Pure Tone & Speech Audiometry

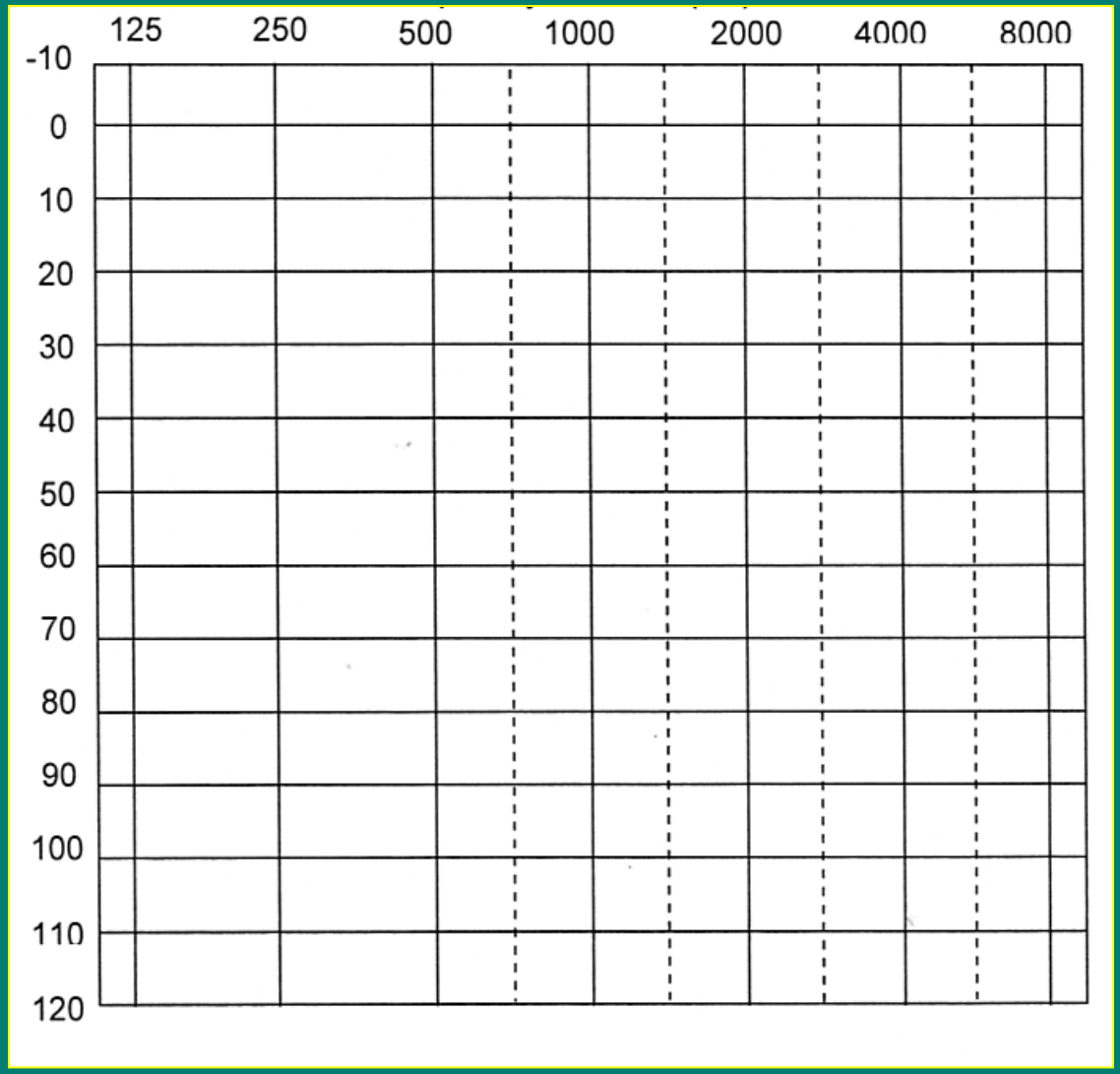
Ted Venema PhD

Speech Audiometry Complements Pure Tone Audiometry

Question:

Who did this to us?

Why is the Audiogram Upside-Down?



Article by James Jerger, International Journal of Audiology, March 2013

Edmund Prince Fowler MD (1872-1966) was a giant in otology during the first half of the 20th century and is perhaps best known for his discovery of loudness recruitment. Harvey Fletcher PhD (1884-1981) was a physicist who joined Bell laboratories and became a pioneer in speech and hearing sciences. No picture of R. L. Wegel AB, who was physicist at Western Electric. Their common interest was in developing an audiometer

Why the Oddiogram is Upside-Down

Once the Vacuum Tube was Invented in 1906

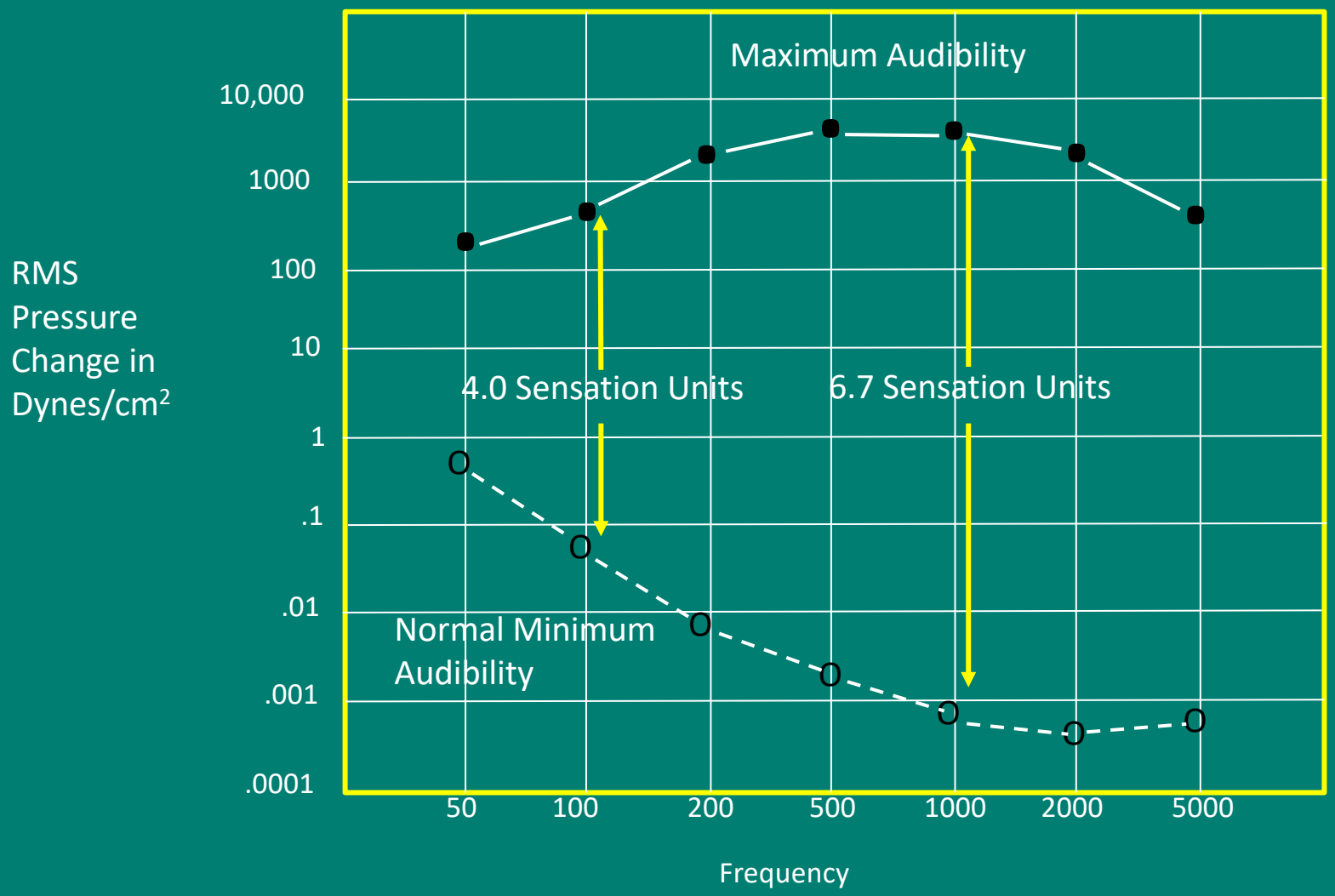
- it was possible to fix intensity of pure tones
- present them through telephone receiver

Vertical axis went from bottom to top (like normal graphs do)

- Wegel (1922) came up with graph of “auditory area”
- logarithmic scale of .0001 to 10,000 dynes/cm^2…
- Fowler divided this into 6.7 sensation units
- if someone’s threshold was 2.1 SU’s above normal,
- then 2.1/6.7=31% HL

Auditory Area & Sensation Units (Wegel & Fowler, 1922)

Each sensation unit was defined by a sound pressure ratio of 10:1



HL could thus be described in % of loss in Sensation Unit's

Fowler went another step: subtract %HL from 100%

- this gives % of normal hearing
- if someone's threshold was 2.1 Sensation Units above normal,
- then 2.1/6.7=31% HL
- so from previous example: 100% - 31% = 69%

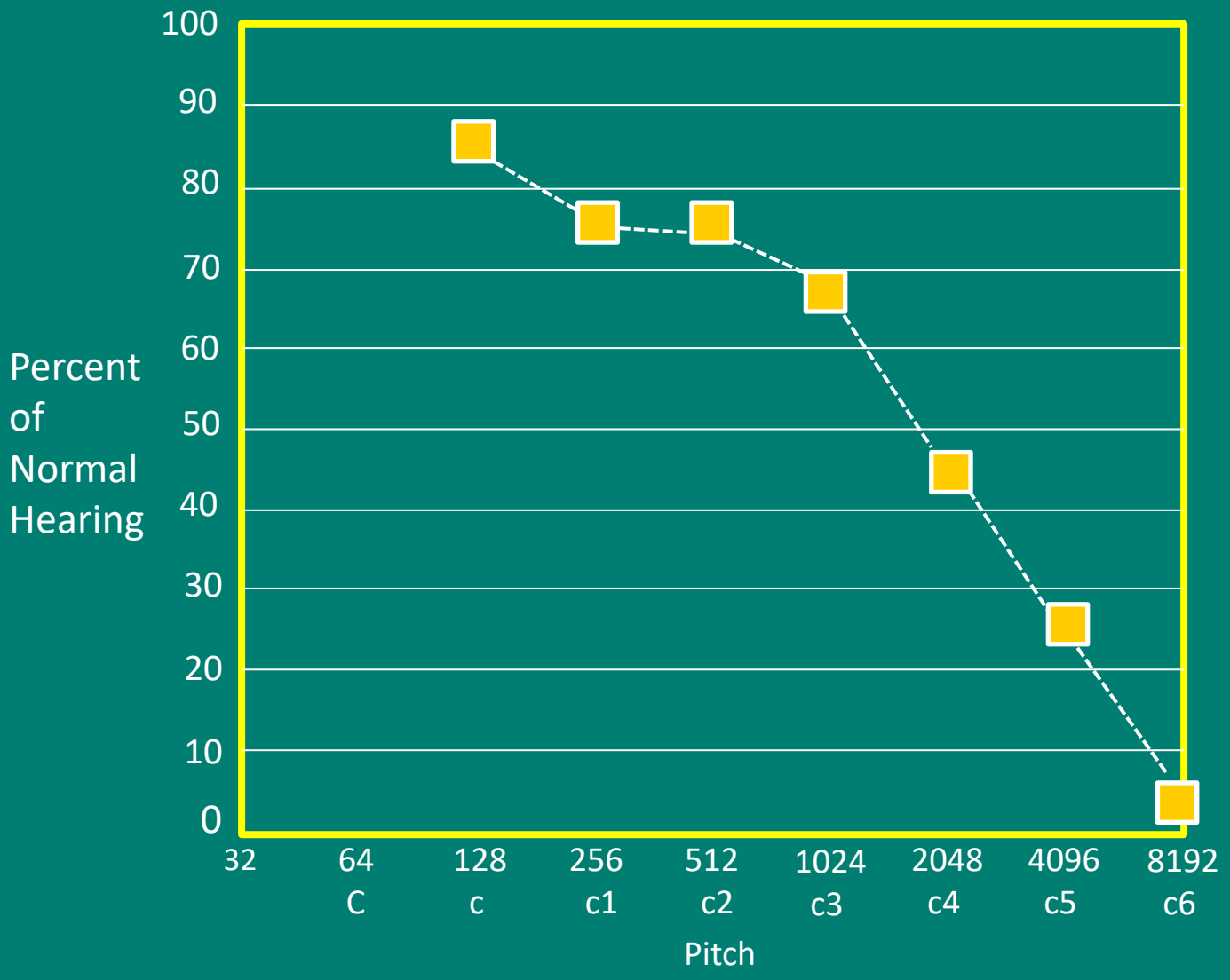
Fowler thought this worked best to counsel clients

- ie, "How much hearing do I have left?"

And there's the rub

- while %'s start at 0 on bottom and rise to 100 on top
- just like normal graphs do…the top line was 100%
- and that was later on, called 0 dB HL!

Fowler's Graph of HL %'s



Fletcher (1925) did not agree with the % approach

Fletcher was physicist

- not a clinician

While %'s were clinically useful in describing to patients

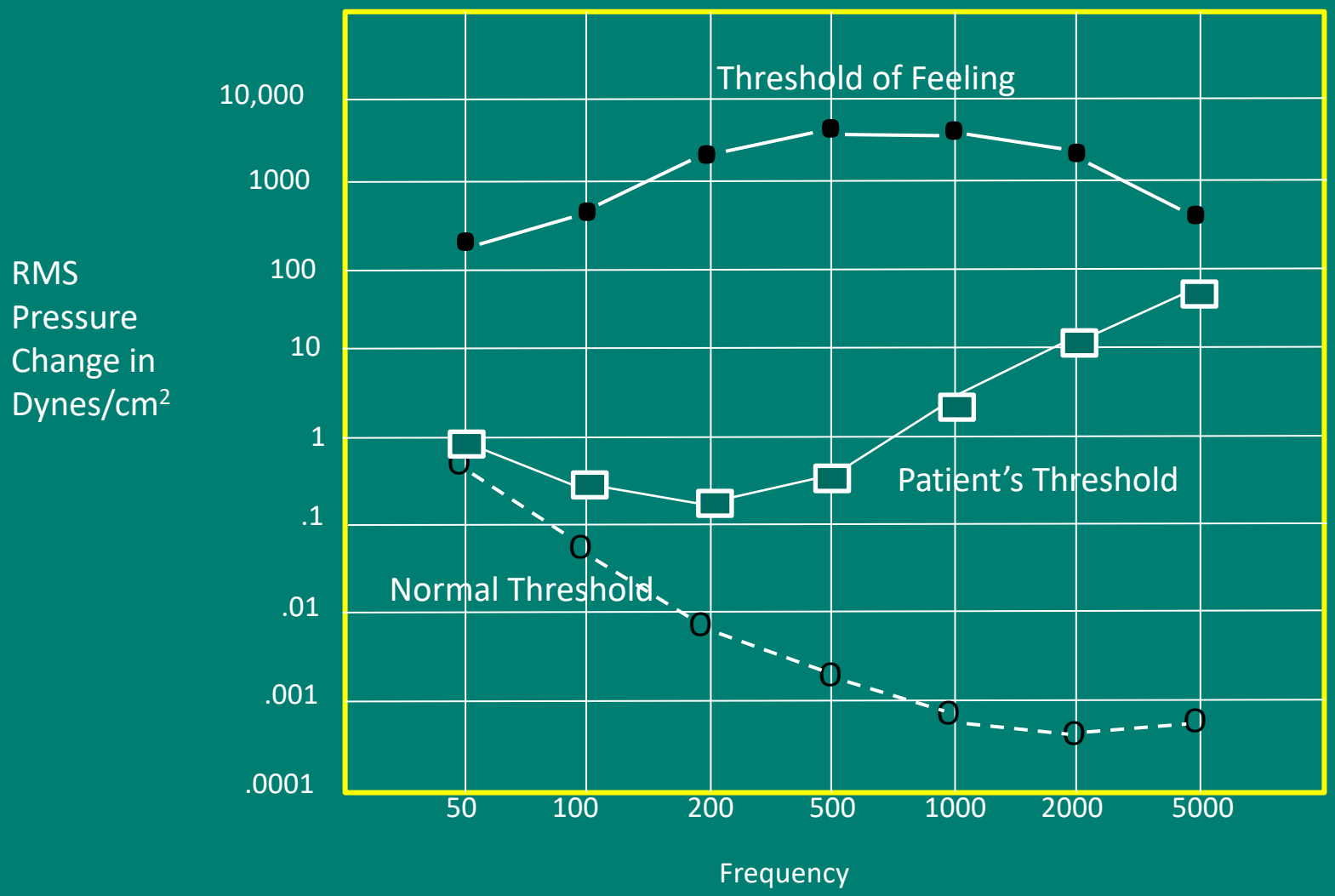
- accurate expression of HL is best described physically
- ie, in Sensation Unit's, not %'s

Look at his graph!

- lots like our Speech Mapping in Real Ear Measurement!

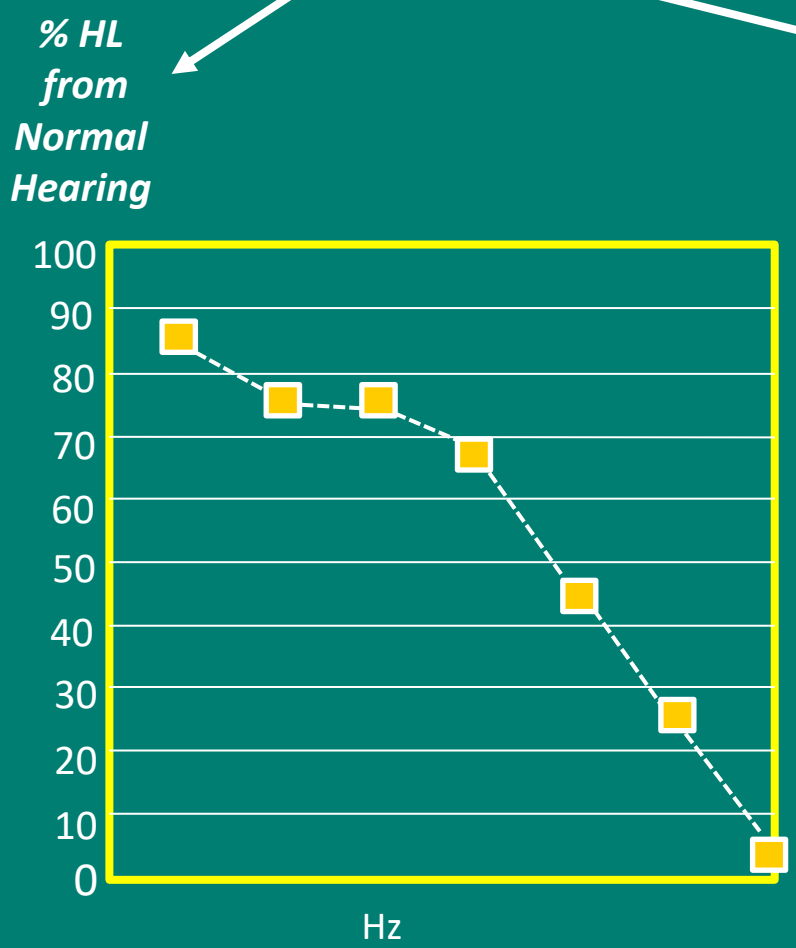
Fletcher's Graph (1923)

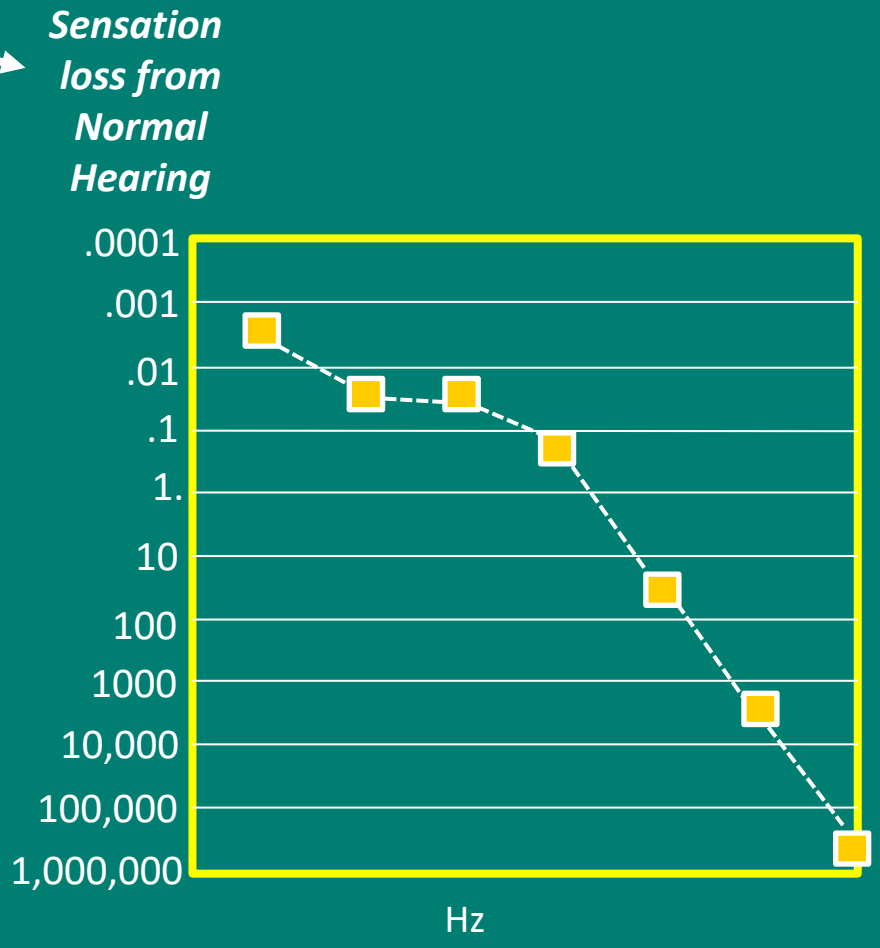
Hypothetical audiometric contour of a person with high-frequency HL



Fletcher convinced Fowler to abandon % HL & Use Physical Sensation Units Along Vertical Axis…

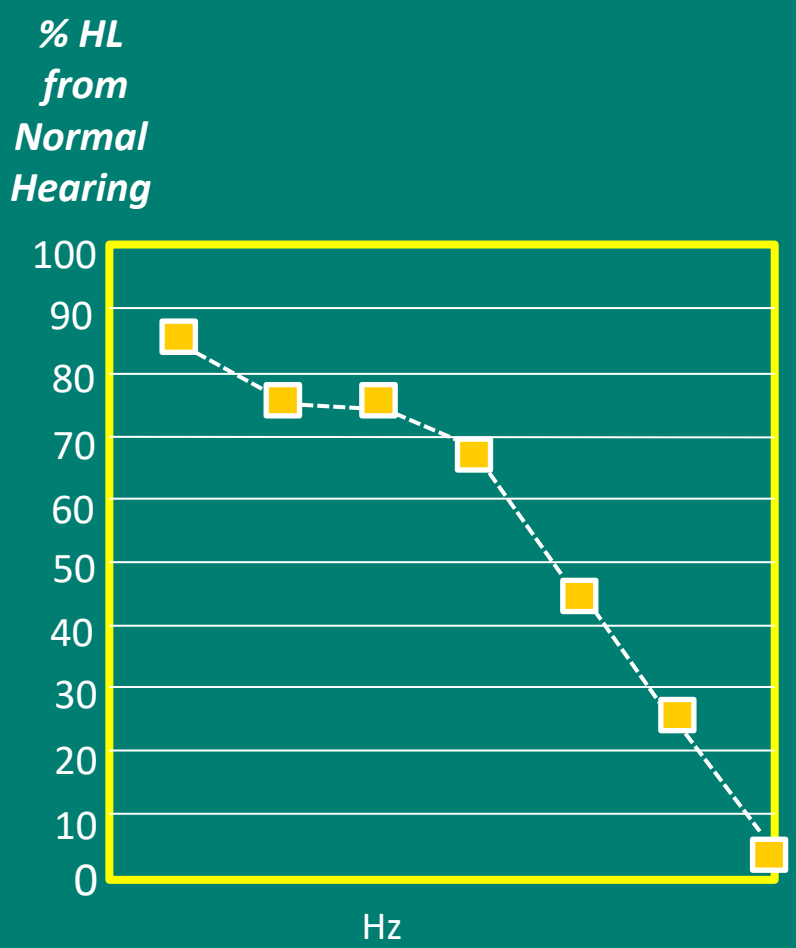
But He Simply Renamed the Vertical Axis as Sensation Units!

