Allied Health Media AudiologyOnline

Programming Hearing Aids for Listening and Playing Music, Presented in Partnership with AAMHL

Presenter: Marshall Chasin, AuD
Musicians Clinics of Canada

Guest Moderator: Wendy Cheng, founder AAMHL

Allied Health Media AudiologyOnline

- Technical Assistance: 800-753-2160
- CEU Total Access members can earn credit for this course
  - Must complete outcome measure with passing score (within 7 days for live webinar; within 30 days of registration for recorded/text/podcast formats)
- Questions? Call 800-753-2160 or use Contact link on AudiologyOnline.com

Allied Health Media AudiologyOnline

Association of Adult Musicians with Hearing Loss (AAMHL)

Wendy Cheng, Founder

HEARING AIDS AND MUSIC-
ITS NOT ALL ABOUT THE MUSICIAN.

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AUD, M.SC., REG. CASLPO, AUD(C)
MUSICIANS' CLINICS OF CANADA

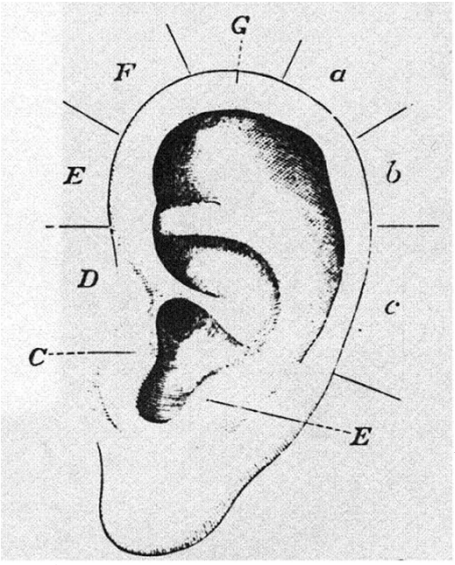
AUDIOLOGYONLINE.COM
MAY 21, 2014

OR…

MUSIC AND HEARING AIDS

OR…

MUSIC AND HEARING AIDS IS
NOT A SOFTWARE ISSUE…



.... A WEBSITE...

www.musiciansclinics.com

- FAQs
- Articles
- Information fact sheets
- Links

FOUR DIFFERENCES ...

