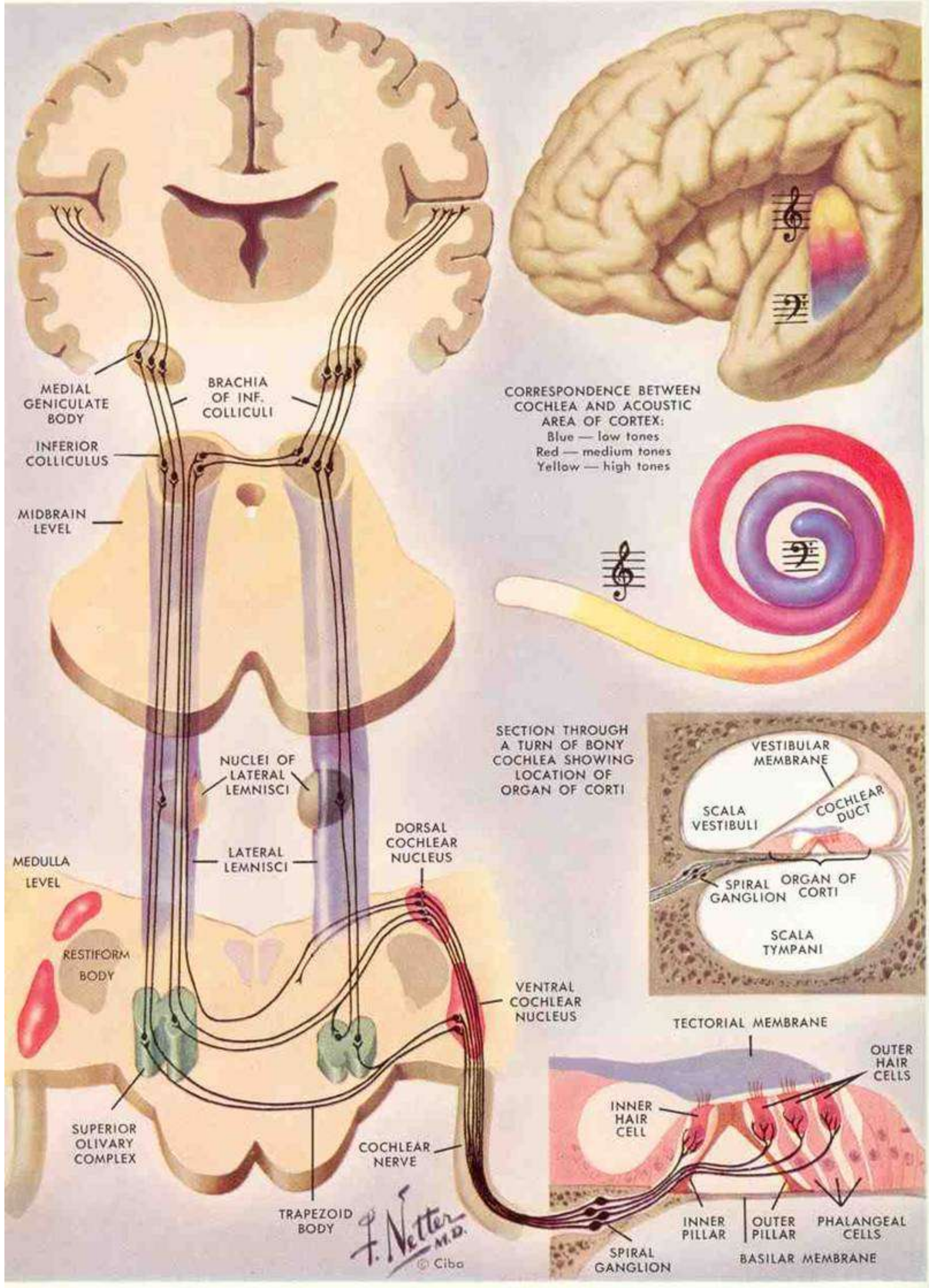
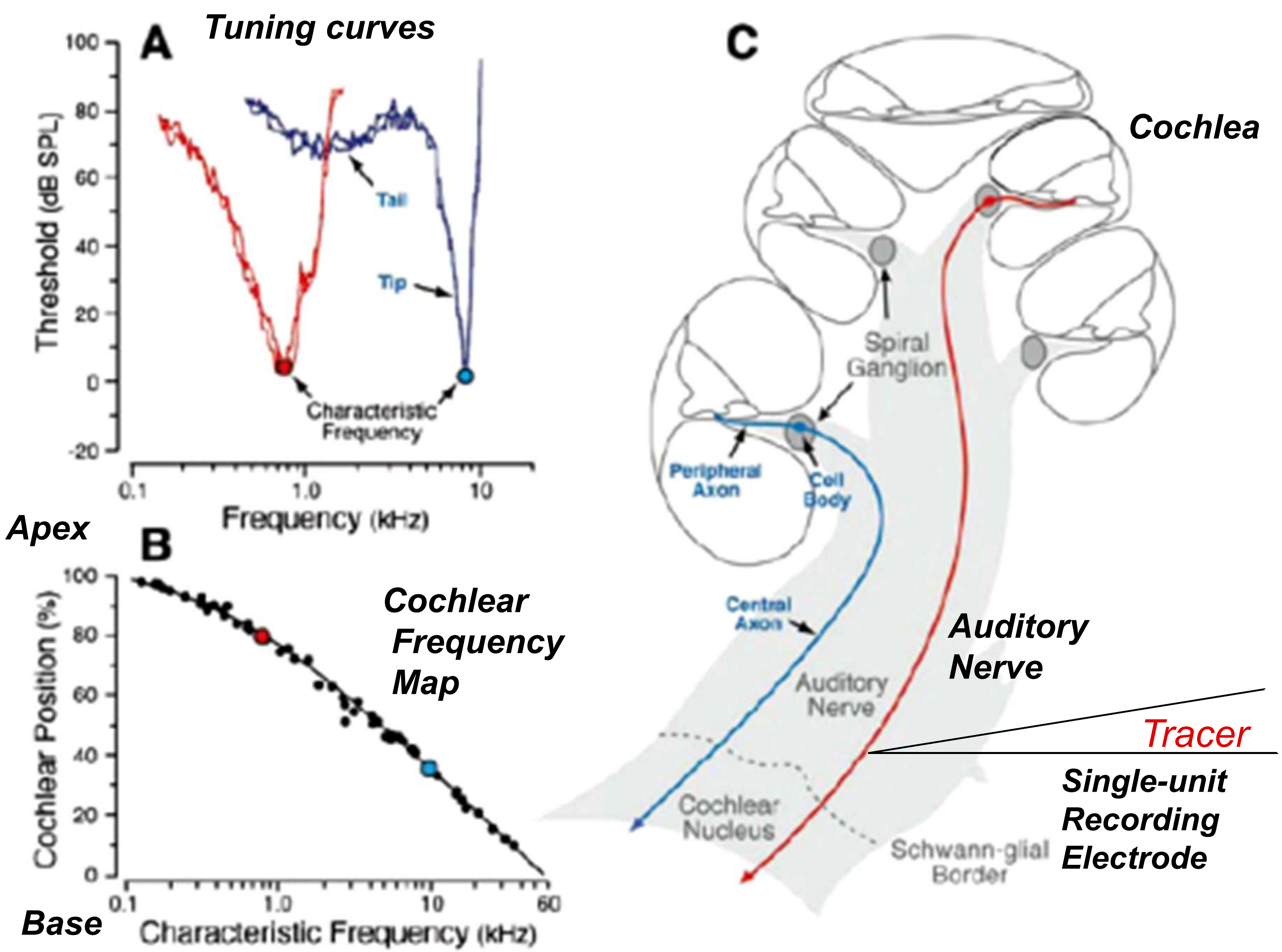
AUDL 4007 & GS12 Auditory Perception