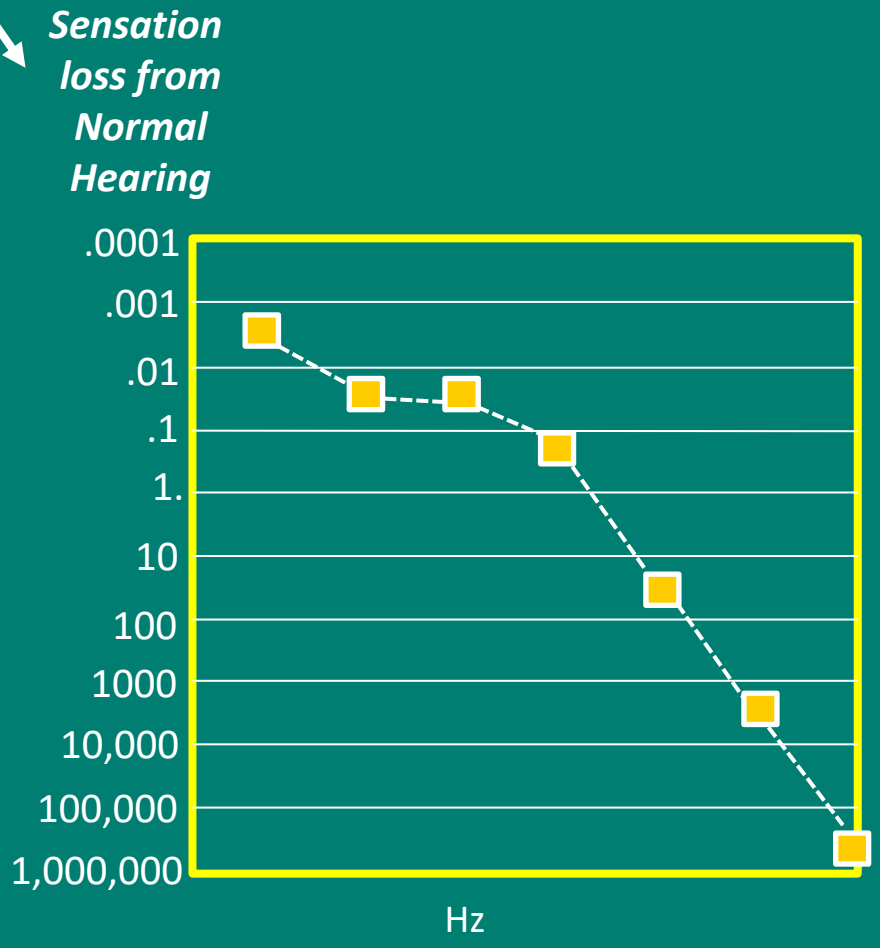




Jerger says, “Alea Jacta Est!”
In other words, “The Die is Cast!

Now less is at the top!

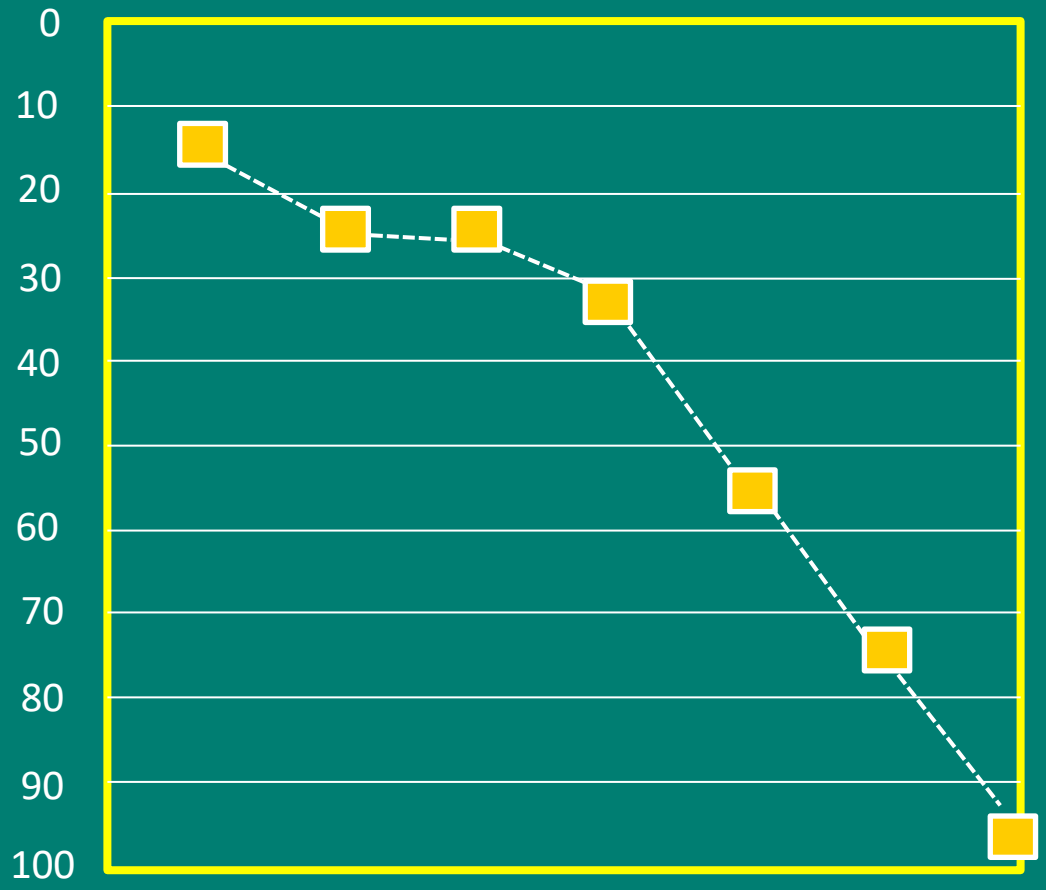




Later on, Sensation Units Deemed too Coarse

The decibel (0-120) offered a finer toothed comb

Fowler's son (Edmund Prince Fowler Jr) in 1943 labelled vertical axis as "Hearing Loss in Decibels

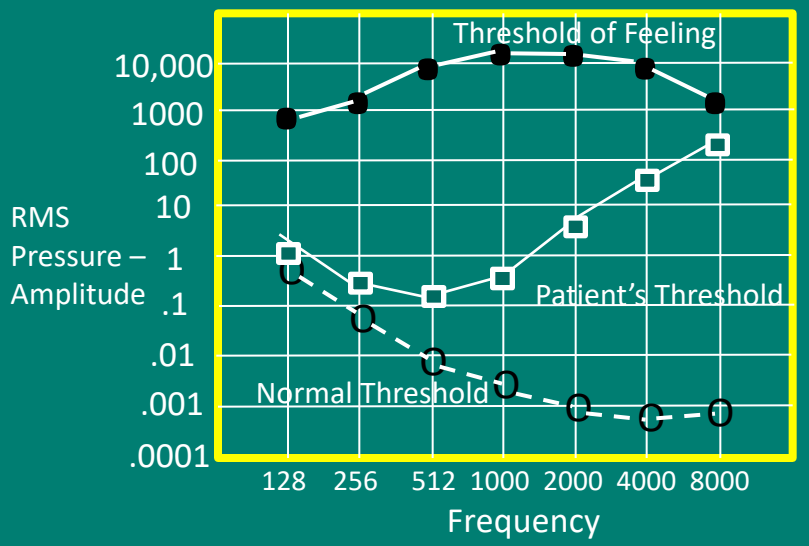


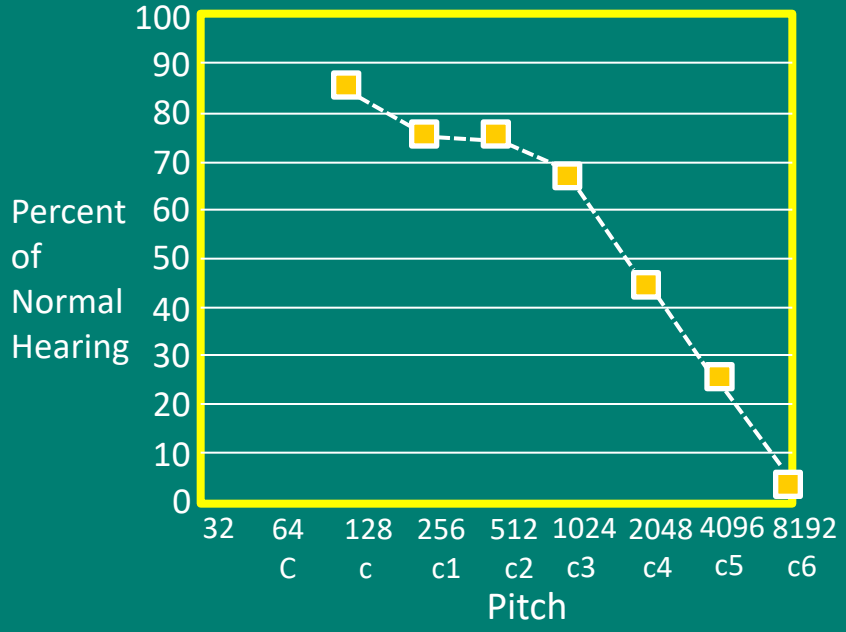
In Conclusion…

- Fletcher's audiogram, which even shows dynamic range!

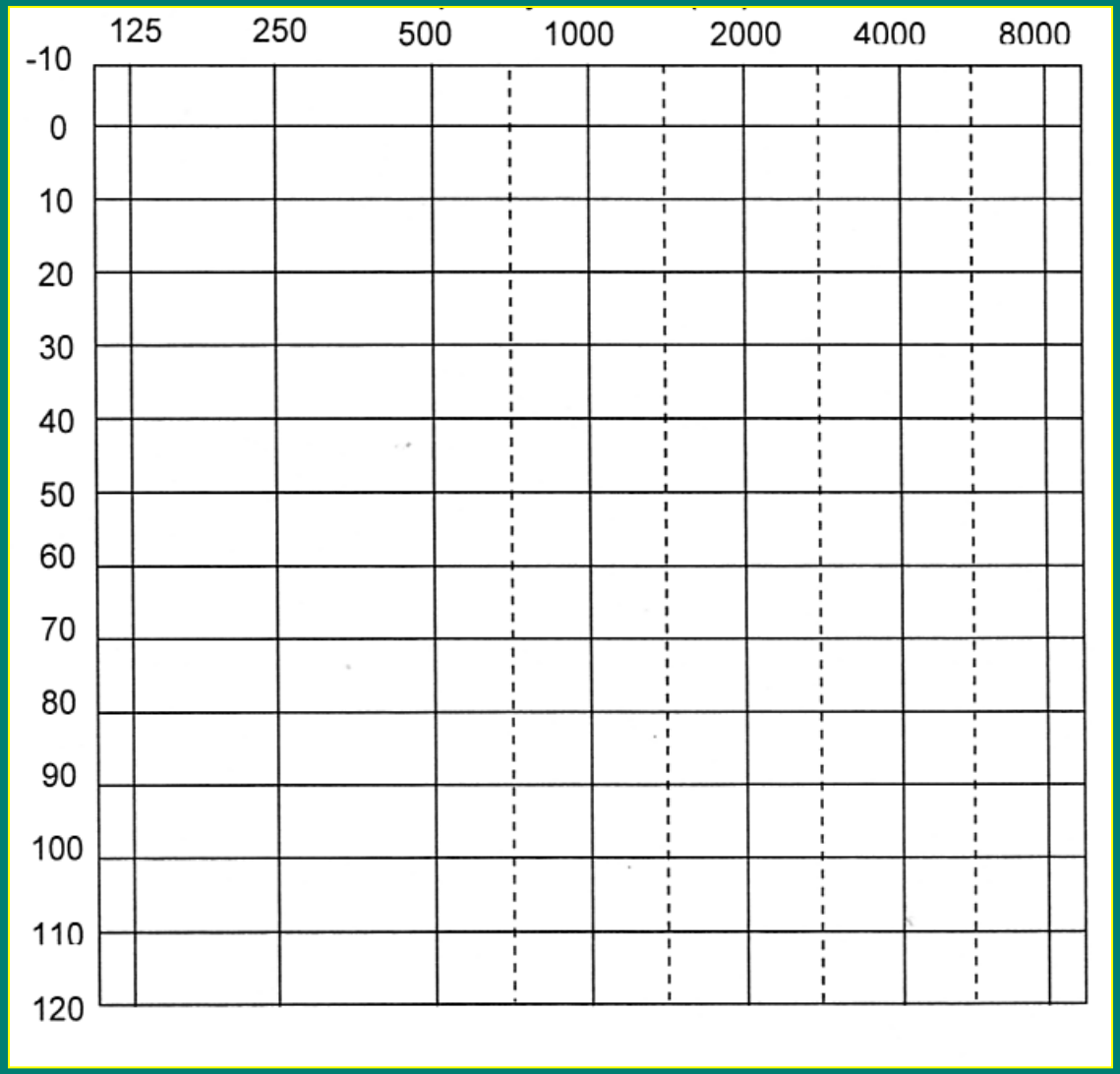
and

- Fowler's audiogram, which shows % of normal hearing





Eventually Led to Our “Oddiogram”



Let’s look at 0 dB HL:

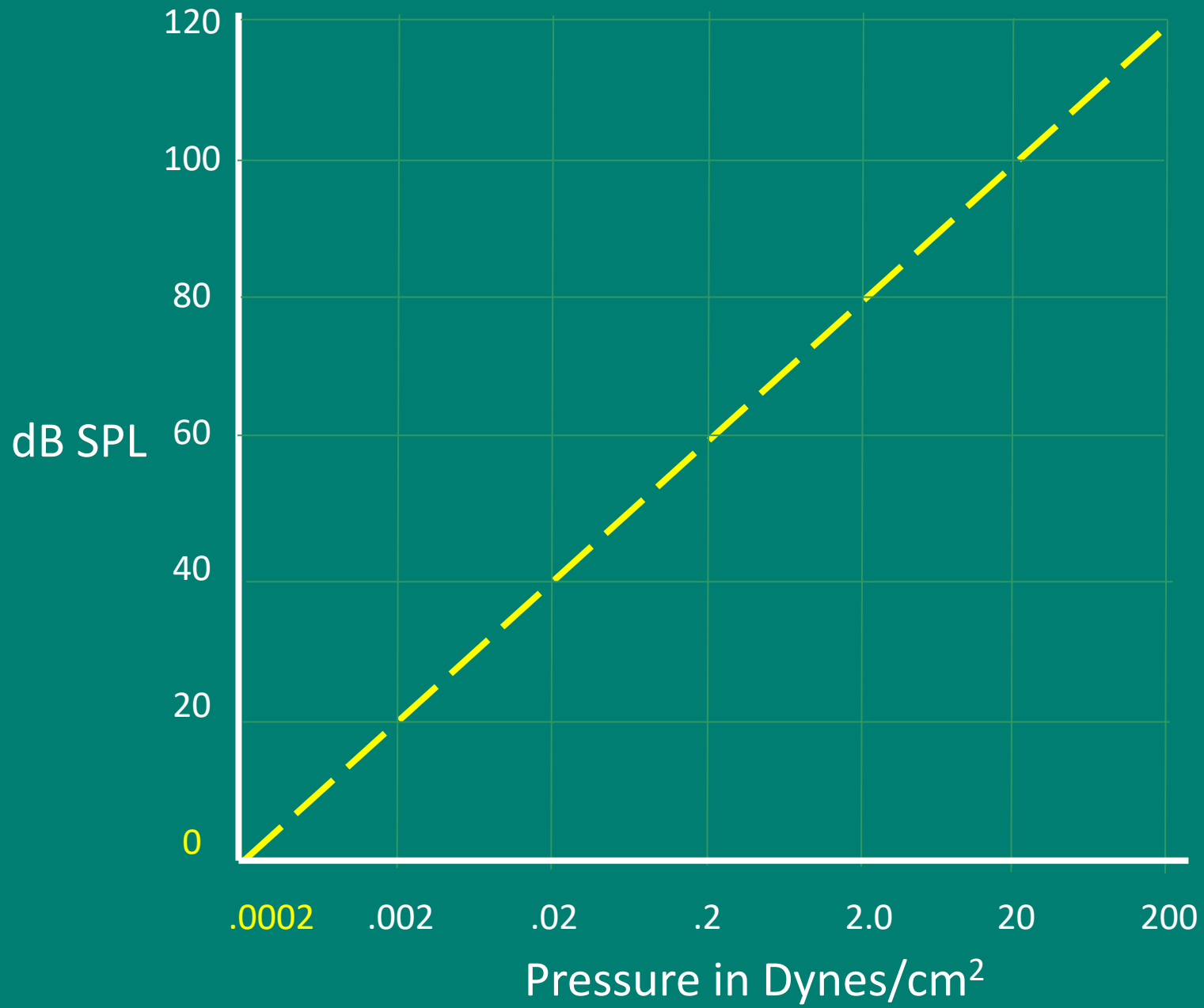
There’s a story here and it has 4 chapters

1. 0 dB SPL
2. Minimal Audible Field (MAF)
3. Minimal Audible Pressure (MAP)
4. 0 dB HL

0 dB Sound Pressure Level (SPL)

- Does not mean absence of sound!
  - it is an arbitrary level to call “zero” or “ground”
- To tell if apartment is 2 X higher than house
  - must know the ground
- Softest pressure required to just barely hear 1000 Hz tone
  - at 1 meter distance from a speaker, with 2 ears
- This is 0 dB SPL!

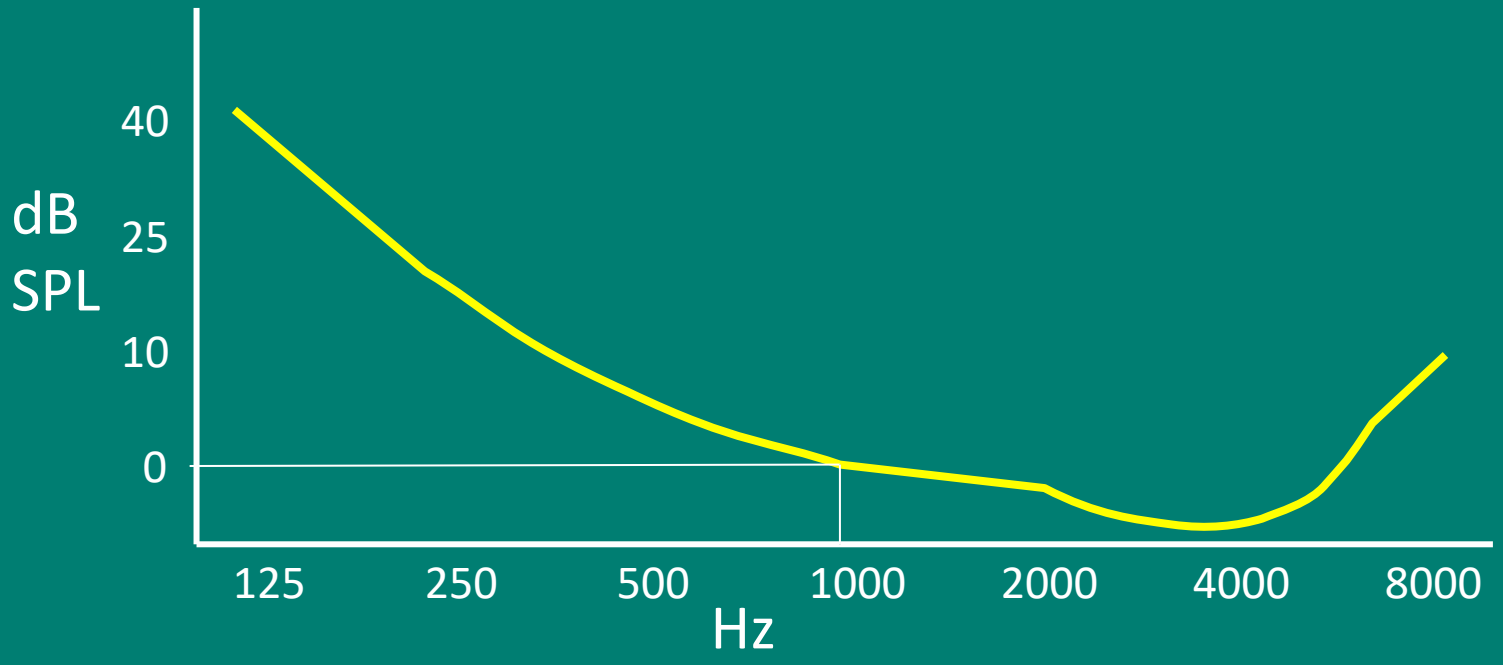
Each time you increase pressure by 10 times, you go up 20 dB



Note: 120 dB SPL has 1,000,000 times the pressure of 0 dB SPL!

