SPEECH AUDIOMETRY

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References

- Audiologic Evaluation and Management and Speech Perception Assessment by Mendel and Danhauer
- Handbook of Clinical Audiology 7th Edition by Katz (sometimes I may refer to the 5th ed.)

Good to read, if available:

- Speech audiometry by Lawson and Peterson

What is speech audiometry?

Procedures that uses speech to assess auditory function

Why do we study the hearing of speech in addition to the hearing of tones?

- Physiologic and acoustic factors
- Linguistic and psychologic factors

Physiologic and acoustic factors

- Each individual's voice has its own
  - *Pitch*
  - *Voice quality*
  - *Speed of production*
- Which are controlled by
  - *Breath support*
  - *Articulatory muscles*
  - *Habitual speaking rate*
  - *Size of the vocal folds*
  - *Oral & nasopharyngeal resonating cavities*

Physiologic and acoustic factors

- Influence the frequency, intensity and duration of the speech signals
- Speech spoken by one person is different from the speech spoken by another person
- These factors also affect how a person perceive speech – a person's physiology determines the speech signals that are transduced mechanically (ie. through the conductive pathway) and neuroelectrically (through the sensory pathway) in the auditory system

Linguistic and psychologic factors

- Language is complex, and due to the complexity, it is difficult to evaluate someone's understanding of speech
- Level of speech/sound perception
  - *Detection*
  - *Discrimination*
  - *Identification*
  - *Comprehension*

Purposes of speech audiometry

- Provide measure of how well listeners understand speech
- Reflect degree of communication handicap caused by hearing loss
- Provide information for planning and managing auditory habilitation/rehabilitation
- Monitor listeners' performance throughout the therapeutic process
- Assess the success of different types of medical/surgical treatments
- Monitor subjects' performance in research studies
- Classify degree and type of hearing loss
- Baseline measure for other test procedures
- Used in various forms of research

Terminology frequently found in speech audiometry

- Intelligibility: the degree of clarity with which an utterance is understood by the average listener
- Articulation: the repeatability of the non-meaningful parts of speech, e.g. nonsense syllables; used when plotting an articulation or performance-intensity (PI) function
- Discrimination: the process of distinguishing among speech sounds or words by differentiating them as same or different
- Recognition/identification: the recognition or establishment of a particular sound or word

Terminology (cont.)

- **Speech detection threshold (SDT):** an estimate of the level at which an individual **perceives** speech to be present 50% of the time (ASHA, 1988); measured as **dB dial or dB HL**
- **Speech recognition threshold (SRT):** an estimate of the level at which an individual **can repeat** back spondaic words (e.g., hotdog, baseball) 50% of the time (ASHA, 1988). However, NOT limited to spondaic words. Also measured as **dB dial or dB HL**
- **Speech recognition score (SRS)/maximum speech recognition score (MSRS)/word recognition score (WRS):** a suprathreshold measure in quiet of the performance (e.g. correctly detected, correctly recognised), measured **as percent correct**

Things to be considered in speech audiometry

- Response format
- Scoring method
- Method of presentation
- Stimulus familiarity
- Types of stimuli
- Phonetic/phonemic balancing
- Carrier phrase
- Presentation levels
- Background noise or speech competition – In quiet? In noise?

Response format

- Open set/free-response – no specified alternatives for answers
  - *Advantages: more flexibility; unlimited number of alternatives so auditory and linguistic factors can help with perception; no guessing*
  - *Disadvantages: not suitable for young children or non-verbal patients*
- Closed set/multiple-choice/forced choice – limited number of response alternatives
  - *Advantages: difficulty and sensitivity of test items can be manipulated (cat/door vs cat/bat/pat vs cat/kit/cut); equal number of alternatives for each test item; easier to score; can be incorporated into computers, allowing patients to record own responses*
  - *Disadvantage: lucky guesses*

Scoring methods

- Types of scoring methods
  - *Synthetic: all or none; have to perceive entire stimulus in order to get correct score*
  - *Analytic: correct score is awarded for any parts of the stimulus perceived correctly e.g. phoneme scoring*
- Factors affecting scoring
  - *Accuracy of examiners' perception of subjects' responses*
    - Speech production errors
    - Hearing loss from audiologists (not all audiologists are normal hearing)
    - Inappropriate discrimination of responses – examiners' anticipation
  - *Inter- and intrajudge scoring reliability (but is it practical?)*