Psychoacoustic reflections of frequency selectivity

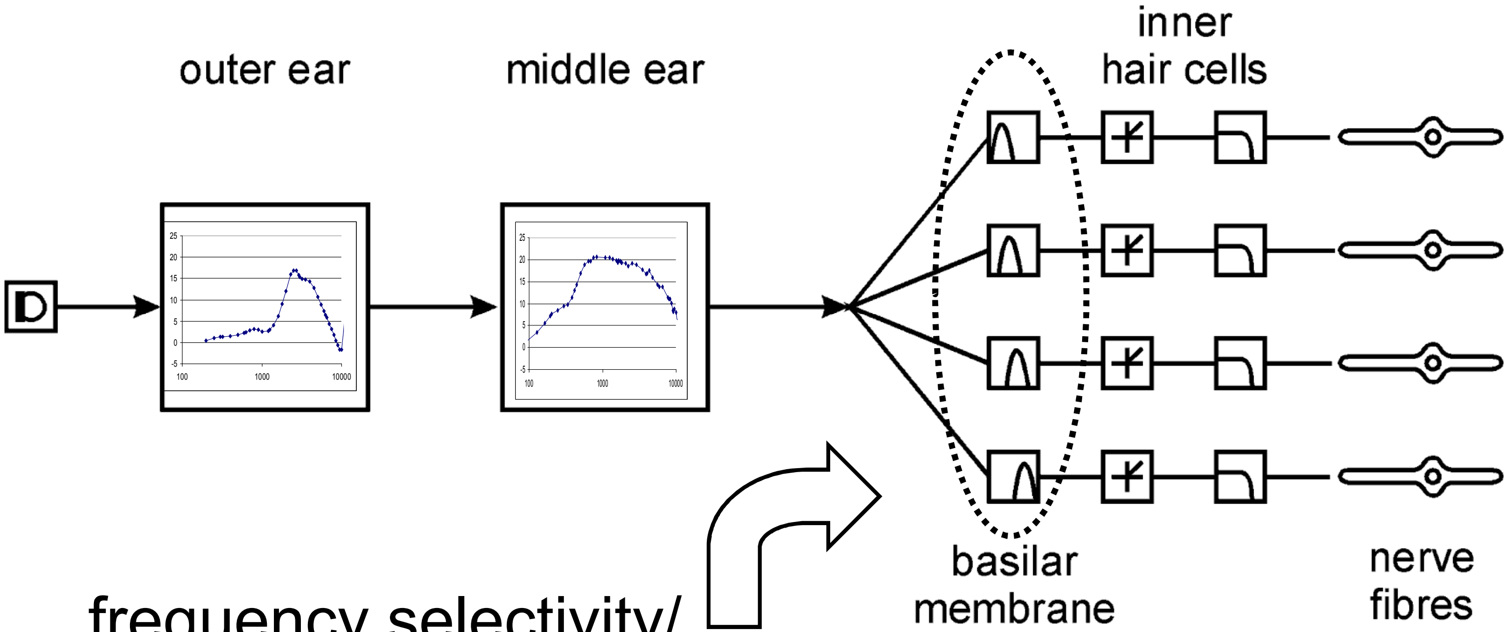


Auditory Nerve Structure and Function



Liberman (1982)

The auditory periphery as a signal processor

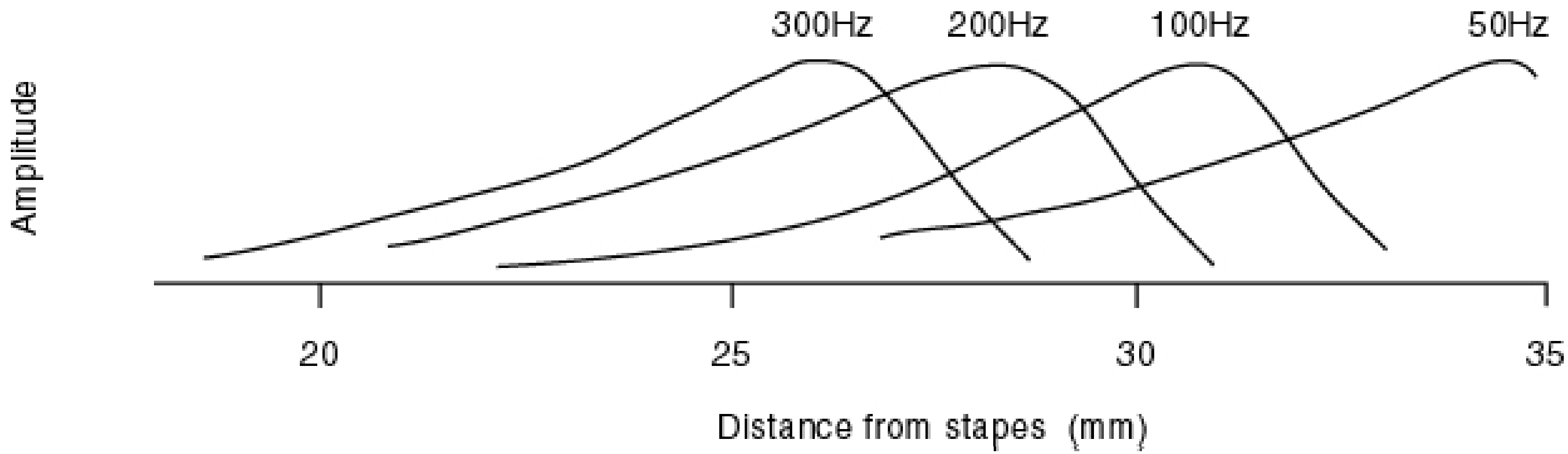


frequency selectivity/
frequency analysis

auditory filters & channels

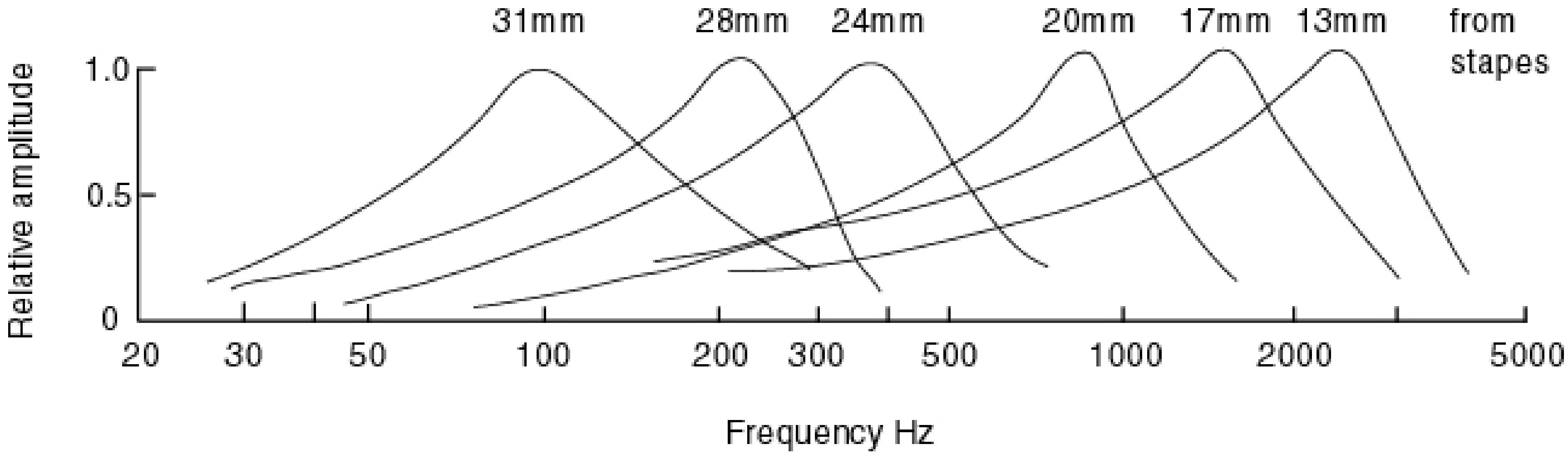
A crucial distinction
excitation pattern vs. *frequency response*

- Excitation pattern — the amount of vibration across the basilar membrane to a single sound.
  - Input = 1 sound.
  - Measure at many places along the BM.
- Essentially the envelope of the travelling wave
- Related to a *spectrum* (amplitude by frequency).



A crucial distinction
excitation pattern vs. *frequency response*

- Frequency response — the amount of vibration shown by a particular place on the BM to sinusoids of varying frequency.
  - Input = many sinusoids.
  - Measure at a single place on the BM.
  - Band-pass filters at each position along the basilar membrane.