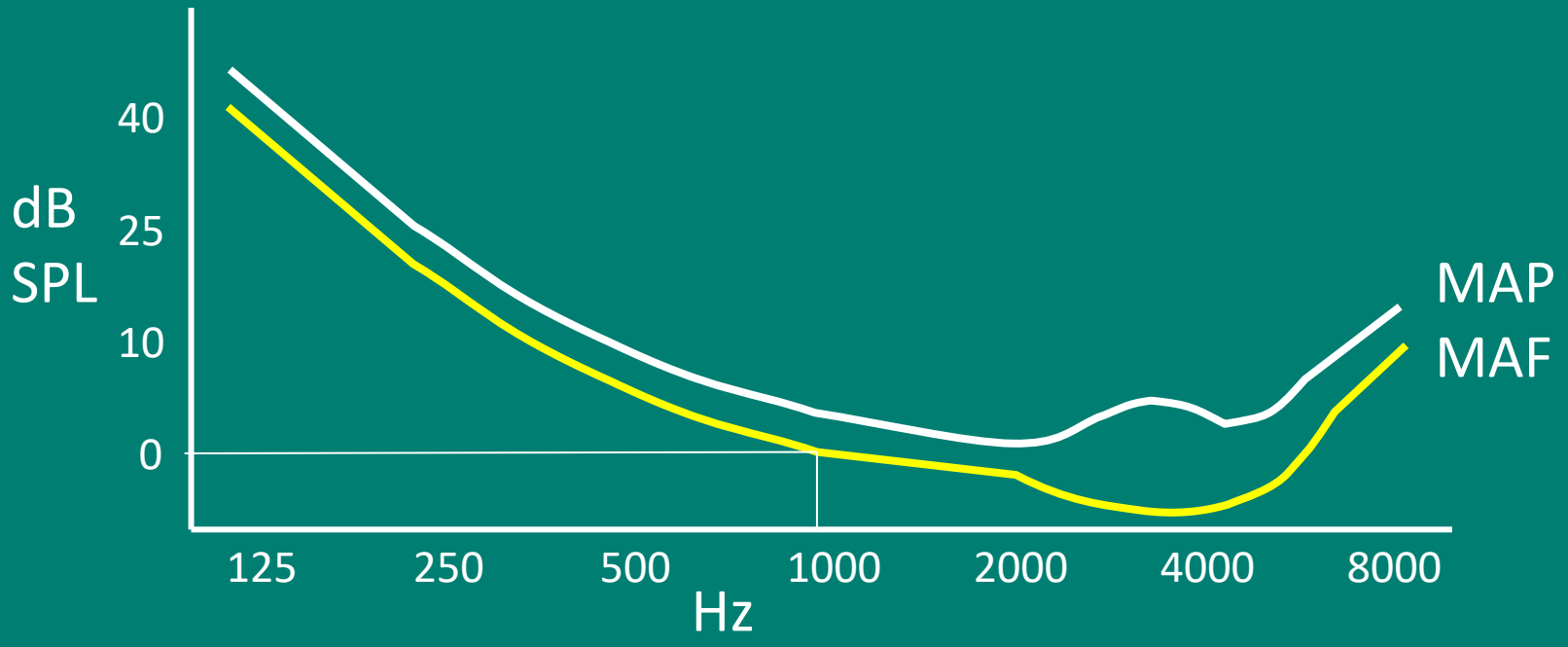
Minimal Audible Field (MAF)

Softest level required to just barely hear ***all the Hz's*** at 1 meter distance from a speaker, with 2 ears



Minimal Audible Pressure (MAP)

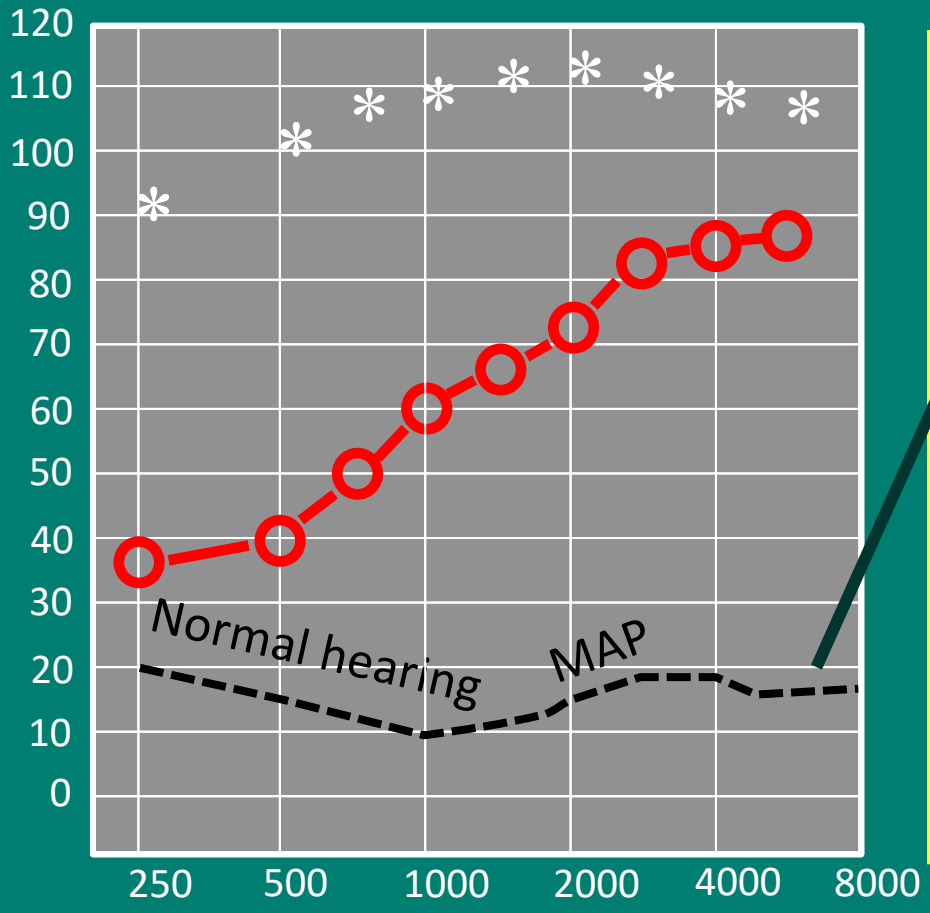
Softest level required to just barely hear ***all the Hz's with 1 ear under a headphone***

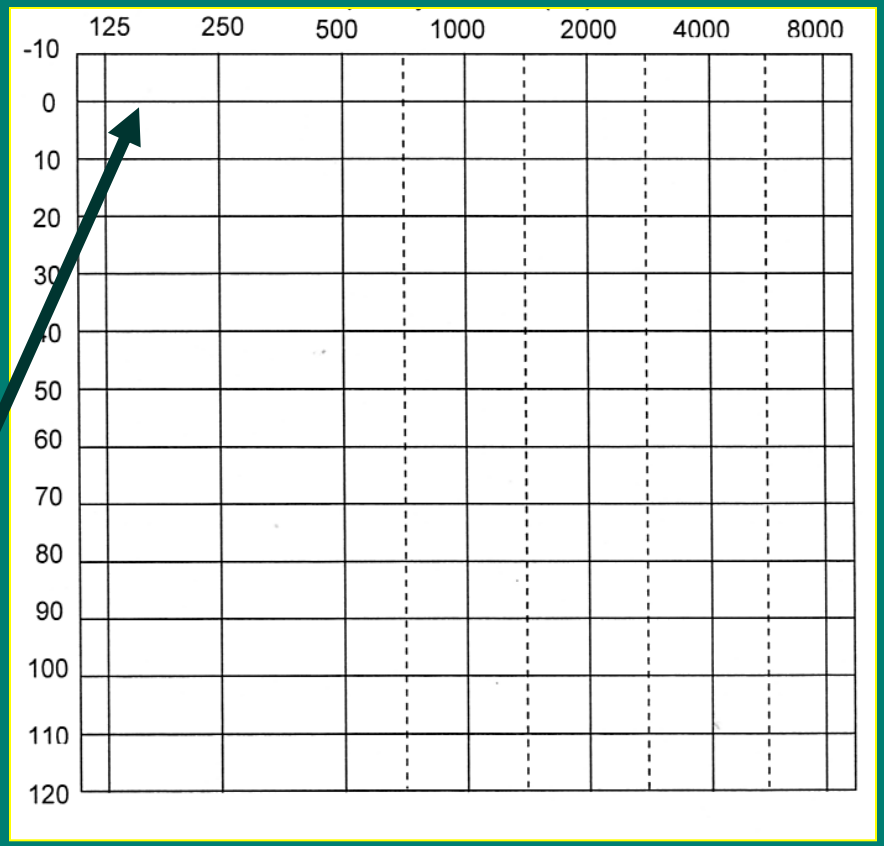


Note: 2 ears are about 5 dB better than 1 ear

Today's Real Ear & Speech Mapping

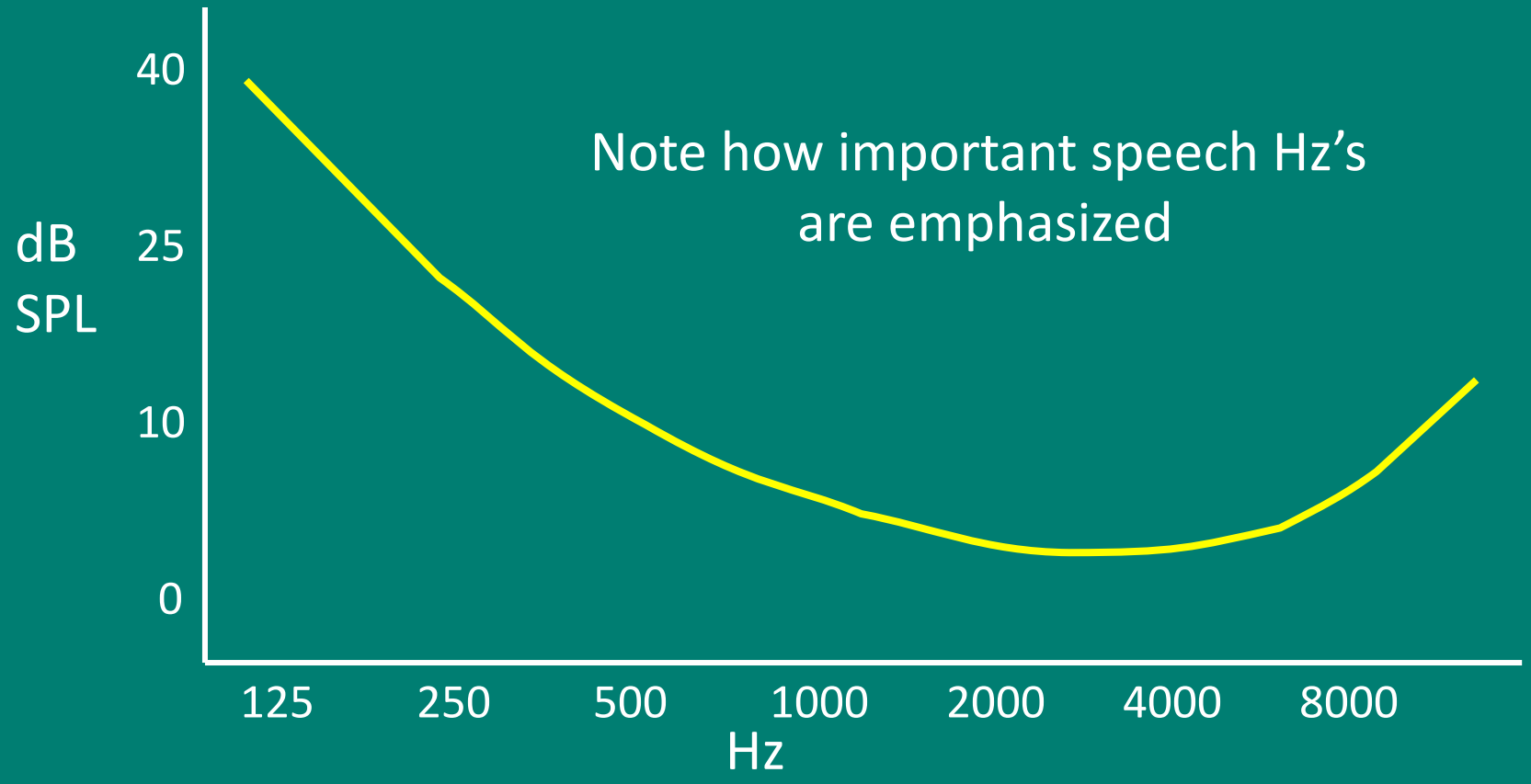
MAP ***IS*** 0 dB HL

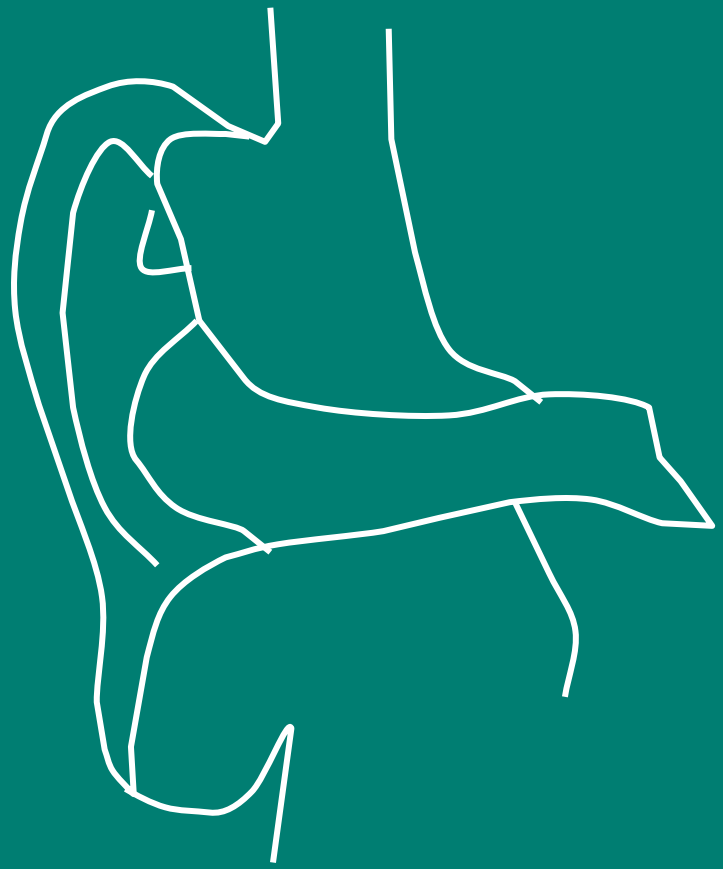


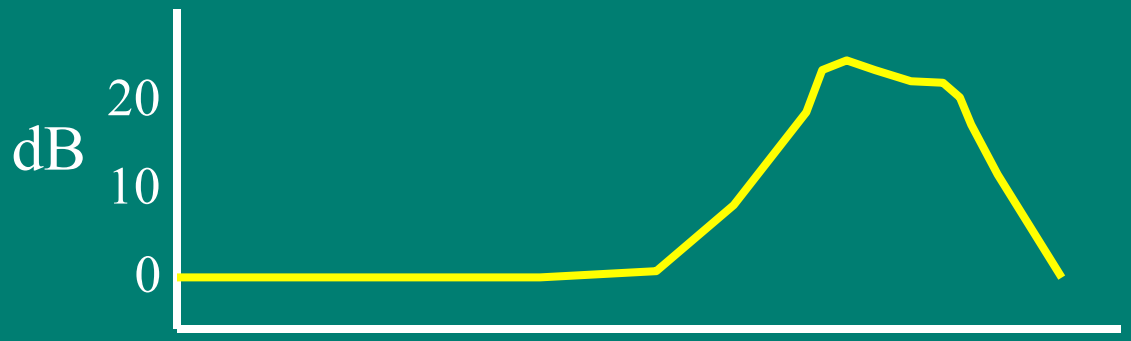


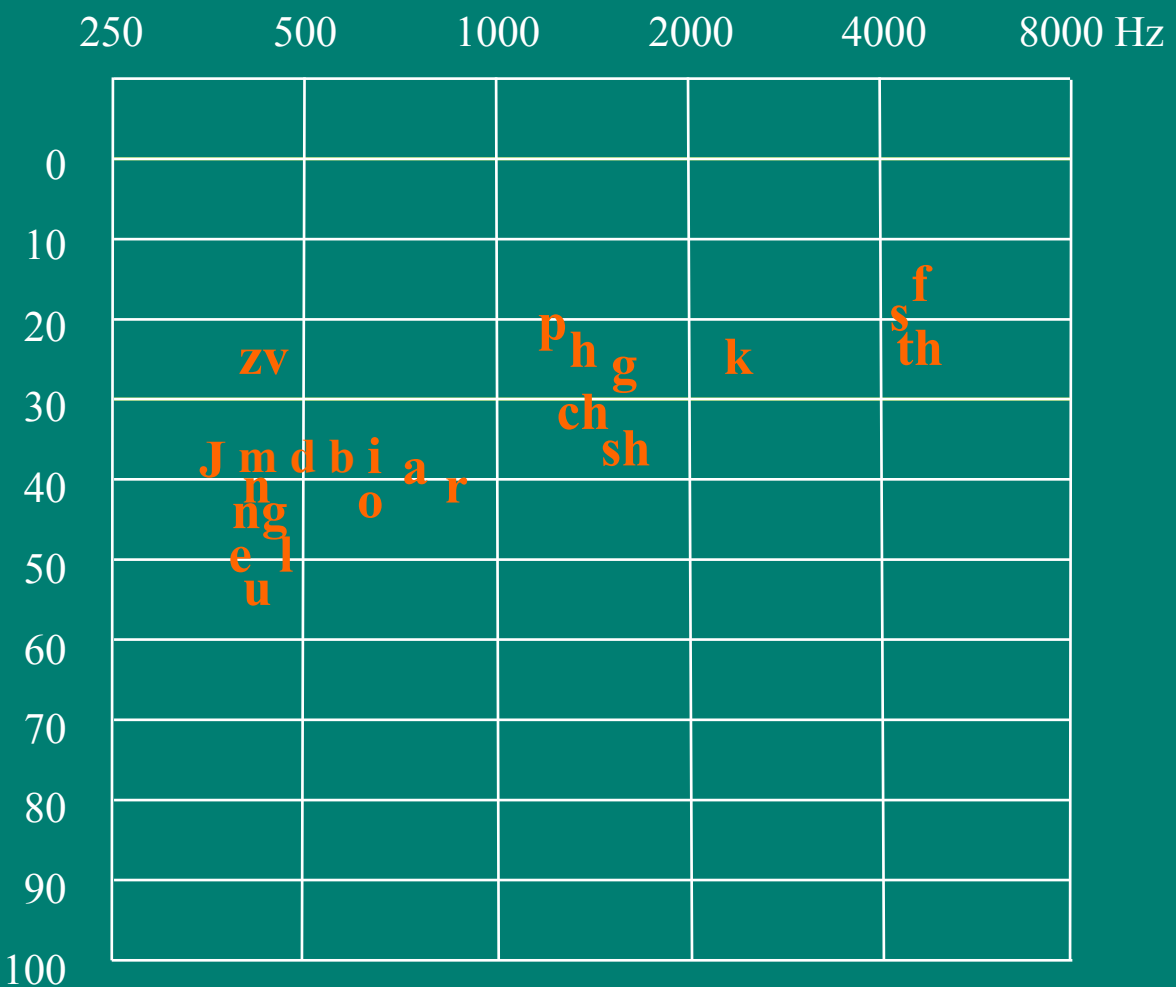
SO, WE HEAR SOME HZ'S BETTER THAN OTHERS

It's why equalizer buttons are shaped like a smile!






dB
20
10
0


250
500
1000
2000
4000
8000 Hz
0
10
20
30
40
50
60
70
80
90
100
zv
p
h
g
k
f
s
th
ch
sh
J
m
d
b
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u

The resonances of the Outer and Middle ears together create an equal loudness curve that shows our best hearing sensitivity is between 1000 to 4000 Hz

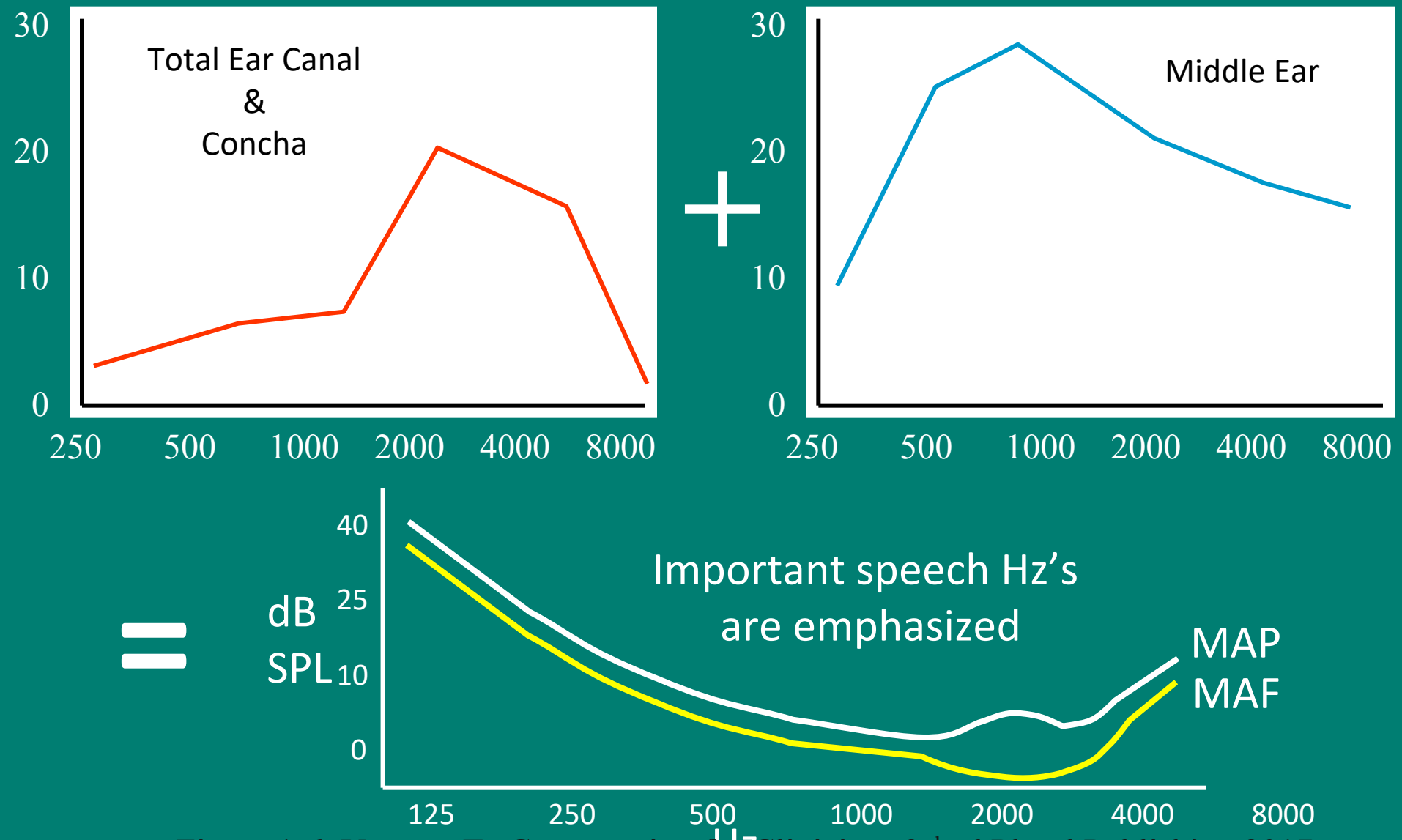


Figure 1-6, Venema T., Compression for Clinicians 3rd ed Plural Publishing 2017

What's the Difference b/w dB & dB SPL?

