THE RELATIONSHIP BETWEEN LOUDNESS CONTOURS AND PREFERRED LISTENING LEVELS

Robyn M. Cox,[1,2] and Genevieve C. Alexander[1]

Department of Veterans Affairs Medical Center[1] and The University of Memphis[2]

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Abstract

The Contour Test determines levels for seven categories of loudness for warble tone stimuli. It was developed for use in fitting linear and non-linear hearing aids. This poster reports the following applications of the contour data: (1) conversion of listening levels into equivalent contours, (2) mean equivalent preferred listening levels for hearing aid wearers, (3) the relationships between preferred listening levels for average speech and listening levels prescribed by the NALR and IHAFF methods, and (4) assessment of audibility and comfort at preferred listening levels for individuals using linear and compression amplification. (Supported by the Department of Veterans Affairs, RR&D Service).

Introduction

Normative data and a psychometric description for the Contour Test were presented at the 1994 AAA convention. The test determines levels for seven categories of loudness for pulsed warble tone stimuli. The loudness categories are*:

1. **Very soft**
2. **Soft**
3. **Comfortable, but slightly soft**
4. **Comfortable**
5. **Comfortable, but slightly loud**
6. **Loud, but O.K.**
7. **Uncomfortably loud**

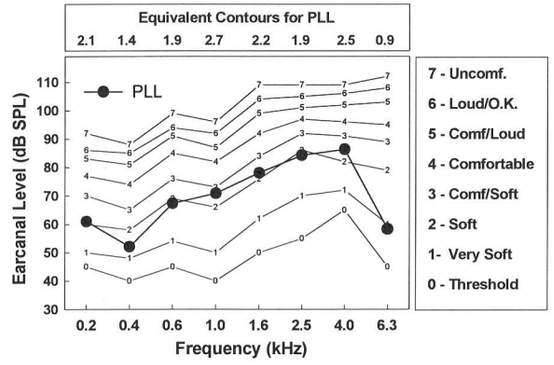
The Contour test was developed for use in selection and fitting of hearing aids. In this poster, we describe some of the results of work with this approach.

*adapted from Hawkins, et al. Ear & Hearing, 8:162-169, 1987.

HARL
Hearing Aid Research Lab.

Transformation of Listening Levels into Equivalent Contours

- Results of an individual's Contour test are expressed in earcanal levels, coupler levels or HL, depending on the intended use.
- Another variable of interest, such as the individual's preferred listening levels (PLLs) at the test frequencies is expressed in the same format.
- By comparing the two sets of data, PLLs can be converted into equivalent contours.
- An example is shown in the figure below. At each frequency, the PLL is converted into the corresponding equivalent contour.



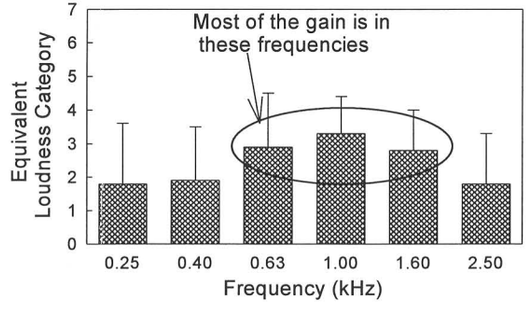
Relationship between Loudness Contours and PLLs for Amplified Speech.

Do PLLs for amplified speech occur at consistent equivalent contour levels across hearing aid wearers?

The figure at right gives the mean equivalent contours for PLLs for linearly amplified speech for 27 experienced hearing aid wearers. The bars show 1 standard deviation.

- In the frequencies where the hearing aid is most active (630-1600 Hz), subjects tended to choose an equivalent contour level of about 3 which corresponds to "comfortable but slightly soft".
- For the frequency with the greatest gain (1000 Hz) the standard deviation was about one category.
- This indicates that hearing aid wearers are fairly consistent in the contour levels that they prefer for listening to speech that has been linearly amplified.