Masking experiments

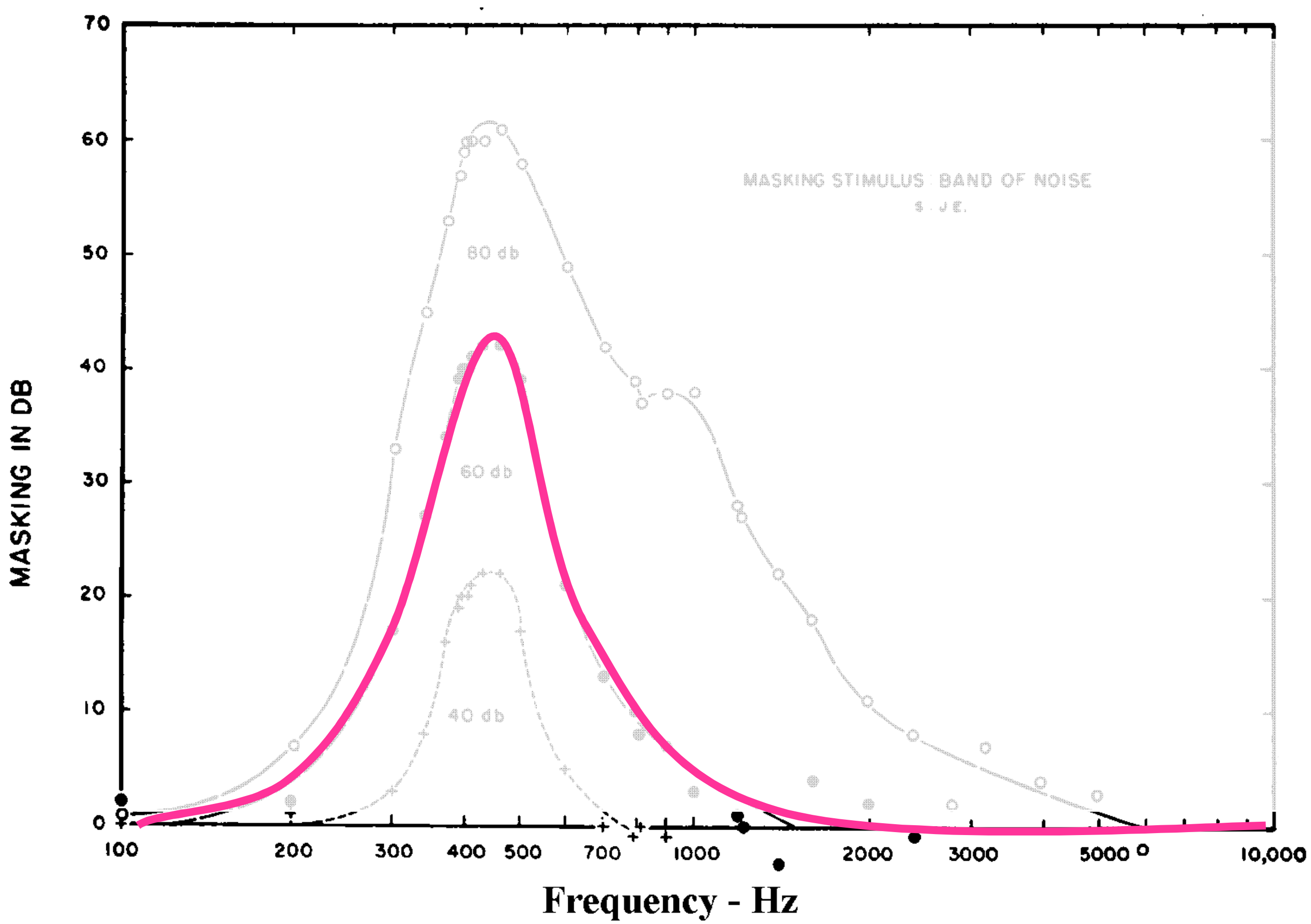
- Listen for a probe (typically a sinusoid) in a background of a masker with a variety of spectral shapes (typically a noise).
- Assume: A listener has independent access to, and can ‘listen’ selectively to the output of an individual auditory filter – the one that will give best performance.
  - *the probe frequency controls the centre frequency of the auditory filter that is attended to*
- Assume: Only noise that passes through the same filter as the sinusoid can mask it.
- Assume: Only the ‘place’ principle applies — no temporal information.
- The *power spectrum model of masking*

The frequency specificity of masking

- Listen for a set of three pulsing tones (the *signal* or *probe*).
- These will alternate with masking noises that occur twice each, and change through the series.
- If two masking noises in a row sound identical, then you can’t hear the probe tone — it has been *masked.*
- When is the tone masked, and when not?

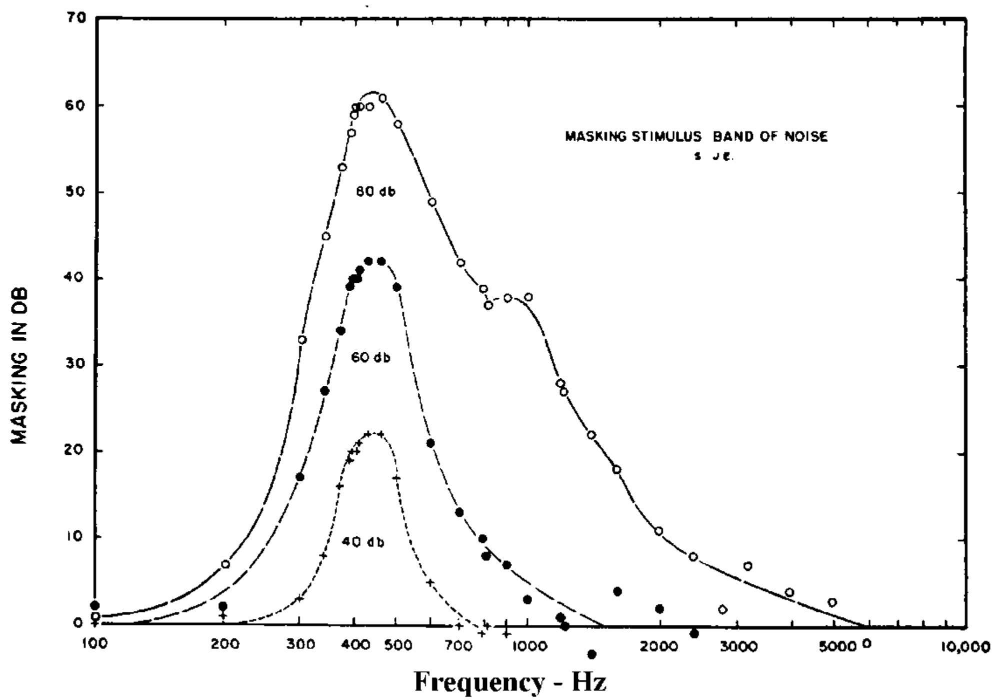
The masked audiogram

For a fixed narrow-band masker, determine the change in threshold for sinusoidal probes at a wide variety of frequencies.

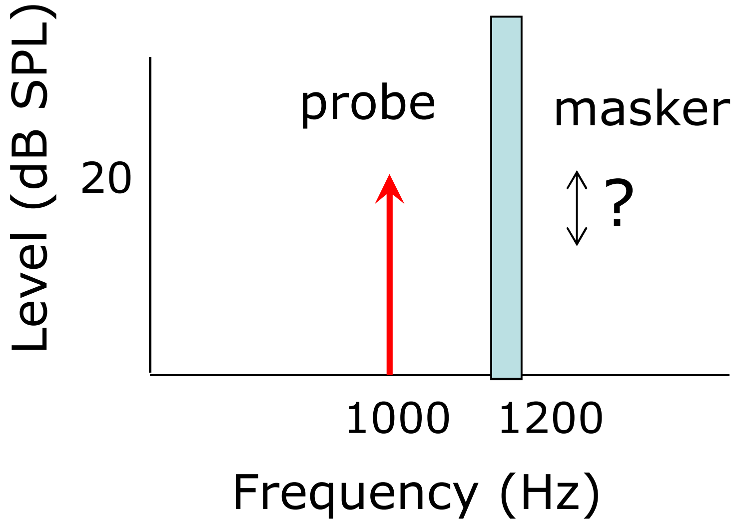


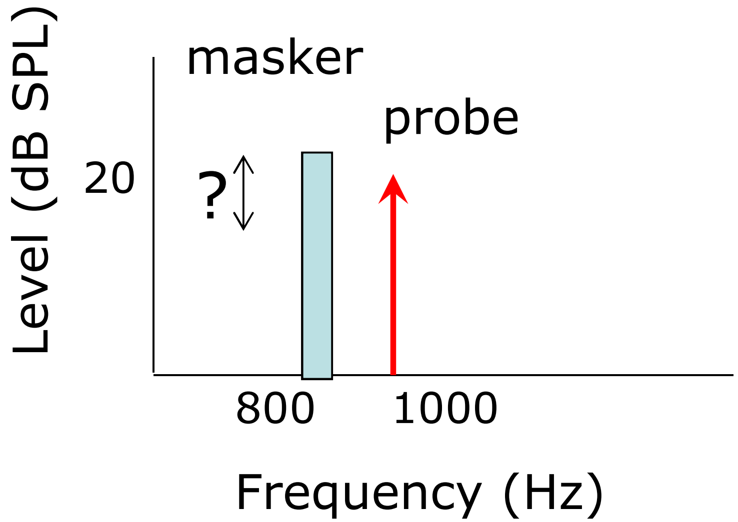
The masked audiogram

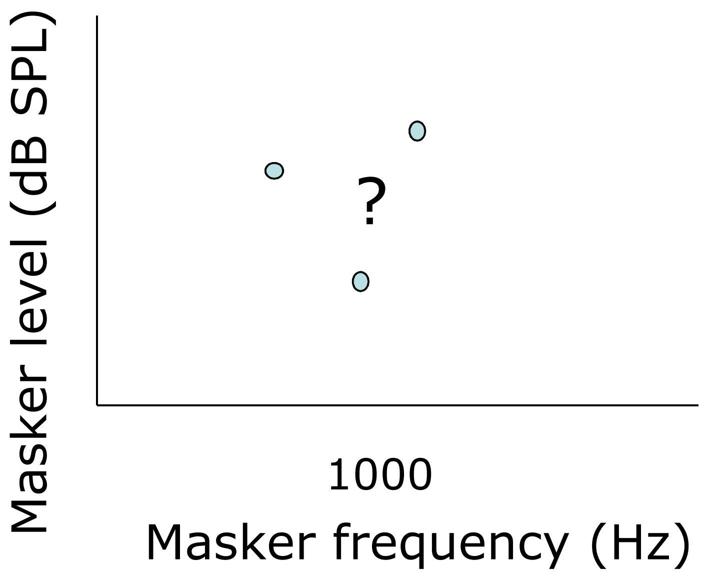
Is a masked audiogram a correlate of an excitation pattern (something like a spectrum) or a tuning curve (something like a frequency response)?