Any particular dB SPL is an "absolute" decibel value referenced to the "ground," namely, 0 dB SPL

To tell if an apartment is twice as tall as a house must know the ground

Cannot add absolute dB SPL values together like 1 + 2 = 3

Eg. two different machines each making 90 dB SPL total 93 dB SPL

What's the Difference b/w dB & dB SPL?

There are also "relative" decibel values
not referenced to the "ground" of 0 dB SPL

Eg. Hearing aid Input and Output are *absolute* values
always stipulated in terms of dB SPL

Gain however, is a *relative* dB value
25 dB SPL Input + 50 dB Gain = 75 dB SPL Output
50 dB SPL Input + 50 dB Gain = 100 dB SPL Output

When adding Absolute + Relative decibel values together
one can add them like 1 + 2 = 3
90 dB SPL + 90 dB SPL = 93 dB SPL (that's a gain of 3 dB)

What's the Difference b/w dB & dB SPL?

Think of time; eg. 4 PM or 6 PM
- these are Absolute time values
- they are referenced to your time zone
- and ultimately to Greenwich standard time

Cannot add together 4 PM & 6 PM either…
- makes no sense

Think of "2 hours"
- this is a Relative time value
- can add 2 hours to 4 PM to get 6 PM
- can add 2 hours to 6 PM to get 8 PM

Pure Tone Thresholds

If you descend

Descend

Descend

Until tone

No longer

Audible

You will get

better

thresholds

than if

you…

Audible

Tone is

Until

ascend

Ascend

Ascend

Why? Because when descending, you know what to listen for!

Hughson Westlake Ascending/Descending Procedure

Combines both procedures

Descend in 10 dB steps until client no longer hears tone

Ascend in 5 dB steps until client hears tone

Tone heard at two ascending steps at same level is threshold

Hughson Westlake Approach
Helps to get around Bias, but not perfect
Clinician's skill important here

"Noise" that interferes with accurate detection of "Signal"

eg. Language barrier
instructions
background noise

Then again, there's client's Bias:

difference b/w what you *can* hear
vs what you *say* you hear

Herb vs Mrs McGillicudy

Tone at 50 dB HL
Subject has normal hearing

	Tone Present	Tone Absent
Yes	True Positive	
No		True Negative

Tone at 5 dB HL
Subject has normal hearing

	Tone Present	Tone Absent
Yes	True Positive	False Positive
No	False Negative	True Negative

Bias One Way or the Other Way…

You still want the issue of threshold
to be as black & white as possible

A good clinician is a psychologist of hearing behaviour:
detect the bias and minimize it as much as possible

Draw the left & right to the centre as much as possible

Psychometric or Performance Index Functions

Show “decibel distance between getting all or diddley all

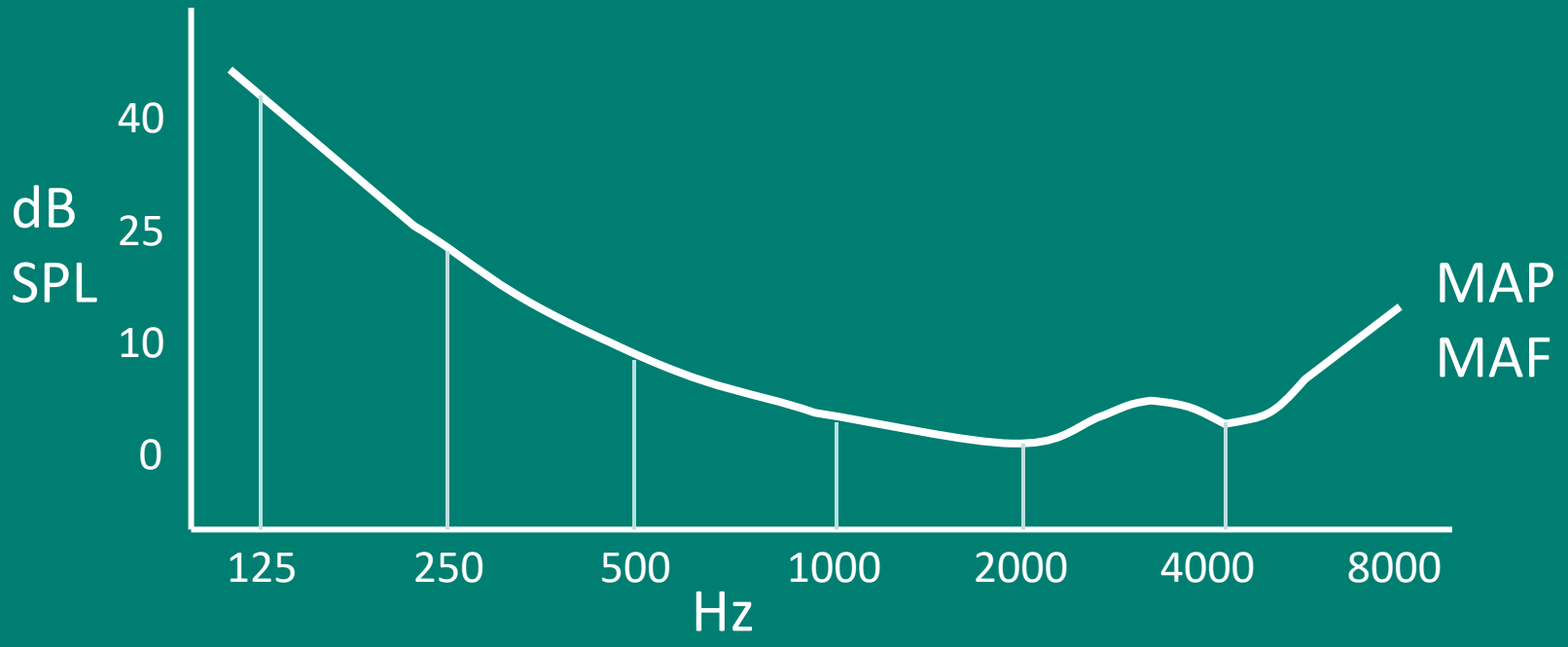
Steep slope shows task is easy
very little gray area; you either get it or do not

Below a certain dB level, nada
above that level, no problem!

Whatever renders steep sloped PI function:
is a good stimulus for testing threshold; ie, black or white

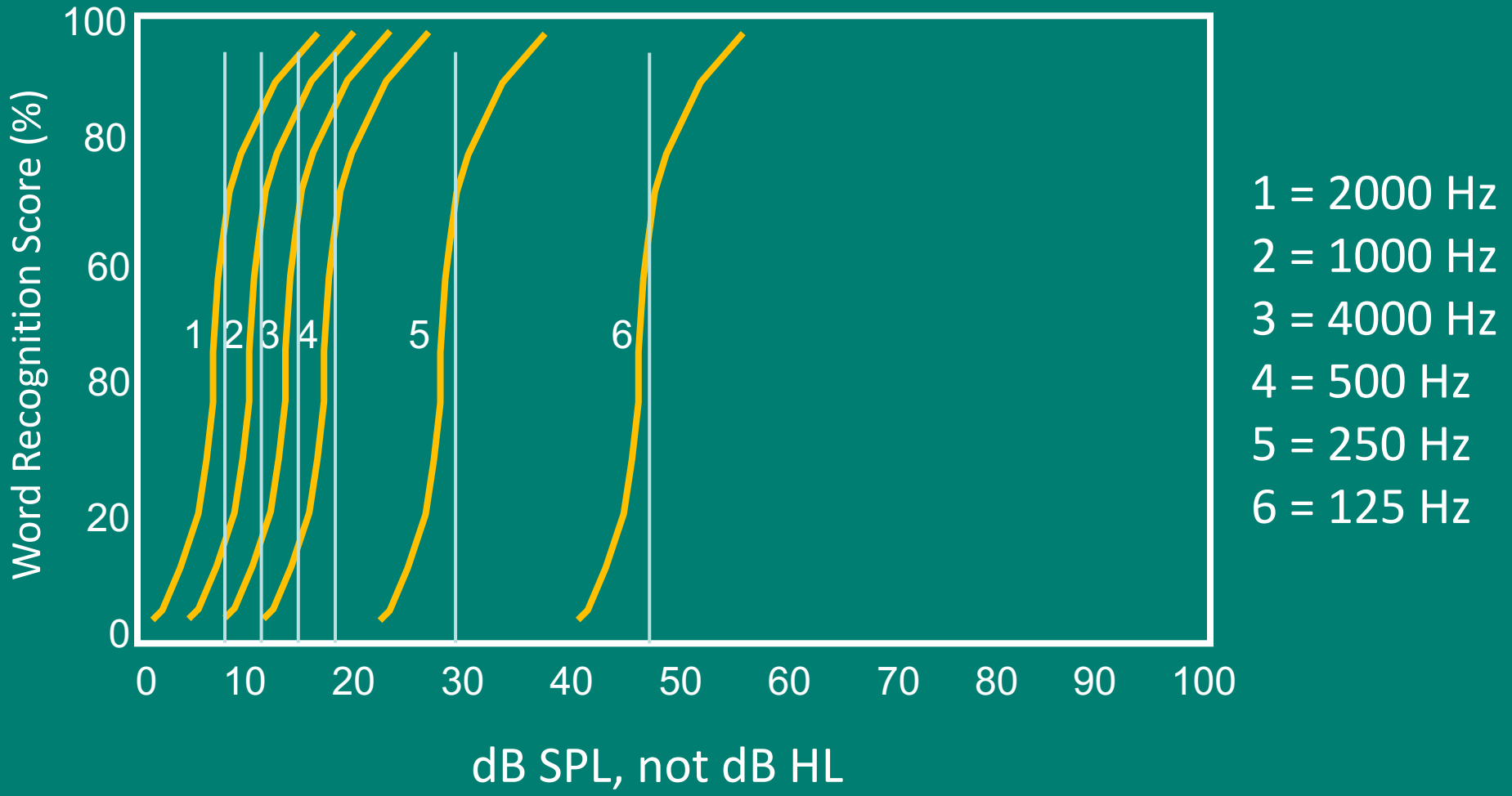
Remember Minimal Audible Pressure (MAP)

Softest level required to just barely hear ***all the Hz's with 1 ear under a headphone***

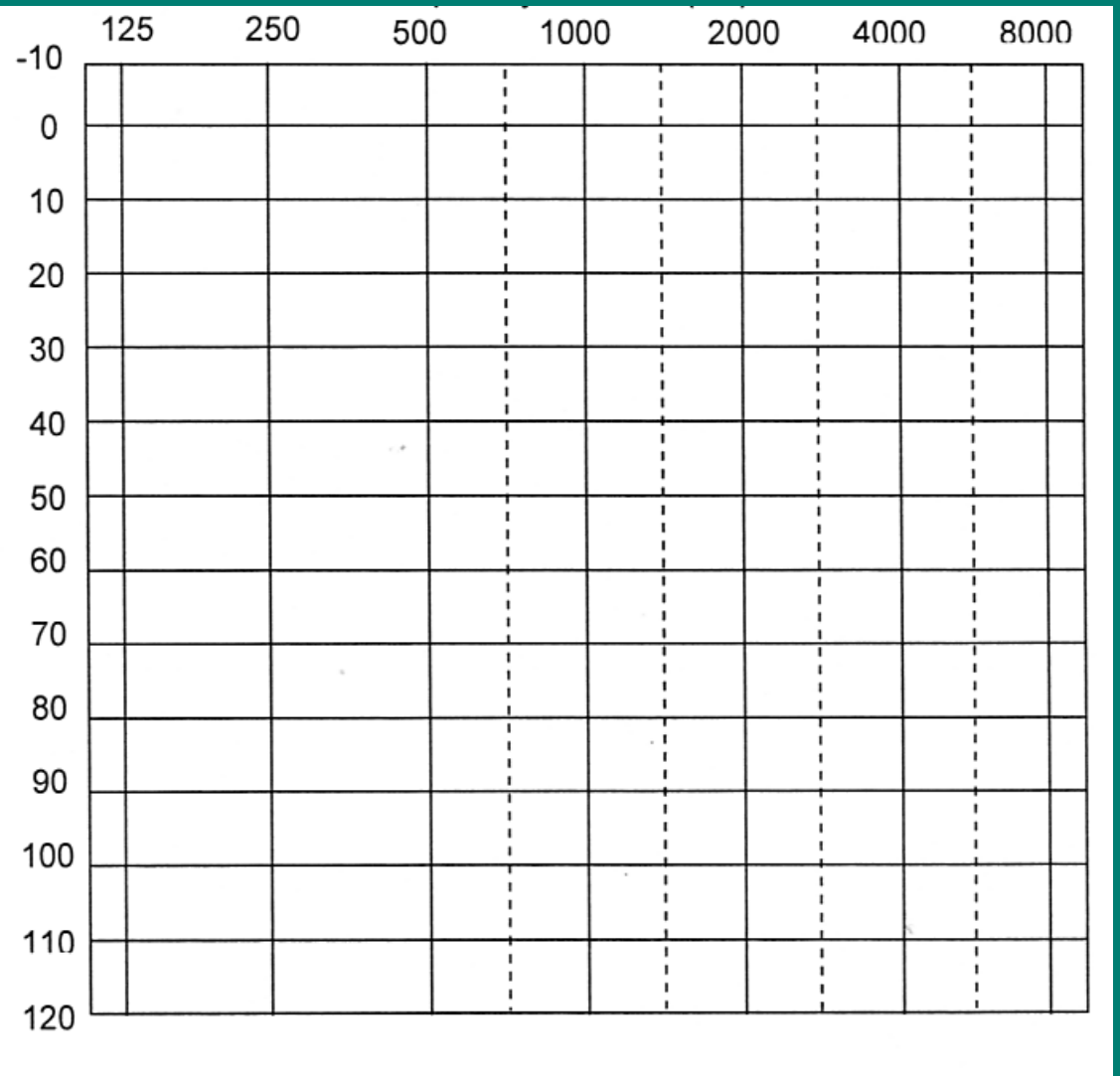


Note: 2 ears are about 5 dB better than 1 ear

Psychometric functions for Pure Tones with 1 ear under a headphone
Note they are Steep!



Speech Audiometry Complements Pure Tone Audiometry



Speech Audiometry

	RE	LE	Bin
SRT			
MCL			
SD1			
SD2			
UCL			

Tympanometry

	RE	LE
Type		

Acoustic Reflexes

	500	1000
Ipsi		
RE		
LE		
Contra		
RE		
LE		

Most Comfortable Loudness (MCL)

Very subjective speech test

depends heavily upon specific instructions

results can vary wildly

Instructions:

"Pretend I am your radio…

if you had to listen to me all day (God forbid)…

turn me to a volume you think would be 'just right'"

Can bracket like pure tone testing too

deliberately above and below client's preferred level

to ensure a more exact MCL

MCL

Good idea to do this speech test 1st
- sets up the level at which to do subsequent tests

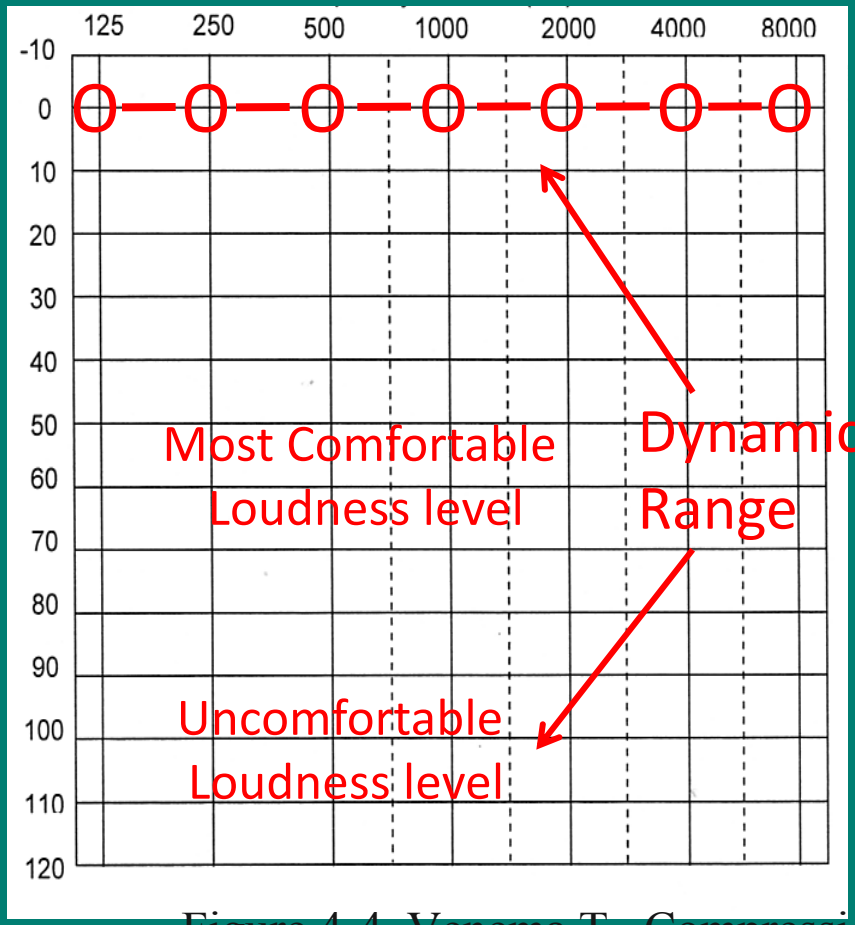
Normal MCL for average conversational speech
- 55-60 dB HL
- 65-70 dB SPL

Is MCL always in the middle of one's dynamic range?
- would seem so, but not in hearing aid fittings
- targets for average speech about 1/3 above thresholds

The Audiogram:
Hearing Loss Reduces Dynamic Range

The “decibel distance” b/w the softest one can hear & the loudest one can tolerate

Normal



Moderate HL

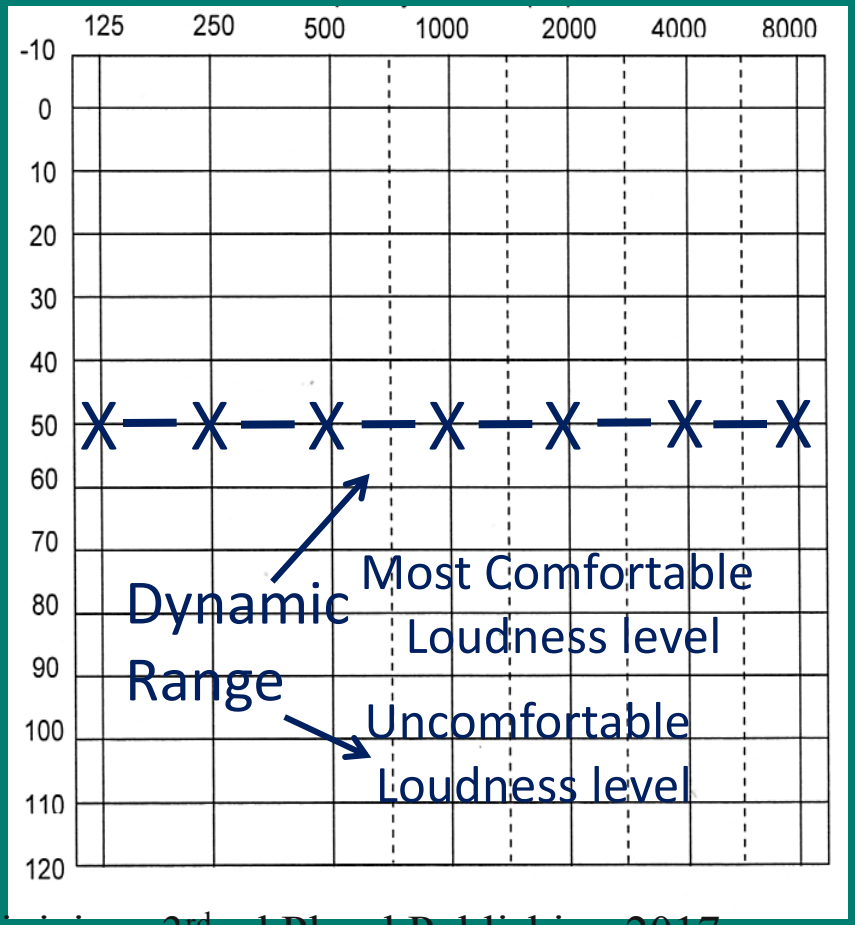
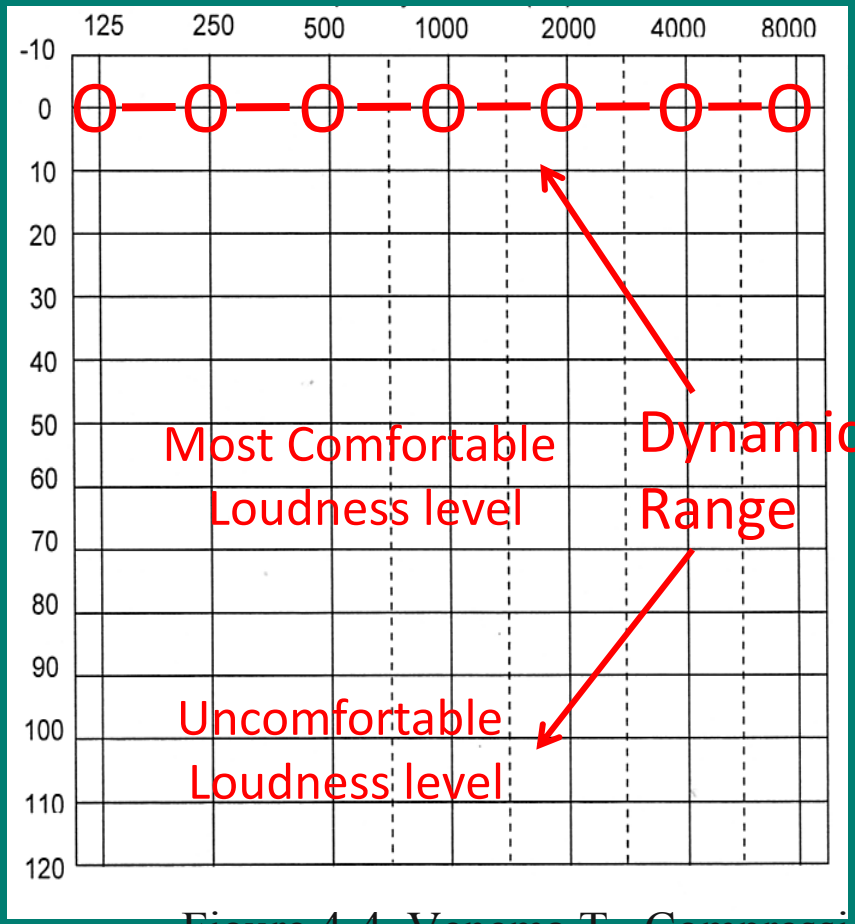


