

Improving hearing aid performance for a piano teacher

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For a piano teacher with hearing loss, listening to music is the highest priority.

After a one month trial a WDRC hearing aid was rejected because of the unacceptable sound quality of music. Hearing aid acceptance was achieved using ADRO.

The measured output spectra and time constants for the WDRC and ADRO hearing aids were quite different. These may be the main factors affecting the perceptual differences.

INTRODUCTION

Hearing loss is an occupational hazard for musicians with major consequences for their enjoyment of music, general well-being, and professional skills. Most hearing aids are designed and fitted with the goal of maximizing speech intelligibility, and often require a special program for listening to music. This case study describes a piano teacher with a moderate high-frequency hearing loss (Figure 1) who was frustrated that the piano did "not sound right" when either she or her students played; she could not hear the metronome; and she was starting to withdraw socially from noisy situations and attending live music performances. She had high speech intelligibility scores in quiet without a hearing aid. Listening to music was her highest priority.

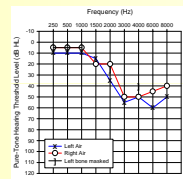


Figure 1. Audiogram

Three pairs of open-fit devices were presented as options for purchase – two with Wide Dynamic Range Compression (WDRC) and one with Adaptive Dynamic Range Optimization (ADRO[®]) amplification. The client selected one of the pairs of WDRC instruments for purchase. The aids were fitted to NAL-NL1 with the "usual" program set to use an adaptive directional microphone, feedback cancellation and noise reduction. The "music" program used an omnidirectional microphone, no feedback manager or noise reduction manager, with slower compression time constants. She reported that her tinnitus improved, she had improved understanding in restaurants and listening to TV. However "music sounded awful" with an echoing quality and very sharp percept for soft high-pitched sounds. Despite repeated fine tuning efforts the hearing aids were rejected.

The client tried the ADRO instruments. The new devices were set up with adaptive directional microphone and feedback manager on in the "usual" program and off in the "music program". Noise reduction was not used in either program. The music program had a flatter gain characteristic than the normal program, with increased comfort targets, maximum output limits, and maximum gains in the low frequencies providing a wider dynamic range at the output of the aids. The client reported that music sounded better in the aided condition than the unaided condition. Over several months of acclimatization, the piano teacher selected the "usual" program and not the dedicated "music" program, when listening to music.

METHOD

To investigate the potential reasons for the perceptual differences between the two hearing aids, two piano pieces were selected by the piano teacher. The Chopin *Nocturne No 1 in B flat minor* was selected as an example of a recording which sounded good with the ADRO hearing aids. The Beethoven *Piano Sonata No 8 Pathétique* was selected as a recording that did not sound acceptable with either WDRC or ADRO based hearing aids. The Chopin recording was described as very clear with each note distinct. The recording of Beethoven was described as lacking clarity with no bass discernable. Both pieces were well known by the pianist who provided commercial quality recordings.

Recording Technique

An in-the-canal microphone was fitted in the right ear canal. The microphone was inserted to a depth of approximately 28mm beyond the intra-tragal notch. The microphone tube was secured by tape outside the ear to reduce the likelihood of the position changing as devices were inserted and removed. It was placed on the floor of the ear canal below the hearing aid's thin tube. The microphone was connected to the sound recording function in Adobe Audition Software via a line input through a purpose built pre-amplifier and a stand alone soundcard. The pianist was seated in the sound proof booth. Piano music was presented from a CD via two speakers. The speakers were positioned directly in front and behind the volunteer at a distance of 1m (Figure 2).



Figure 2. In the canal microphone recordings, test booth set-up (left), microphone positioned in ear canal (centre), the microphone used for recordings (right).

Presentation Levels

The piano music was presented at levels determined to be soft (Chopin 40-50dBA, Beethoven 40-60dBA), medium (Chopin 50-55dBA, Beethoven 50-70dBA), or loud (Chopin 60-70dBA, Beethoven 55-75dBA), by the pianist. Loud was selected to be at performance level while seated at the piano. These levels were determined by the piano teacher while wearing her ADRO hearing aids. The recordings of 1.5 minutes of Chopin and 2 minutes of Beethoven were made at each volume level for three conditions: Unaided, WDRC and ADRO. The "music" program was selected by the piano teacher for WDRC and the "usual" program for ADRO as the preferred listening program for both hearing aids. These programs were used for the recordings.

