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SONIC innovations

Patient Complaints in the Frequency and Amplitude Domains

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Abstract

A large portion of time during hearing aid fittings is taken up by addressing patients' sound quality complaints. Many solutions are related to the level of technology fit on the patient (trim pots, crossover frequencies, compression ratios, etc.). With the advent of more flexible fitting systems and more control in the frequency and amplitude domains, additional information is needed to help deal with these common complaints. A new description of the relationship between a subject's complaints and the frequency/amplitude domains will be provided.

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INTRODUCTION

Hearing aid fittings have progressed from a purely mechanical process (venting, canal structure, etc.) to a complex interaction between physical features of hearing aid design and clinician-controlled signal processing. Devices are no longer pre-programmed with respect to output, gain, and slope, but can be adjusted, often in multiple dimensions. The flexibility is designed to improve performance, comfort, sound quality, and the range of hearing losses and audiometric configurations that can be fit, but with this flexibility comes increased complexity when adjusting devices during fine tuning.

In order to address some of the issues of how to program devices to fit hearing losses, fitting algorithms have been developed based upon the amount of hearing loss across frequencies. These algorithms attempt to balance comfort, performance, volume, and in the case of non-linear fitting algorithms, level-dependent output. But the fitting process is still perceived as an art because of variability among individuals and the fine tuning needed to produce the desired sound-quality to the device wearer. Common difficulties involve the patient's own voice, annoyance of particular sounds, and listening in specific environments, but methods for addressing these issues are not necessarily obvious, nor well understood.

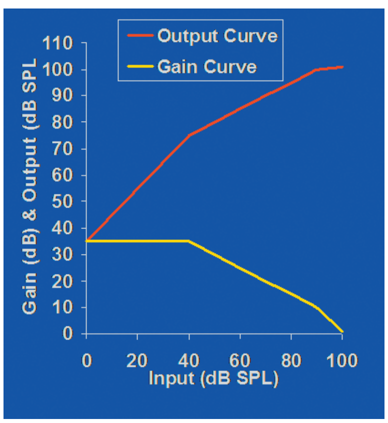


Figure 1: Input/Output function

This poster will define a common representation of amplification systems, and provide a systematic and theoretically satisfying method of addressing these complaints.

INPUT/OUTPUT

Hearing aid performance can be quantified by plotting the input level of a signal versus the output level after processing in that device. This plot distinguishes linear devices from compression systems, as well as clarifying how gain changes with input level (e.g. across kneepoints). Because the fitting adjustments to be discussed require some level of compression and frequency shaping, the example presented will assume a minimum of two kneepoints, and multiple compression channels. The function for one channel of this system is displayed in Figure 1. Two responses are shown on a combined scale: input/output and input/gain. Gain (the lower yellow line) is just the difference between the input and output, and is helpful in visualizing linear versus compression segments.

In multi-channel systems, the input/output function operates separately in each compression channel, and the functions can be assembled to represent the system in a 3-D view1. Figure 2 illustrates in 3-D a baseline fitting using WDRC, with compression kneepoints at 40 dB SPL, no expansion, and a flat frequency response from 750-3000 Hz. Maximum gain is applied to low input levels, and this occurs in a frequency-dependent form to accommodate the loss of sensitivity of the individual. Modifications to this 3-D function will be used to address the specific complaints of the patient. It is important to relate the specific controls available for the device in question and how changes to these controls will impact this function. Changes to compression ratio will alter the roll-off of gain as input level increases. Programming handles must be thought of with respect to the input level with which they are associated. The more flexibility in the programming system, the easier it is to modify at any targeted frequency or input level.

When describing input levels and frequencies where changes to the fitting correlate to patient complaints, regions or areas will be described on the 3-D function. The variability between programming systems as well as listening situations makes more specific values unnecessary.