Psychophysical tuning curves (PTCs)

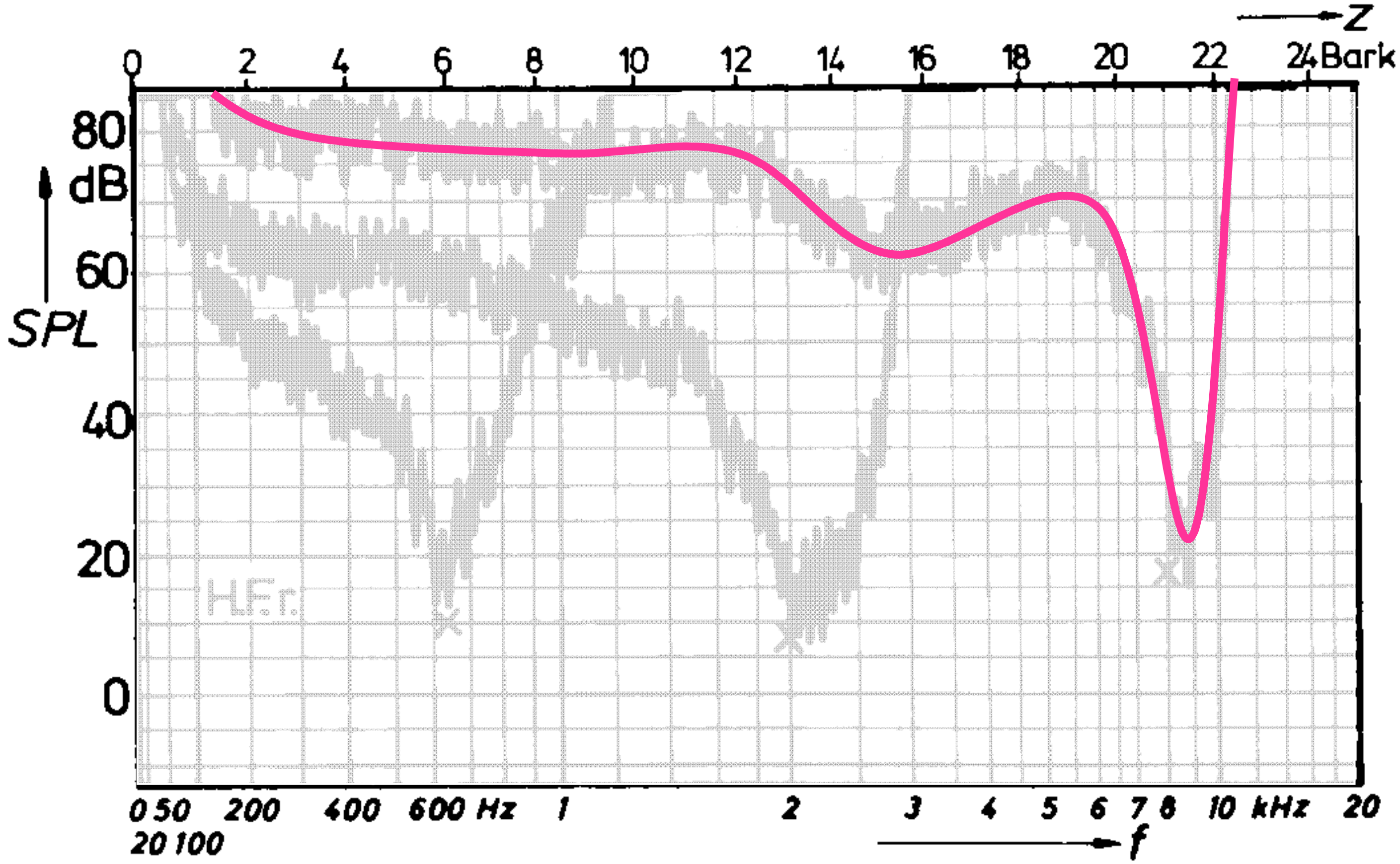




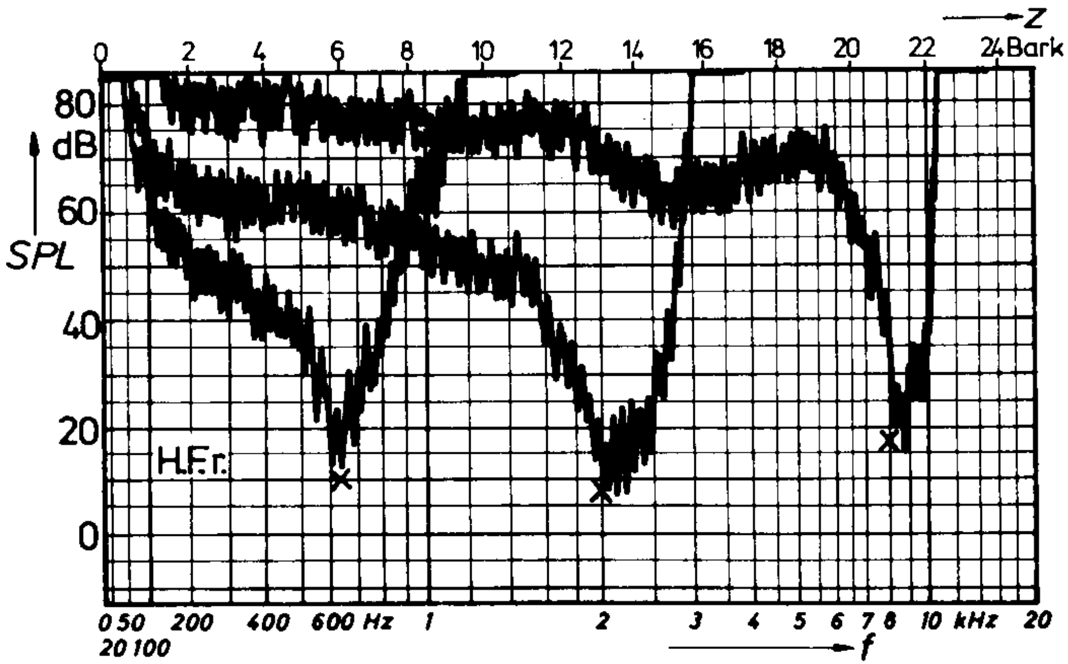


Psychophysical tuning curves (PTCs)

Determine the minimum level of a narrow-band masker at a wide variety of frequencies that will just mask a fixed ***low-level*** *sinusoidal probe.*



Psychophysical tuning curves (PTCs)



Is a psychophysical tuning curve a correlate of an excitation pattern (something like a spectrum) or a tuning curve (something like a frequency response)?

Why you can't easily interpret PTCs at higher levels: Off-frequency/ place listening