RESULTS AND DISCUSSION

The hearing aid fittings had similar characteristics

	WDRC "music" program						ADRO "usual" program							
Channels	6						32							
Compression Time	7.5ms/546.25ms (ANSI 96)						10s (ANSI 96)							
Noise Management	Off						Off							
Directionality	Omni						Adaptive							
Feedback Management	Off (Feedback Cancellation)						On (Feedback Suppression)							
Thin Tube	Smallest & no dome						Smallest & no dome							
Processing Delay	6.3 ms						6.5 ms							
Frequency (Hz/kHz)	250	750	1.5	2.5	4.5	7	250	500	750	1	2	3	4	6
MPO/MOL dB SPL re eardrum	78	92	99	102	100	106	71	66	69	70	87	101	101	101
Gain for Soft Inputs (2cc)	0	6	10	15	10	23	1	1	2	4	9	10	9	5

Table 1. Characteristics of the fitted and fine tuned WDRC and ADRO hearing aids used for comparison. The MPO for WDRC and MOL for ADRO have been adjusted to 1/3 octave band values in dB SPL re eardrum for easy comparison.

Time Domain Waveform

The time domain waveforms (Figure 3) indicate that the slower time constants of ADRO preserve more of the temporal envelope variations on a short time scale than the faster time constants for WDRC. This may account for the greater clarity reported anecdotally by the pianist. Although ADRO acted more like a linear amplifier over short time scales, the long-term average spectra show that ADRO reduced the gain more than WDRC for the loud passage of music. Effectively, ADRO had a higher compression ratio than WDRC for long-term variations in intensity, and WDRC had greater compression ratios than ADRO for short-term variations.

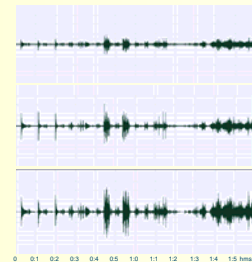


Figure 3. Waveforms for Beethoven piano music at a loud volume in the Unaided (top), ADRO (centre) & WDRC (bottom) conditions. The WDRC waveform has been reduced to highlight differences between peaks & troughs.

Frequency Spectra

The recorded spectra for WDRC were flatter for the mid frequencies relative to the low frequencies relative to the ADRO device which had more mid-frequency gain, to compensate for the mid-to-high frequency hearing loss. This is also shown by the gain values in Table 1.

The accepted wisdom is that it is difficult to achieve gain at low frequencies in an open fitting. The observed output levels at low frequencies for the aided WDRC recordings compared to the unaided recordings, may be attributable to the partial occlusion of the canal by the recording microphone which was 4mm in diameter. The low frequency output for the WDRC was also higher than expected from the programmed gain shown in Table 1.



Figure 4. The long term frequency spectra for soft (top), medium (middle) and loud (bottom) recordings of the Chopin *Nocturne No 1 in B flat minor* (left panels) and the Beethoven *Piano Sonata No 8 Pathétique* (right panels). The recordings were made with no hearing aid in the canal (Unaided), with the WDRC hearing aid set to the music program (WDRC) and the ADRO hearing aid set to the usual program (ADRO).

CONCLUSIONS

This study led to four main conclusions:

- ADRO was strongly preferred to WDRC for listening to music.
- Specific characteristics of music affected the performance of the hearing aids.
- The different fitting parameters of WDRC and ADRO across the full frequency range resulted in marked spectral differences between the two aids for both pieces of music.
- The temporal processing of the two types of devices were also different, resulting in greater short-term linearity for ADRO compared to WDRC, and greater long-term compression for ADRO compared to WDRC. These differences may contribute to the clearer sound and distinctness of the notes reported for ADRO, and greater comfort for loud sounds.

ACKNOWLEDGEMENTS

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