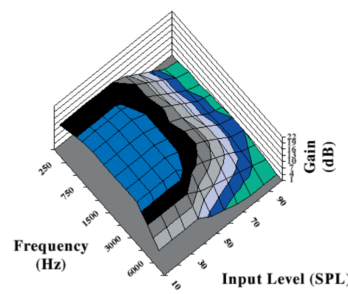
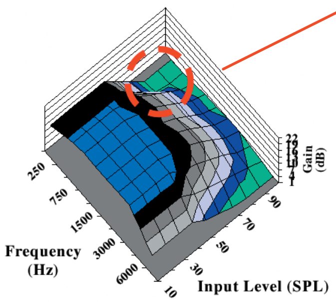


Figure 2: 3-D fitting space

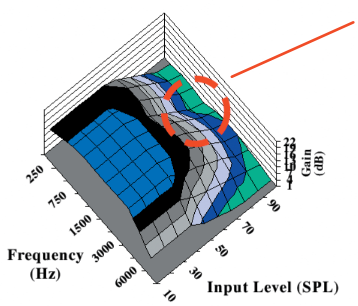
COMPLAINTS AND SOLUTIONS

A group of common complaints will now be listed with the frequency range and input level where adjustments should be made to resolve the complaint. The effectiveness of the needed change will depend upon the flexibility of the particular system in use.

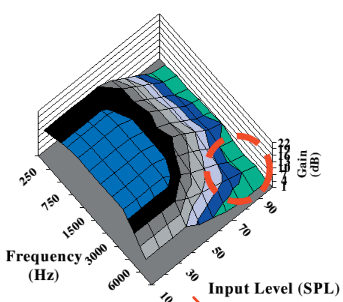
Own Voice



OCCLUSION: An increased level of the voice in the low frequencies (between 100 & 300 Hz) leads to the perception of occlusion. Reducing the gain applied to high-intensity, low-frequency signals (increasing the compression relative to low level inputs) will help with this complaint.

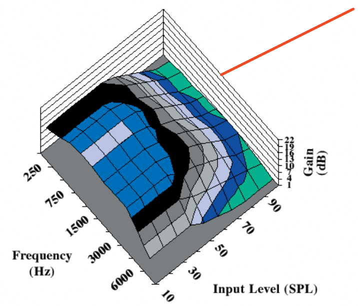


NASALITY & THROATINESS: The perception of one's voice above or below the mouth contributes to the complaints of nasality or throatiness. Reducing the level of loud, mid frequency sounds will move the voice perception down from the nose. Likewise, increasing the level in this frequency range will move the voice up out of the throat. Perception of the voice coming from in or out of the head is associated with the overall level of all high-intensity sounds. Increasing the gain for high level sounds (decompressing) will move the voice perception out of the head.

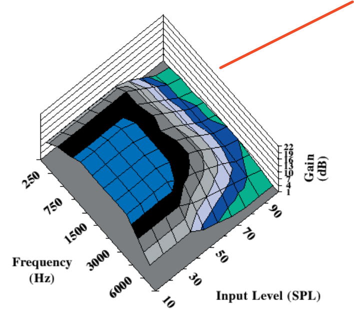


HARSHNESS/ECHO WITH CONSONANTS: If high-frequency components of speech (or other sounds) are over-amplified, they can saturate in the ear and sound like an echo. Reducing the level of high intensity high frequencies will resolve this issue.

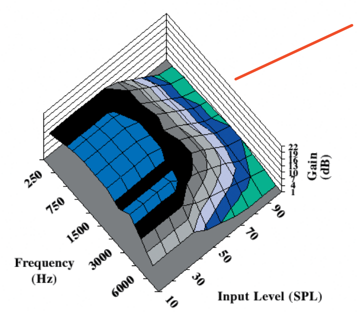
Environmental Sounds



VOLUME OF SPEECH: The perceived volume of speech is highly related to the volume of vowel energy, and adjusting the gain for lower intensity, mid-frequency inputs will increase/decrease the volume of speech.



ROOM NOISE/ ROAD NOISE: Most objectionable noise sources are of low to moderate intensity in the low frequencies. Reducing the gain for soft sounds at 500 Hz and below will reduce their perceived level.



FEEDBACK: The majority of feedback occurs at input levels associated with maximum gain, in the higher frequencies where the receiver peak and canal resonance is located Reducing gain in the high frequencies for soft inputs should eliminate the problem.

CONCLUSIONS

Many difficult fitting issues can be addressed in a systematic way. The difficulty remains in translating these changes to the particular fitting system you are working with. The recommended approach is to identify the acoustic characteristics in frequency and amplitude of the objectionable sounds, and make the appropriate programming adjustments to the targeted regions. This approach will be most successful when using highly flexible programming systems.

REFERENCES

1. Bray & Nilsson (2000). Evaluation of NAL-NL1 Using the NATURA DSP Hearing Aid. Poster, AAA 12th annual convention, Chicago, IL.

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