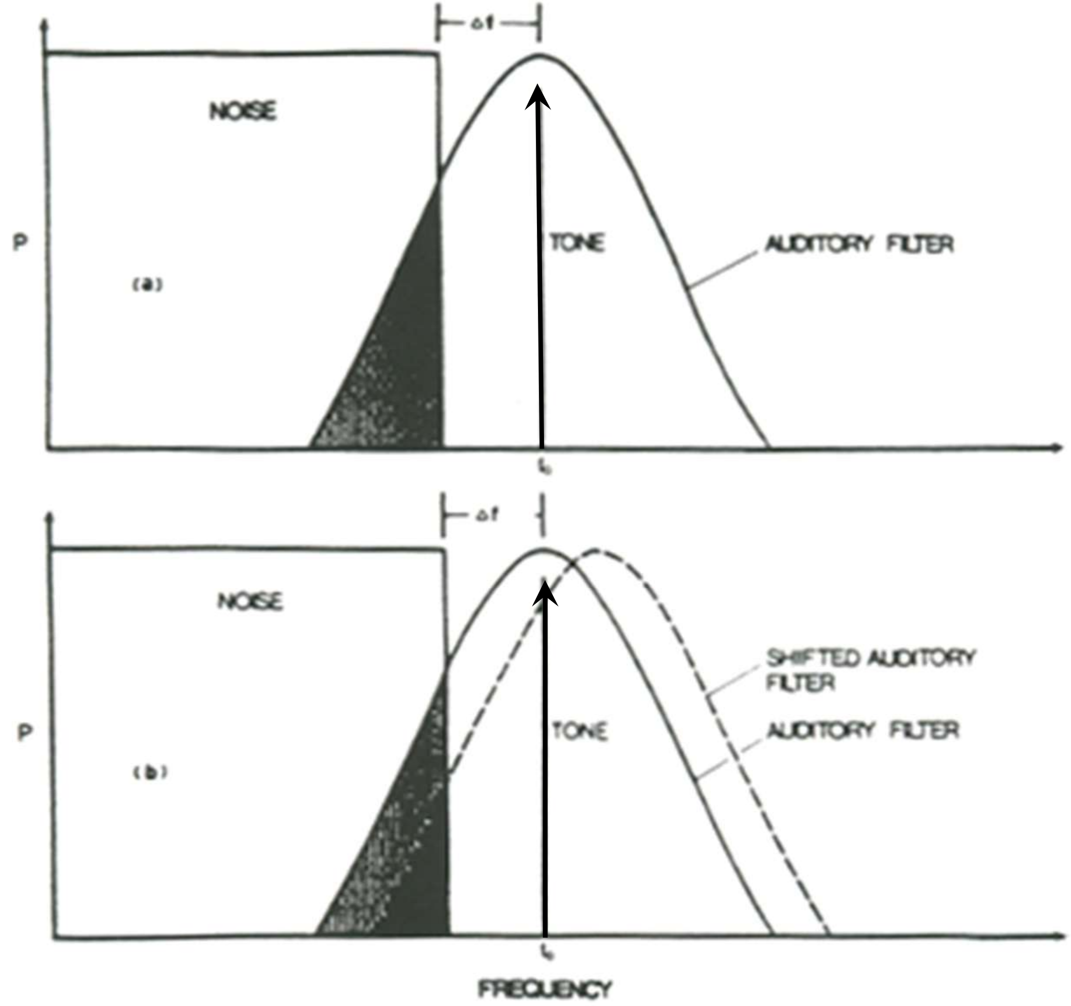
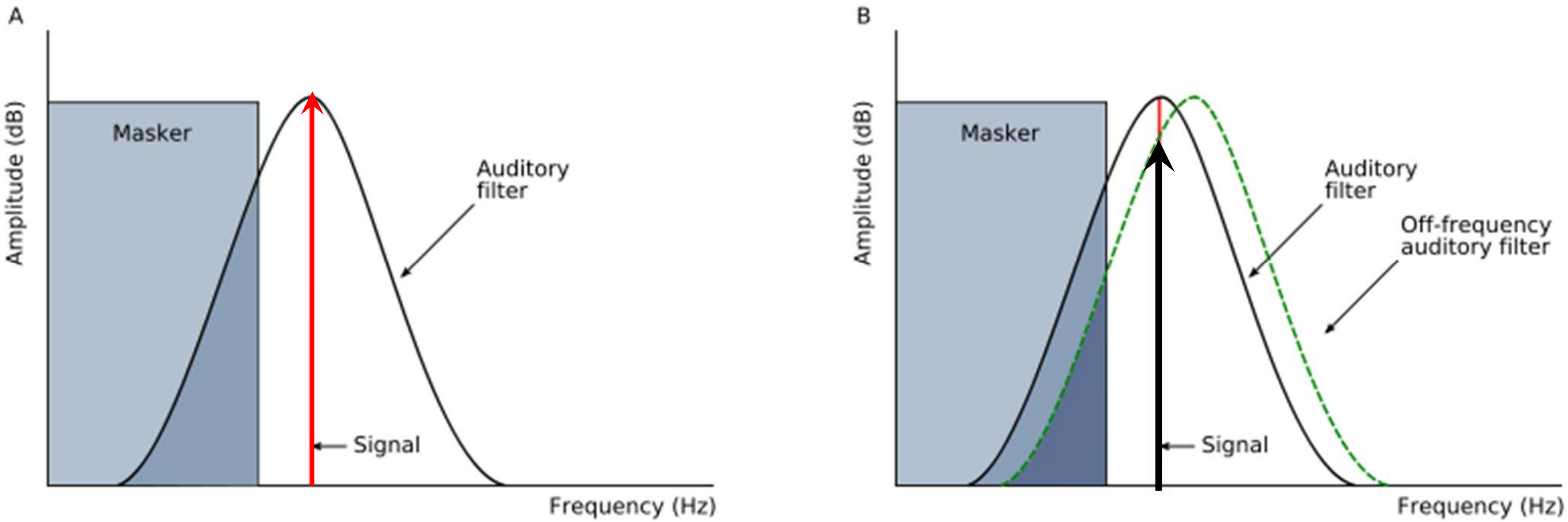


Figure 10.8 In both graphs, the solid curve represents the auditory filter centered at the test tone and the square at the left portrays a lower frequency masking noise. Off-frequency listening occurs when the subject shifts to another auditory filter (indicated by the dashed curve in graph *b*) in order to detect the presence of a test signal. (Adapted from Patterson [33], with permission of *J. Acoust. Soc. Am.*)

From Gelfand (1998)

PTCs at high levels do not involve only a single auditory filter: Off-frequency [*off-place*] listening



lower probe level out of the filter can be offset by even lower masker level

Notch (*band stop*) noises limit off-place listening

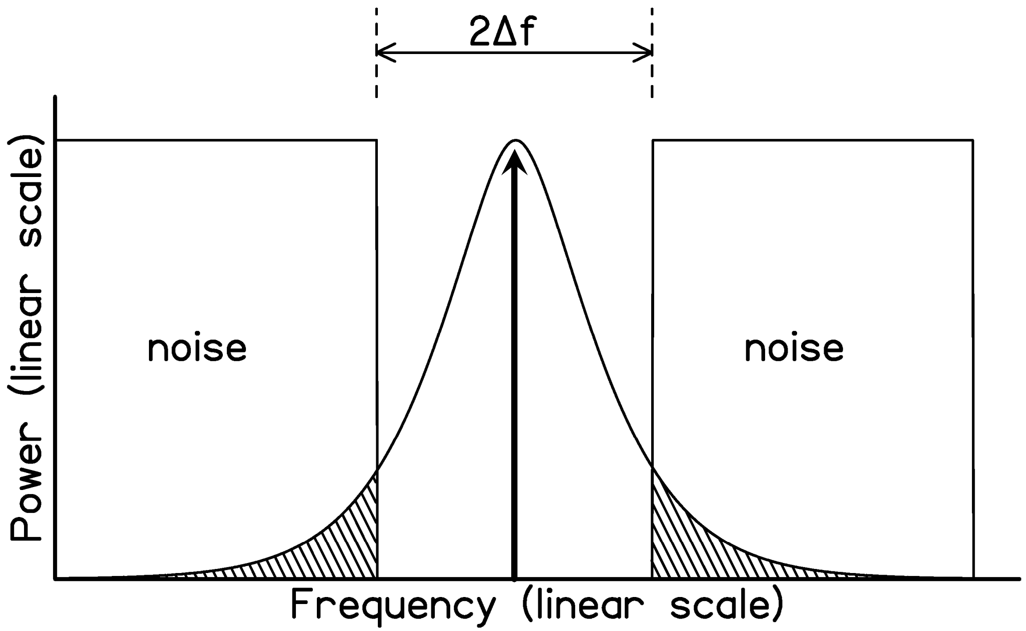
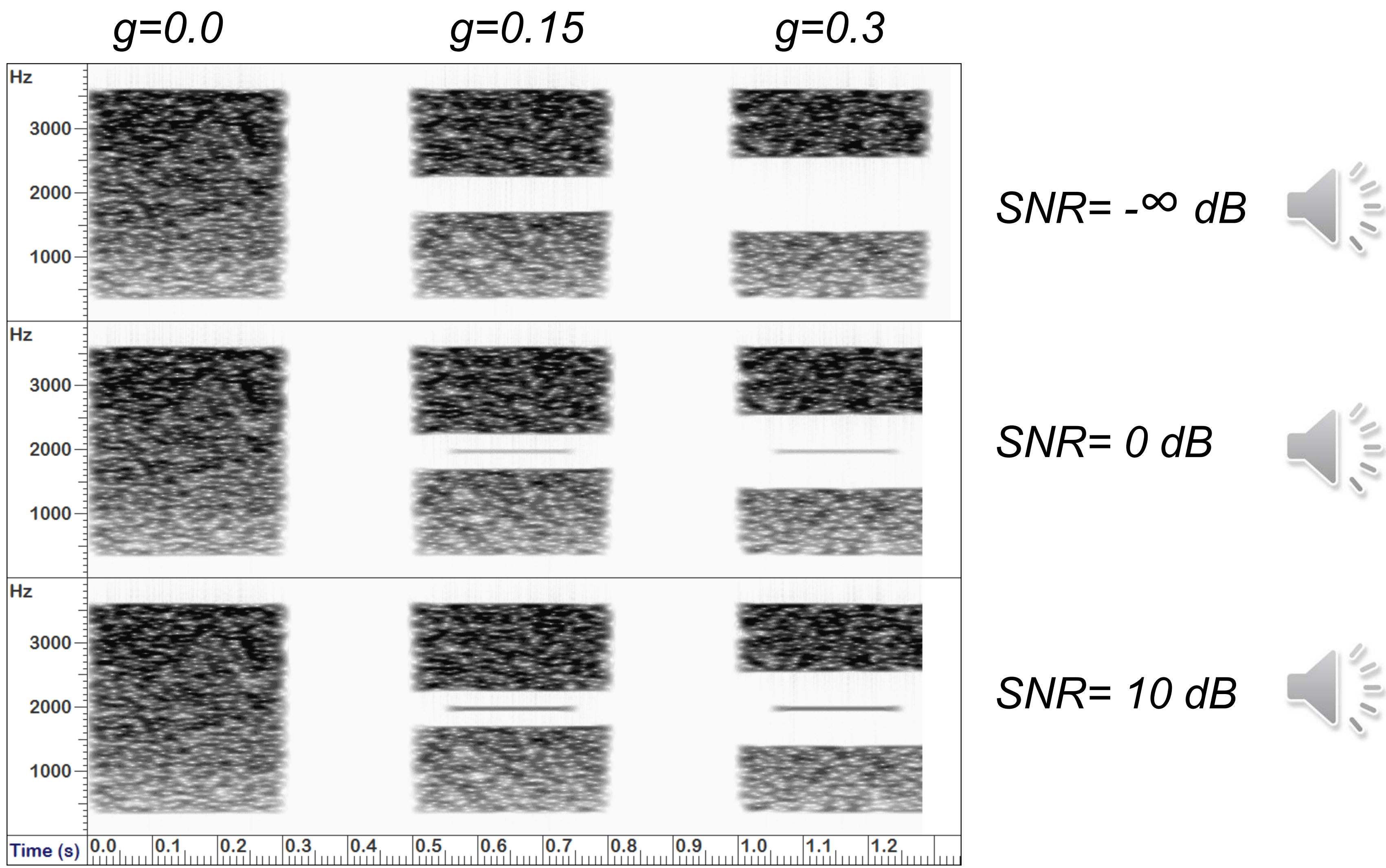


