MEASUREMENT OF AUDITORY RESOLUTION AND ITS APPLICATION TO AMPLIFICATION SELECTION (F02-PS24)

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INTRODUCTION

When we measure the extent to which amplification improves the ability of hearing-impaired persons to understand speech, it is common to observe substantial between-subject differences, even for individuals with similar pure tone thresholds, especially if speech intelligibility is measured in the presence of a competing noise. Some investigators have hypothesized that these between-subject differences in benefit may be related to differences in the frequency and/or temporal analysis abilities of the individuals' auditory systems.

One factor that complicates the evaluation of any relationship between hearing aid benefit and resolution abilities is the effect of stimulus level. Both frequency and temporal resolution are known to vary with stimulus level in normal-hearing listeners and it is reasonable to suggest that they would do so in the hearing-impaired as well. If auditory resolution varies with stimulus levels, the relationship between resolution and hearing aid benefit would be influenced by the listening levels for amplified and unamplified speech.

Before the relationship between auditory resolution and hearing aid benefit can be explored, it is necessary to formulate procedures for measurement of frequency and temporal resolution in hearing aid wearers. Most laboratory methods are quite arduous and may be too demanding for the typical elderly hearing aid wearer, especially if we wish to generate resolution data at several frequencies and stimulus levels.

This poster describes a frequency resolution index (FRI) and a temporal resolution index (TRI), that were developed for use with hearing aid wearers.

PROCEDURE

Each index is measured using a Bekesy tracking procedure.

Test frequencies = 0.5, 1.25, 2.0, and 3.0 kHz.

Threshold is measured for a pulsed test tone with each of two maskers.

Each masker is gradually increased in level from near threshold to LDL.

Growth-of-masking functions are obtained for each masker.

The index is the difference between the two masking functions at a particular masker level.

ACKNOWLEDGEMENT

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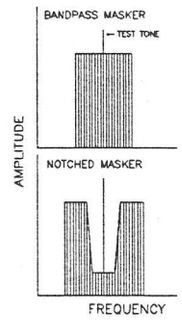
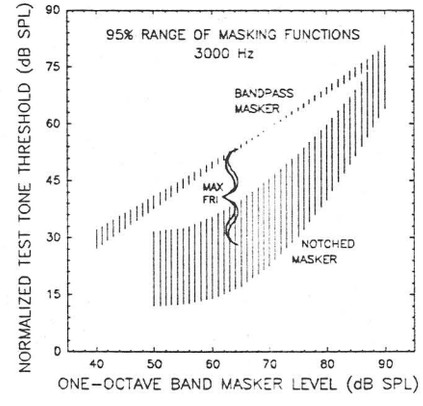
Frequency Resolution Index (FRI):



For each test tone, growth-of masking functions are obtained for two maskers that differ in spectrum as shown in the figure at left.
The bandpass masker is about 1 octave wide.
The notched masker contains a deep notch centered at the test frequency.

Norms for the 3kHz test frequency are illustrated in the figure below. After growth-of-masking functions for the bandpass masker are normalized at a masker level of 70 dB, 95% of results for both maskers from normal hearing listeners fall within the shaded areas.



Keeping in mind that the FRI is the DIFFERENCE between the two masking functions at a given masker level, we see that:

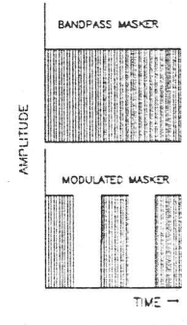
- The magnitude of the FRI changes as masker level rises.
- The maximum FRI is seen at a masker level of 65 dB.
- At lower and higher masker levels, the FRI is reduced.

Results for other test frequencies are qualitatively similar to these for 3kHz.

These results suggest that, for listeners with normal hearing, there is an optimal listening level at which ability to detect sounds situated within a spectral notch is greatest.

