Lesson 8

Fitting Strategies

- Recently, prescriptive procedures for fitting hearing aids have become more popular.
- These techniques attempt to assess an individual�much frequency response and gain requirements using a specific formula.
- A hearing aid is then selected which best matches the calculated specifications.
- There are several prescriptive procedures, and the selection of a particular technique is due in large part to the dispenser's familiarity with a specific technique.

- Fitting a hearing aid involves determining the output and gain requirements for the hearing aid user.
- Selective amplification is the process of matching the frequency response of a hearing aid to the audiogram of an individual.
- One of the first examples of selective amplification was the **mirror-fitting technique**, developed by Watson and Knudsen in 1940.
- Using this technique, the frequency response of the hearing aid was set to the mirror image of the hearing loss, so the poorest hearing regions on the audiogram received the greatest amplification.

- The mirror-fitting technique has proven unsatisfactory as a fitting strategy for hearing aids, mainly because it leads to over amplification.
- In addition, the frequency response of the hearing aid is based on measurements obtained in a coupler, and does not account for coupler/real ear differences or insertion loss created by the hearing aid.

- Lybarger, in 1944, developed a fitting technique in which the optimal frequency response curve would by about 1/2 of the audiogram curve.

- This is the origin of the **half-gain rule**, which is often incorporated into several of today's fitting strategies.

- Lybarger made a very important observation: the amount of gain chosen by people as the most comfortable level (MCL) was approximately half the amount of threshold loss.

- For mild to moderate sensorineural loss, the threshold of discomfort is only a little different from normal hearing.
- MCL is half way between threshold and uncomfortable level (UCL), so MCL increases by 0.5 dB for every 1dB increase in hearing loss.
- This explains why gain is half the hearing loss. Of course, if the aim is to raise speech to MCL, then we cannot predict how much gain is needed at each frequency unless we take into account the speech intensity at each frequency.

- Because the low frequency components are more intense than the high frequency components, therefore the half gain rule needs to be modified.

- Either a little less low frequency gain has to be given, or a little more high frequency gain, or both.

- The half –gain rule has to be further modified for severe and profound losses.
- For hearing threshold greater than 60dB HL MCL remains half way between threshold and uncomfortable level, but discomfort or UCL thresholds are significantly above normal.
- Therefore the gain must be more than half of the hearing loss for hearing losses greater than 60dB HL.

