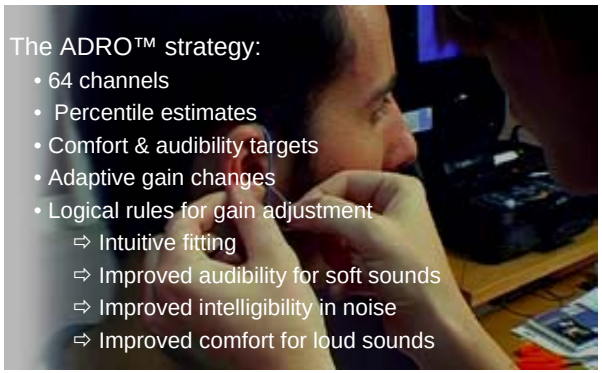
Real-time Statistical Analysis to Optimise Sound within the Dynamic Range

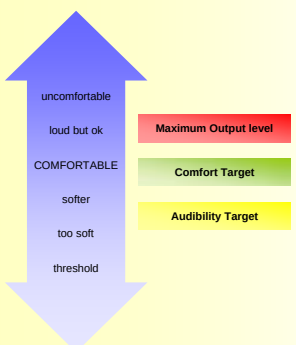
Lois Martin[1], Peter Blamey[1] and Todd Fortune[2], [1] Dynamic Hearing, Australia, [2] Interton, USA



Introduction: The ADRO™ strategy uses statistical rules to keep the hearing aid output within the comfortable listening range

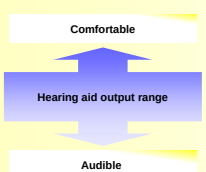
A new approach to the problems of hearing impairment uses real-time statistical analysis of the amplified output signal. In up to 64 frequencies, the 30th and 90th percentile levels of the intensity distribution are estimated continuously. Audibility and comfort rules are used to increase or decrease the gain to control the output. If the sound is too soft, it is gradually made louder. If the sound is too loud, it is gradually made softer. Two additional rules prevent the output level from exceeding the maximum output level and prevent the gain from exceeding the maximum value at each frequency.

Application of these statistically-based rules produces good speech perception in quiet and in noise, as well as providing a good balance between audibility and comfort for listeners with impaired hearing.



ADRO™ rules

1. Maximum Output Level is the limit in each frequency channel.
2. Comfort rule: if the 90th percentile is above the Comfort Target then decrease the gain.
3. Audibility Rule: if the 30th percentile is below the Audibility Target then increase the gain.
4. The gain in each frequency channel is limited by the Maximum Gain.



ADRO™ processing

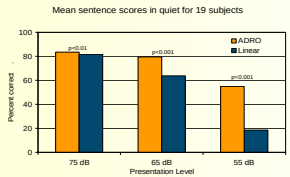
1. Targets are set within the listener's dynamic range.
2. The ADRO™ processor estimates percentiles and applies gain adjustment rules.
3. The ADRO ™ rules continually adjust the gain to keep the hearing aid output within the fitting targets, keeping sound comfortable and audible.
4. The Maximum Output rule acts instantaneously to control sounds that would otherwise exceed the Maximum Output Level.

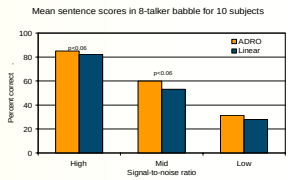
Overview of three clinical studies tested speech perception in quiet and in noise.

Abstract: ADRO™ is a digital amplification strategy that uses statistical analysis and logical rules to maintain the output of the hearing aid within the listener's dynamic range. Gain is decreased if the 90th percentile of the signal exceeds the Comfort Target and increased if the 30th percentile falls below the Audibility Target. The strategy was evaluated against conventional linear and compression amplification strategies to determine whether more gain would be applied to low level signals and whether speech in noise would be comfortable and intelligible. Results from three separate clinical studies showed significant improvement for soft sounds and improved intelligibility of speech in 8-talker babble.

ADRO™ in comparison to linear amplification.

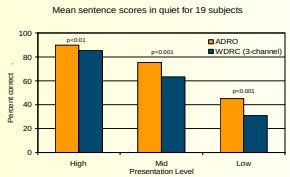
Study 1: The ADRO™ strategy produced higher speech intelligibility in quiet and in noise than a linear amplifier with the NAL-RP prescribed frequency response for listeners with moderate to profound hearing loss.