Figure 4-4, Venema T., Compression for Clinicians 3rd ed Plural Publishing 2017

Interesting to know that in REM, targets for average speech are not placed ½ way inside one's dynamic range

Normal



Moderate HL

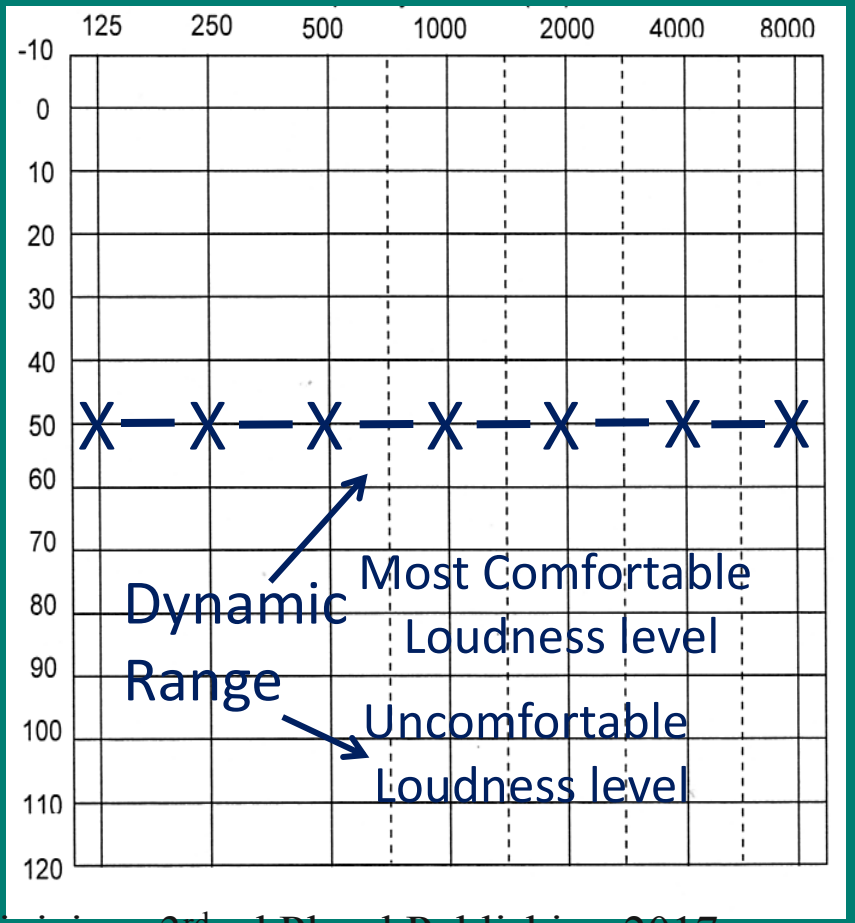
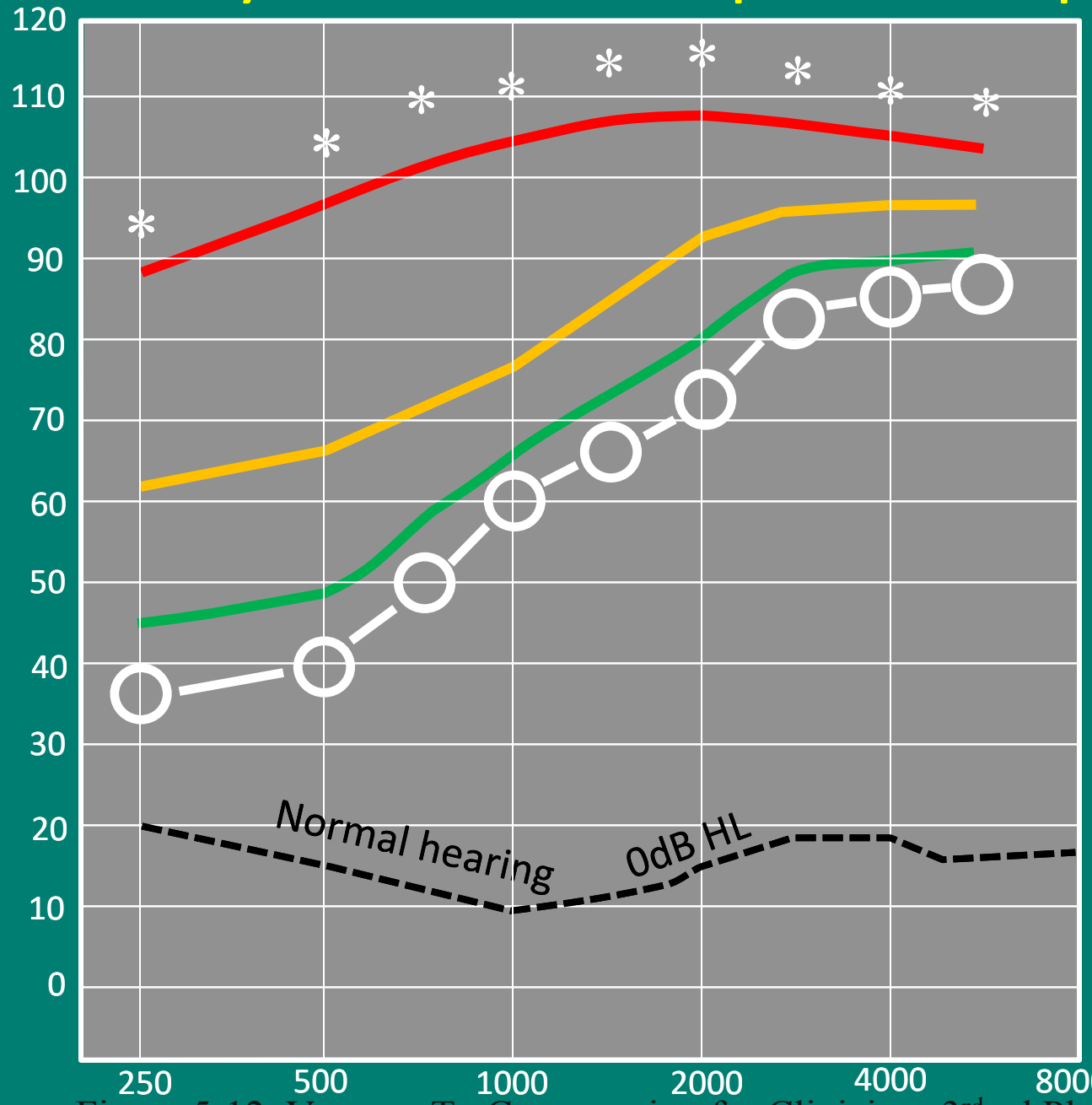


Figure 4-4, Venema T., Compression for Clinicians 3rd ed Plural Publishing 2017

Today's Real Ear & Speech Mapping



Target outputs for these inputs:

Soft

Average

Loud

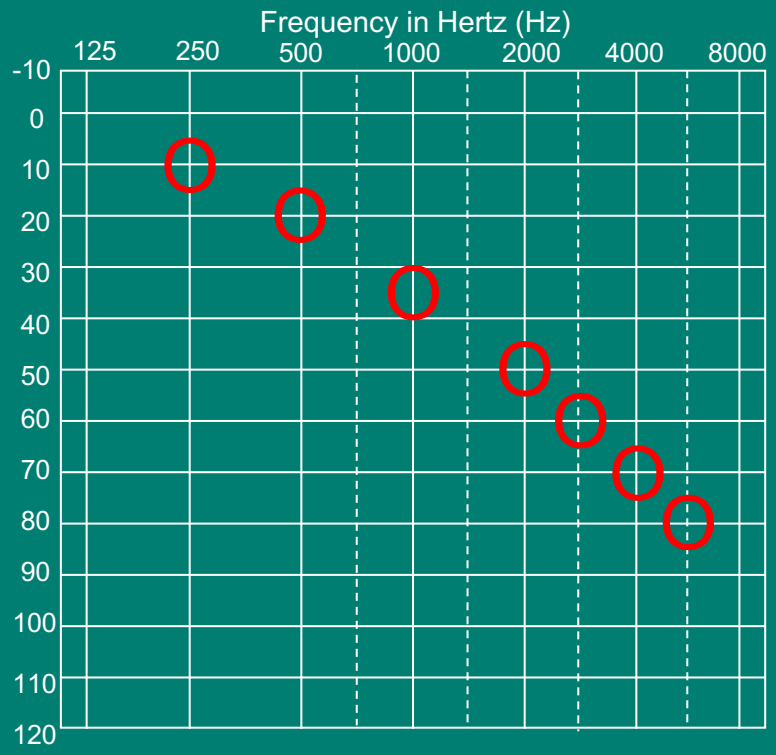
Map Soft, Average, Loud Speech Into Remaining Dynamic Range

Figure 5-12, Venema T., Compression for Clinicians 3rd ed Plural Publishing 2017

Sloping Hearing Loss

NAL-NL1 ——

DSL 4 - - - - -



Targets for DSL 4 vs NAL-NL1

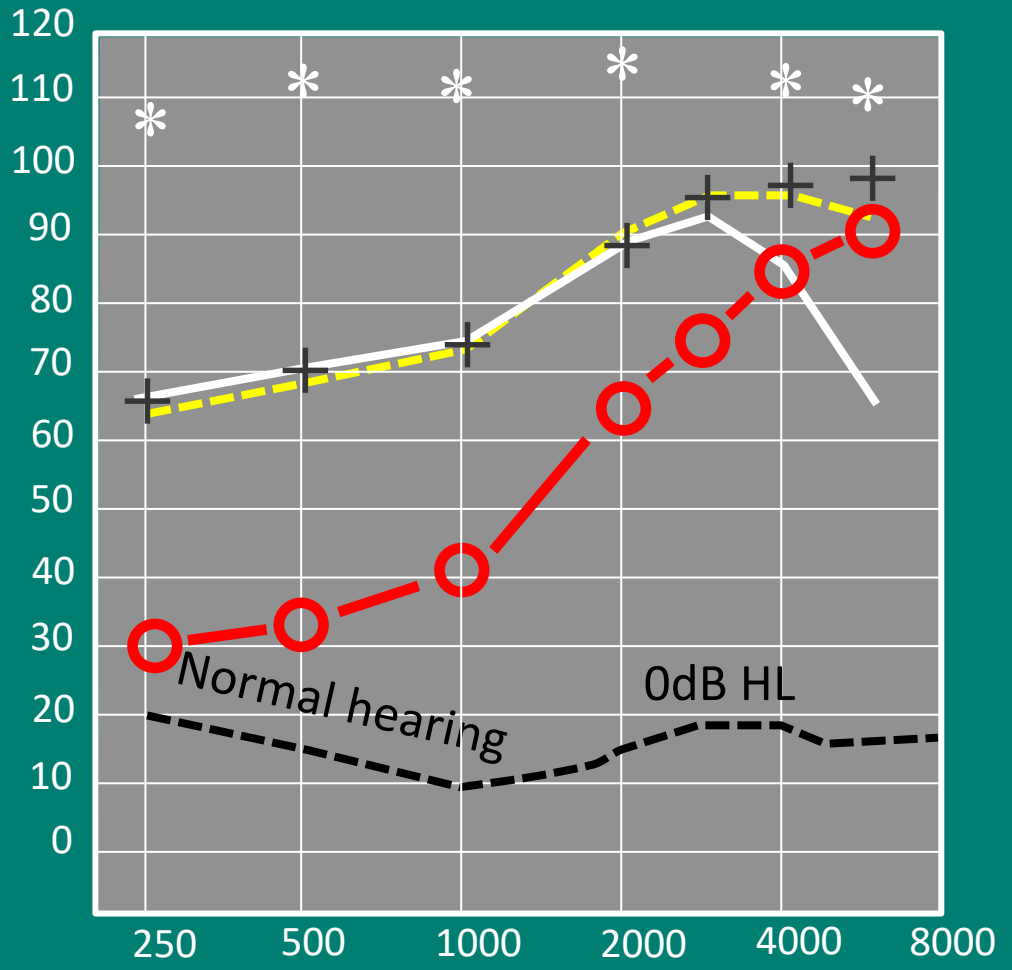


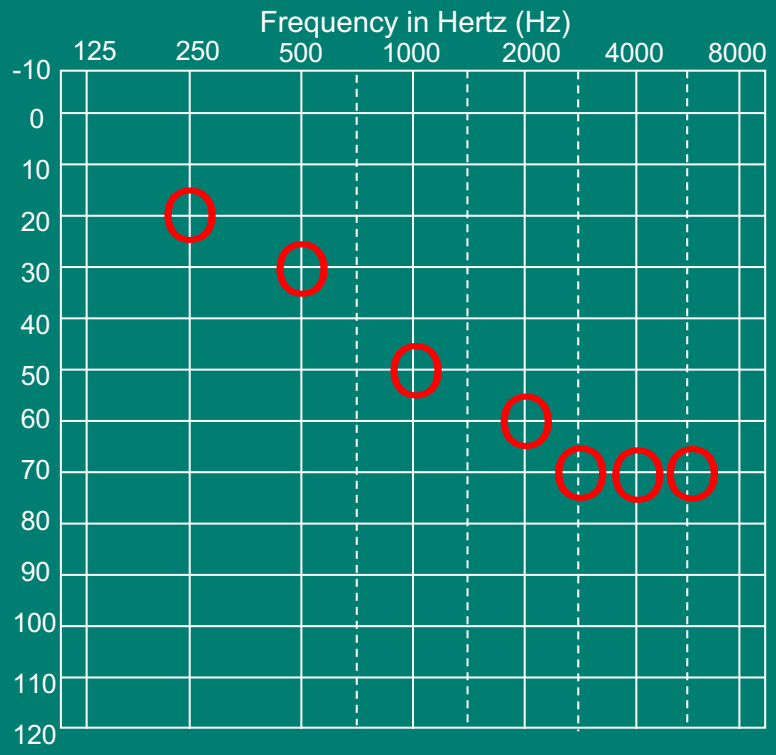
Figure 6-8, Venema T., Compression for Clinicians 3rd ed Plural Publishing 2017

Sloping Hearing Loss

DSL 5 Adult ——

NAL-NL2 ——

Input 65 dB SPL



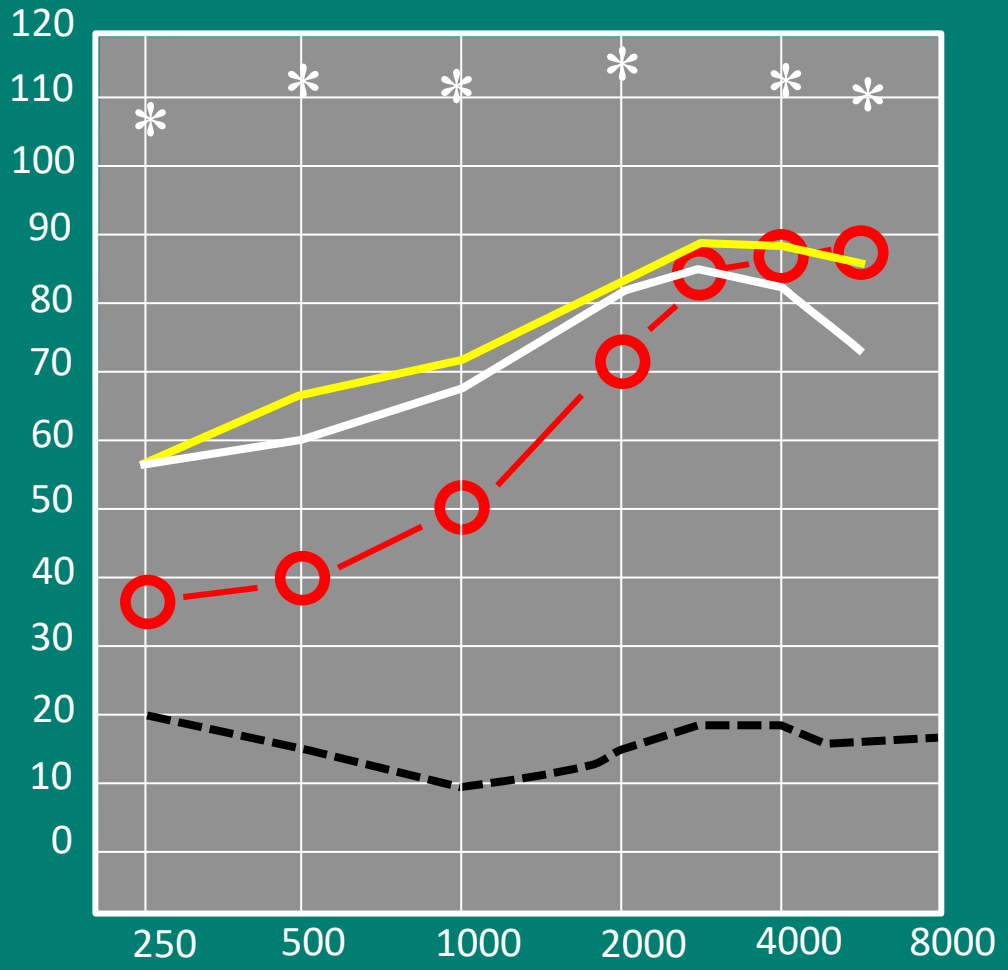


Figure 6-12, Venema T., Compression for Clinicians 3rd ed Plural Publishing 2017

MCL

Interesting thing about MCL:

usually artificially low for someone with SNHL who has not worn hearing aids

Eg. Mild-to-moderate sloping SNHL

will show MCL close to normal (55-65 dB HL)!

After some time (say a year) of wearing hearing aids:

notice MCL has increased by about 10 dB

client is no longer straining to hear

Speech Reception (or recognition) Threshold (SRT)

Threshold for person to *recognize* previously heard speech:

- the only speech test where *threshold* is the question
- all other speech tests are supra-threshold tests

SRT uses spondee words *because it has* to!

- two syllable words; even emphasis on each syllable
- each word is made up from two smaller words
- can be guessed easily
- if client gets one part, can easily guess other part

Why does SRT Use Spondees?

Because as with pure tone testing:

your question is the same…

ie, threshold

did you hear it or did you not?

Spondees are the *only speech stimulus*

that gives black & white results

at varying dB levels

Mono-syllabic words do NOT!

Spondee words (W1) for SRT testing

Ira Hirsh, 1952
at CID
36 words

Note: They are not phonetically balanced

airplane
armchair
baseball
birthday
cowboy
daybreak
doormat
drawbridge
duckpond
eardrum
farewell
grandson
greyhound
hardware
headlight
horseshoe
hotdog
hothouse
iceberg
inkwell
mousetrap
mushroom
northwest
oatmeal
padlock
pancake
playground
railroad
schoolboy
sidewalk
stairway
sunset
toothbrush
whitewash
woodwork
workshop

SRT Procedure

Normally tell client you will say or present words and have client repeat
- tell client the words will get softer & softer
- keep trying to repeat what you hear
- if you aren't sure, just guess

Read or present Spondee list at client's MCL
- decrease by 10 dB; read two words
- if client gets these, go down 10 dB, read two more words, etc
- as long as client keeps getting both words, keep descending
- just like pure tone audiometry

SRT Procedure

When client misses both words, go up 5 dB,

read two more words

if client gets these…

can descend by 10 again, like pure tone audiometry

SRT = ascending level where client gets both words

Psychometric or Performance Index Functions

Describe, compare & contrast speech tests

show “decibel distance between getting all or diddley all

Steep slope:

task is easy; very little gray area; you either get it or do not

below a certain dB level, nada

above that level, no problem!

Whatever renders steep sloped PI function:

is a good stimulus for testing threshold; ie, black or white

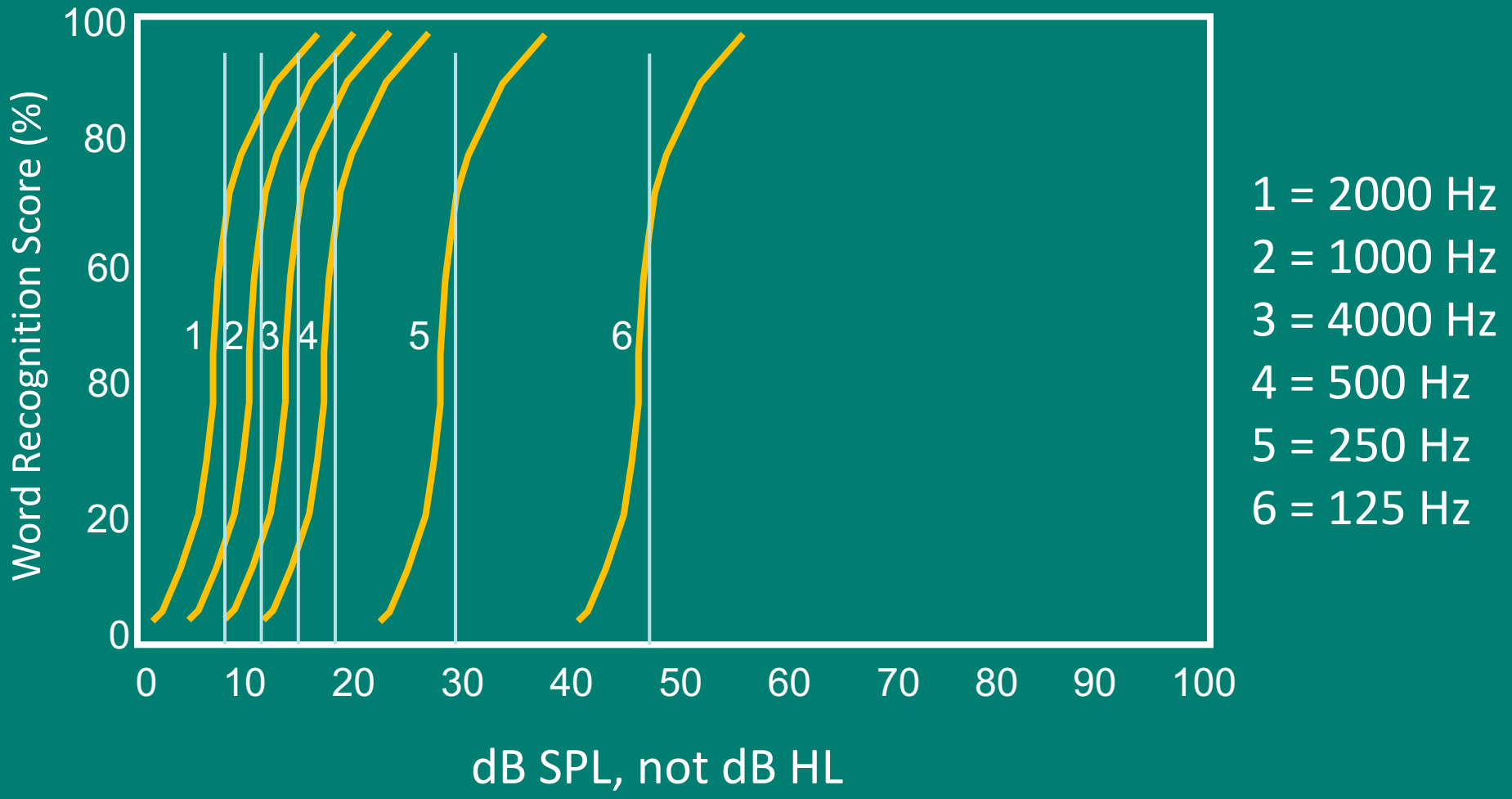
eg. Spondees!