FIG. 3.6 Schematic illustration of the technique used by Patterson (1976) to determine the shape of the auditory filter. The threshold of the sinusoidal signal is measured as a function of the width of a spectral notch in the noise masker. The amount of noise passing through the auditory filter centred at the signal frequency is proportional to the shaded areas.

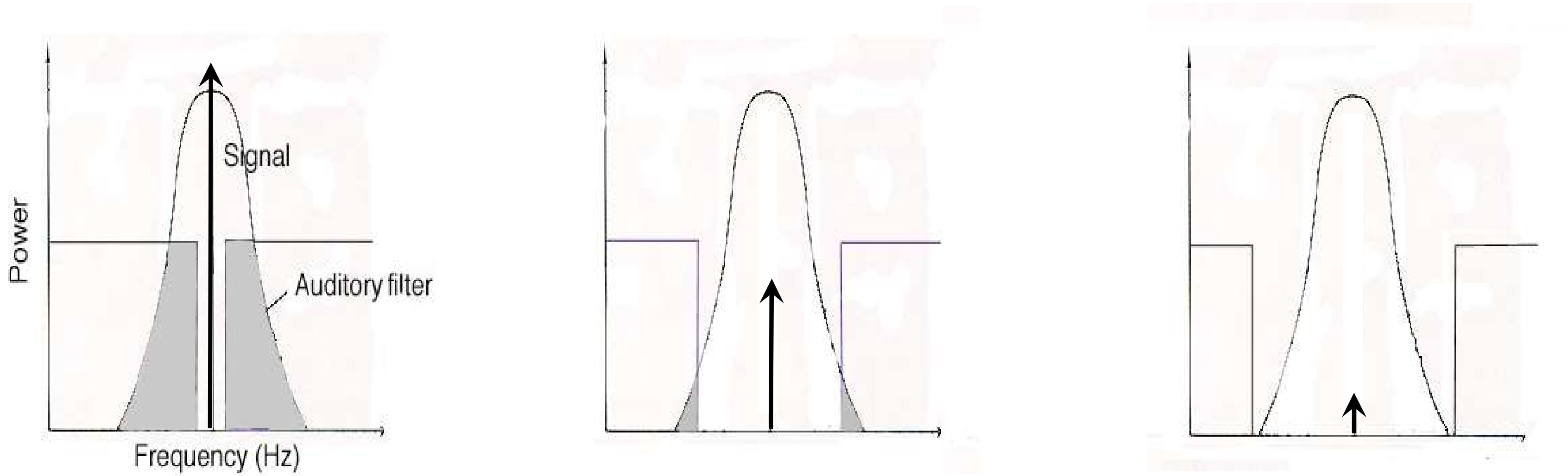
From Moore (1997)