Dynamic range and hearing loss

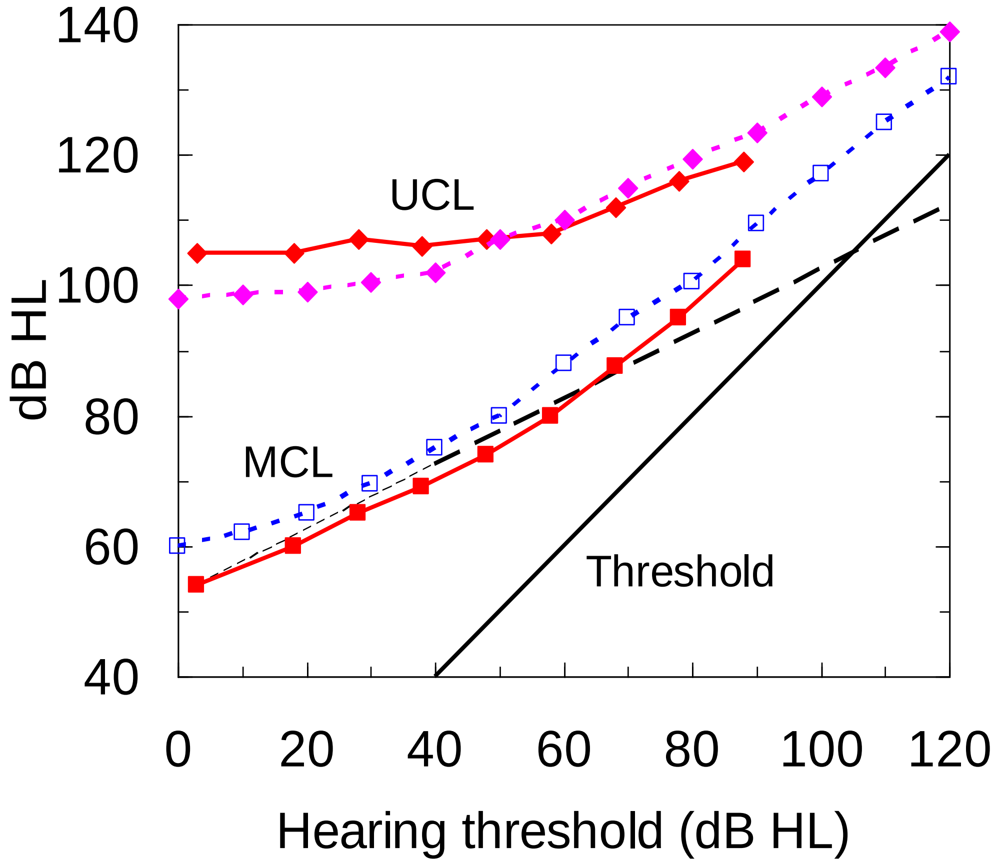

Figure 9.1 Uncomfortable listening level and most comfortable level for people with sensorineural hearing loss, averaged across 500, 1k, 2k, and 4 kHz. Data shown with filled symbols are from Schwartz et al. (1988) and those with open symbols are from Pascoe (1988). The dashed line has a slope of 0.5, illustrating the relationship between MCL and the half-gain rule.

Source: Dillon (2001): *Hearing Aids*

- McCandless and Lyregaard developed the **prescription of gain and output (POGO**) in 1983, which defines the insertion gain and maximum power output requirements for individuals with sensorineural hearing losses of less than 80 dB.

- Compared to Lybarger's technique, POGO results in less low frequency amplification, which may improve speech intelligibility in noisy conditions.

- In 1986, the revised **National Acoustics Laboratory(NAL)** prescriptive technique was developed by Byrne and Dillon.

- The revised NAL is a prescription for selecting the real-ear gain and frequency response of a hearing aid.

- Unlike some other non-linear prescriptive rationales that are currently used, the NAL formula does not attempt to restore normal loudness at each frequency.

The underlying rationale is to maximize speech intelligibility, so that the overall loudness of speech at any level is no more than that perceived by a normal hearing person.

To derive the gain-frequency response that achieves this at each input level, it was necessary to examine some characteristics of hearing loss.

- Hearing loss not only reduces audibility, but also reduces the person's ability to recover useful information, even when speech is audible.
- This research finding was taken into account when NAL was developed.
- The NAL procedure makes sure that there is not too much emphasis for low or for high frequencies.
- NAL prescribes much less low frequency gain below 1000Hz than other rationales.
- NAL also prescribes less gain in the region of greatest hearing loss.