Method of presentation

- Monitored live voice (MLV) vs recorded voice

	MLV	Recorded voice
Advantages	• Relatively easy to administer – only the stimulus list is needed • More flexible • Does not require extra equipment or software	• Standardised material – consistent level and voice quality for every presentation; more reliable results
Disadvantages	• Difficult to keep at a consistent level of presentation • Different quality of voice between speakers	• Require extra equipment (CD player/audio player) or extra software installed into audiometer

Stimulus familiarity

- Most word lists use familiar words
- Greater word familiarity, higher intelligibility
- Factors affecting stimulus familiarity
  - Appropriate vocabulary level for a variety of patients
  - Different types of response foils (choice) used in closed-set tests
  - Level of predictability of the item in sentences due to context
  - Number and variety of stimulus items in the test – number of stimulus decreases, amount of familiarity or practice effects increases
- How about easily pictured words? Examples?

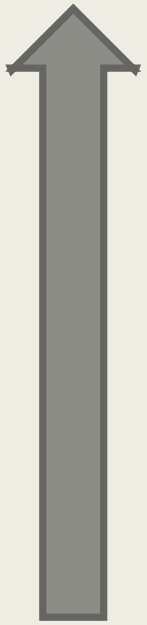
Types of stimuli

- Various types of speech stimuli are used in speech audiometry
  - *Syllables/nonsense syllables e.g. Six Ling sounds*
  - *Monosyllabic words*
  - *Spondaic words/Spondee: two syllable word spoken with equal emphasis on each syllable, e.g. toothbrush, eardrum, grandson, baseball*
  - *Multisyllabic words*
  - *Sentences*
  - *Digits (one, two, three…)*

More linguistic cues

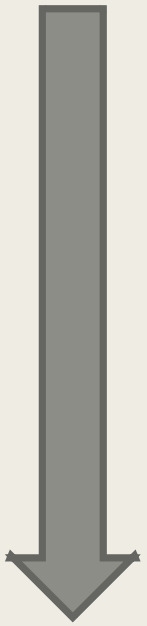
Sentences

Less difficult



Spondaic/multisyllabic words

Monosyllabic words



Less linguistic cues

Nonsense syllables

More difficult

Phonetic/phonemic balancing

- Phonetic balance – sounds within the list occur with the same frequency as they do in a representative sample of the speech of the language
- Phonemic balance – lists in which initial consonant, each vowel, and each final consonant appear with the same frequency of occurrence in the test list
- Isophonemic word list – phonemes in the list are the most frequently occurring in the language
- Not all developers of speech audiometry material agree on phonetic/phonemic balance

Use of carrier phrase

- Precedes the test items; used to alert the listener on the oncoming stimulus item and assist the tester in monitoring the presentation level of the stimulus
- E.g. “Say the word.....”, “You will say....”
- Disagreement on the use of carrier phrase:
  - *Martin, Hawkins and Bailey (1962) reported no significant difference in performance between stimulus with and stimulus without carrier phrase*
  - *Gladstone and Siegenthaler (1971) found that stimuli without carrier phrases were more difficult to identify*
- Advantages? Disadvantages?

Presentation levels

- Different presentation levels elicit different responses from the listener
- Can be seen through the psychometric function of the performance, also known in speech audiometry as **performance-intensity (PI) function**
- Displays the changes in the dependent variable (on the y-axis) based on the changes of the independent variable (x-axis)
- Gives you the information on
  - *Speech audiometry threshold (e.g. SRT)*
  - *Speech recognition score, reflecting the discrimination ability*

