise floor low

WIDEX DREAM


Paired Comparisons for All stimuli: Visit 1
Number of subjects = 10
Dream
Clear
*
100
90
80
70
60
50
40
30
20
10
0
Preference (%)
High
Low
Stimulus Level

3. FRONT END COMPRESSION PRIOR TO THE A/D CONVERTER

Several hearing aid companies (e.g. Resound, 106 dB SPL) are starting to use an analog compressor prior to the A/D converter …

… and then digitally

re-establish gain after…

4. POST 16 BIT ARCHITECTURE

20 and 24 bit architecture A/D converters that have > 96 dB dynamic range.

- Sound Design Wolverine,
- ON Semi-Conductor Ezairo 5900
- Motorolla 24 bit system

- For each bit (n) add 6 dB to dynamic range
  $(20n)\log 2 = 20n \times 0.3$


HIT OF THE PARTY
OH, Marshall YOU'RE WONDERFUL!
Did he say 20nlog2!!

4. POST 16 BIT ARCHITECTURE

Some new 24 bit systems:

Unitron North (119 dB SPL max)

Phonak Venture (119 dB SPL max)

Oticon Opn

Widex Unique

… AND EVERYTHING ELSE…

1. One channel is better than multi-channel
2. Similar compression characteristics as speech. (Davies, Souza & Fabry, 2009)
3. Disable noise reduction and feedback management systems.
4. No frequency transposition
5. 6 dB lower OSPL90 and gain than the speech-in-quiet program.

… AND ONE MORE THING…

If we can't change the hearing aid, then maybe we can change the music.

Music can be created with the fundamental and first two harmonics below 500 Hz. This increases accessibility for hard of hearing children to have audible kid's music…

MUSICIANS AND HEARING AIDS

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www.musiciansclinics.com

www.HearingHealthMatters.org/HearTheMusic