NAL-R for a flat loss

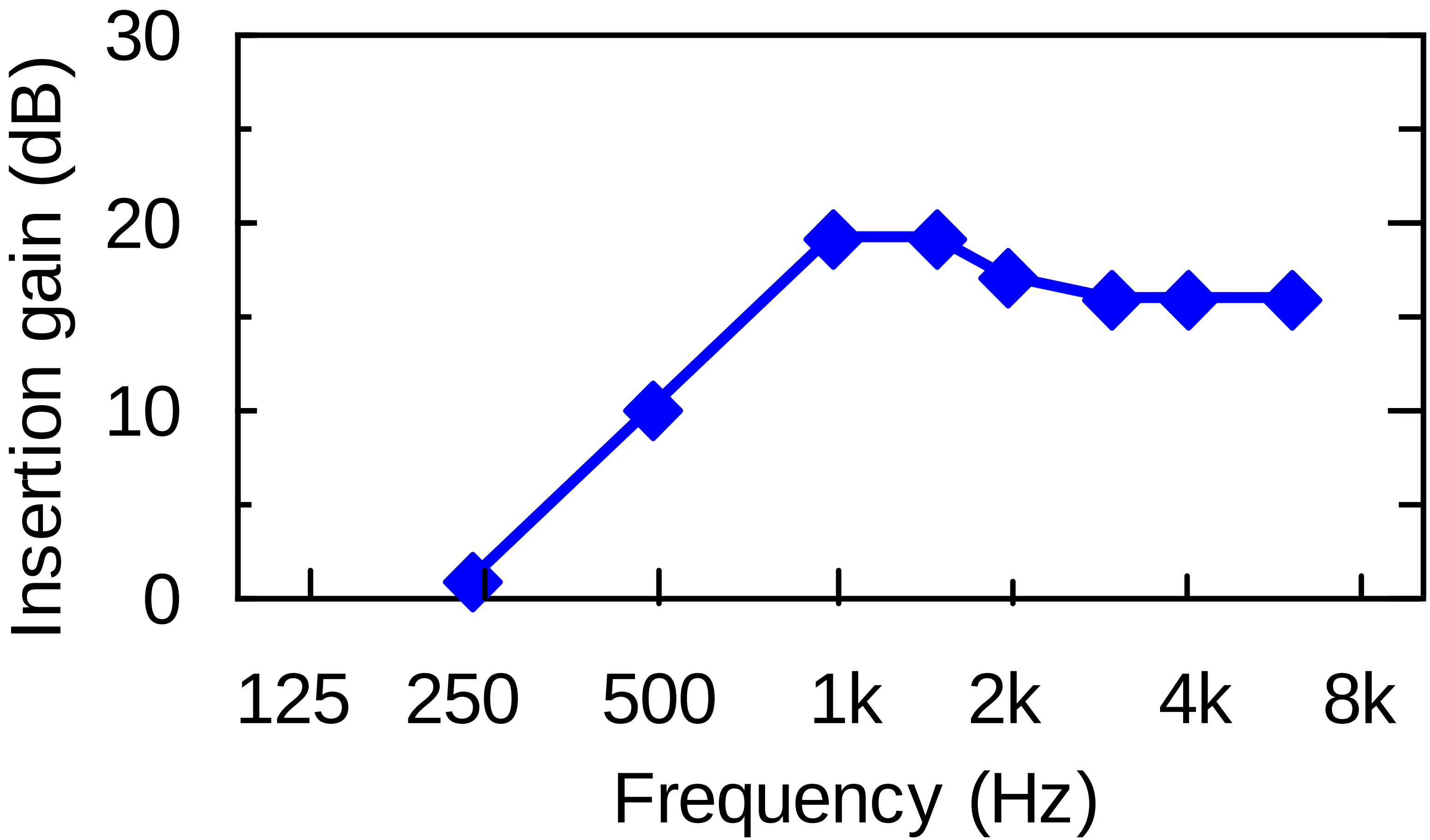

Figure 9.2 The insertion gain response prescribed by the NAL-R formula for a flat 40 dB hearing loss.

Source: Dillon (2001): *Hearing Aids*

- This prescription uses speech spectrum data.
- A standard speech spectrum has been developed within which speech at normal conversational levels is usually understood.
- The spectrum is represented as bands of hearing levels.
- Without amplification, these bands are between 35 and 70dB and vary somewhat among the different frequencies(200 Hz - 6000 Hz).
- With normal hearing, thresholds of hearing at the various frequencies are below or within the speech spectrum.

- The goal of fitting is to identify the hearing threshold at each of various frequencies, and then raise the speech spectrum bands which fall below the patient's threshold for hearing.

- The speech spectrum bands are elevated by amplifying the sound in those frequencies.

- In this way, as much of the speech spectrum as possible occurs above the person's thresholds.