Conclusion: It might be appropriate to fit linear hearing aids so that the RMS levels of 1/3 octave bands of speech above about 500 Hz are amplified to approximately a contour level of 2.5.

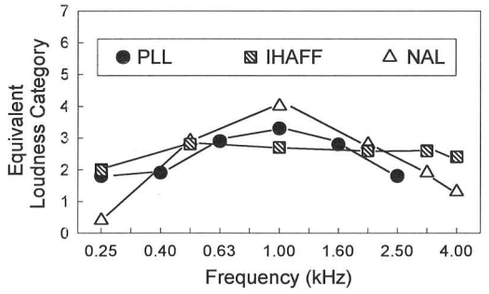


Relationship between PLLs and Prescribed Listening Levels

It seems logical to expect that PLLs for average speech should correspond fairly closely to prescribed listening levels for average speech.

To test this, we converted prescribed listening levels for average speech into equivalent contour levels for two prescription methods: NALR and IHAFF.

This figure displays, for comparison, the mean prescribed listening levels derived from the NALR and IHAFF methods and the mean PLLs for a group of 27 hearing aid wearers.



- The IHAFF equivalent contour is fairly flat at about category 2.5.
- The NALR equivalent contour has a peaked shape, providing greater loudness in the middle of the frequency range and less at the extreme frequencies.
- The PLL equivalent contour is shaped like the NAL contour. This shape reflects the fact that each hearing aid was fitted to the NAL prescription before it was adjusted to the preferred listening level.
- The overall level of the PLL equivalent contour is similar to that of the IHAFF contour.

Conclusion: Both procedures generate prescribed listening levels for average speech that correspond fairly well with typical PLLs.

Assessment of Audibility at Preferred Listening Levels

How much speech is actually audible when the volume control is set to the PLL?

This question is always difficult to answer but it is especially problematic for non-linear hearing aids, due to the complex interactions between compression threshold, compression ratio, attack/release times, input levels, and temporal characteristics of input signals.

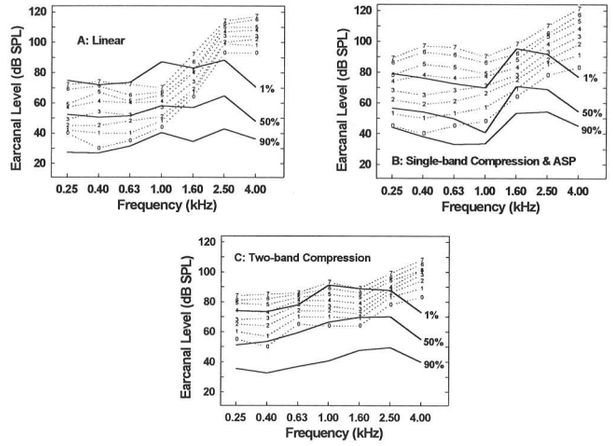
To assess these interactions directly, we can compare an individual's loudness contour map with the amplitude distribution of speech after processing through his/her hearing aid.

Using this approach, we can determine the extent to which the fitting provides both comfort and audibility for speech.

The results can be surprising. Three examples are given below.

Dotted lines are loudness contours. Solid lines show 1%, 50% and 90% exceedance levels for a raised voice (68 dB SPL) adjusted to PLL.

(The 1% exceedance level is the level that is exceeded 1% of the time)



- If we define full audibility as speech above threshold 90% of the time, none of the hearing aids provides full audibility across the frequency range.
- Hearing aid A might be somewhat uncomfortable because it exceeds contour 7 at 1000 Hz. Even so, speech is audible less than 50% of the time at 1600 Hz and none of the time above about 2000 Hz.
- Hearing aid B provides audibility about 50% of the time through 2000 Hz, however, low frequency levels seem lower than they could be, perhaps due to the ASP action.
- Hearing aid C provides audibility about 50% of the time through 2000 Hz. Given the narrow dynamic range of the individual, this might be close to an optimum fitting.
- Despite the different processing schemes used by these hearing aids, the amplitude distributions of hearing-aid-processed speech are not remarkably different