Shallow sloping PI function:

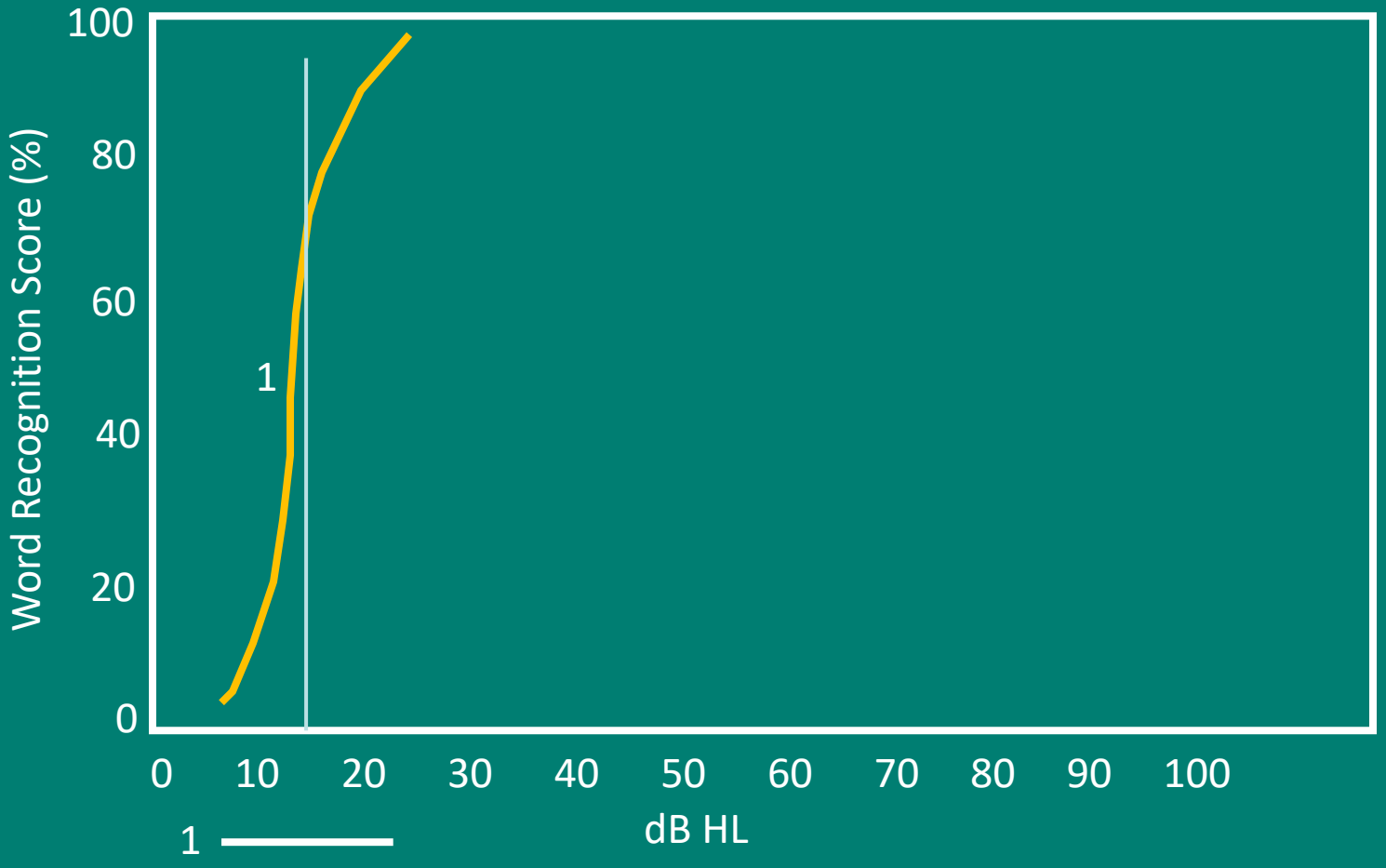
shows a more difficult task; eg. mon-syllabic words!

increased decibels grudgingly give way to better performance

Psychometric functions for Pure Tones Are Steep!

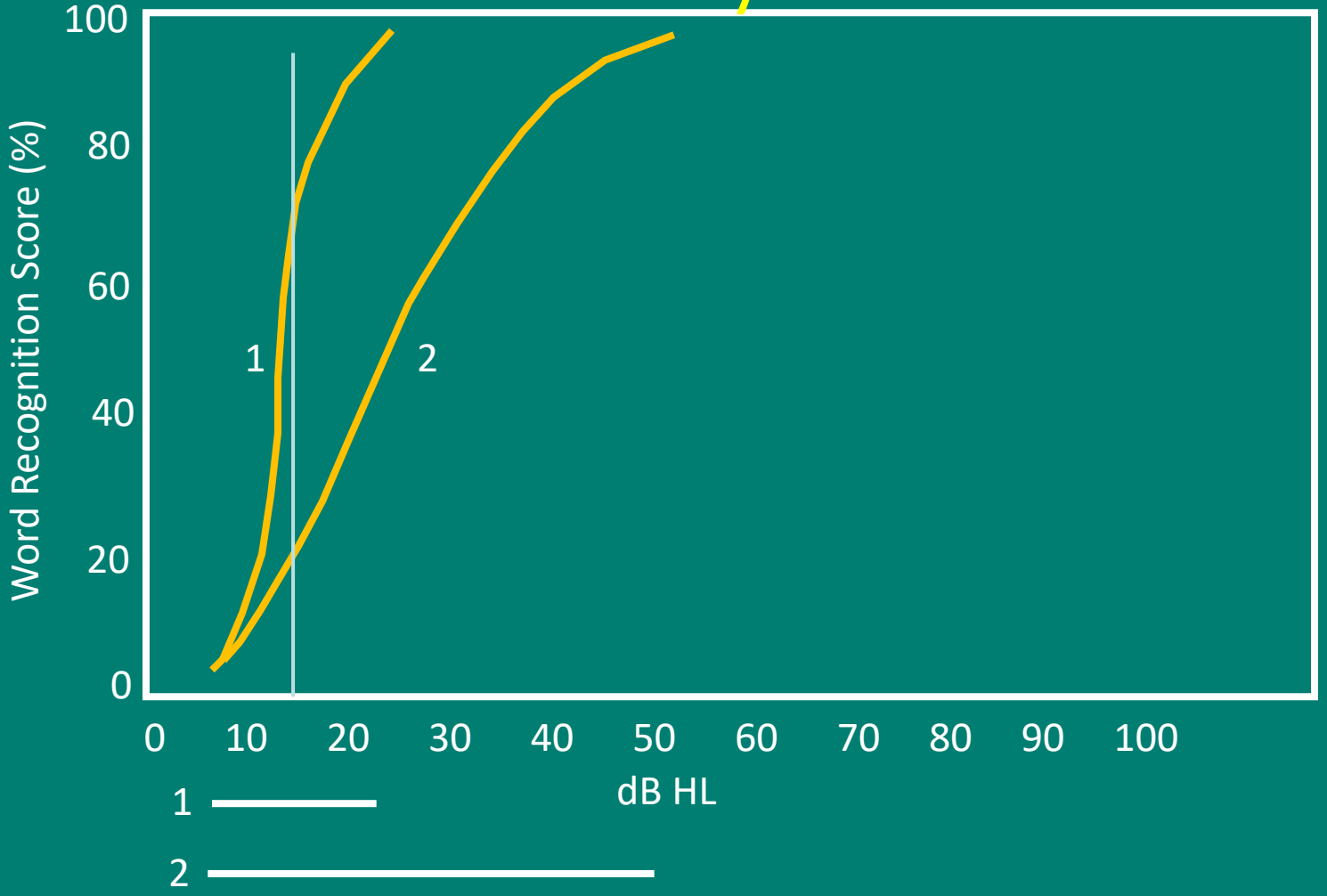


Same Steep functions for Spondee Words



1 = spondee words; at 5dB above 10 dB HL threshold, all words correct

Psychometric functions for Spondees vs Mono-syllabic words



1 = spondee words; at 5dB above 10 dB HL threshold, all words correct

2 = mono-syllabic words; harder, need about 50 dB HL to get all correct

Speech Awareness Threshold (SAT)
or
Speech Detection Threshold (SDT)

Done when SRT cannot be done

eg. language barrier, left corner audiogram

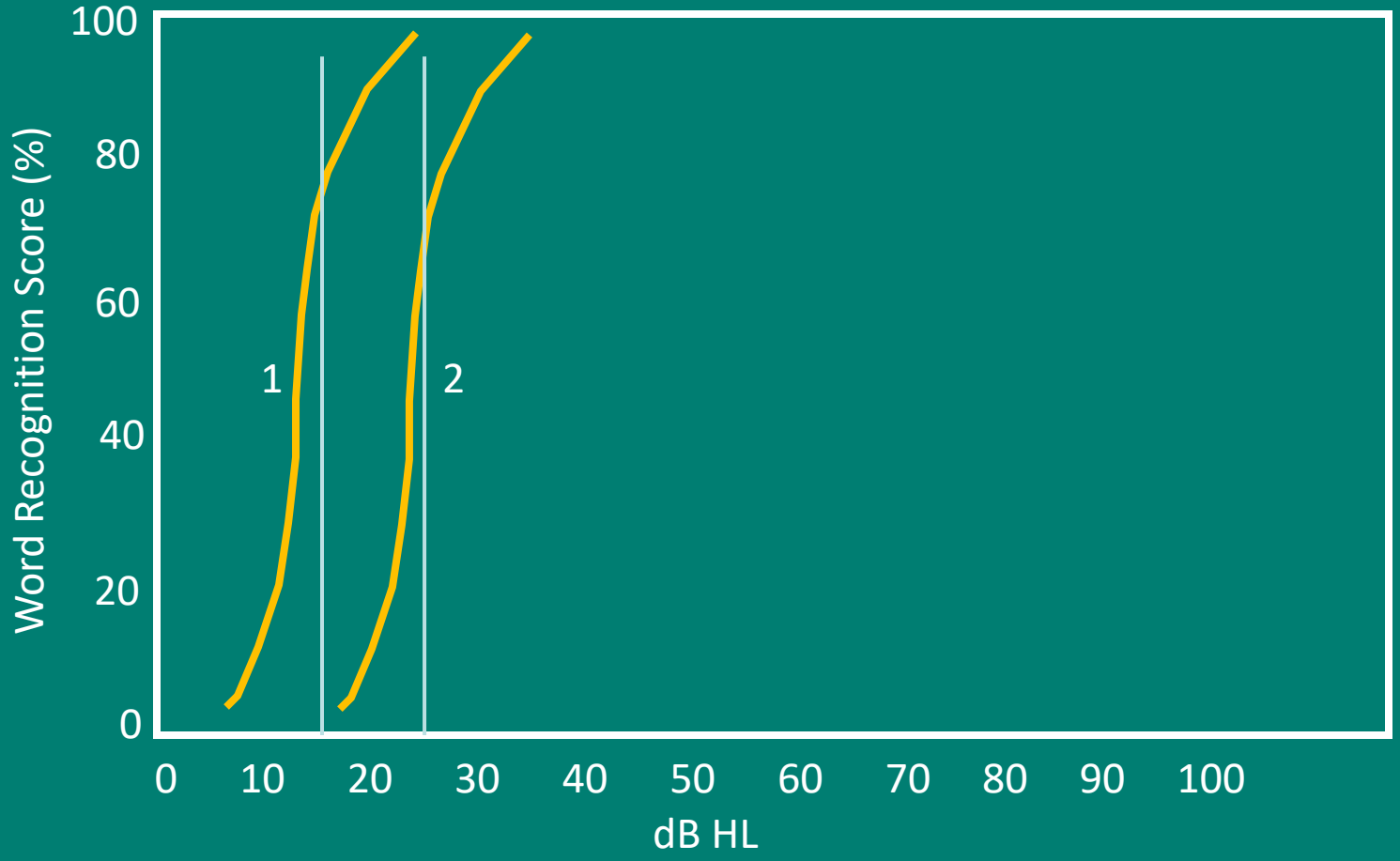
Should be 10 dB better than PTA

why?

identifying the presence or absence of speech is…

easier than recognizing *what* the words is

Psychometric functions for SRT vs SDT or SAT



1 = SDT or SAT

2 = SRT

SRT & PTA

SRT should be within + or – 5 dB of PTA

often = best two thresholds of 500, 1000, and 2000 Hz

this especially with precipitous SNHL

Malingerers:

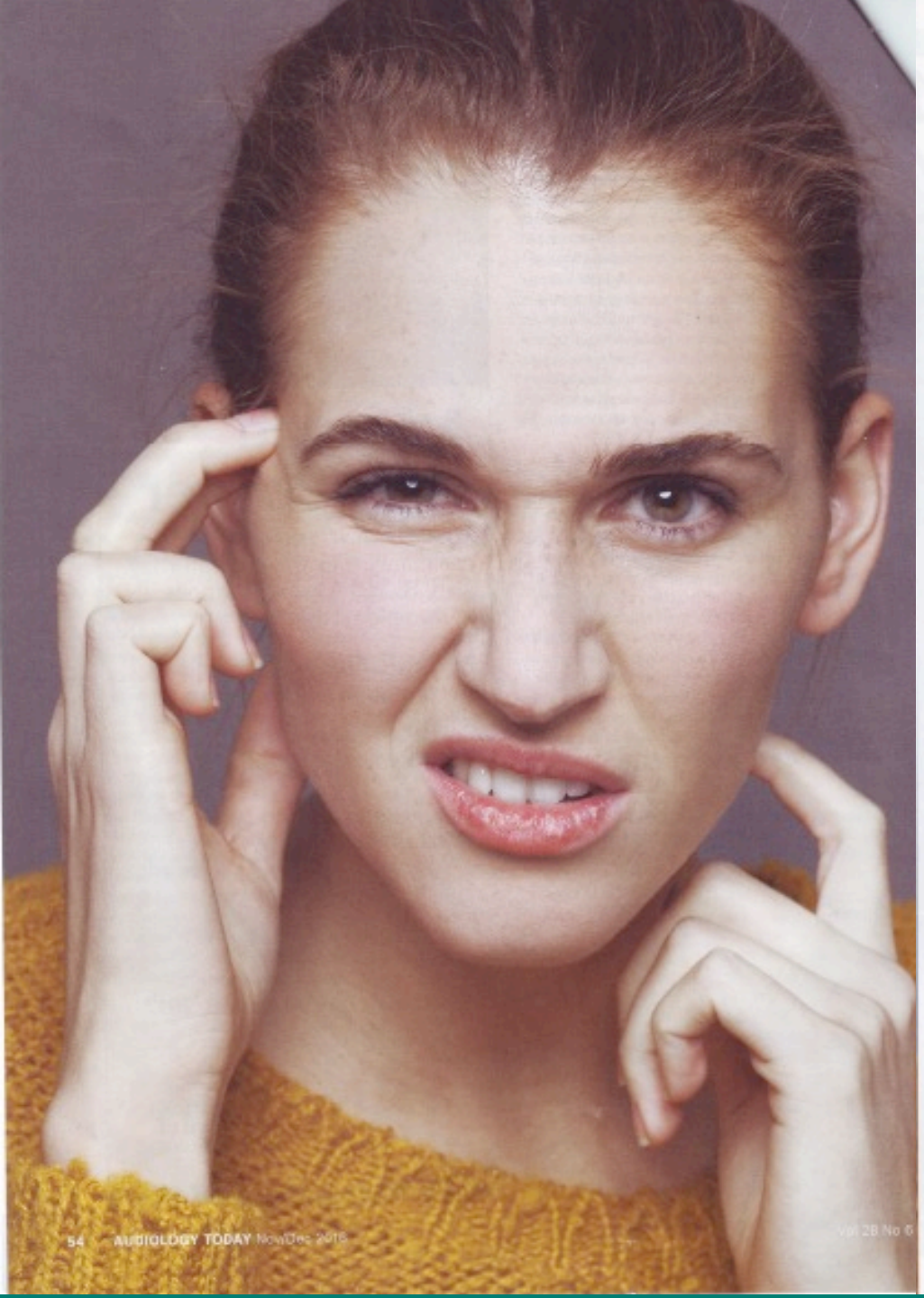
SRT is better than PTA; why?

b/c speech is broadband signal; pure tones are narrow band

perceived loudness of speech thus greater at softer levels

PTA = SRT is 1st sign of a good test

1st thing looked at when auditing an audiogram



THE IMPENDING SPONDEE CRISIS

AUDIOLOGY IN THE AGE OF THE MILLENNIAL

BY FRANK BIALOSTOZKY

Say the word: hot dog. Yes ... SAY THE WORD: HOT DOG. In an age of blue-tooth connectivity, nanotechnology, deep-brain stimulation, and robotic surgery, audiologists are asking their patients to say a word describing a food developed over a hundred years ago that is potentially composed of meat by-products. Regardless of how many vegans are in the waiting area, requesting the repetition of hot dog (or airplane or ice cream, for that matter) may not be an appropriate way for audiologists to introduce themselves to a new generation of patients. What message does "hot dog" send about professional knowledge and skills in what should be viewed as a highly technical field? Audiology is facing a spondee crisis. It can be averted if action is taken quickly, but responsibly.

TWENTY-FIRST CENTURY SPONDEE LIST

SMARTPHONE	GEARHEAD
HASHTAG	ROADRAGE
UPLOAD	WINDFARM
BIKESHARE	BITCOIN
CASHCOW	YOUTUBE
DOGPARK	SPEEDCAM
CROWDSOURCE	PODCAST
RINGTONE	KICKSTART
LAPTOP	FACEBOOK
ZIPCAR	MASHUP
EYEPAD (IPAD)	BLOGPOST
FLASHMOB	BRAINFREEZE
BACKPACK	CALLDESK
MAXOUT	HOTSPOT
DEADBEAT	FATFREE
BANDWIDTH	HIPHOP
WINGNUT	SNAPCHAT
STARBUCKS	BUZZKILL

POTENTIAL ALTERNATE WORDS

DROPSHIP	DIRTBIKE
JET LAG	WORKOUT
OUTSOURCE	HOUSEMATE
STAR WARS	MINECRAFT
SLAMDUNK	MANCAVE
SUNBLOCK	EARBUD
PHASEOUT	WILDCARD
POP TART	SHAKESHACK

BUT HERE'S THE BEST PART…

The millennials may also need to be viewed as a special population for whom accommodations must be made…

The audiologist may be concerned when silence follows a request to say a word: hashtag, (or any other word). What could be the motivation for not responding when the millennial should be able to hear the presentation?

Although most boomers are perfectly willing to talk into microphones, millennials can occasionally appear non-verbal. They often prefer to communicate though texting…Ask the millennial to text the word. problem solved.

BUT HERE'S THE BEST PART…

The millennials may also need to be viewed as a special population for whom accommodations must be made…

The audiologist may be concerned when silence follows a request to say a word: hashtag, (or any other word). What could be the motivation for not responding when the millennial should be able to hear the presentation?

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Now I've heard of indulging, but this is ridiculous

My Mom has this up in her kitchen

Speech Discrimination

- Often the 3rd speech test done
- Unlike SRT, question is no longer threshold…
- Now the question is: How clear do you hear, my dear?
- Stimulus is mono-syllabic words
- These are " phonetically balanced"

CID Auditory Test W-22

List 1A	List 2A	List 3A	List 4A
1. an	1. yore (your)	1. bill	1. all (awl)
2. yard	2. bin (been)	2. add (ad)	2. wood (would)
3. carve	3. way (weigh)	3. west	3. at
4. us	4. chest	4. cute	4. where
5. day	5. then	5. start	5. chin
6. toe	6. ease	6. ears	6. they
7. felt	7. smart	7. tan	7. dolls
8. stove	8. gave	8. nest	8. so (sew)
9. hunt	9. pew	9. say	9. nuts
10. ran	10. ice	10. is	10. ought
11. knees	11. odd	11. out	11. in (inn)
12. not (knot)	12. knee	12. lie (lye)	12. net
13. mew	13. move	13. three	13. my
14. low	14. new	14. oil	14. leave
15. owl	15. jaw	15. king	15. of
16. it	16. one (won)	16. pie	16. hang
17. she	17. hit	17. he	17. save
18. high	18. send	18. smooth	18. ear
19. there (their)	19. else	19. farm	19. tea (tee)
20. earn (urn)	20. tare (tear)	20. this	20. cook
21. twins	21. does	21. done (dun)	21. tin
22. could	22. too (two, to)	22. use (yews)	22. bread (bred)
23. what	23. cap	23. camp	23. why
24. bathe	24. with	24. wool	24. arm
25. ace	25. air (heir)	25. are	25. yet
26. you (ewe)	26. and	26. aim	26. darn
27. as	27. young	27. when	27. art
28. wet	28. cars	28. book	28. will
29. chew	29. tree	29. tie	29. dust
30. see (sea)	30. dumb	30. do	30. toy
31. deaf	31. that	31. hand	31. aid
32. them	32. die (dye)	32. end	32. than
33. give	33. show	33. shove	33. eyes (ayes)
34. true	34. hurt	34. have	34. shoe
35. isle (aisle)	35. own	35. owes	35. his
36. or (oar)	36. key	36. jar	36. our (hour)
37. law	37. oak	37. no (know)	37. men
38. me	38. new (knew)	38. may	38. near
39. none (nun)	39. live (verb)	39. knit	39. few
40. jam	40. off	40. on	40. jump
41. poor	41. ill	41. if	41. pale (pail)
42. him	42. rooms	42. raw	42. go
43. skin	43. ham	43. glove	43. stiff
44. east	44. star	44. ten	44. can
45. thing	45. eat	45. dull	45. through (thru)
46. dad	46. thin	46. though	46. clothes
47. up	47. flat	47. chair	47. who
48. bells	48. well	48. we	48. bee (be)
49. wire	49. by (buy	49. ate (eight)	49. yes
50. ache	50. ail (ale)	50. year	50. am

Phonetically Balanced Word Lists

Contain all the sounds spoken in English
in proportion in which they are found in English!

