AUDIOLOGICAL RESEARCH DOCUMENTATION

News from Oticon

October 2006

# Benefits of 'upgrading' children to Sumo DM hearing instruments

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This study examines the performance of 12 school-aged children with profound hearing loss following an upgrade to an advanced multiple channel non-linear hearing instrument (Sumo DM). This was to overcome the concern raised in previous studies where there was difficulty in separating the improvement from the child's normal development versus the improved audibility provided by the test hearing aids.

Unique to this study was the utilisation of an ABA design where the child's old hearing aids were refitted at the end of the study so that direct comparison could be made. Significant improvements were found in terms of audibility, speech understanding in quiet and noise and reports by the children and parents of performance in specific listening situations. Importantly, the study indicated that performance with the old hearing aids remained stable, while performance with Sumo DM continued to improve. Therefore, the gains made in the current study were solely due to the new hearing aids and not due to the child's natural development. This study builds on the increasing evidence that children with a profound hearing loss should be given the opportunity to try the latest advanced superpower hearing instruments designed to provide the best possible auditory outcome.

# Introduction

Hearing instrument fitting for children with a profound hearing loss presents a special challenge to the audiologist due to the extent of destruction to the cochlear, combined with reduced auditory resolution leading to the necessity to rely on temporal cues for speech understanding. A number of studies have shown the benefit of multichannel non-linear (MCNL) hearing instruments for these clients (*Davis, & Pogash, 2002; Flynn, Davis & Pogash, 2004; Marriage & Moore, 2003; Pogash & Flynn, 2003*). Children, are even more dependent on the best signal they can get, as they need to learn the language through an immature auditory system that has not yet matured (*Boothroyd et al, 1988*). Despite this need, paediatric audiologists are understandably cautious to fit new technologies in children if their benefit has not been demonstrated.

Sumo DM is the Oticon SuperPower hearing instrument that combines latest technology with child-friendly design. The non-linear signal processing enhances soft sounds and makes loud sounds comfortable within the individual dynamic range. Eight compression channels processed through a sophisticated digital filter system allow shaping the frequency response to match the child´s individual hearing loss. A speech shaped noise management protects the signal in the speech relevant frequencies and reduces amplification in the other areas. Feedback limits are increased by a Dynamic Feedback Cancellation system which operates without loosing gain or compromising the signal. This feature is of special importance for children with severe-to-profound losses because of the likelihood of feedback related to their auditory characteristics as well as in young children because of their rapid ear canal growth.

# Study Method

The purpose of the study was to compare performance of the child's current hearing aids with Sumo DM. To investigate performance, three measures were selected;

1. Aided audibility;
2. Speech understanding in quiet and noise;
3. Subjective report of benefit by children and parents on the Listening Situations Questionnaire (LSQ).

***Participants***

In total 12 children from three different hearing centres in the USA participated in this study. The average age of the students was 11 ½ years. All children had a severe or profound sensorineural hearing impairment with no conductive overlay (Figure 1). They attended regular schools, and used speech as their primary communication mode. No other disability other than the hearing loss was present.