- The **Desired Sensation Level (DSL)** formula aims to provide the aid user with an audible and comfortable signal in each frequency.
- It differs from NAL and POGO in at least three ways.
- First the target it prescribes is a real ear aided gain rather than a real ear insertion gain.

- Second, the DSL procedure has been well integrated with measurement methods that are convenient for use with young children and infants, without the use of average correction factors.

- Last, the DSL procedure does not attempt to make speech equally loud in each frequency region, the procedure specifies a desired sensation level.

- Some prescriptive procedures are computer assisted.
- Threshold data from several frequencies are entered into the computer, which converts the data from dB HL to dB SPL, and the required gain and frequency response are calculated.
- Some computer programs can also serve as data base systems to help find a particular model hearing aid that fits the prescription.

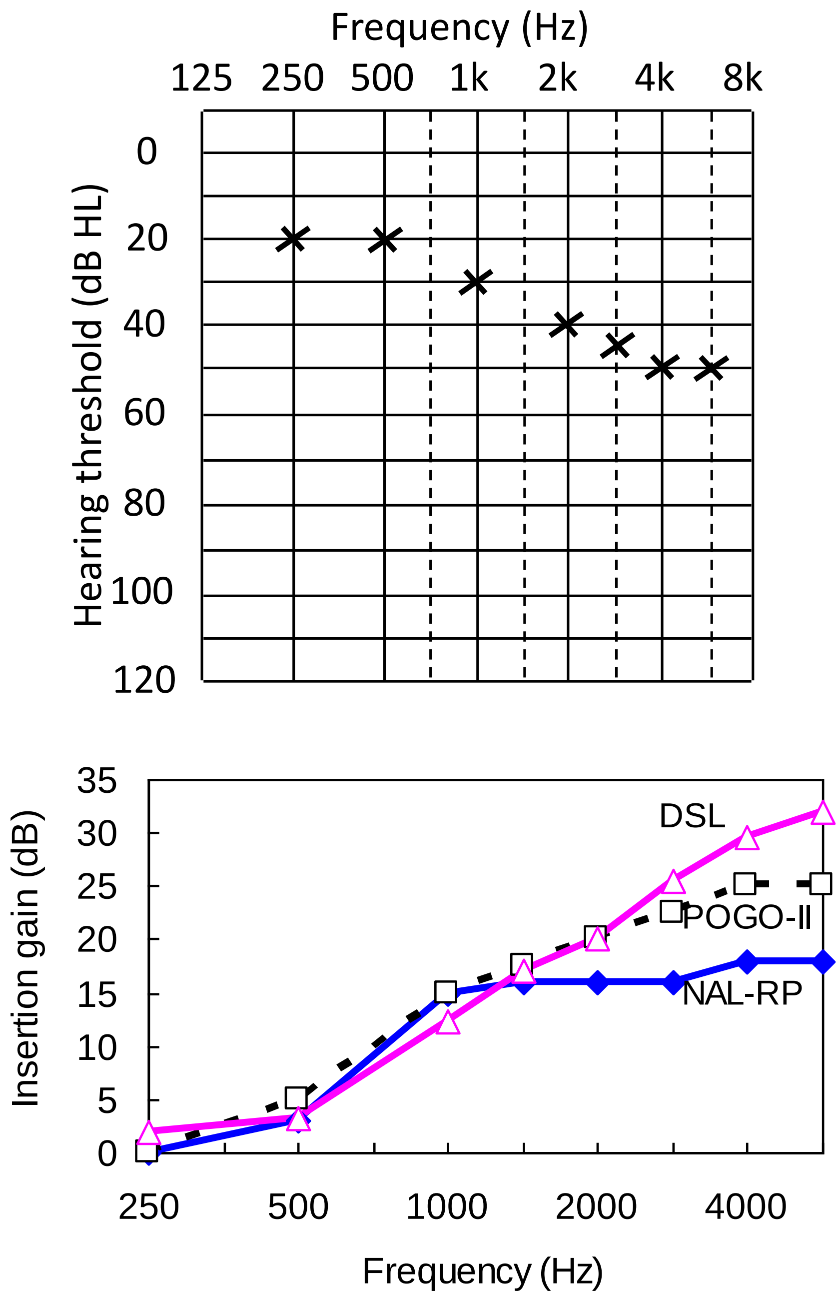

Figure 9.4 Audiogram of a mild, gently sloping sensorineural hearing loss, and insertion gains prescribed by the DSL (triangles), POGO-II (squares) and NAL-RP (diamonds) procedures.

Source: Dillon (2001): *Hearing Aids*

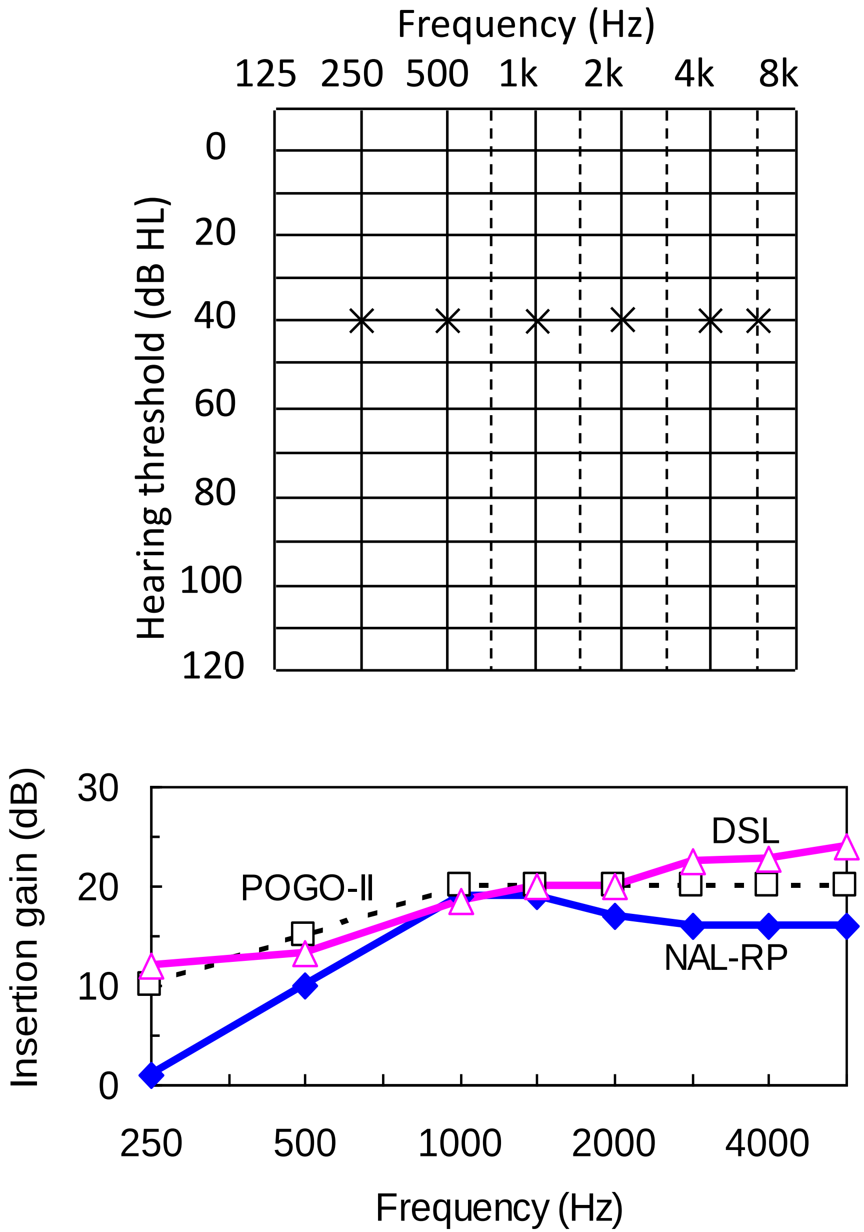

Figure 9.5 Same as Figure 9.4, but for a moderate, flat sensorineural hearing loss.