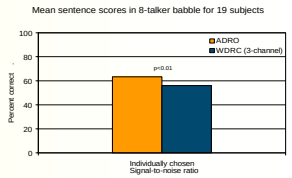




ADRO™ in comparison to 3-channel compression in a BTE.

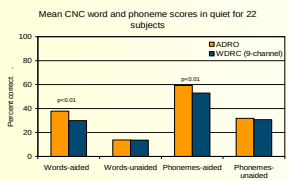
Study 2: In a blind trial with BTE hearing aids, the ADRO™ strategy produced higher speech intelligibility scores in quiet and in noise than a 3-channel wide dynamic range compression amplification scheme (WDRC with NAL-NL1 prescription). The 19 listeners had moderate to profound hearing loss.

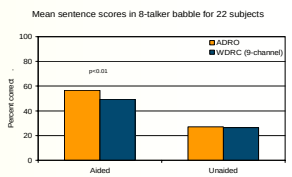




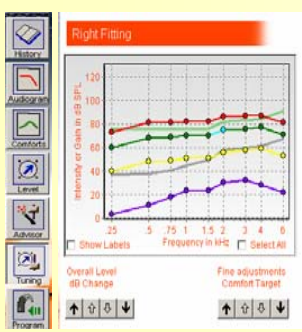
ADRO™ in comparison to 9-channel compression in an ITE.

Study 3: In a balanced cross-over design, The ADRO™ strategy produced improved speech intelligibility in quiet and in noise compared with a commercial 9-channel WDRC ITE hearing aid. The 22 listeners had mild to moderate hearing loss.





Fitting an ADRO™ hearing aid



1. Comfortable levels are predicted from the audiogram and are checked through the hearing aid with narrow band noise
2. ADRO™ targets are predicted from the comfortable levels.
3. Maximum Output Level (RED) is adjusted to limit sudden loud sounds. The Comfort Target (GREEN) controls the loudness of high and medium level sounds. The Audibility Target (YELLOW) and the Maximum Gain (PURPLE) control the loudness for low level sounds.

The ADRO™ processing adjusts the output levels based on the ADRO™ rules.

Results of Clinical studies conducted at The University of Melbourne:

Study 1 compared the ADRO™ strategy with a linear NAL-RP fitting in a desk-top digital signal processor (DSP) for 15 subjects with moderate to profound hearing loss (PTA range 44 – 98 dB HL). Open-set sentences were presented at three levels (75, 65 and 55 dB SPL). As the level decreased there was an increasing advantage to the ADRO™ strategy: 2% difference at 75 dB, 16% at 65 dB and 36% at 55 dB. Ten subjects were tested in background noise (8-talker babble) at three signal-to-noise ratios (SNR). Results were significant at the highest SNR (3% advantage to ADRO™) and at the mid-level SNR (7% advantage to ADRO™).

Study 2 compared the ADRO™ strategy with 3-channel compression (WDRC) in a BTE hearing aid in 19 subjects with moderate to profound hearing losses (mean PTA = 62.5 dB HL). Sentences in quiet were again presented at three levels customised to individual hearing loss. Results showed a significant advantage to the ADRO™ program at each level: 4.5% difference at the high level, 12% at the mid level, 14% at the low level. Sentences in babble were tested at one individually set SNR that was neither too hard nor too easy for the degree of hearing loss. Results showed a significant advantage (7.3%) for the ADRO™ program.

Study 3 compared the ADRO™ strategy with a commercial 9-channel WDRC in-the-ear hearing aid in 22 subjects with mild to moderate hearing losses (PTA between 30-60 dB). Subjects were fitted with the compression hearing aid or the ADRO™ hearing aid in the first phase and then the conditions were reversed in the second phase. Monosyllabic words (CNC) were used to test perception in quiet at an individually set but low presentation level (45-65 dB SPL). Results showed a significant advantage for the ADRO™ hearing aid for word and phoneme scores (8% advantage for words, 6% advantage for phonemes). Unaided scores were not significantly different. Sentences in a 8-talker babble showed significant 7% advantage for the ADRO™ hearing aid.

DYNAMIC HEARING