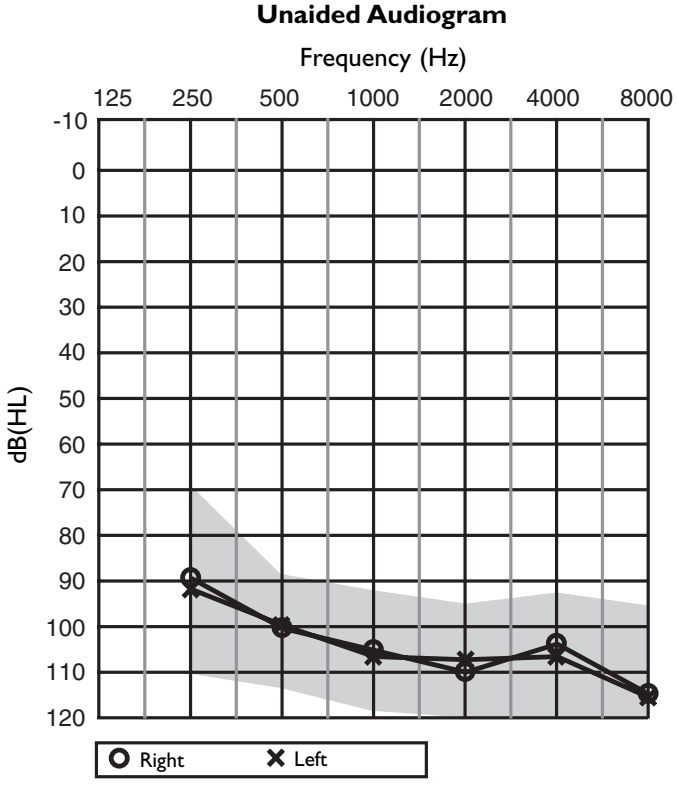


**Figure 1. Average hearing threshold levels and one standard deviation for left and right ears.**

### Previous hearing instruments

Consistent with previous studies (*see Flynn et al, 2003*), the purpose was to design a 'well fitted upgrade' study. All hearing aids were currently available and fitted within the past four years; eight children used a linear rationale, and four used multi-channel non-linear (MCNL). All hearing instruments were fitted according to manufacturer specification and verified that aided gain was at least 1/3 of the hearing loss at 500, 1000 and 2000 Hz. All hearing instruments were worn for at least 8 hours a day and none of them experienced acoustical feedback in daily use and all participants reported loud sounds as being tolerable. All children reported that their own hearing aids were physically comfortable to wear.

### Fitting of new hearing aids (Sumo DM)

All children were fitted according to manufacturer specification and the prescription provided in Genie 7.0. To take individual ear canal acoustics into account, and to verify that targets were accurately met, all fittings were verified with real-ear measurements. Fine-tuning was only conducted in the rare cases of feedback or loudness tolerance issues.

### Study design

The study consisted of a series of test sessions. Initially, a complete audiological evaluation was conducted to confirm degree and type of hearing loss. All current hearing aid fittings were evaluated for appropriate fit and function according to the strict test criteria described above. Once this was completed, aided thresholds were obtained. Speech understanding in quiet and noise was obtained using word perception tests. In addition, standardized questionnaires about the current hearing aids were completed by the parents (*Bamford et al, 1999; Grimshaw, 1996*). The children completed their questionnaires with the assistance of their parents or the audiologist.

### ABA method

The evaluation was conducted in an ABA design, which means that children were refitted with their previous instruments after having used Sumo DM for three months. The children were tested first with their own instruments, then fitted with Sumo DM. After 8 weeks, the same tests were performed with Sumo DM, and another 4 weeks later, the test with Sumo DM was repeated. Children were then refitted with their previous instruments and underwent the same test procedure. Therefore, all testing of the previous hearing instruments and the test instruments were conducted at the same time so that child development was not a confounding factor.

# Results and Discussion

***Audibility*** Aided threshold assessment results found that on average, a substantial increase in the range of 10dB was possible with Sumo DM. This is consistent with the basic premise of non-linear amplification, that gain will be increased for softer inputs. Additionally, the implementation of a dynamic feedback cancellation system increased the feedback limits and therefore the amount of available gain for the child. This provided an increased ability to 'hit' prescribed targets, While aided thresholds do not necessarily imply intelligibility, it is well established that making previously inaudible sounds audible can often increase speech understanding. The mean results of aided threshold assessment of both previous aids and Sumo DM instruments are illustrated in Figure 2, where they are superimposed on an audiogram displaying the long term average speech spectrum (LTASS). This data shows an increase in audibility of speech sounds across all frequencies and importantly for the high frequency sounds. This finding clearly indicates that multiple channel non-linear amplification provides improved audibility of speech sounds for children with a severe or profound hearing loss.