Source: Dillon (2001): *Hearing Aids*

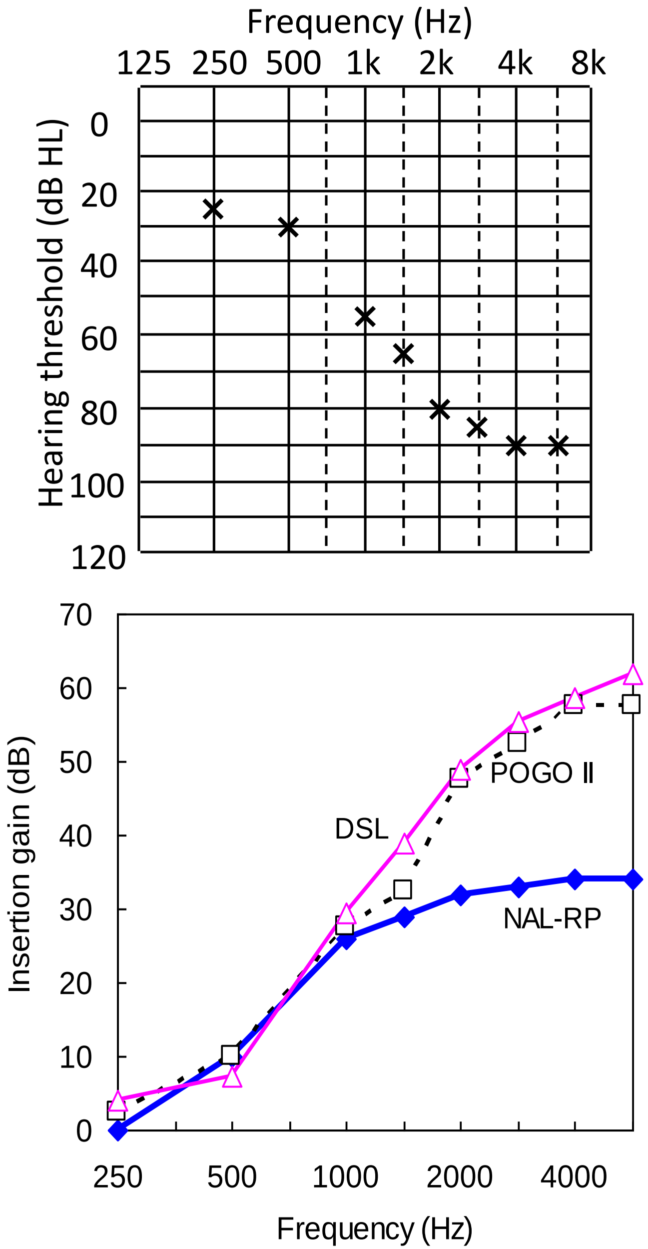

Figure 9.6 Same as Figure 9.4, but for a moderate, steeply sloping sensorineural hearing loss.