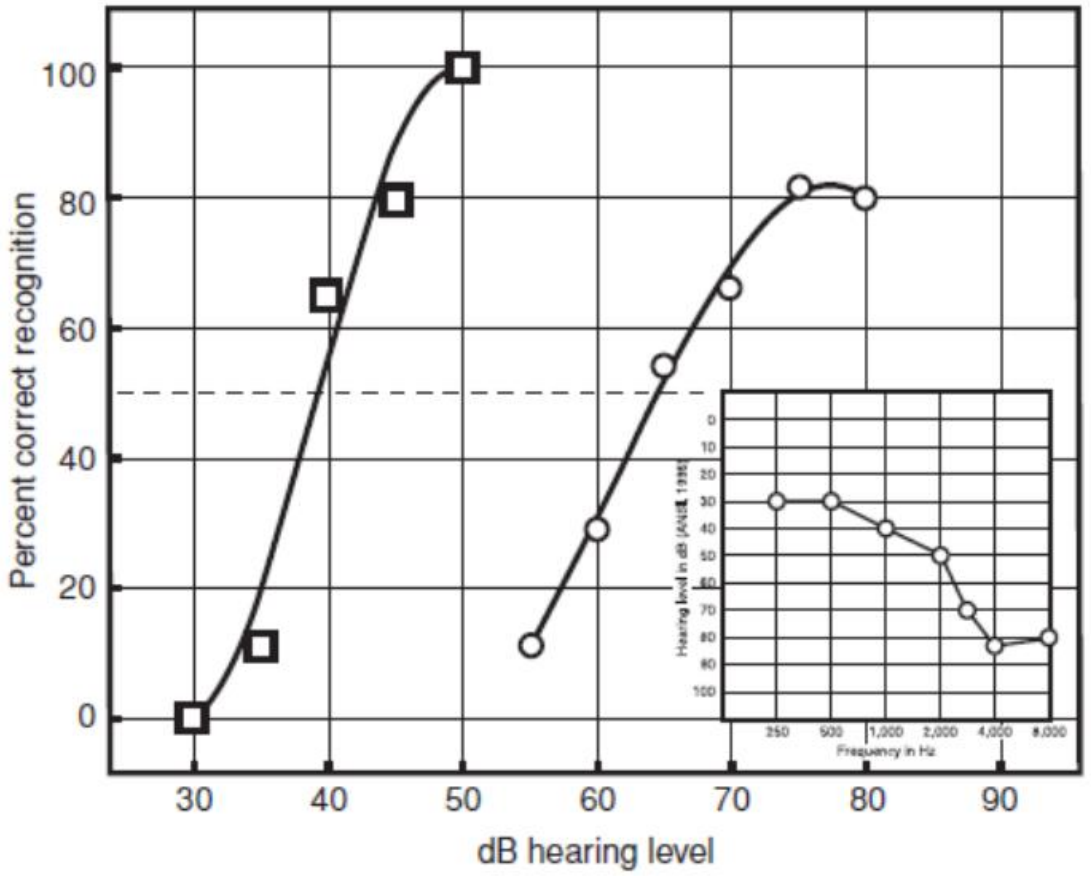


FIGURE 5.1 Psychometric functions of word recognition performance measured in percent correct (ordinate) for a listener with hearing loss as a function of presentation level (abscissa). The *dashed line* indicates the 50% point. The function to the left is the SRT function whereas the function to the right is the SRS function.

(Katz, 2015)