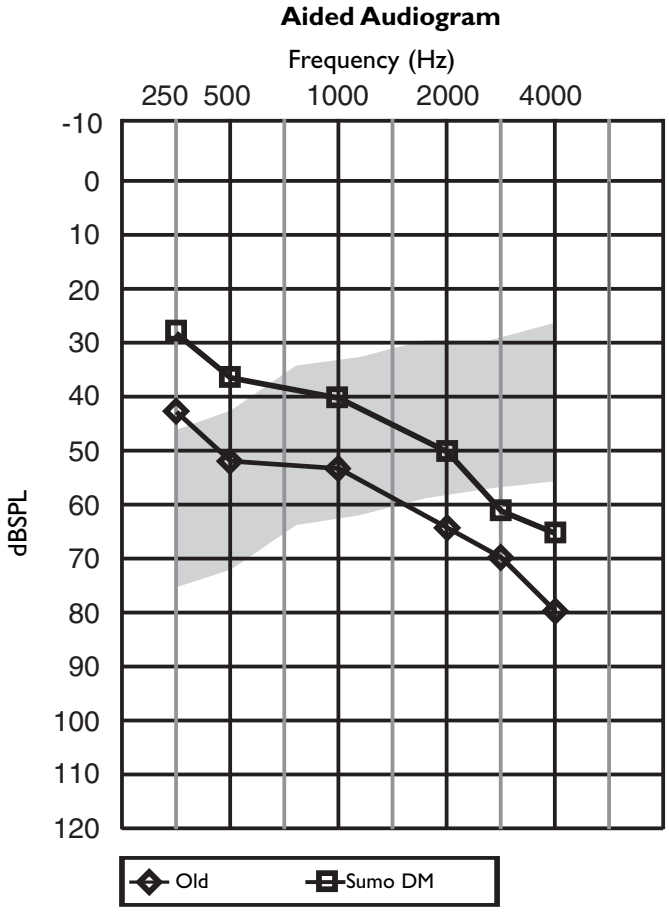


**Figure 2. Mean aided thresholds of own aids and Sumo DM. The long-term average speech spectrum is underlayed to indicate the increased access to speech information provided by Sumo DM.**

### *Speech Understanding*

To determine if the children were able to make use of this improved audibility, speech perception performance was measured (Figure 3). Figure 3 indicates that Sumo DM provided an immediate benefit over the child's original hearing aids in both quiet and noise. Importantly, examination of results at three months post fitting indicated that the performance with the Sumo DM continued to improve over time. Conversely, performance with the child's own hearing aids showed no difference in quiet or noise. Thereby indicating that the continued improvement of Sumo DM over time was not due to natural maturation but due to the child continuing to learn to take advantage of the increased availability of auditory cues in quiet and noise.

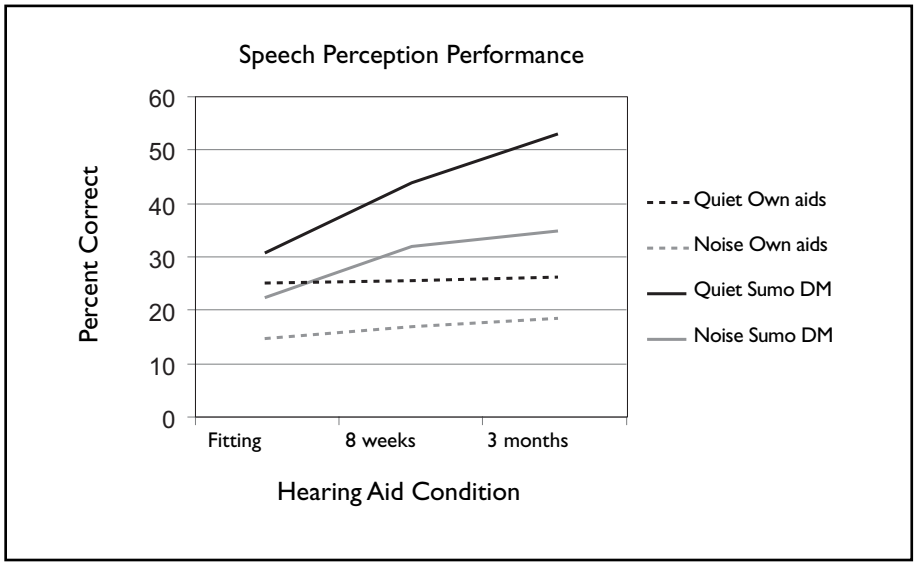


**Figure 3. Average results across all the participants for open-set speech understanding in quiet and noise showing the benefit for advanced multiple channel non-linear amplification (Sumo DM) over the children's previous hearing aids. Importantly, this benefit was independent of any normal maturation by the child.**