Source: Dillon (2001): *Hearing Aids*

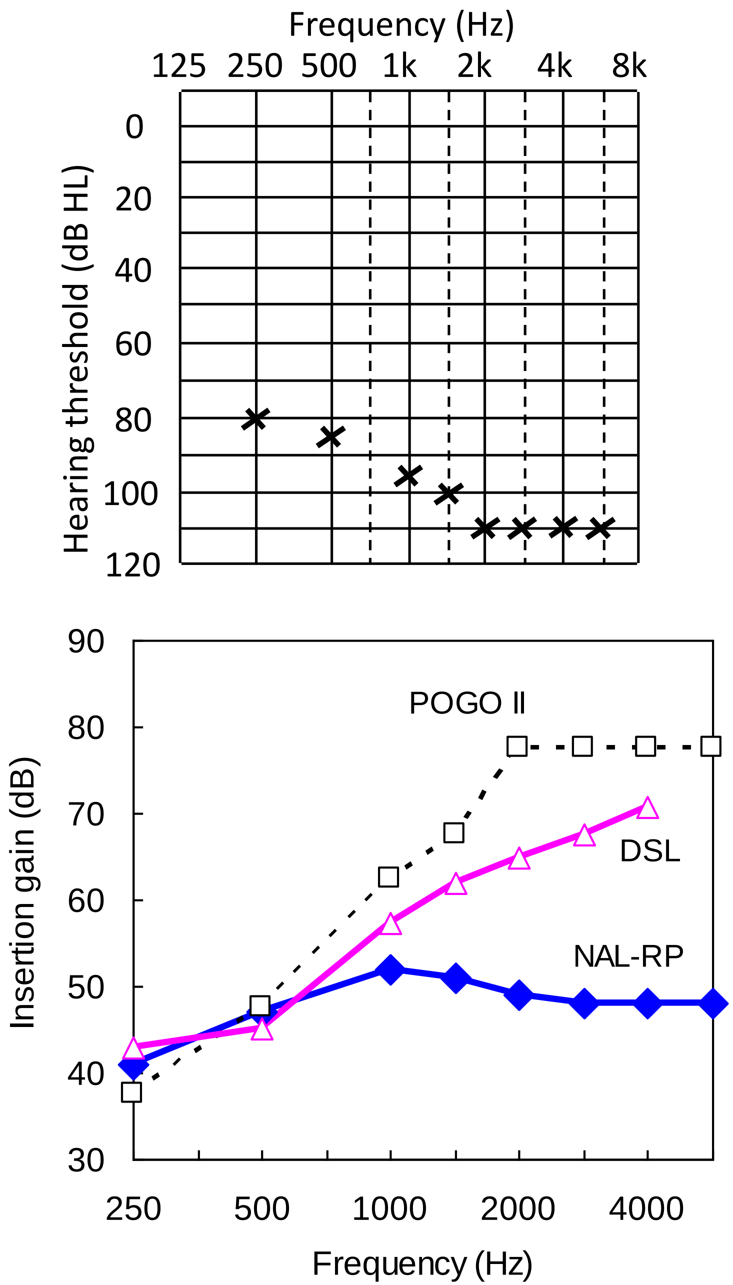

Figure 9.7 Same as Figure 9.4, but for a profound, gently sloping sensorineural hearing loss.

Source: Dillon (2001): *Hearing Aids*

- **Maximum Output:**
- Main goal is to avoid discomfort

- Guiding Principles:

- Set OSPL90 equal to or just below the UCL

- Set OSPL90 as high as possible without causing discomfort to avoid excessive saturation.

- The minimum acceptable OSPL90 is one that would not limit slightly loud speech (ie 75 dB SPL).