Speech vs. Music Spectra

Phonemic vs. phonetic requirements

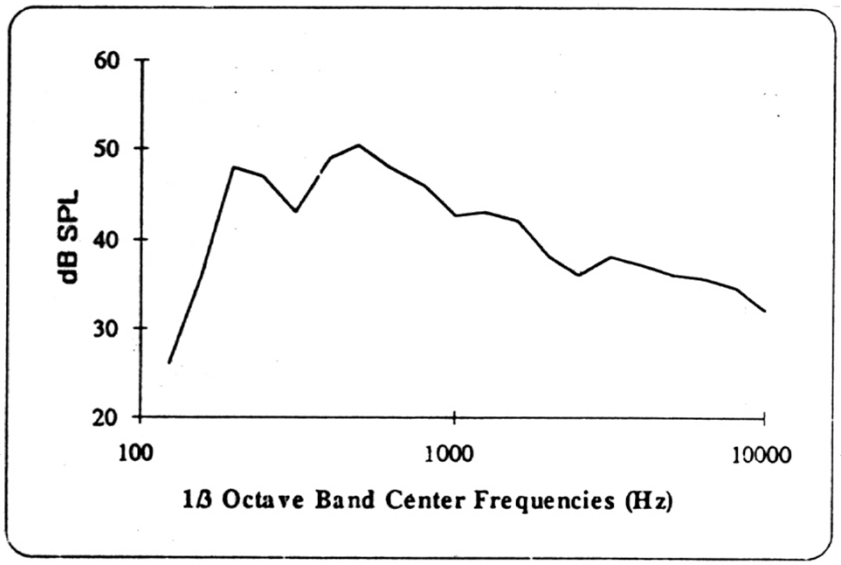
Differing intensities

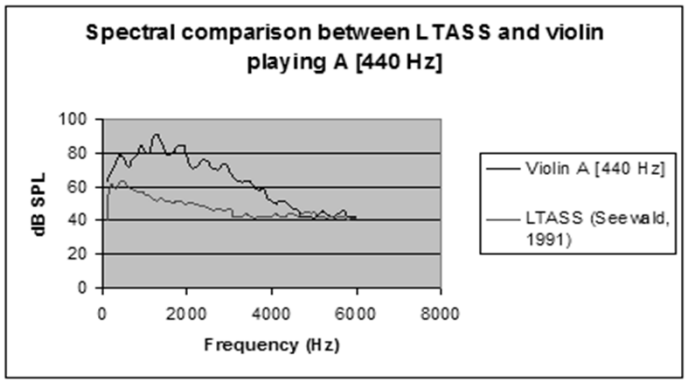
Crest factors

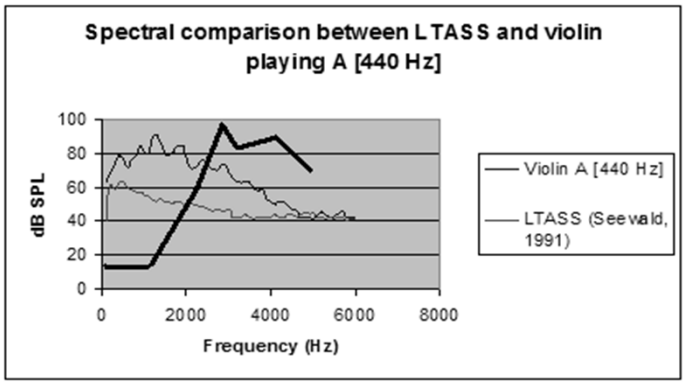
FOUR DIFFERENCES ...

(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”


60
50
40
30
20
dB SPL
100
1000
10000
1ß Octave Band Center Frequencies (Hz)


Spectral comparison between LTASS and violin playing A [440 Hz]
100
80
60
40
20
0
dB SPL
0
2000
4000
6000
8000
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.

FOUR DIFFERENCES ...

(3) Differing intensities:

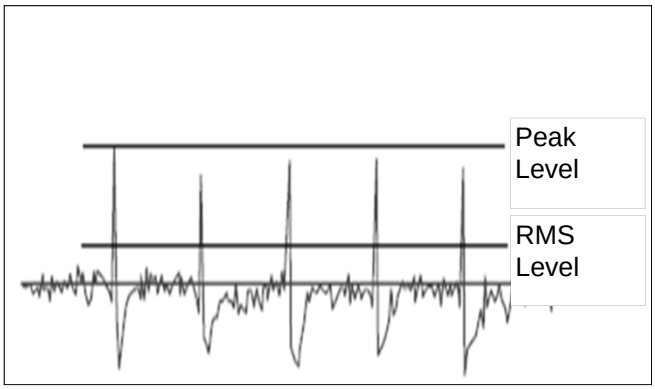
- *Speech is 65 dB SPL ± 12 dB*
  - (53 dB SPL to 77 dB SPL)
  - Shouted speech can be 82 dB SPL
- *Music can reach 105 dBA; peaks of 120 dBA*

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

WHAT ABOUT HARD OF HEARING
MUSICIANS ...
... OR NON-MUSICIANS WHO LIKE
TO LISTEN TO MUSIC?

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

INTENSE MUSIC AND LOW “CEILING”

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

THEREFORE ....

PEAK INPUT LIMITING LEVEL SHOULD BE AT LEAST 105 DB SPL

SOFTWARE CHANGES?

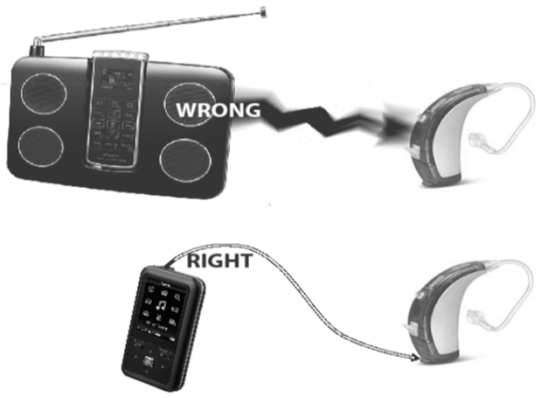
Many manufacturers have tried frequency response changes. This may take the effect of a low cut, a low frequency boost, a high cut, a high frequency boost, or alterations to the mid-frequencies.

None work well, and are probably 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

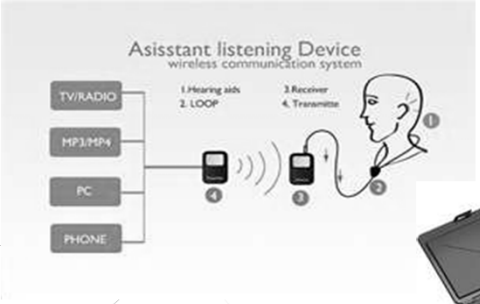
1. LOWER THE VOLUME OF THE INPUT (AND RAISE THE VOLUME CONTROL IF NECESSARY)…



... TURN DOWN THE INPUT...