### *Listening situations questionnaire*

To further evaluate benefit, the children and parents were asked to evaluate the new hearing aids in a series of listening situations and to make an overall preference. The Listening Situations Questionnaire (LSQ) (*Bamford et al, 1999; Grimshaw, 1996*) investigates eight typical different listening situations in daily life (listening in quiet, in noise, from a distance, outdoors, listening in a car / bus. listening to a TV, listening to music via hearing instruments). The children as well as the parents were asked to rate how helpful the hearing instruments were in the described situations, how much difficulty was experienced and how satisfied the child / the parents were with the hearing instruments. The goal is to find out whether the subjective evaluation matches the objective results and whether the students and their parents correspond in their estimation of the two different hearing instruments.

### *Overall score*

Transposing the verbal answers into numerical scores, an overall score for all questions can be obtained (Figure 4). Both the children and parents provided significantly higher composite scores for the Sumo DM hearing aids over their previous hearing aids.

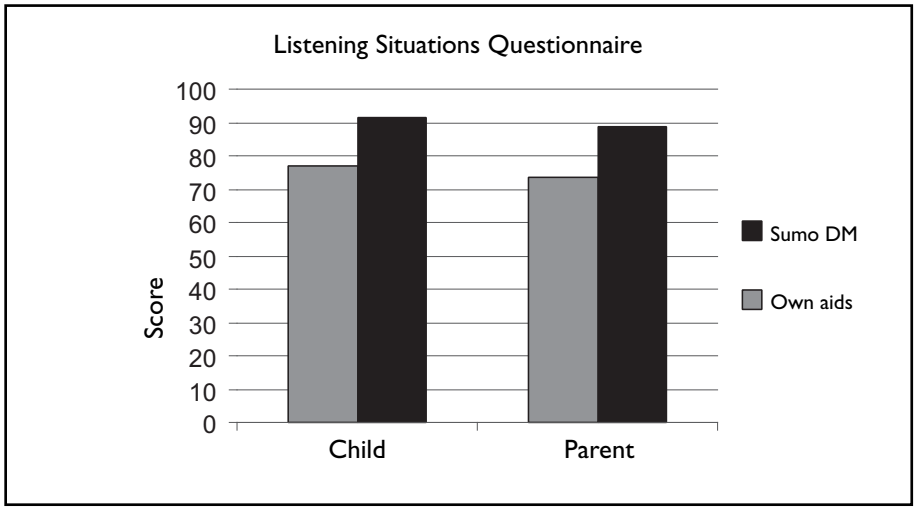


**Figure 4. Improvement in composite Listening Situation Questionnaire scores from Previous Aids to Sumo DM.**

### *Situations Score*

If we look deeper into the situations of interest, it becomes clear that the parents and the children agree in their estimation of the benefit that Sumo DM shows in different listening situations (Table 1). Sumo DM is always rated higher than the previous instruments. In almost all of the questions, this difference reaches a level of significance (*=p<.05) or high significance (**=p<.01).

| | Child Previous | Child MCNL | Parent Previous | Parent MCNL |
|---|---|---|---|---|
| Listening in Quiet | 3,41 | **4.08*** | 3.31 | 3.70 |
| Listening in Noise | 2.58 | **3.63**** | 2.58 | **3.23*** |
| Listening at a distance | 3,04 | 3.50 | 2.36 | **3.13*** |
| Listening outdoors | 2.63 | **3.38*** | 2.81 | 3.20 |
| Listening in a car, bus or taxi | 3.07 | **3.92**** | 2.86 | **3.57*** |
| Listening to TV | 2.93 | **3,63*** | 2.53 | **3.37*** |
| Listening to Music | 3.07 | 3,38 | 2.94 | 3.27 |
| Listening to the sound of vehicles approaching | 2.47 | **3,67**** | 2.86 | **3.57**** |