Presentation levels

- Different types of hearing loss elicit different patterns of PI function

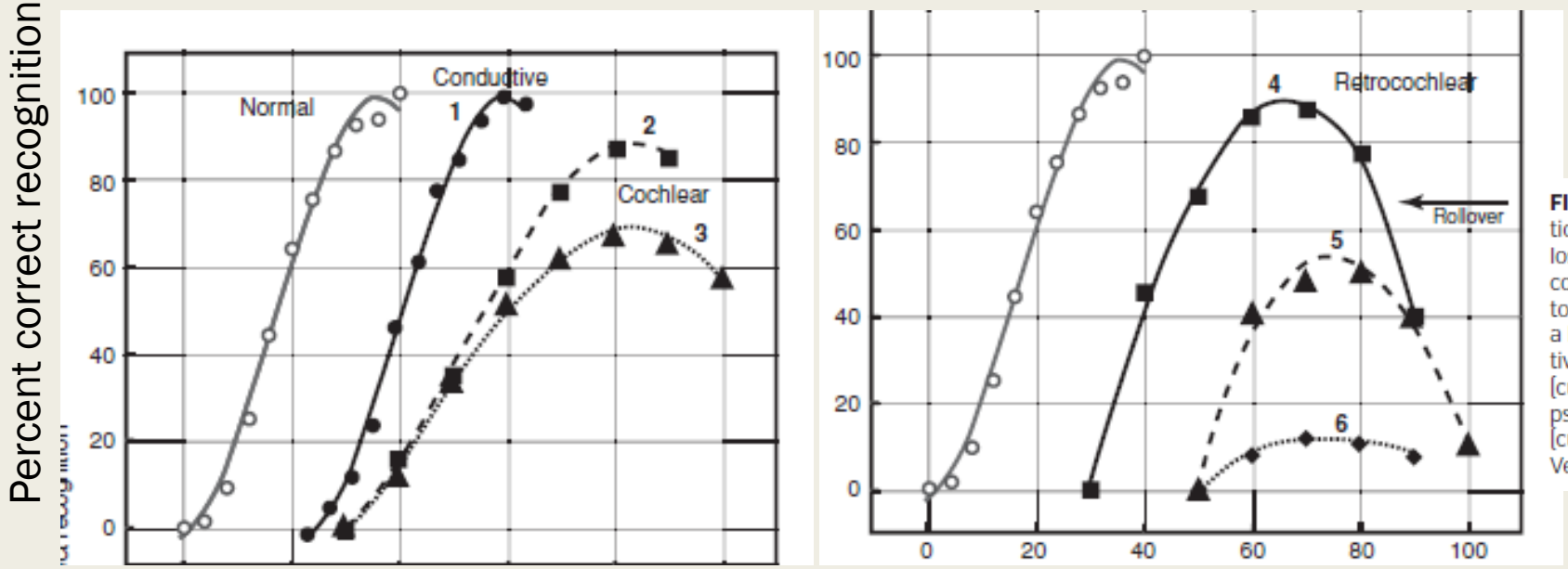


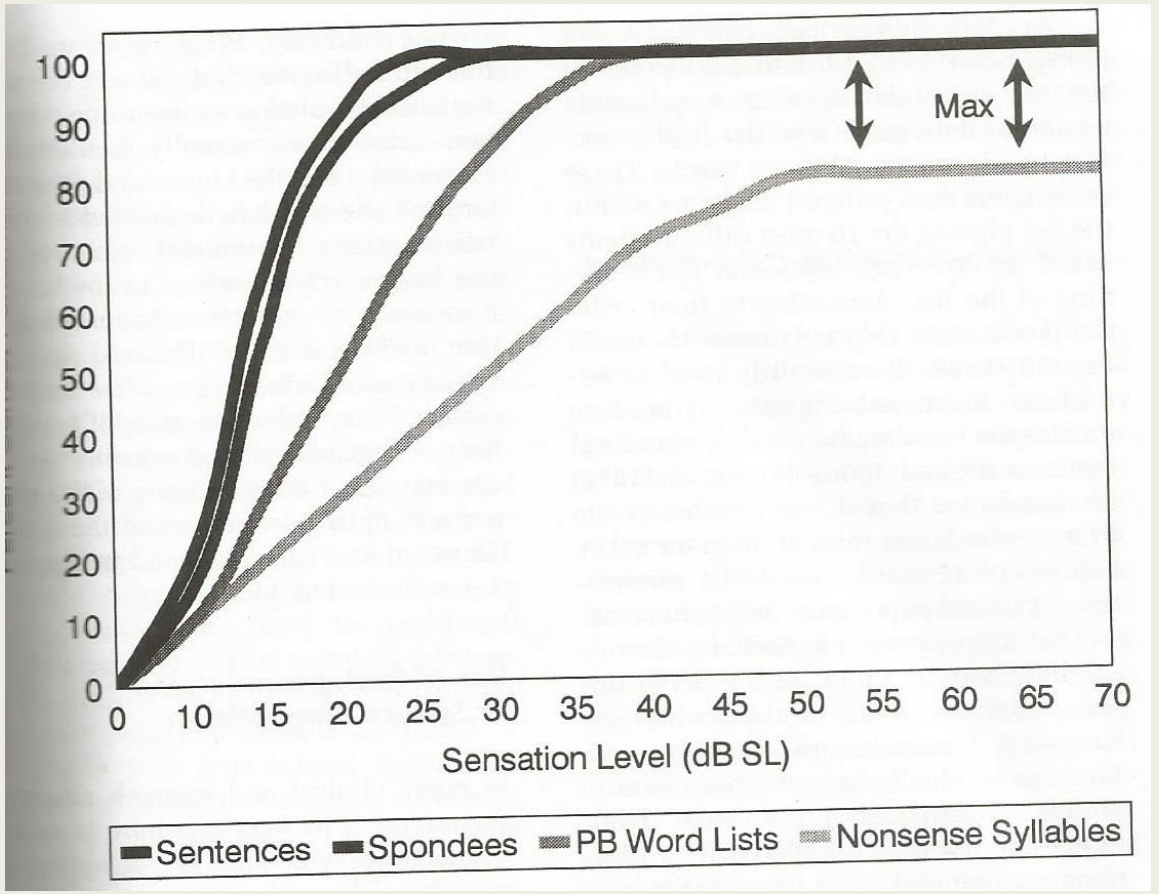
FIGURE 5.2 Psychometric functions of word recognition performance illustrating various types of hearing loss can be seen in both panels as a function of percent correct (ordinate) and presentation level (abscissa). The top panel illustrates a sample psychometric function for a listener with normal hearing (*open circles*), conductive hearing loss (curve *#1*), and cochlear hearing loss (curves *#2* and *#3*). The bottom panel shows possible psychometric functions for retrocochlear hearing loss (curves #4, #5, and #6). (Adapted from Department of Veterans Affairs (1997).)