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 is more intense than speech, maybe removing the

hearing aids

may be the

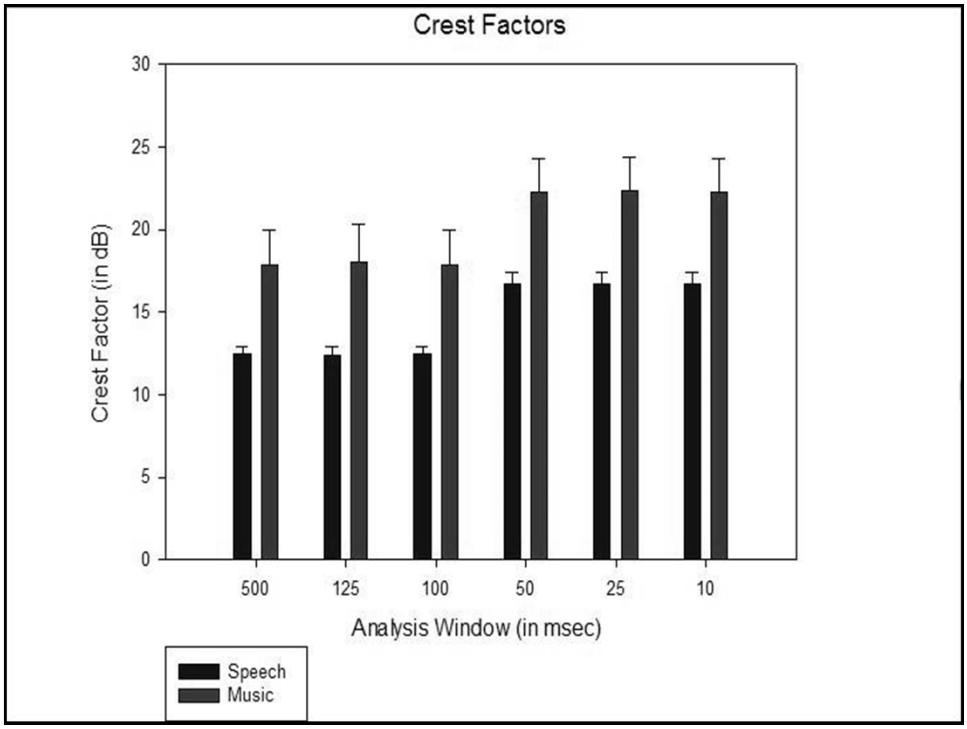
best thing?

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

LET'S RE-EXAMINE THE CREST FACTOR FOR SPEECH …

Analysis window (msec)	**500**	**400**	**300**	**200**	**125**	**100**	**50**	**25**
Crest factor (dB)	12.46	12.48	12.46	12.45	12.46	13.22	16.68	16.68



LET'S RE-EXAMINE THE CREST FACTOR FOR SPEECH ...

Sivian and White (1933)

and Cox et al. (1988)

-assumed the analyzing window should be 125 msec.

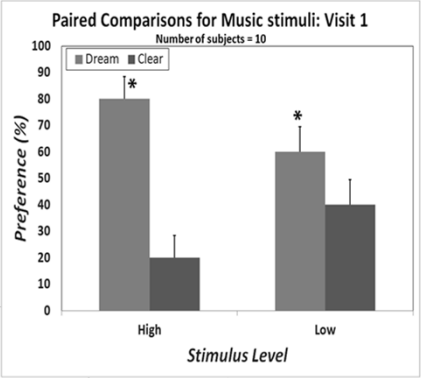
… but we are not talking about our auditory systems, only the front end.

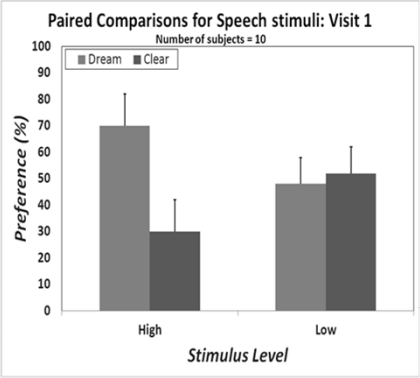
WHAT THE CREST FACTOR CAN TELL US ABOUT SPEECH…

If the crest factor is actually a function of the window of analysis, then a hard of hearing person's own voice can overdrive their own hearing aid!

