# THE CONTOUR TEST: APPLICATIONS TO HEARING AID SELECTION AND FITTING

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**Abstract:** Three experimental approaches are described to illustrate ways in which results of the Contour test (see companion poster) can be used to assist in the selection and fitting of hearing aids. They are: (1) Loudness growth curves for the hearing-impaired subject are compared to norms to derive rough estimates of needed gain and maximum output, (2) A software program (VIOLA) is used to facilitate determination of optimal input/output functions based on the Contour data, and (3) A full Contour map is the underpinning for REAR-based evaluation in which the dynamic range of amplified speech is compared to the hearing-impaired individual's dynamic range. (Supported by the Department of Veterans Affairs RR&D Service).

### Introduction

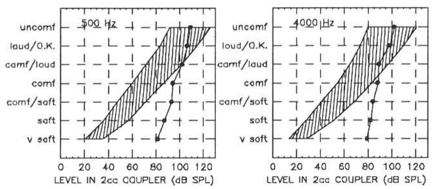
The Contour test is more fully described in a companion poster for this convention. Briefly, the test is used to generate level-by-frequency data for seven categories of loudness from "very soft" to "uncomfortably loud". This poster describes three experimental approaches that are under evaluation for using Contour test data from hearing-impaired persons to choose and fit hearing aids.

HARL
Hearing Aid Research Lab.

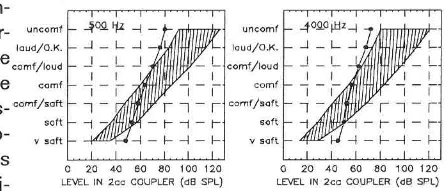
## 1. *Rough Estimation of Needed Amplifiction.*

Loudness growth data from the hearing-impaired individual are compared with norms to develop gain requirements. Comparison with norms for the lower five categories is suggestive of gain requirements for most speech inputs. Comparison with norms for uncomfortable loudness is indicative of limiting requirements for the fitting.

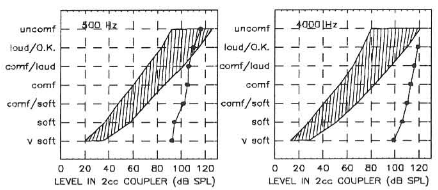
This example illustrates a typical finding. These figures depict norms for 500 and 4000 Hz together with test results for an individual with a moderately-severe, flat hearing loss. By comparing loudness growth for the hearing aid candidate with that of normal hearers we see that this person has a need for 40-45 dB of amplification across the frequency range for low level inputs and about 20 dB of gain for midlevel inputs. However, his uncomfortable loudness level is completely consistent with those of normal-hearers, suggesting that a maximum output of 100-110 dB would be appropriate.




In this example, we see data for a woman who reported hearing difficulties and inquired about a hearing aid. Despite the mild to moderate hearing loss registered by her audiogram, her loudness data suggest a minimal loss of loudness perception for very low level input, normal loudness perception for mid level inputs, and rather low tolerance for loud sounds. It seems unlikely that amplification will be very helpful in this case. After trying a hearing aid for 10 weeks, this client elected not to continue.




This individual (moderately-severe to profound hearing loss) shows a typical pattern in the low frequencies, calling for substantial gain for low and mid level inputs and output limiting at 110-115 dB. In the high frequencies, however, the loudness perception data suggest a need for substantial gain at low, mid, and high input levels. In addition, tolerance for loud sounds was greater than normal, suggesting that a relatively high limiting level would be acceptable.



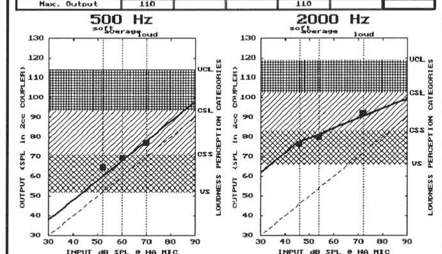

## 2. *Selection of Input/Output Functions with the help of VIOLA the Visual Input/Output Locator Algorithm*

The relationships between typical speech input levels and Contour data for warble tones have been derived at several frequencies for normal-hearing listeners. It is assumed that optimal amplification would restore these loudness relationships for a hearing aid wearer. The VIOLA facilitates the choice of hearing aid parameter values that will achieve this goal.

- ❖ The hearing-impaired individual's Contour data for two dispenser-chosen test frequencies (typically one low and one high) are entered into the computer program which then displays a graphical comparison of (1) soft, comfortable, and loud perception ranges (horizontal shading) and (2) the input levels of soft, average, and loud speech (vertical dotted lines).
- ❖ The dashed diagonal line depicts zero gain. A filled square indicates the target value for each speech input level. The difference between the diagonal line and the target value gives the target gain for that speech input level at the test frequency.
- ❖ The dispenser's task is to construct input/output functions for the two frequencies that (1) approximate the goals and (2) can be realized with an available hearing instrument.