(Katz, 2015)

Presentation levels

- Type of stimuli also affect PI function

Effect of stimulus type on PI function



(Mendel and Danhauer, 1997)

Use of background noise or speech competition

- Some speech audiometry is done in quiet, some in noise, e.g. Hearing-in-noise test (HINT)
- Types of noise
  - *White noise*
  - *Speech*
  - *Environmental noise*

Use of background noise or speech competition

- Why in noise?
  - *Simulate real-life situation*
  - *Enhance sensitivity in detecting and demonstrating communication difficulties*
- But,
  - *Test becomes more difficult*
  - *Scores decrease*
  - *Unknown whether the result is more diagnostically useful than test in quiet*

So how to calculate SRT/SDT and MSRS?

- Speech recognition/detection threshold
  - ***Definition of SRT:*** *an estimate of the level at which an individual* ***can repeat*** *back spondaic words (e.g., hotdog, baseball) 50% of the time (ASHA, 1988). However, NOT limited to spondaic words (Note: refer to previous slide for SDT)*
  - Find the peak or the highest correct score (can also be percent correct) on the performance-intensity function (also known as speech audiometry curve), note the score (e.g. 100%, 96%, 34 over 40)
  - Divide the score into two – 50%, 48%, 17 over 40
  - Note the presentation intensity level (dB dial) for the divided score
  - The noted level is the ST

So how to calculate SRT/SDT and MSRS?

- MSRS
  - ***Definition:*** *a suprathreshold measure in quiet of the performance (e.g. correctly detected, correctly recognised), measured* ***as percent correct***
  - The highest percentage correctly repeated by the listener
  - find the peak or the highest score achieved by the listener along the P-I function/speech audiometry curve - MSRS

What is available in Malaysia?

- Bisyllabic Malay Speech Audiometry (BMSA)
- Malay Matrix Sentence Test
- MyHINT
- Malay Dichotic Digit Test

Bisyllabic Malay Speech Audiometry word lists

- C:\Users\Marina\Dropbox\Thesis\Test Kit.docx

BMSA

- 15 different lists, each with 10 CVCV words forming 40 phonemes
- Phonetically balanced, open set
- How to perform:
  - *Familiarisation:*
    - Calculate the PTA (250, 500, 1000, 2000, 4000 Hz)
    - Present 1 familiarisation list at PTA + 30 dB
    - If patient can perform, stop at the middle of the list and continue with actual test. If not, increase presentation level by 10 dB and familiarise again
    - The level at which patient is familiarised with the test is the initial presentation level

BMSA

- How to perform (cont.)
  - *Actual testing:*
    - Present 1 list at initial presentation level (IPL). Record responses.
    - Continue testing at 10dB descending steps. Use a new list every time
    - Stop when the correct responses is less than 50% (if scores at initial presentation level is 100%) or half than the maximum correct scores
    - To measure plateau, present another list at 20 dB above the initial presentation level, increase by 20dB (or 10 dB, whichever comfortable for the patient) to seek rollover

BMSA

- How to score
  - 1 mark for each correct phoneme
  - Total score per word – 4
  - Total score per list – 40
  - Example:
    - Stimulus word: BAJU
    - Response: BAJU – 4 marks
    - Response: LAJU – 3 marks
    - Response: KEJI – 1 mark