84 dB input + 16 dB crest factor > 96 dB

BENEFIT EVEN FOR HIGH LEVEL SPEECH…





SOME 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…

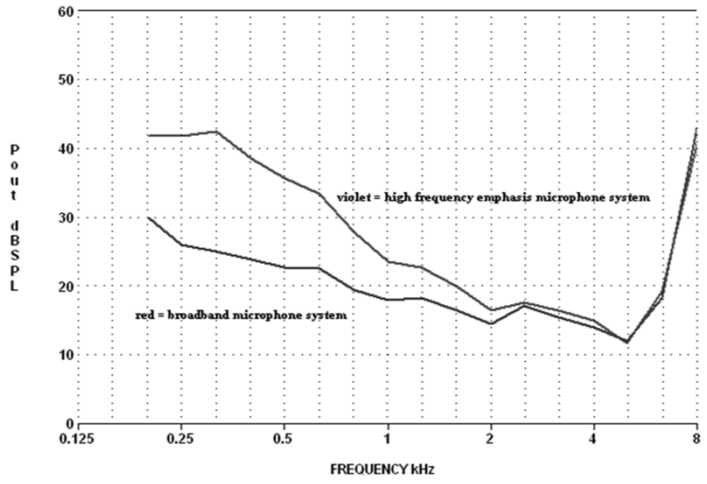
1. -6 DB/OCTAVE LOW CUT MICROPHONE

SO…. We can use a desensitized microphone.

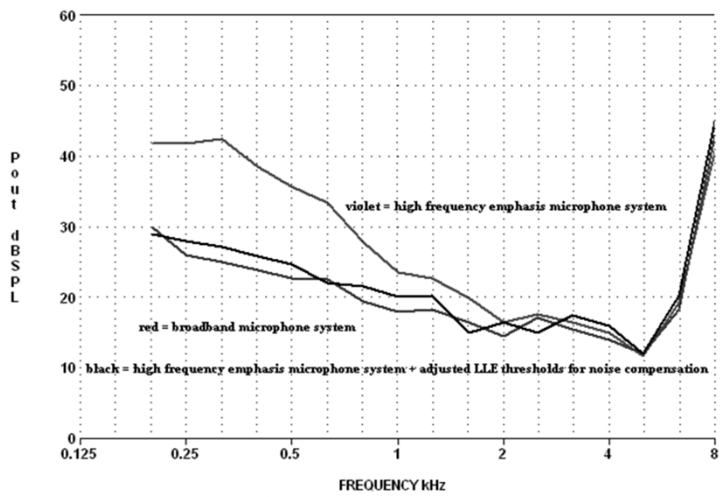
Use a high frequency emphasis (-6 dB low frequency roll-off) microphone.

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

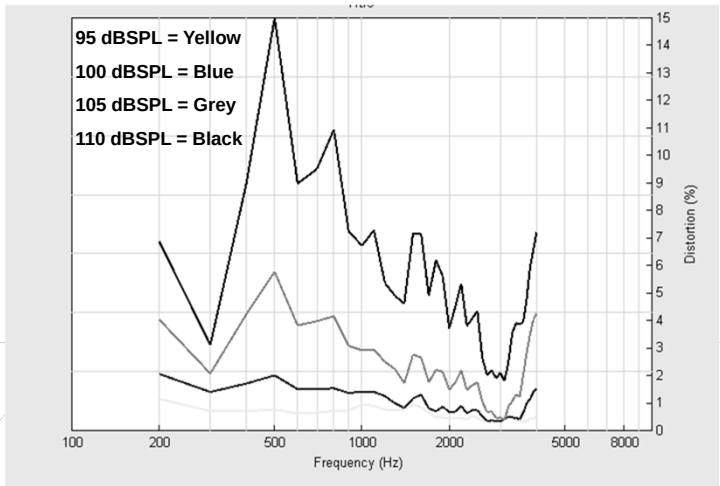
MICROPHONE NOISE…
YOU WILL NEED EXPANSION…



