Volume Control for an ADRO Hearing Aid

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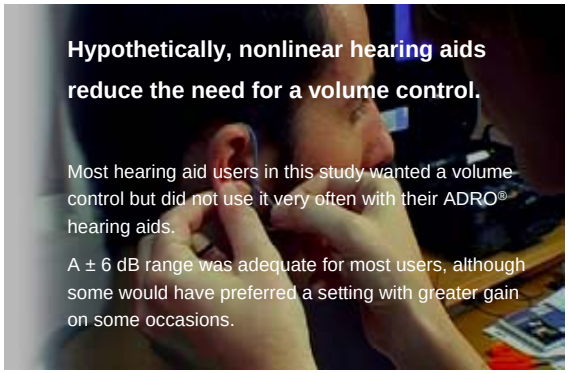


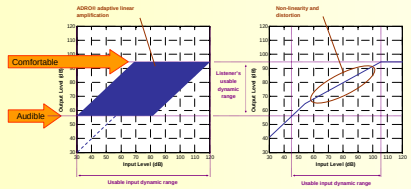
Hypothetically, nonlinear hearing aids reduce the need for a volume control.

Most hearing aid users in this study wanted a volume control but did not use it very often with their ADRO® hearing aids.

A ± 6 dB range was adequate for most users, although some would have preferred a setting with greater gain on some occasions.

The need for a volume control

Linear hearing aids apply the same gain to all sounds, until they reach the maximum power output (MPO); Nonlinear hearing aids, such as wide dynamic range compression (WDRC) apply different gains to sounds depending on the input level of the sound; and Adaptive Dynamic Range Optimization (ADRO) hearing aids have a variable gain that changes only when a sound becomes too loud or too soft for the listener.



In compression circuits, gain and output levels follow fixed rules, defined by basic gain, compression ratios, and kneepoints. ADRO changes the gain smoothly and only when necessary.

Volume controls were introduced into linear hearing aids to allow listeners to hear both soft sounds and loud sounds more easily. Although both WDRC and ADRO are designed to handle different input sound pressure levels, there are still likely to be benefits in providing a volume control on the hearing aid:

- Reduced fatigue for listeners
- Compensation for poorly fitted aids
- Compensation for variations in middle ear function
- Compensation for fluctuating hearing loss such as Meniere's disease.
- Compensation for adaptation and acclimatization to sound
- Compensation for individual differences and preferences
- Reduced incidence of feedback

The range of volume adjustment is an important parameter that has not been investigated systematically. If set too wide, the user may find the VC hard to adjust, and sounds may be much too loud or soft if it is incorrectly adjusted. If set too narrow, the user will not be able to achieve the desired volume.

STUDY DESIGN

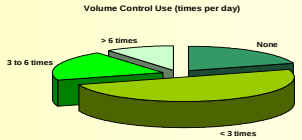
Ten adults with a mean age of 71 years and pure tone three frequency average from 20 to 73 dB HL participated in the study. Nine participants had symmetrical sensorineural hearing loss. Four had a flat loss (less than 10 dB difference between 1 and 2 kHz) and five had sloping high frequency losses (at least 20 dB between 1 and 2 kHz). The remaining participant had a mixed symmetrical hearing loss, mild in the mid frequencies, moderate in the low frequencies and sloping to severe in the high frequencies.

Participants wore ADRO hearing aids fitted using the procedure described here. The hearing aids contained one program with no volume adjustment, and another with either +6/-6 dB or +6/-12 dB volume control range (randomly assigned to participants in the first week). After one week, the non-zero volume control range was reprogrammed to the other condition.

Participants reported:

- how many times the volume control was adjusted and why,
- whether they would have used a greater volume range if it was available,
- whether they had any difficulty in adjusting the VC,
- whether they had any difficulty balancing the loudness of the left and right aid.

Participants were also asked to complete a Profile of Aided Loudness questionnaire for each hearing aid program (no VC, +6 dB, -6 dB, and -12 dB volume setting).



Patterns of volume control use

Two participants did not use the volume control at all. One used the volume control more than six times a day. Participants tended to turn the VC up as often as they turned it down, indicating that the fitted VC level (0 dB on the volume scale) was appropriately set.

Four participants reported that they would have liked to be able to use a higher volume setting than +6 dB. Only one participant reported a desire to use a lower volume setting than -6 dB, and this person would have liked a setting lower than minus 12 dB.

Four subjects reported that they had difficulty adjusting the volume control in the first week, and three in the second week. Only one subject reported (a little) difficulty in achieving loudness balance between the two ears.