Notched noises

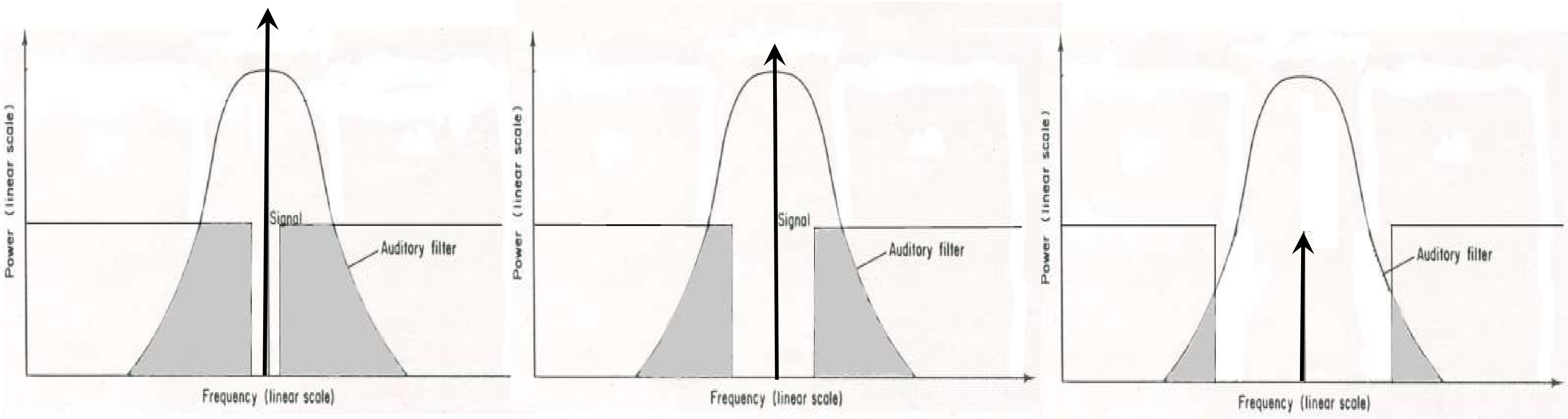


Narrow vs broad filters

Narrow filter

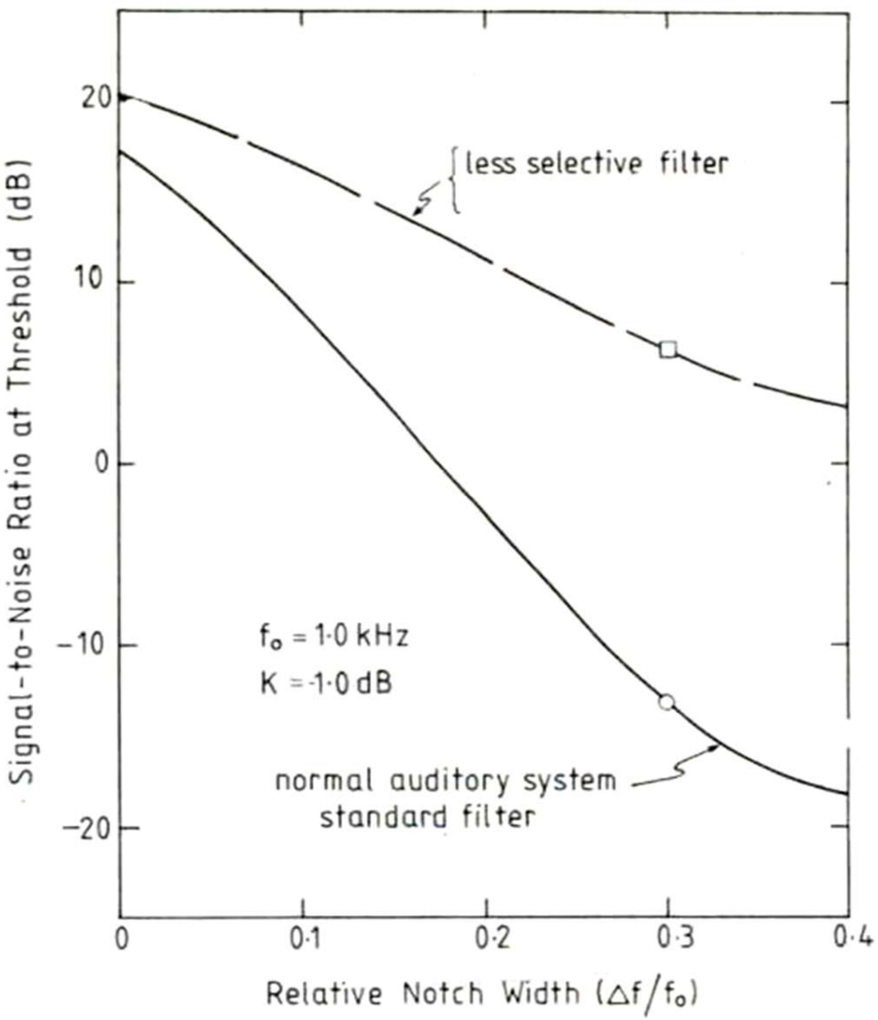


Broad filter



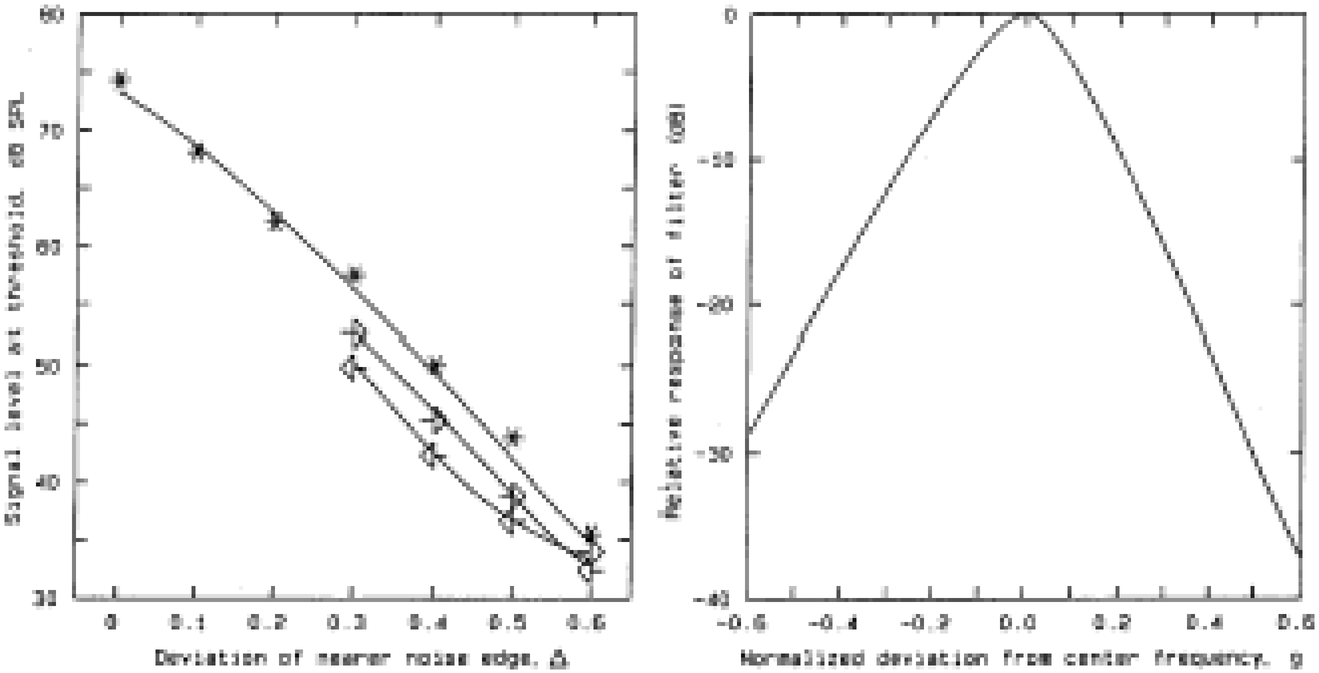
Notch gets wider ⟶

Thresholds at different notch widths

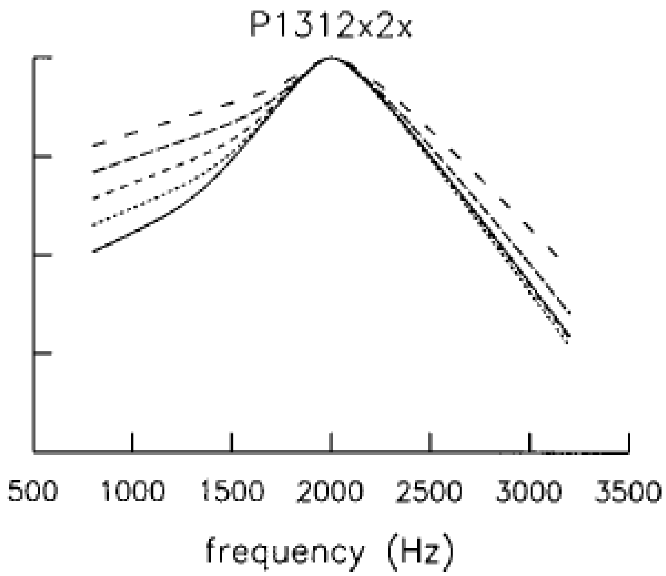


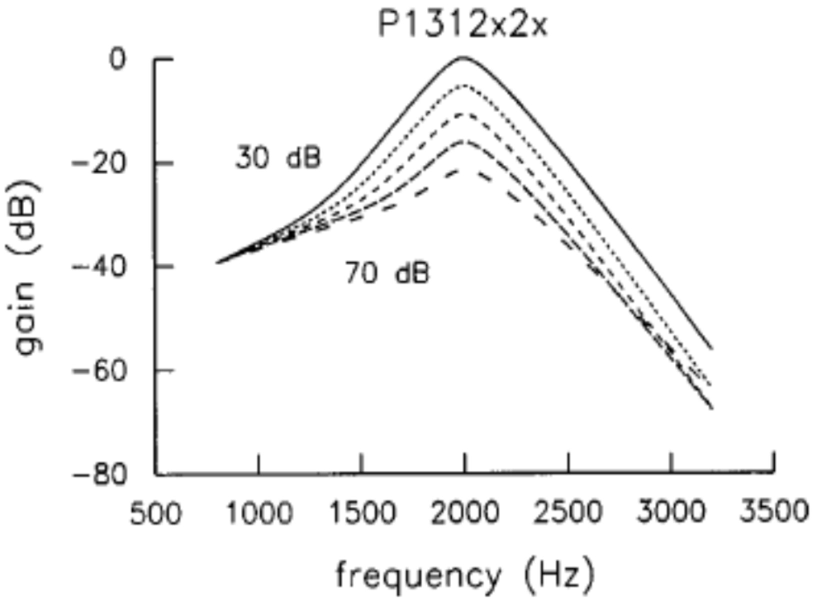
From Patterson et al. (1982)

Typical results at one level, and a fitted auditory filter shape (symmetric & asymmetric notches)

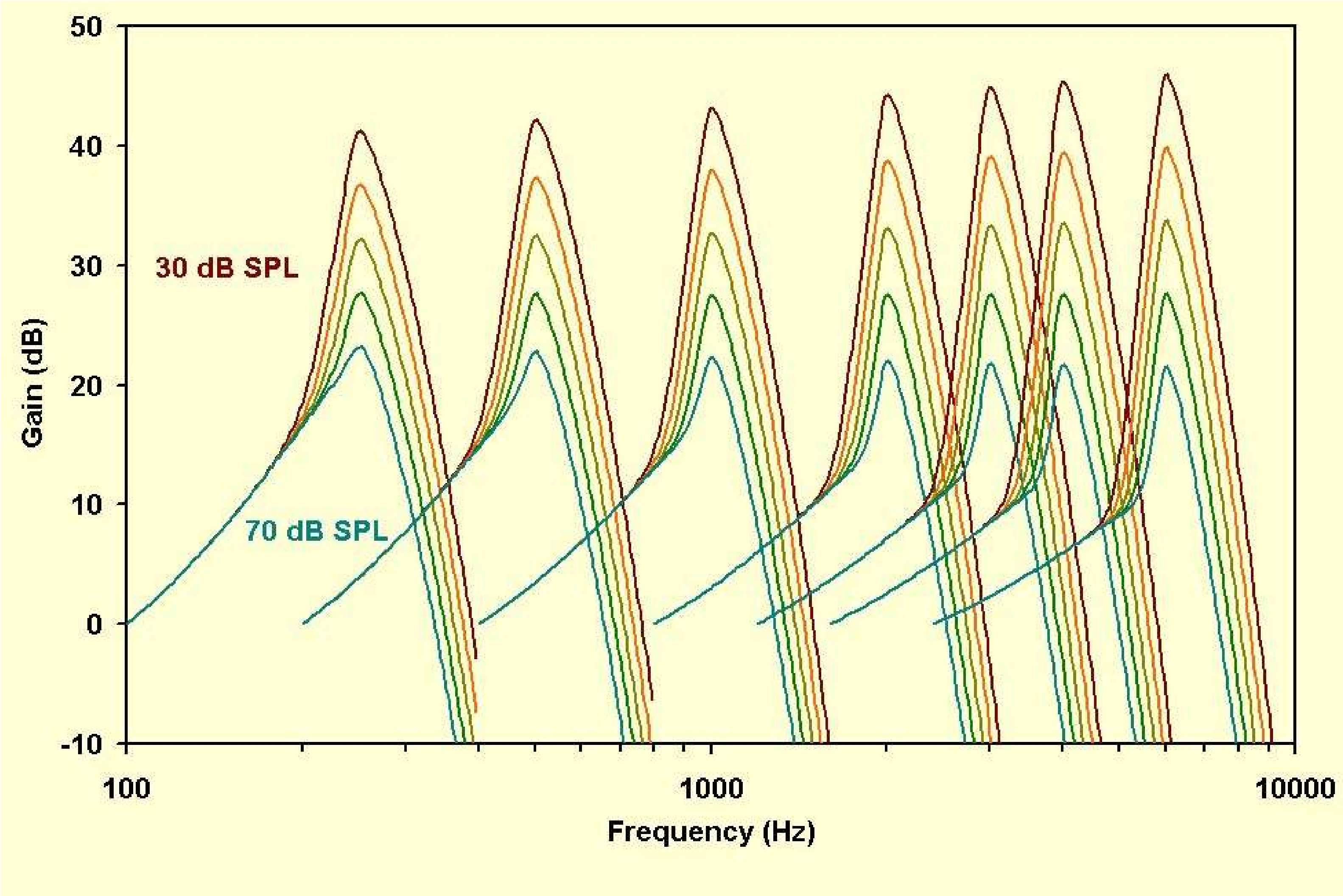


Now measure across level and assume filter linearity at frequencies substantially lower than CF