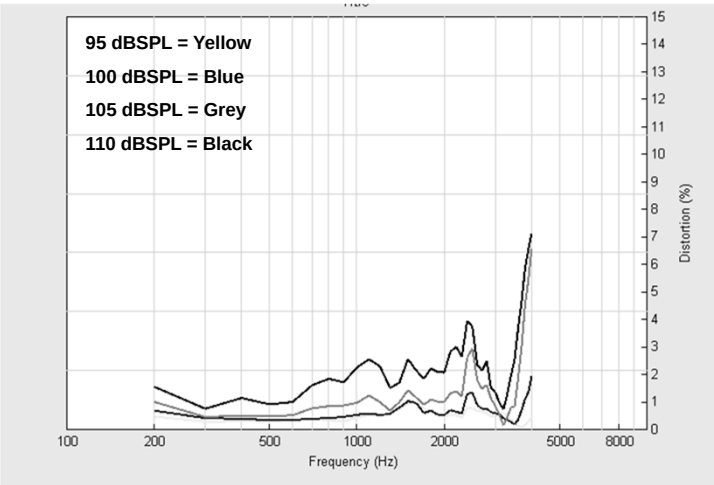
EXPANSION COMES TO THE RESCUE



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



2. SHIFTING THE DYNAMIC RANGE UPWARDS

Bernafon Live Music Plus

has shifted the dynamic range up

from 0- 96 dB SPL

to 15 dB – 111 dB SPL

LOW GAIN/HIGH OUTPUT TEST
(105 DB SPL INPUT)

Bernafon Chronos 9 on Live Music Plus function:
<3% distortion

Bernafon Chronos 9 with function disabled:
20- 24% distortion

2. SHIFTING THE DYNAMIC RANGE UPWARDS

Another approach (Widex Dream)

Transformer effect by doubling the voltage

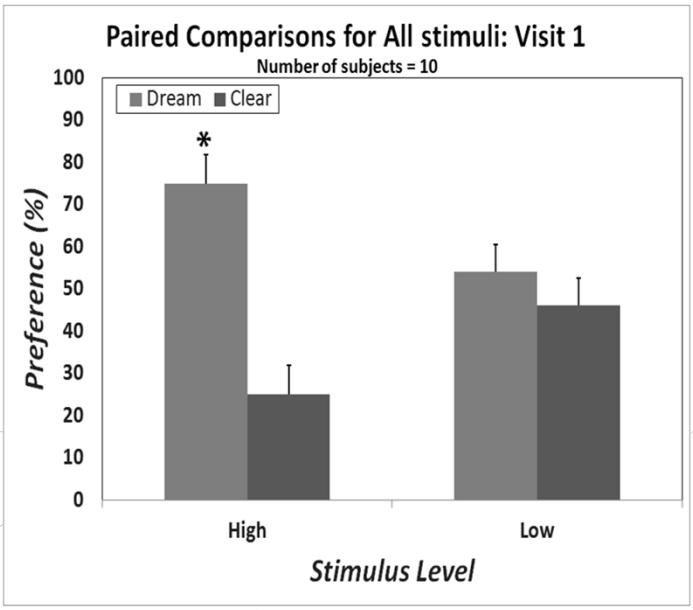
Different than amplification because it increases top end while keeping the noise floor low

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

Several hearing aid companies are starting to use an analog compressor prior to the A/D converter …

… and then digitally re-establish gain after…

WIDEX DREAM (INPUT COMPRESSION FOLLOWED BY DIGITAL EXPANSION)



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,

- For each bit (n) add 6 dB to dynamic range
- (20n)log2 = 20n x 0.3

... 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.**

THE ONE THING THAT IS NOT ON THIS LIST

Frequency response….

… based more on limitations of auditory system and not input stimulus

Based on the work of Brian Moore and Todd Ricketts:

If mild loss then broadest possible bandwidth

If steeply sloping loss then narrower may be better (dead regions)

If >60 dB HL then narrower may be better (dead regions)

1. ONE CHANNEL IS BEST…

The lower frequency fundamental energy is treated in the same way as the higher frequency harmonic energy

The balance of music is maintained

…. the shape of the spectrum is maintained.

…. At least for classical music…

2. SIMILAR COMPRESSION

Compression is implemented in order to re-establish the loudness growth function of the damaged cochlea and not the characteristics of the input signal.

Davies et al. (2009)… "Chasin and Russo (2004) suggested that WDRC…. That hypothesis was supported by the present data." (p. 696).

3. DISABLE ADVANCED FEATURES

Disable the noise and feedback management systems.

- **The signal (music) is so intense that any microphone noise would be inaudible.**
- **The gain is so low (due to intense inputs) that may not need feedback control. Chirping due to uncanceled feedback signal?**

4. NO FREQUENCY TRANSPOSITION

Any change in frequency will be disastrous- may improve things after a lengthy training period, but doubtful if any musician will tolerate this.

EXCEPT if a child has successfully adapted to transposition for speech then…?

5. 6 DB LOWER OSPL90 AND GAIN

Given similar compression characteristics between speech and music, and given a 6 dB greater crest factor for instrumental music….

-6 dB OSPL90 than speech-in-quiet program

-6 dB gain than speech-in-quiet program

MUSICIANS AND HEARING AIDS

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www.musiciansclinics.com

www.HearingHealthMatters.org/HearTheMusic