Easier said than done
lots of work done at Bell telephone labs
right after WWII

Word lists used to test integrity of trans Atlantic
telephone lines

Speech Discrimination

- NU 6 word lists
- Slightly harder than W22 word lists
- Always state which word list you used!

NU-Auditory Test No. 6 (Alphabetized)[3]

List I	*List II*	*List III*	*List IV*
1. bean	1. bite	1. bar	1. back
2. boat	2. book	2. base	2. bath
3. burn	3. bought	3. beg	3. bone
4. chalk	4. calm	4. cab	4. came
5. choice	5. chair	5. cause	5. chain
6. death	6. chief	6. chat	6. check
7. dime	7. dab	7. cheek	7. dip
8. door	8. dead	8. cool	8. dog
9. fall	9. deep	9. date	9. doll
10. fat	10. fail	10. ditch	10. fit
11. gap	11. far	11. dodge	11. food
12. goose	12. gaze	12. five	12. gas
13. hash	13. gin	13. germ	13. get
14. home	14. goal	14. good	14. hall
15. hurl	15. hate	15. gun	15. have
16. jail	16. haze	16. half	16. hole
17. jar	17. hush	17. hire	17. join
18. keen	18. juice	18. hit	18. judge
19. king	19. keep	19. jug	19. kick
20. kite	20. keg	20. late	20. kill
21. knock	21. learn	21. lid	21. lean
22. laud	22. live	22. life	22. lease
23. limp	23. loaf	23. luck	23. long
24. lot	24. lore	24. mess	24. lose
25. love	25. match	25. mop	25. make
26. met	26. merge	26. mouse	26. mob
27. mode	27. mill	27. name	27. mood
28. moon	28. nice	28. note	28. near
29. nag	29. numb	29. pain	29. neat
30. page	30. pad	30. pearl	30. pass
31. pool	31. pick	31. phone	31. peg
32. puff	32. pike	32. pole	32. perch
33. rag	33. rain	33. rat	33. red
34. raid	34. read	34. ring	34. ripe
35. raise	35. room	35. road	35. rose
36. reach	36. rot	36. rush	36. rough
37. sell	37. said	37. search	37. sail
38. shout	38. shack	38. seize	38. shirt
39. size	39. shawl	39. shall	39. should
40. sub	40. soap	40. sheep	40. sour
41. sure	41. south	41. soup	41. such
42. take	42. thought	42. talk	42. tape
43. third	43. ton	43. team	43. thumb
44. tip	44. tool	44. tell	44. time
45. tough	45. turn	45. thin	45. tire
46. vine	46. voice	46. void	46. vote
47. week	47. wag	47. walk	47. wash
48. which	48. white	48. when	48. wheat
49. whip		49. wire	49. wife
50. yes		50. youth	50. yearn

[3]Reproduced by permission of Dr. Tom W. Tillman.

SD Question now a matter of *clarity*
No longer a threshold thing

Present word list at client's MCL
- do *not* familiarize 1st
- precede with "say the word:"

Tell client you will say words that will NOT become softer
- these will stay the same in loudness
- keep trying to repeat what you hear
- if you aren't sure, just guess

If client gets 1st 10 words, clinicians often stop there
- give 100%

If client misses a word, do 25 words
- calculate % of words correct

SD Performance

90 – 100%	Excellent
80 – 90%	Good
70 – 80%	Fair
60 – 70%	Poor
Below 60%	Do SD again with visual cues; note how client improves

Speech Audiometry, by Gary Lawson & Mary Peterson, 2011

Lawson1 reported when using the standard 95% critical difference criteria (ie, the most common criteria applied in behavioral statistics), we employ a statistical model to state with 95% certainty that two scores are either the same or different. Specifically, given a patient with a symmetric mild-to-moderate sensorineural hearing loss (SNHL) and given a 25-word list from the most common word recognition tests (CID-W22, NU-6, etc), if the sum total of the first Word Recognition Score (WRS) is 88% correct, the range of scores, which are statistically the same as the first score (88%), is from 68% to 100%.

Of course, we can improve and tighten the range by using a 50-word list for each presentation; however, few clinicians use 50-word lists. Nonetheless, given a 50-word list, and assuming the first score was (again) 88%, the range of scores statistically the same as the first score (88%) would be from 74% to 96%.

This same phenomenon has been known and described for decades (see Thornton and Raffin, 19782), yet this same important and interpretative knowledge rarely makes it past the soundbooth door. Specifically, when given a WRS of 88% in the first ear (based on a 25-word presentation), if the other ear WRS is 72% or 96%, there is an excellent chance many clinicians will assume these scores are statistically different. They are not. The WRS test itself is not a very powerful test and the “clinical difference” noted is simply a fallacy. Indeed, if one were to repeat the same test in an hour, a day, or week, there is a reasonable chance the scores would vary—and they may even reverse!

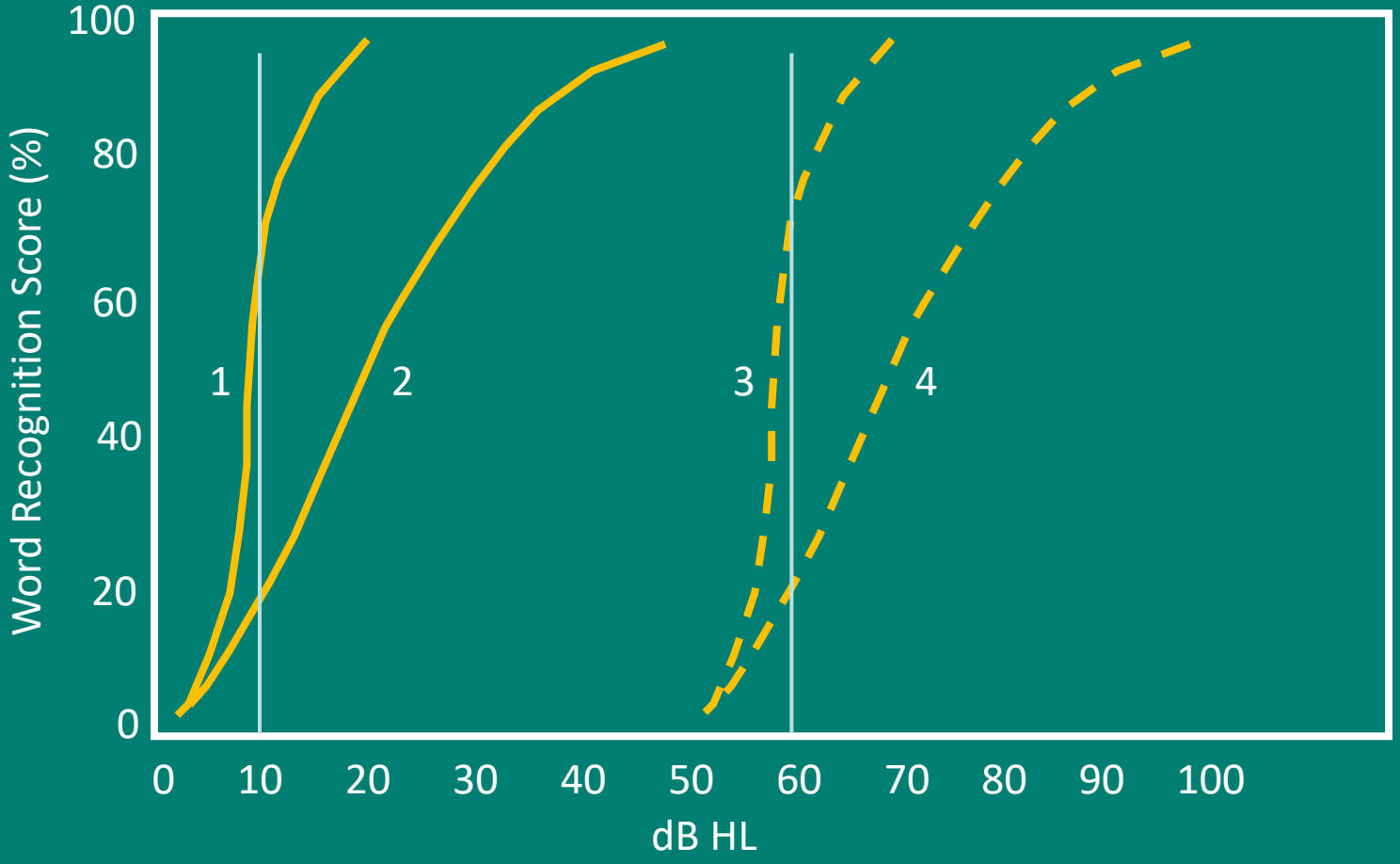
SD & Conductive HL

Client with Conductive HL will have excellent SD
- at elevated levels
- client's MCL will obviously be higher

I always describe Conductive HL as a plug in the ear
- earplugs give ourselves a Conductive HL on purpose

For Optimal SD
- crank up volume and all is generally OK

Psychometric functions for a Conductive HL
Note how things simply shifted to the right



1 = spondee words; at 5dB above 10 dB HL threshold, all words correct

2 = mono-syllabic words; harder, need about 50 dB HL to get all correct

3 = spondee words & Conductive HL; same shape, just shifted to the right

4 = mono-syllabic words & Conductive HL; same shape, just shifted to the right

SD & Sensori-Neural HL

Varying SD % at various elevated levels

depends on client's outer vs inner hair cell damage…

"Sensori"

OHC damage

mild-moderate sloping SNHL; typical presbycusis

fair SD at slightly elevated levels

Acoustic Reflexes (ARs) present at reduced SLs

"Neural"

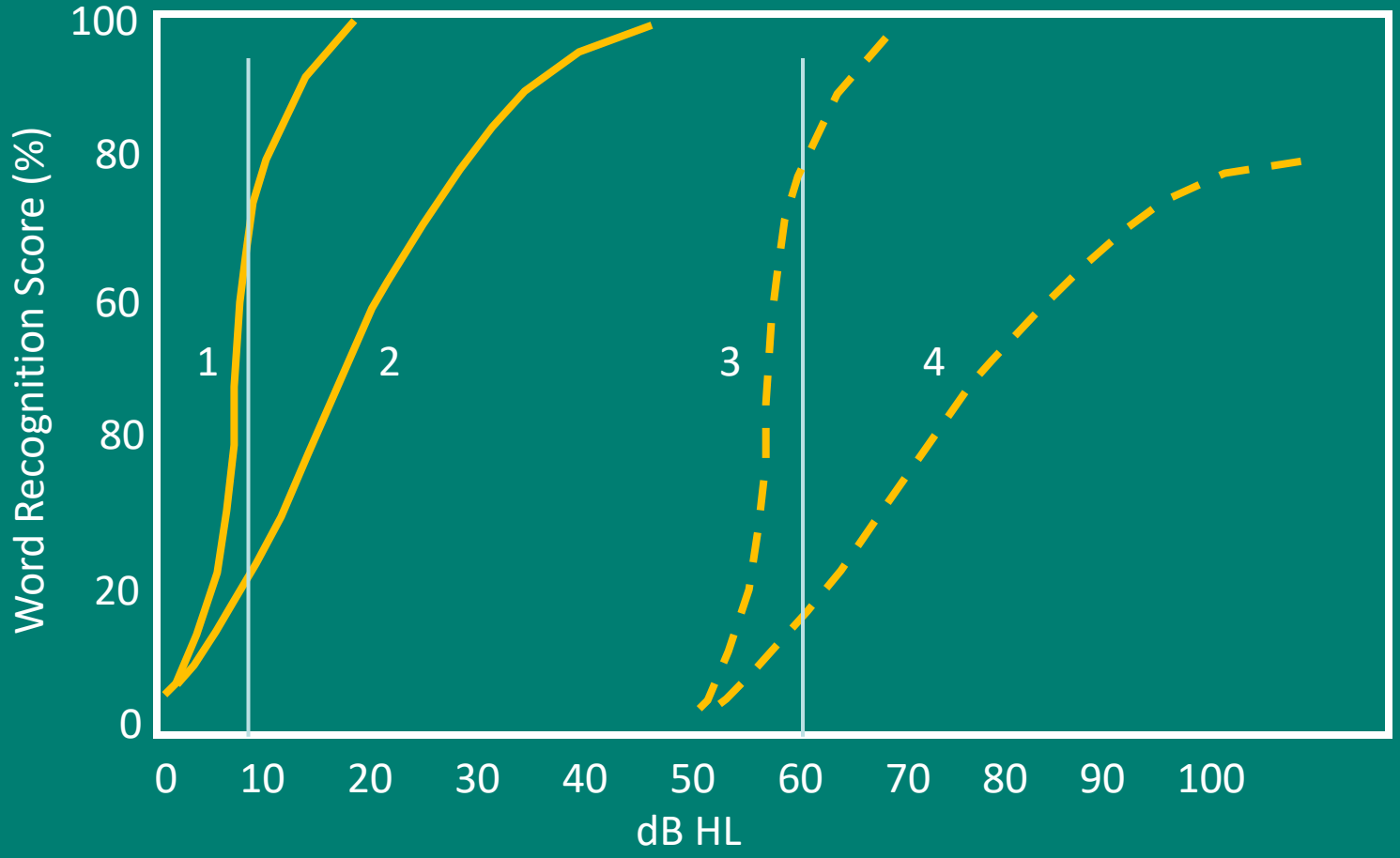
OHC & IHC damage

usually more sever SNHL

poor SD

ARs absent

Psychometric functions for a SNHL
Note SRT simply shifted right; SD however is different



1 = spondee words; at 5dB above 10 dB HL threshold, all words correct

2 = mono-syllabic words; harder, need about 50 dB HL to get all correct

3 = spondee words & SNHL; same shape, just shifted to the right

4 = mono-syllabic words & SNHL; shifted to the right but also poorer

SD & SNHL

Recall how MCL is artificially low in someone with SNHL
who has not worn hearing aids

An interesting “point of sale” here:
do SD again at client’s MCL + 10 dB
note increased SD performance
helps to show benefit of hearing amplification!

Summary
Psycho-metric Functions for various speech stimuli

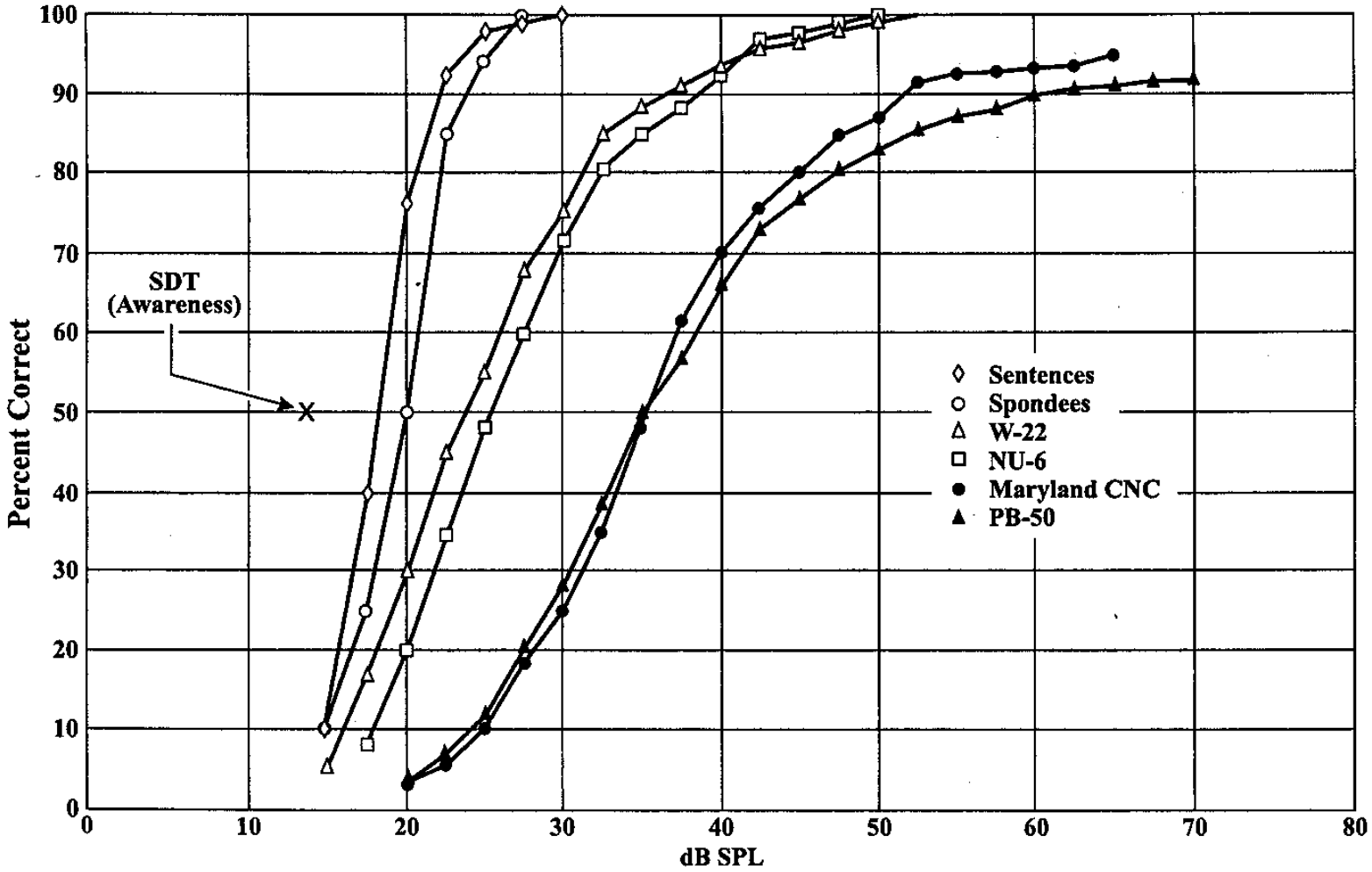
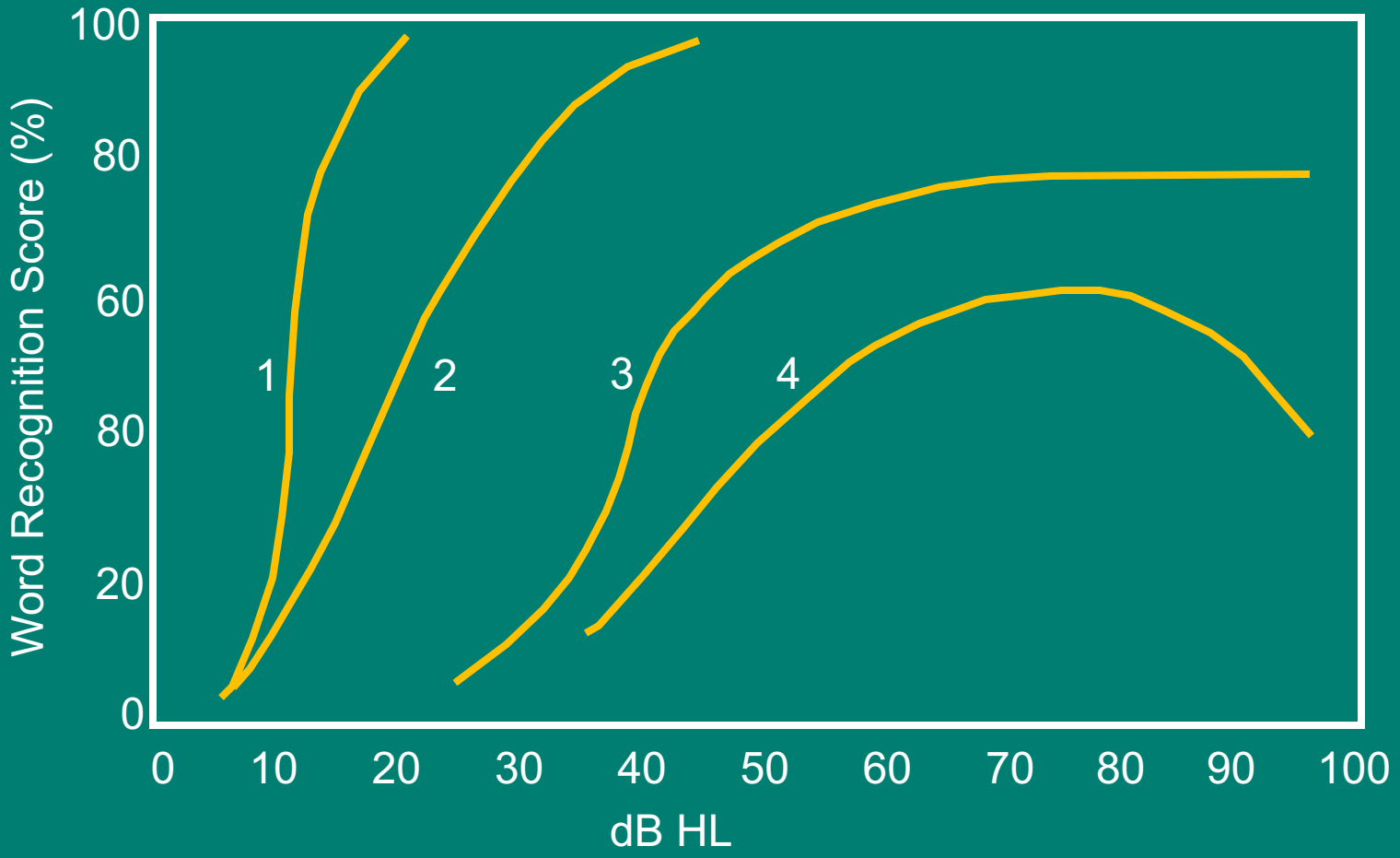


Figure 7.2. Performance-intensity functions for a variety of speech materials for different groups of normal-hearing young adults. The data are based on the original male-voice recordings but have been interpolated and converted to TDH-49/50 earphones for comparison purposes. (Sentence data from Fletcher and Steinberg, 1929: 848; Spondaic Word, CID W-22, and PB-50 data from Davis and Silverman, 1960: 190; NU-6 and Maryland CNC data from Causey et al.; 1994: 558 and 566.)