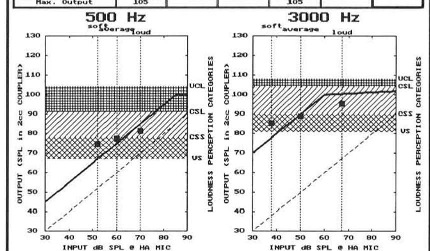
Parameters for input/output functions (low level gain, compression threshold, compression ratio, maximum output) are entered by the dispenser. Corresponding I/O functions are displayed for comparision with the target values. Up to three I/O functions can be displayed on each graph simultaneously. The hearing aid with the best-fitting I/O function is identified using trial and error methods.

| BLAM-ITE | 500 1 | 500 2 | 500 3 | 2000 1 | 2000 2 | 2000 3 |
|---|---|---|---|---|---|---|
| Gain at 40 dB | 8 | | | 32 | | |
| Comp Threshold | 40 | | | 45i | | |
| CR begin | 1 | | | 2 | | |
| CR end | 1 | | | 2 | | |
| Max. Output | 110 | | | 110 | | |



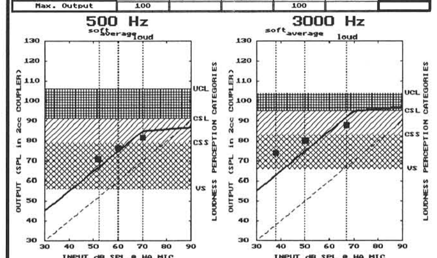

In this example, well-fitting I/O functions suggest a need for linear processing with about 8 dB gain in the low frequencies and input compression in the high frequencies with a compression threshold of 45 dB and compression ratio of 2.

| SUTT-ITE | 500 1 | 500 2 | 500 3 | 3000 1 | 3000 2 | 3000 3 |
|---|---|---|---|---|---|---|
| Gain at 40 dB | 15 | | | 40 | | |
| Comp Threshold | 100o | | | 100o | | |
| CR begin | 15 | | | 15 | | |
| CR end | 15 | | | 15 | | |
| Max. Output | 105 | | | 105 | | |




This example is fairly well accommodated using an instrument with output compression limiting starting at 100 dB. Note that the match between the targets and the I/O functions is not precise. At this time, we do not know how accurate the match needs to be.

| AKEN-ITE | 500 1 | 500 2 | 500 3 | 3000 1 | 3000 2 | 3000 3 |
|---|---|---|---|---|---|---|
| Gain at 40 dB | 15 | | | 25 | | |
| Comp Threshold | 70i | | | 70i | | |
| CR begin | 10 | | | 10 | | |
| CR end | 10 | | | 10 | | |
| Max. Output | 100 | | | 100 | | |




This figure depicts an example that has been fitted using an input compression instrument with a compression threshold of 70 dB and compression ratio of 10. The illustration suggests that the high frequency content of soft speech will be considerably too soft with this fitting but all the other targets are fairly closely matched.

## 3. *Dynamic Range Assessment.*

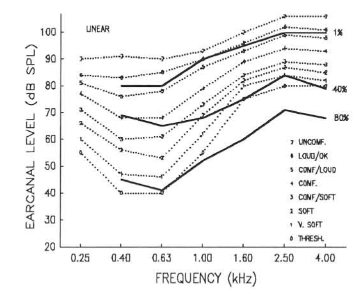
A complete contour map, expressed in earcanal sound pressure levels, can serve as the underpinning for evaluation of a fitting.

- ❖ Hearing-aid-processed speech is recorded in the earcanal via a probe microphone and computer-based analysis is used to assess its dynamic range. This process can be repeated under various conditions of amplitude compression.
- ❖ The short-term speech amplitudes can then be compared with the Contour map to evaluate the likely acceptability of soft, normal, and loud speech.
- ❖ Laboratory data suggest that, for comfortable listening, the 1% peaks of speech should approach, but not usually exceed, the "loud but OK" category (category 6).

Examples are shown below.

- Dotted lines = loudness contours.
- Solid lines = 1%, 40% and 80% exceedance levels for hearing-aid-processed speech. (The 1% exceedance level = the level that is exceeded 1% of the time).
- The frequency response has been shaped so that the 1% levels approach but do not exceed category 6.

The upper figure illustrates the result of linear processing. Note that, below 1000 Hz, most of the speech energy is available to this listener. However, above 1000 Hz, only the top 40% of speech is above threshold.




The lower figure shows the effect of compressing the speech using a low compression threshold (about 66 dB) and a fast release time (about 20 msec). Note that speech is still fully audible below 1000 Hz but now considerably more of the high frequency speech information is also above threshold.