Loudness normalization

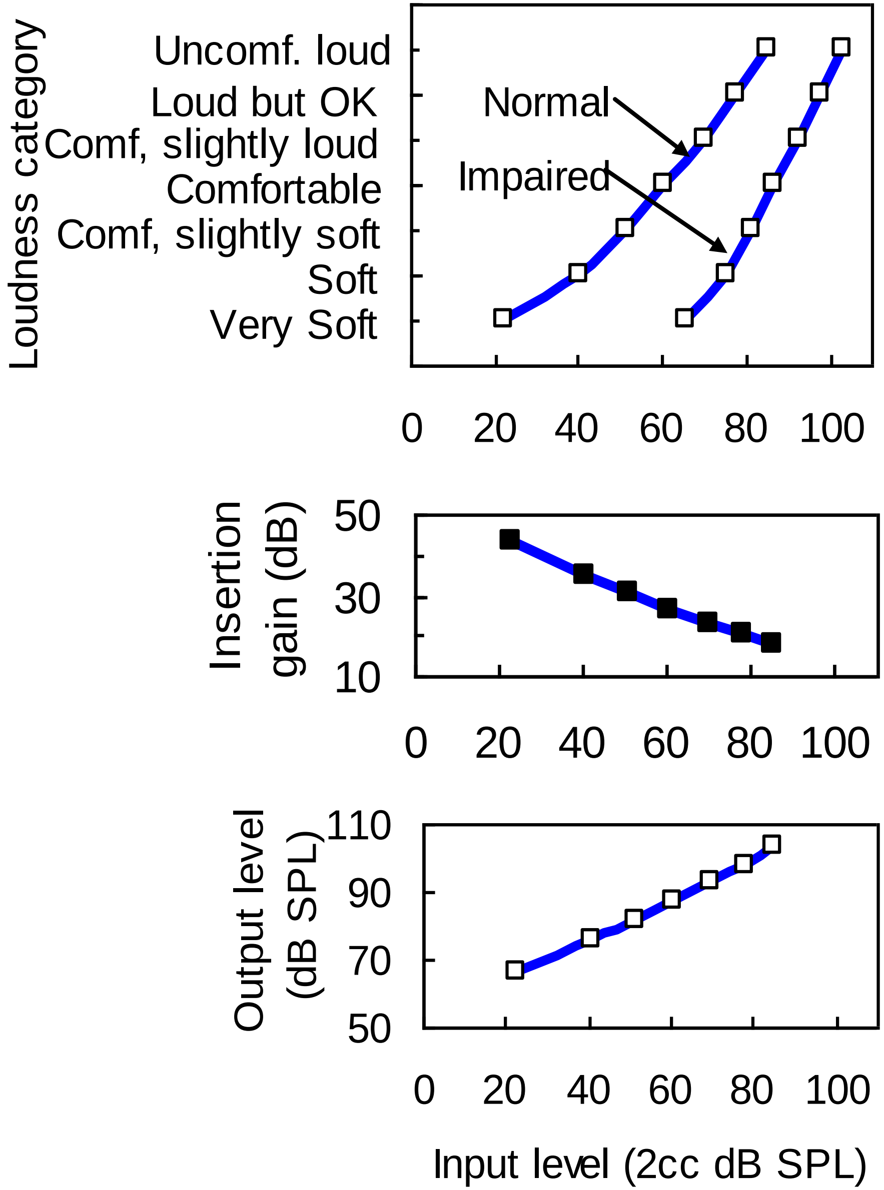

Figure 6.10 (a) Loudness growth curves for normal hearing people and a hearing impaired person with a 50 dB hearing loss. (b) Insertion gain needed for the impaired listener to receive a normal loudness sensation. (c) The corresponding I-O curve.

Source: Dillon (2001): *Hearing Aids*

- The phenomenon of binaural summation is considered one of the practical advantages of hearing with two ears.

Binaural Loudness Summation

Binaural Loudness Summation

Improvement in hearing threshold when compared to monaural hearing.

+3 dB at threshold

+6 dB at 50 dB HL

+9 dB at 90 dB HL

- But, what about asymmectrical ears? Can they produce loudness summation?
- It has been demonstrated that binaural summation of speech in noise can occur even when the signal levels at the two ears differ as much as 25-30 dB

- Binaural summation is an advantage when fitting hearing aids because less gain is required in each ear to achieve the same loudness.
- With less gain, target gains are reached more easily, generally resulting in less opportunity for acoustic feedback.
- Consequently, most hearing aid prescription formulae automatically decrease gain by about 3 dB if the fitting is to be binaural.
- However, suprathreshold binaural summation is even greater than binaural summation at threshold, and hearing aids are fitted at suprathreshold, not threshold levels.

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