Let’s try

- List 2
- List 4
- List 6
- List 8

Answers ☺

- List 2
  - *T A L I*
  - *C U B A*
  - *B E K U*
  - *G U L A*
  - *S A T U*
  - *K I R A*
  - *D A R I*
  - *S E P I*
  - *M A N A*
  - *L O J I*
- List 4
  - *R E D A*
  - *H O B I*
  - *G U R U*
  - *L A L I*
  - *P E N A*
  - *S I T U*
  - *M A S A*
  - *J A T I*
  - *C U R I*
  - *K A L A*

Answers ☺

- List 6
  - *R E L A*
  - *K O P I*
  - *D A Y A*
  - *F A S A*
  - *B E L I*
  - *S E R I*
  - *K A M I*
  - *H A J I*
  - *C A T U*
  - *G U N A*

- List 8
  - *J I W A*
  - *K A S A*
  - *S U H U*
  - *B A C A*
  - *P E T I*
  - *M U T U*
  - *K A R I*
  - *L I G A*
  - *N A D A*
  - *L O B I*

Masking in Speech Audiometry

- Based on van Zyl (n.d.)

https://vula.uct.ac.za/access/content/group/27b5cb1b-1b65-4280-9437-a9898ddd4c40/Speech%20Audiometry.pdf

Rule of thumb:

IAA for suprathreshold headphones – 40 dB

IAA for insert earphones – 60 dB

Masking in Speech Audiometry

- Masking rule for SRT testing
  - *If difference between SRT_{TE} and best pure tone BC_{NTE} equals to or more than IAA, mask*
  - *If difference between SRT_{TE} and SRT_{NTE} equals to or more than IAA, mask*

How to mask in SRT testing (van Zyl)

- First, find unmasked SRT for both ears, note the score
- If masking is needed
  1. Present masking noise (speech noise or white noise) at 10 dB above the SRT of the non-test ear
  2. Present a list to the test ear at the same level as the unmasked SRT
  3. If listener attains the same score as in unmasked SRT, increase the masking noise by 5 dB and present a new list
  4. Repeat step 3 until masking level has been increase by 15 dB from the original masking level (three increments of 5 dB)
  5. If listener still attains the same score after the 15 dB increment, the level can be noted as the masked SRT

How to mask in SRT testing (van Zyl)

- If listener does not attain the unmasked score during masked presentation
  - keep the masking level constant, and increase the stimulus level by 5 dB. Present a list
  - Repeat the above step until 50% correct (or half peak score) is attained
  - Increase the masking noise by 5 dB increment (while keeping the stimulus level constant)
  - Repeat the process until plateau is achieved with 15 dB increase of masking noise

Masking in Speech Audiometry (alternative method)

- Based on Yacullo (1999)
- Indication (i.e. when to mask):
  - *Whenever the presentation level of the speech signal in dB HL at the test ear (PL_T) minus interaural attenuation (IA) equals or exceeds the best pure tone bone conduction threshold in the nontest ear (best BC_{NT})*

$$PL_T - IA \geq Best\ BC_{NT}$$

Interaural attenuation: 40 dB

Best BC: best BC threshold in the frequency range from 250 to 4000

Masking in speech audiometry

- Before you start masking, determine
  - *Minimum masking level (M_{min}) to prevent undermasking*

$$M_{min} = PL_T - IA + Max\ AB\ Gap_{NT}\ dB$$

Max AB Gap_{NT} = maximum air bone gap in the non test ear in the 250 to 4000 Hz frequency range

  - *Maximum masking level (M_{max}) to prevent overmasking*

$$M_{max} = Best\ BC_T + IA - 5\ dB$$

  - *Midmasking level to determine whether the effective masking level is acceptable*

$$M_{mid} = (M_{max} - M_{min})/2$$

Masking in speech audiometry

- Effective masking level:

  $dB\ EM = PL_T - 20\ dB$

  Provided that,

  - *There are no significant (≥ 15 dB) AB gaps in either ear*
  - *Speech are presented in moderate sensation level (30-40 dB SL) relative to the measured or estimated SRT*

Clinical functions of speech audiometry (in general)

- Loss of hearing sensitivity
  - *Based on SRT – SRT > 20 dB HL*

- Agreement between pure tone and speech thresholds

  SRT = PTA ± 10 dB

  In literature, if SRT is better than PTA by 12 dB or more, pseudohypacusis in a reasonable suspicion