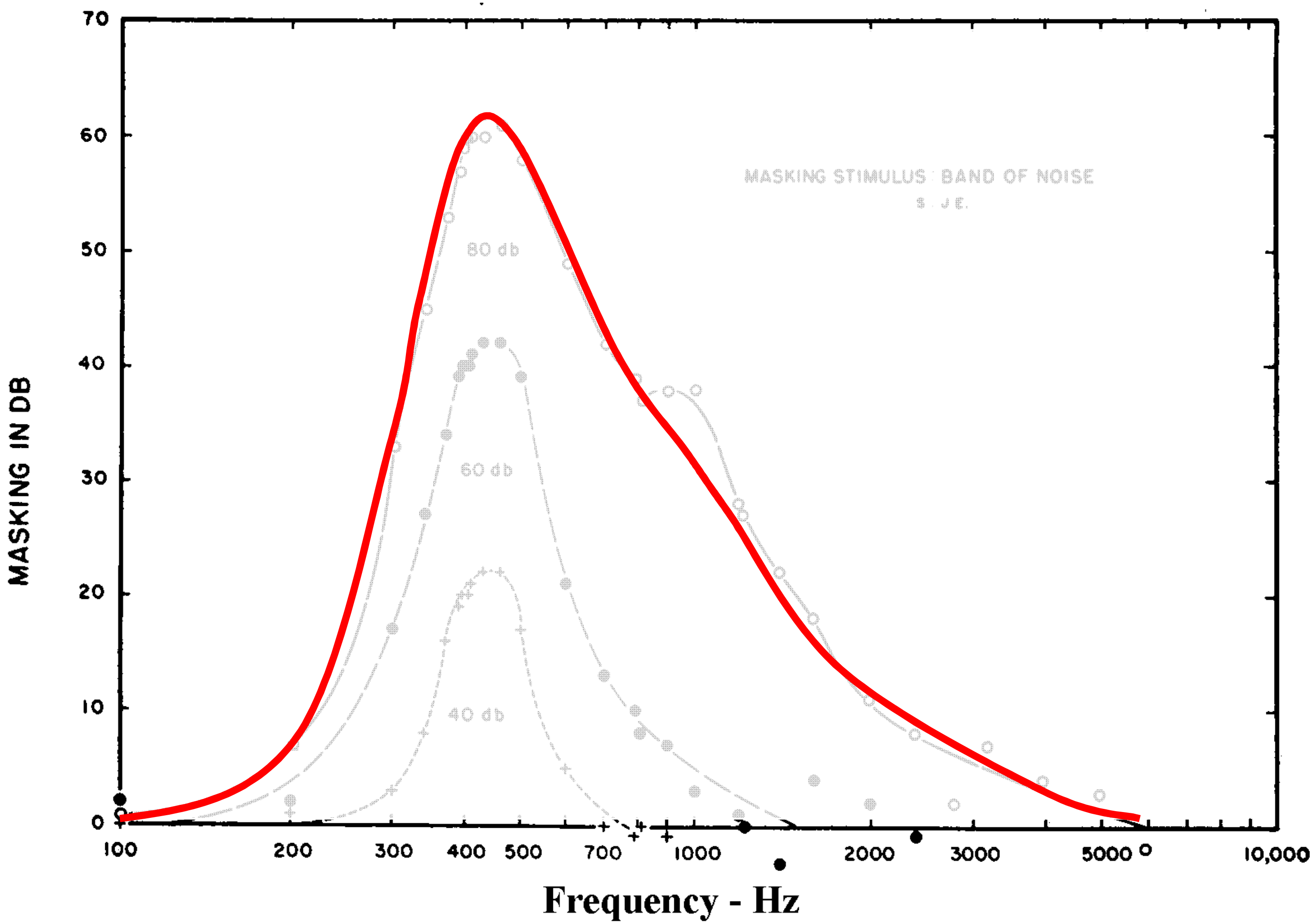




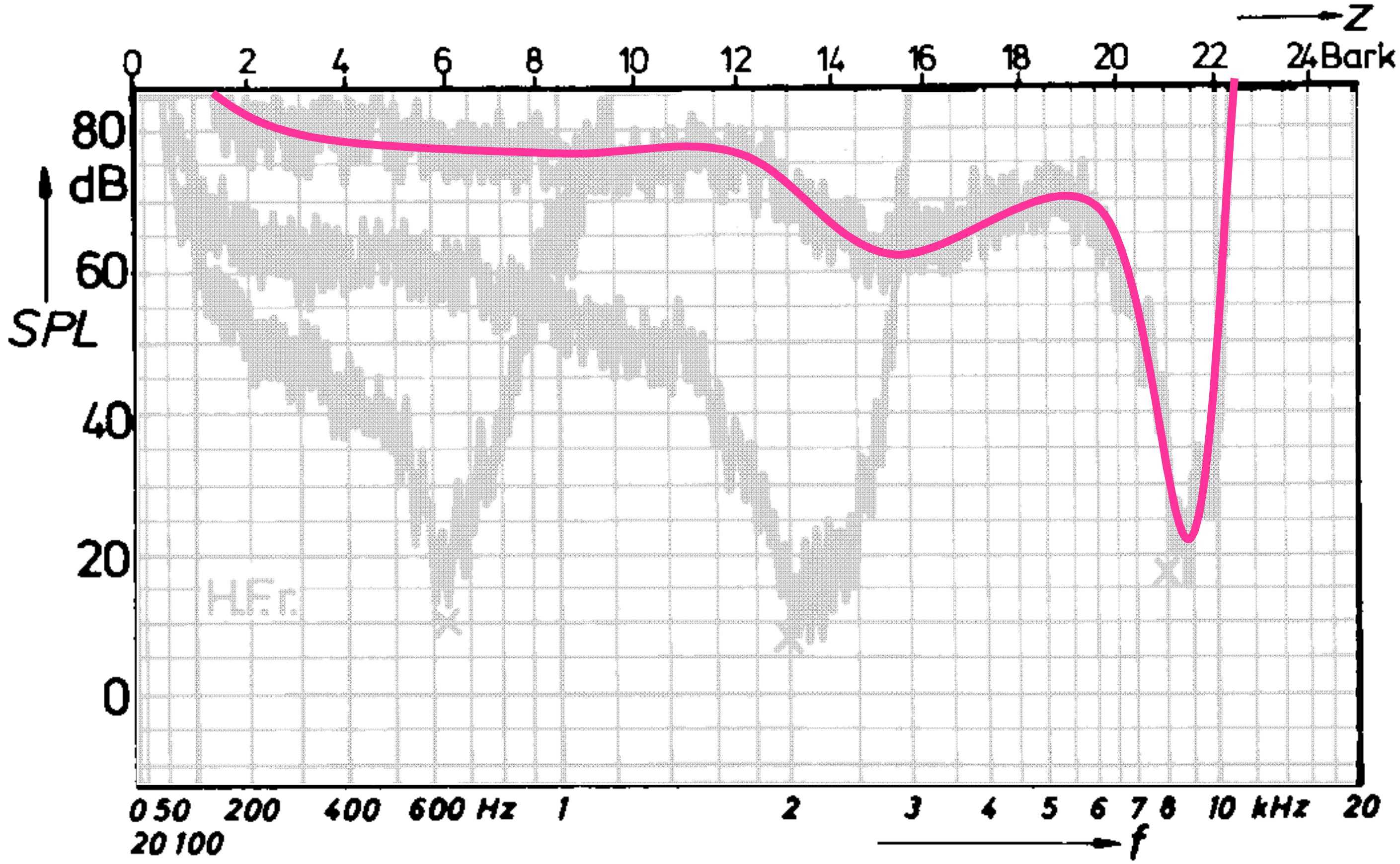
Auditory filter shapes across level & frequency: Note the asymmetry



Low masks high, but not v.v.
Excitation patterns



Low masks high, but not v.v.
Frequency responses



Main points

- The “filters” through which we listen are the filters established in the inner ear, in SNHL as well as normal hearing.
  - supported by the similarity between physiological & behavioural measurements

- The width of the auditory filter is an important determinant in many aspects of auditory perception, e.g. …
  - how well we can hear sounds in noise (which is almost always).
  - how different spectral components contribute to loudness
  - whether phase changes are audible in sounds

Main points

- Spectral components that go into one auditory filter strongly interact …
  - whereas those that go into different filters typically influence one another less
- Another terminology
  - Sounds that fall into one auditory filter are often said to fall into the same ***critical band***
- People will use whatever information is available to them, even when the task is as trivial as detecting a tone.