**Table 1: Results of the Listening Situations Questionnaire related to the different topics. (*'=p<.05, '**'=p<.01)**

Importantly, the conditions in which the children and parents reported greatest benefit were in the more difficult listening situations. Significantly, situations that involved background noise were all indicated to be significantly better with Sumo DM than with the child's previous instruments. Importantly, the addition of a noise management system in Sumo DM did not affect the children's understanding nor did it make the listening for alerting signals such as traffic more difficult.

The results of the LSQ strongly match the child´s performance in speech understanding in quiet and in noise with Sumo DM hearing instruments right from the first day of use. That means that even without a time span of familiarisation with the new sound, the children benefited from the enhancement of soft sounds, which is due to non-linear amplification.

Children spend much of their listening day in noisy environments. The most common example is the school, where children have to cope with challenging classroom acoustics (noise, reverberation, distance) especially in the time they are expected to understand all that is being said and taught. When listening is significantly improved in those situations (understanding in noise, at a distance and listening when lip-reading is not always possible), the listening effort for the child will be reduced and attention and mental concentration can be used more efficiently.

Importantly, all children in the study had the TriState Noise Management system turned on. Therefore, the results support the premise that noise management systems such as TriState that are combined with dedicated speech detectors can reduce the distraction of noise without removing valuable speech information. Additionally, the results support that noise reduction systems rebalance the sound picture to prioritise speech but they do not remove the awareness of important noise sources such as traffic noise. In that both the children and parents report a significant improvement for situations when vehicles are approaching. This makes life much safer for the kids and helps them to feel more secure and self-confident.

# Conclusions

The results of this study document that children with a profound hearing loss benefit from hearing instruments such as Sumo DM which provide a MCNL approach and a dynamic feedback cancellation system that allow more gain in the soft and in the loud listening area without compromising the speech signal. In addition, speech focused noise management preserves speech understanding in noisy situations by protecting the speech signal. The ABA design of the study, allowed retesting the previous hearing instruments and thus excluded developmental effects, showed that improvements are not due to learning or test effects, but are rather effects of the advanced technical features the Sumo DM SuperPower instruments offer.

All participants showed significant benefits of the Sumo DM SuperPower hearing instruments in objective as well as in subjective evaluations. Importantly, at the completion of the study all children chose to keep their Sumo DM hearing aids.

# References

Bamford J, McCracken W, Peers I, Grayson P. (1999). Trial of a two-channel hearing aid (low-frequency compression-high-frequency linear amplification) with school age children. *Ear and Hearing, 20,* 290-298.

Boothroyd, A., Springer, N., Smith, L., & Schulman, J. (1988). Amplitude compression and profound hearing loss. *Journal of Speech and Hearing Research, 31,* 362-376.

Davis, P., B., & Pogash, R. (2002). Power for kids. *The Hearing Review, 9(3),* 52-57.

Flynn MC, Davis PB, Pogash R. (2004). Multiple-channel non-linear power hearing instruments for children with severe hearing impairment: long-term follow-up. *International Journal of Audiology, 43,* 479-485.

Flynn, M. C., & Schmidtke, T. E. (2002). Four fitting issues for severe and profound hearing impairment. *The Hearing Review, 9(11),* 28-33.

Grimshaw, S. (1996). The extraction of listening situations which are relevant to young children , and the perception of normal-hearing subjects of the degree of difficulty experienced by the hearing impaired in different types of listening situations. *MRC Institute of Hearing Research.*

Marriage, J.E. & Moore, B.C. (2003). New speech texts reveal benefit of wide-dynamic range, fast-acting compression for consonant discrimination in children with moderate-to-profound hearing loss. *International Journal of Audiology, 42,* 418-425.

Pogash, R., Flynn, M. C. (2003). SuperPower for Kids: A Clinical Evaluation. *News from Oticon, April 2003*.

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910 14 410 00 / 10.06 Printed in Denmark