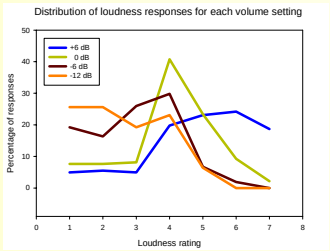
Profile of Aided Loudness (PAL) results

The PAL asks for loudness and satisfaction ratings for a set of 12 situations. Four situations are classified as "soft", four as "average", and four as "loud" by normally-hearing listeners (Palmer et al. 1999).

As expected, the distribution of loudness ratings (accumulated over all situations and all participants) moved towards the softer end of the scale (rating 1) for the negative volume settings and towards the louder end of the scale for the positive volume setting.

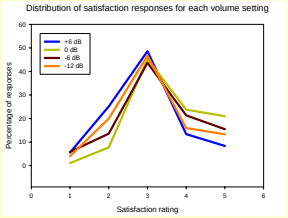
Also as expected, highest proportion of "Comfortable" ratings was obtained for the 0 dB volume setting.

Although about 20% of responses were "uncomfortably loud" for the +6 dB volume setting, four participants would have used a louder volume setting in some situations if it was available. This is confirmed by the fact that there are still some "very soft" responses at this volume setting.



"soft" sounds	"average" sounds	"loud" sounds
your own breathing	an electric razor or hairdryer	a door slamming
water boiling on the stove	a television newsreader or a public speaker	traffic noise when standing on the kerb of a busy road
a car indicator signal or a clock ticking	the dryer or washing machine running	a barking dog
you chewing soft food	a microwave buzzer sounding	a lawn mower

Loudness ratings	Satisfaction ratings
1. Very soft	1. Not good at all
2. Soft	2. Not too good
3. Comfortable but slightly soft	3. Okay
4. Comfortable	4. Pretty good
5. Comfortable but slightly loud	5. Just right
6. Loud but OK	
7. Uncomfortably loud	



The 0 dB volume setting had the highest proportions of "just right" and "pretty good" responses, and the lowest percentage of "not good at all" responses. The +6 dB setting had the highest proportion of unsatisfactory responses, followed by the -12 dB setting.

These results confirm that the 0 dB setting is the most appropriate volume setting for ADRO processing if there is no volume control.

CONCLUSIONS

- Most subjects in the study wanted access to a volume control but did not use it very often.
- A higher volume setting than +6 dB would have been useful for four participants.
- The PAL showed that there is more chance of hearing uncomfortably loud sounds with the VC at +6 dB and very soft with the VC at -6 or -12 dB.
- Most sounds were comfortable when the volume was set at 0 dB. Since most subjects did not adjust the volume range very often, the 0 dB setting provides the best volume for most listening situations.
- These results confirm that ADRO does a good job of optimising the sound for many different listening levels and environments.

There are four easy steps to fitting an ADRO hearing aid:

1. **Enter the audiogram.**
   The fitting program will then calculate initial Comfortable Levels for the next step.
2. **Balance loudness across frequencies at a comfortable level**.
   This is analogous to setting the graphics equalizer on your stereo. The fitting software will probably have an in-situ measurement facility to generate narrow-band noises with controlled level and frequency inside the hearing aid. The audiologist (or the listener) should adjust these until they are in the comfortable range and equally loud across frequencies. This should take no more than a few minutes per ear. There is no need to establish the Maximum Comfortable Level or to do Loudness Scaling. The fitting software will automatically calculate the ADRO fitting from the audiogram and the Comfortable Levels.
3. **Adjust the overall volume to the preferred level for conversational speech.**
   This is like adjusting the volume on your stereo – one adjustment makes everything louder or softer. Different clients will have different preferences, even if they have the same audiogram. Just turn on the hearing aid and have a natural two-way conversation with the client while you are adjusting the volume. It is much easier for clients to choose the best volume setting this way than to rely on loudness scaling with beeps and pure tones.
4. **Fine tune Maximum Gains and Maximum Output Levels (if necessary).**
   The Maximum Gains control the loudness of soft sounds. If soft background noises are too loud, the maximum gain should be reduced at the appropriate frequencies. If soft speech is too soft, the maximum gain should be increased. The low-frequency maximum gain settings can also be used to change the sound of the client's own voice. The high-frequency maximum gain settings can be reduced to avoid feedback if necessary.
   The Maximum Output Levels (MOLs) control the loudness of sudden loud sounds. If loud sounds sound distorted, then the MOLs should be raised. If sudden loud sounds are uncomfortable, then the MOLs should be reduced at the appropriate frequencies.

DYNAMIC HEARING