From Katz, Handbook of Clinical Audiology 5th ed

Psychometric functions
For various pathologies



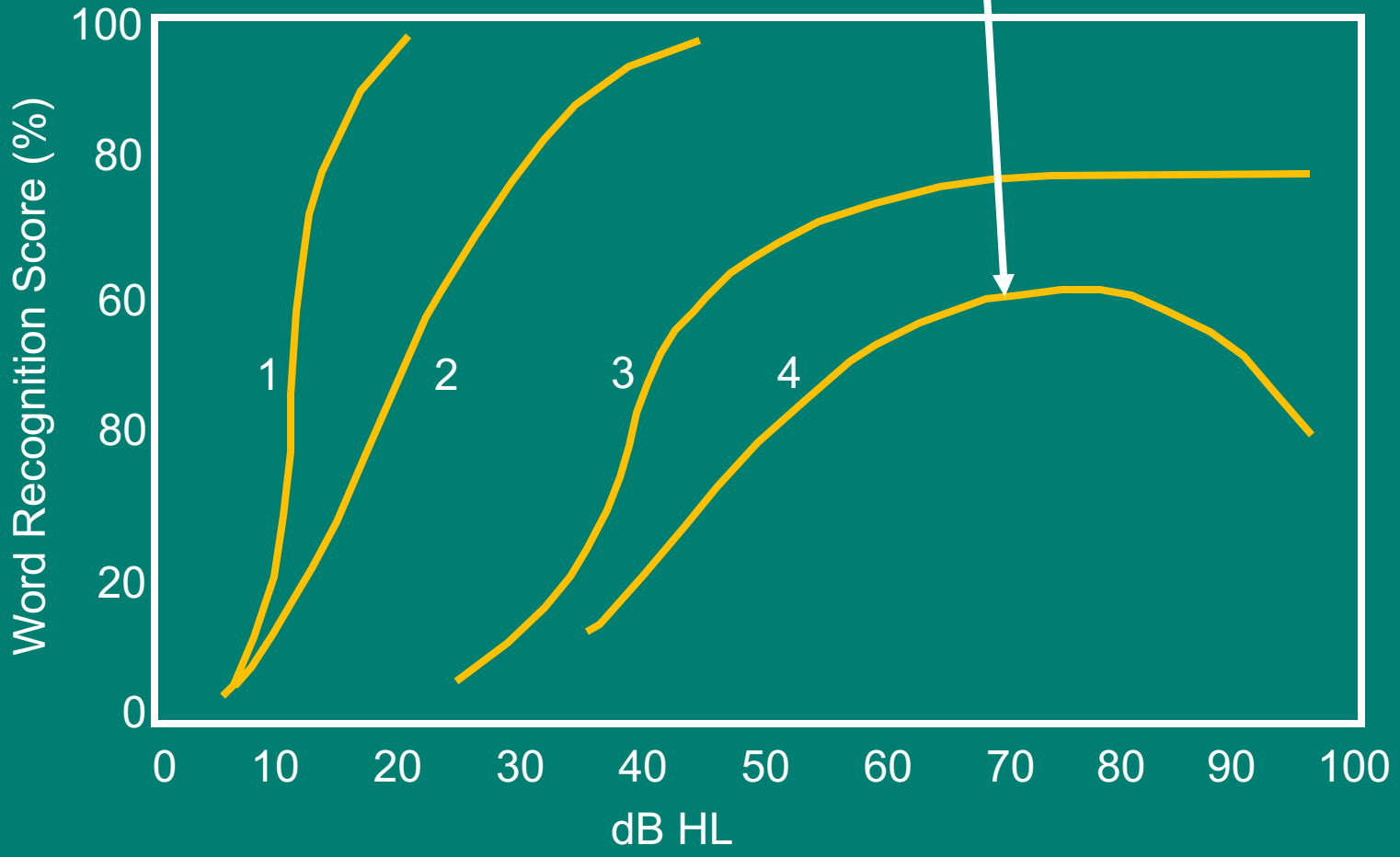
1 = spondee words; at 5dB above 10 dB HL threshold, all words correct

2 = mono-syllabic words; harder, need about 50 dB HL to get all correct

3 = mono-syllabic words & SNHL; fair speech discrimination

4 = mono-syllabic words & retro-cochlear pathology; “rollover”

What's with "Roll-Over?"
Why does no one do this?



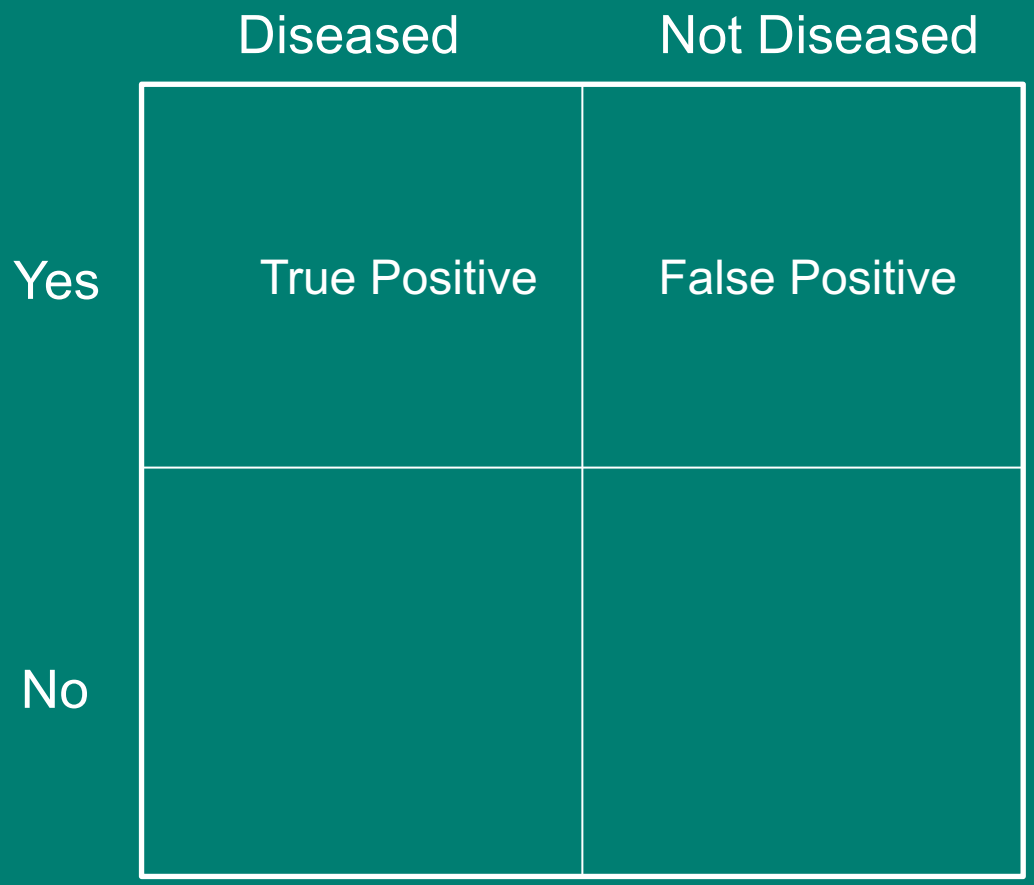
Because we have better tests for retro-cochlear pathology

Non-behavioural tests: eg. ARs, ABR, CT scans, MRI

Test May Be 100% Sensitive

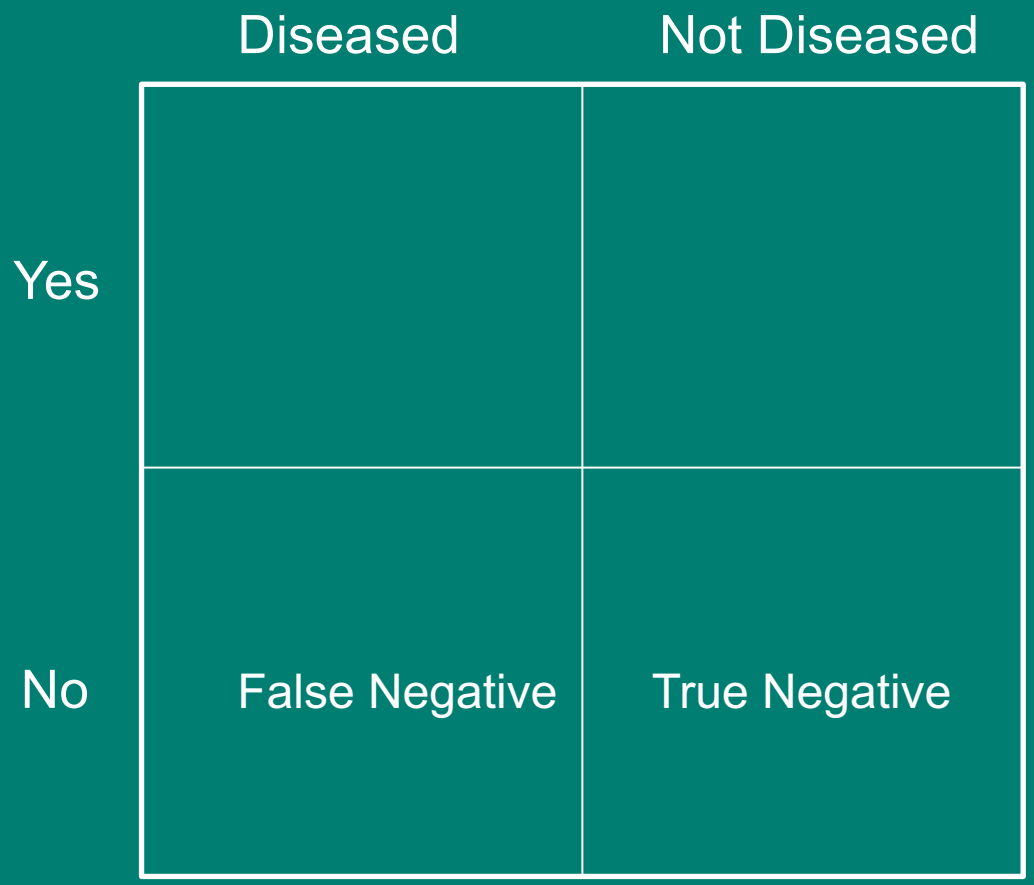
Catch all with disease (True +)

But also ID lots of normal as diseased (False +)



Test May Be 100% Specific

Pass all without disease (True -)
But also ID lots of diseased as normal (False -)



Sensitivity vs Specificity

"Gold Standard"

test that is 100% sensitive & 100% specific

eg. otoscopy identifying tube in TM

eg. MRI w/ Gadolium dye almost Gold Standard

In general, especially for ID retro-cochlear pathology

non-behavioural tests better than behavioural

Behavioural: tone decay, roll-over, SISI

Non-Behavioural: AR, AR Decay, ABR, CT scan, MRI

People often ask:
Why test speech in quiet? My problems are mostly in noise!

SD in quiet under headphones
is as good as it's going to get

Important baseline for counselling
can always test speech in noise afterward
to get better idea of real life situations

Signal-to-Noise Ratio (SNR)

SNR = level of signal (speech you want to hear)
versus level of competing noise

Eg. 70 dB speech in 60 dB noise = +10 SNR
60 dB speech in 60 dB noise = 0 dB SNR
60 dB speech in 70 dB noise = -10 dB SNR

Typical Face-to-Face SNRs

Pearsons KS, Bennett RL, Fidell S: Speech Levels in Various Noise Environments. EPA Rep 68 01-2466. Environmental Protection Agency, Washington DC, 1977.

When noise is 55 dB SPL,
people speak at about 61 dB SPL
+6 dB SNR: *easy*

When noise is 65 dB SPL,
speech often 68 dB SPL
+3 dB SNR: *harder*

When noise is 75 dB SPL,
speech often 74 dB SPL
-1 dB SNR: *challenging*

Quick SIN™ developed in 2001, Etymotic Reseach

Takes 5-10 minutes

- female talker sentence intensity is fixed
- background noise level 4 talker babble varies

Sentences presented at loud MCL (75 or 80 dB HL)

- CD automatically changes SNR in 5 dB steps
- sentence by sentence
- starts at +25 SNR; down in 5 dB steps

5 key words scored in each sentence

- 1 point for each correct word
- subtract # correct words from 25.5

Instructions

Imagine you are at a party
there's a woman talking…
several talkers in background

Woman's voice easy to hear at first, then gets harder
repeat what woman says

As task becomes more difficult
keep trying, and guess when not sure

Example

	SNR	# correct
To have is better than to wait & hope	25	5
The screen before the fire kept in the sparks	20	5
Thick glasses helped him read the print	15	4
The chair looked strong but had no bottom	10	3
They told wild tales to frighten him	5	1
A force equal to that would move the earth	0	0

Total correct = 18

SNR Loss = 25.5 – 18 = 7.5

Why the 25.5?

Tillman Olsen method

- 2 spondees presented starting at level where all words correct
- decrease in 2 dB steps until no responses for several words

Spondee threshold

- starting level plus 1 dB minus total # spondees correct

Simple arithmetic comes from 2 dB steps & 2 words per step

- audiometer has 5 dB steps
- corresponding method uses 5 words per step

Takes starting level at 2.5 dB (half the step size just as in 2 dB steps)

- minus total # spondees correct

Quick SIN has 5 dB steps & 5 words per step

- highest SNR is 25 dB
- so we take 25 + 2.5 dB = 27.5 minus total spondees correct

Quick SIN Shows:

How client hears in noise compared to normal-hearing
ie, the SNR increase required by hearing impaired client

Normal hearing requires 0 – 2 dB SNR to understand 50%
client with 7.5 dB SNR requires 7.5 – 9.5 dB SNR

Final score or SNR Loss		*Technology Needs*
Normal	*0-2 dB*	*Omni or Dmic*
Mild	*2-7 dB*	*Dmic*
Moderate	*7-15 dB*	*Beamforming mic*
Severe	*>15 dB*	*FM system*

Solutions for Speech in Noise

Presently, there are two...

Directional mics (Dmics)

- *objectively* improve speech/noise performance

Digital noise reduction (DNR)

- *subjectively* enhances comfort in noise

DNR does not

Objectively, reliably, statistically

Improve speech reception in background noise

DNR does

Subjective enhance listening comfort in noise

Hearing Aids & SNR:

If you can bring a hearing aid to the speaker's lips

You obviously increase the SNR

For example, remote mics, FM system…

Isn't that exactly what it does??

So does a Dmic, but to a lesser extent

Maybe by 5 dB in a lab; 2-3 dB in real life

For those with normal hearing...

Speech & noise have to be of similar intensity to understand 50% of the speech

Signal to Noise Ratios (SNR) here is 0 dB
may differ from lab to lab…

+5 dB SNR yields 100% speech recognition
-5 dB SNR is very difficult

For mild-to-moderate SNHL, however...

+5 dB SNR gets 50% speech recognition
directional mics try to hit this number

+10 dB SNR yields best speech recognition
results in *up to* 10% speech improvement

Basically, an <u>additional</u> 5 dB SNR is required
for mild-moderate SNHL

In Summary

Magic number is around “5”
directional mics try to hit this number

Each additional 1 dB SNR
results in *up to* 10% speech improvement

In reality, each additional dB SNR
results in about 5% speech improvement
Dmics improve SNR by about 2-3 dB

Articulation Index

Mueller & Killion, 1990

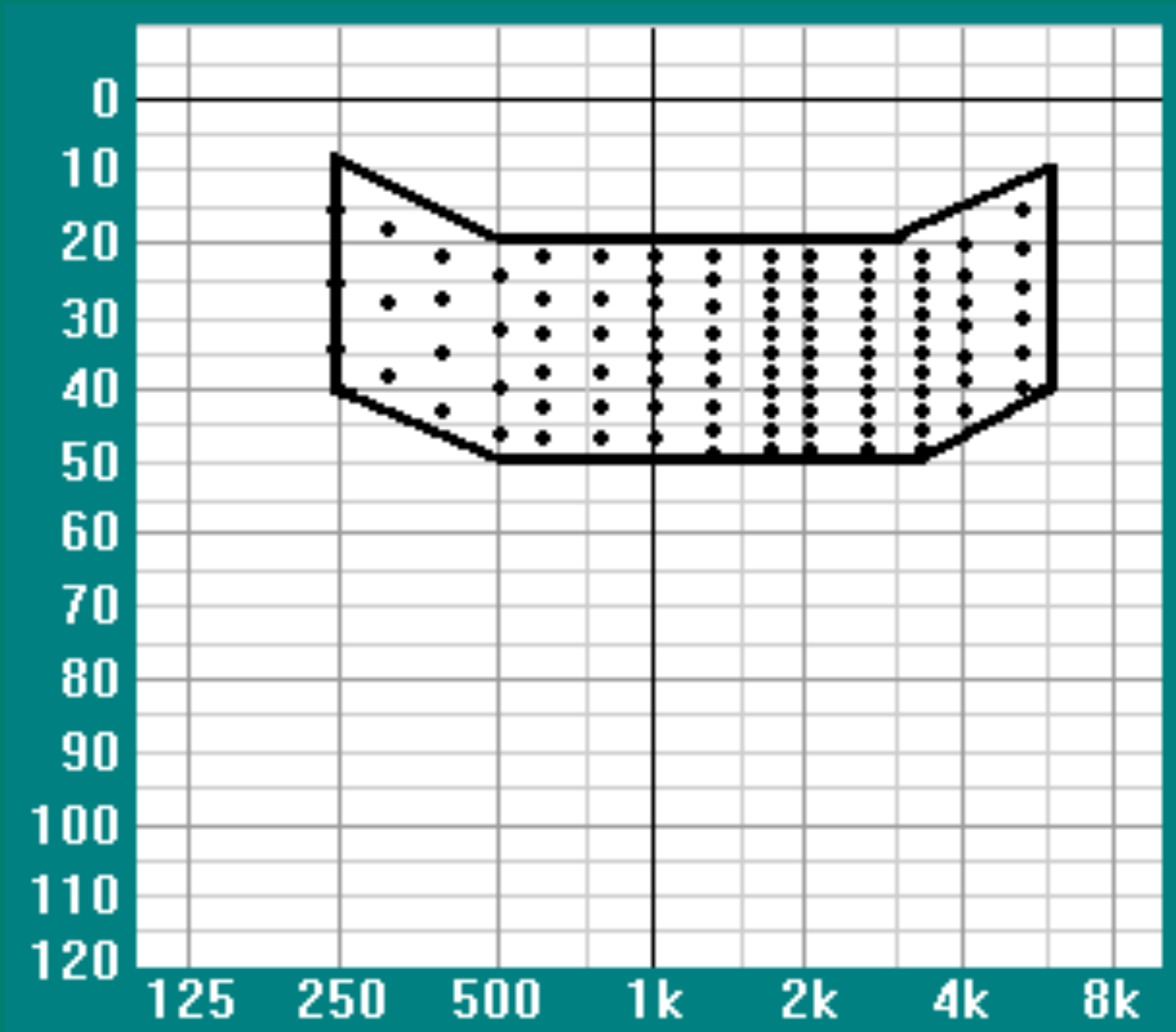


Fig 8-7, Venema, T. Compression for Clinicians 2nd edition, Cengage 2006

Required SNRs for Various Degrees of HL

Killion, Hearing Review, Dec 1997

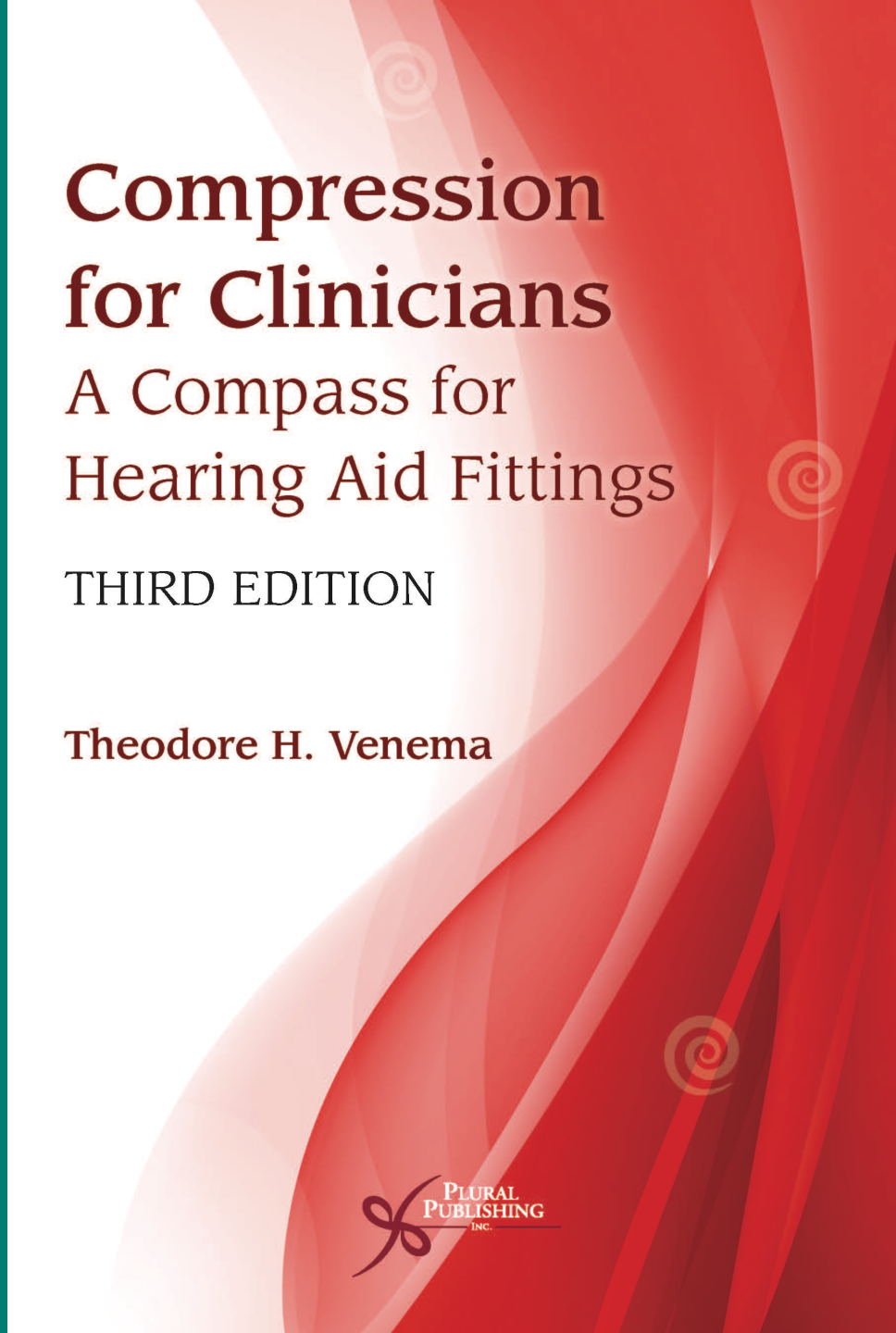
HL (PTA)	SNR Required
30	4
40	5
50	6
60	7
70	9
80	12
90	18

Affiliations

Hearing Instrument Sciences Program
Ozarks Technical Comm. College
Springfield MO
Email: venemat@otc.edu

Hearing Instrument Practitioner Program
Douglas College
Coquitlam BC
Email: venemat@douglascollege.ca

Compression for Clinicians
3rd Edition 2017
Plural Publishing




Venema
OPEN