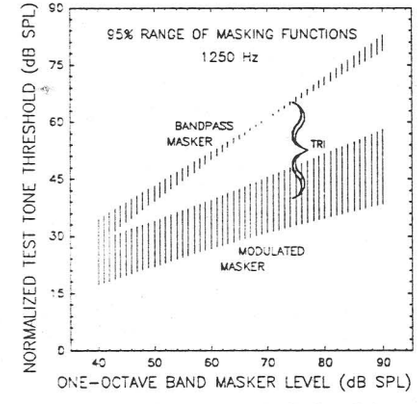
We would hypothesize that recognition of speech cues that depend on this ability would be maximum at this listening level.

Temporal Resolution Index (TRI):



For each test tone, growth-of masking functions are obtained for two maskers that differ in temporal characteristics as shown in the figure at left.
The bandpass masker is continuous.
The modulated masker pulses at a rate of 14 Hz, producing temporal gaps of about 36 msec.

Norms for the 1250 Hz test frequency are illustrated in the figure below. After growth-of-masking functions for the bandpass masker are normalized at a masker level of 70 dB, 95% of results for both maskers from normal hearing listeners fall within the shaded areas.



Recalling that the TRI is the DIFFERENCE between the two masking functions at a given masker level, we see that:

- The magnitude of the TRI increases monotonically as masker level increases.
- The TRI does not assymptote even at the highest masker level used.

Results for other test frequencies are qualitatively similar to these for 1250 Hz.

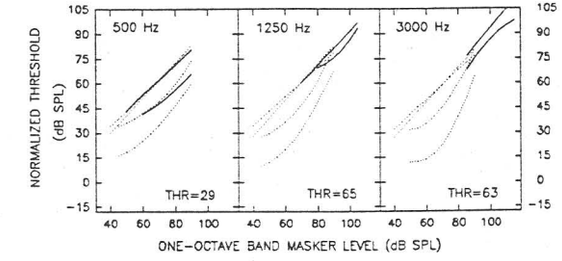
These results suggests that, for listeners with normal hearing, ability to take advantage of brief gaps in a background noise improves as listening level increases all the way up to the loudness discomfort level.

We would hypothesize that recognition of speech cues that depend on this ability would increase with listening level.

Results with Hearing-Impaired Listeners:

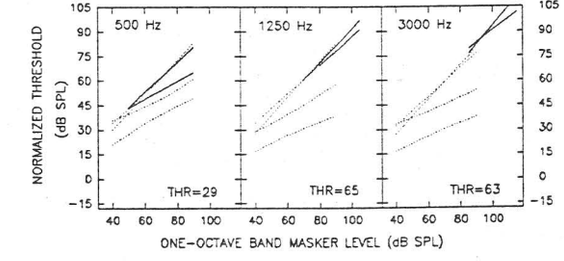
These figures show results obtained for an elderly listener with sensorineural hearing impairment, tested at low, mid, and high frequencies. Norms are shown using dotted lines. Solid lines give the data for the hearing-impaired individual.

FRI data



- At 500 Hz, where hearing threshold is close to normal, the FRI data are within the normal range.
- At 1250 Hz, FRI is much less than for normal hearers at moderate listening levels but could be considered "normal" for high listening levels.
- At 3000 Hz, the FRI shows an anomalous pattern and remains fairly constant regardless of listening level.

TRI data



- At 500 Hz, despite close to normal thresholds, TRI data indicate poorer than normal temporal resolution ability.
- At 1250 and 3000 Hz, temporal resolution, as measured with this procedure, is very poor compared to normal performance.

Can we apply this to hearing aid fitting?

Aided FRI - Unaided FRI = ΔFRI

Aided TRI - Unaided TRI = ΔTRI

In a preliminary investigation, ΔFRI and ΔTRI in low, mid, and high frequency regions accounted for 40% of the variance in hearing aid benefit.

Future studies will provide more information about the ways in which FRI and TRI data can be used to help predict hearing aid benefit and improve hearing aid fittings.