FRONT-END PROCESSING

Research Summaries

Improved pre-processing or front-end processing provides significant benefit to cochlear implant users in everyday life situations. In addition to AutoSound™ and the T-Mic™, which have been available to Advanced Bionics (AB) users for several years, the collaboration between AB and Phonak has made it possible to implement even more advanced acoustic pre-processing features in the newest sound processors from AB. Scientists around the world have conducted studies to document the listening benefits provided by AB's advanced front-end processing. Several studies are summarized below.

T-Mic™

Advanced Bionics offers the patented T-Mic™ microphone placed at the opening of the ear canal. This strategic placement utilizes the outer ear's natural sound-gathering capabilities, just like normal-hearing ears.

Study Type	Summary	Presentations/Publications
Clinical Study Medical University of Hannover, Germany	This study compared the T-Comm™ to (1) the headpiece microphone of the Neptune™ and (2) a Harmony™ and T-Mic in 10 adult users. Speech perception results showed similar intelligibility when speech and noise both came from in front of the listener. **However, when speech was in front and noise was presented from the sides and the rear (±90°, 180°), the two T-Mic conditions led to an improvement of more than 2 dB compared to the headpiece microphone condition.**	**Microphone Location Effects on Speech Perception Using the T-Comm for Off-ear Sound Processors.** Brendel M, Geißler G, Fredelake S, Büchner A. *Submitted to CI international*
Pilot Study York University, UK	Three microphone placements were compared using a Head and Torso Simulator acoustic mannequin. The spatial-sensitivity patterns recorded with the cochlear-implant microphones placed in the T-Mic™, BTE and Kinder clip positions were compared with the reference pattern recorded with ear- canal microphones. **The T-Mic position produced the best results in terms of both physical measurements of spatial sensitivity and accuracy of sound localisation.**	**Effects of microphone location on the performance of bilateral cochlear implants.** Summerfield AQ, Kitterick PT. *Advanced Bionics White Paper, 2010.*
Clinical Study Medical University of Hannover, Germany	Four listening conditions were compared in 12 adult CII/HiRes™ 90k users: the standard built-in microphone, the T-Mic™, a Bluetooth® device positioned over the T-Mic, and a direct connection between a mobile telephone and processor. Individual word scores were better with the T-Mic, Bluetooth headset, and built-in microphone compared to the direct connection. Speech perception results for the T-Mic , built-in microphone and Bluetooth were similar. **The T-Mic was the preferred option for half the group.**	**Connection of a mobile phone to a cochlear implant system.** Rottmann T, Brendel M, Büchner A, Lenarz T. *Presented at the 9th Advanced Bionics European Investigators' Conference, Amsterdam, The Netherlands, March 12-13, 2010*
Clinical Study Mayo Clinic, USA	This study evaluated 14 adult Auria™/Harmony™ users and 20 Freedom users using an R-SPACE setup. Speech reception thresholds were compared between the T-Mic™ and BTE microphone for the AB subjects, and between the Everyday, Noise and Focus programs for the Cochlear subjects. **The T-Mic produced a significant 4.4 dB average advantage over the BTE microphone,** equivalent to the advantage provided by the Focus program compared to the everyday noise program. **The T-Mic was recommended for everyday use.**	**Speech perception for adult cochlear implant recipients in a realistic background noise: effectiveness of preprocessing strategies and external options for improving speech recognition in noise.** Gifford RH, Revit LJ. *J Am Acad Audiol. 21(7):441-51.* *Also presented at the 10th International Conference on Cochlear Implants and Other Implantable Auditory Technologies, San Diego, California, April 10-12, 2008.*
Clinical Study Midwest Ear Institute, Kansas, USA	Five children with unilateral implants and four children with sequentially implanted bilateral devices were tested with the BKB-SIN test. Speech was presented from the front while noise was presented from the front, from 90° toward side of implant and, for bilateral subjects, from 90° on the side of the second implant (presumably the poorer ear because of limited device use). Six of nine subjects demonstrated improved speech recognition in at least one noise condition with a Harmony™ and T-Mic™ compared with their own processor and microphone configuration. **Questionnaire results revealed that all parents preferred the Harmony and T-Mic to their child's own processor and/or microphone configuration.**	**Evaluation of the Harmony processor and T-Mic in children.** Osberger MJ, Cowdrey L, Lewis K, Lisbona K. *Poster at 6th Asia-Pacific Symposium on Cochlear Implants and Related Sciences October 30–November 2, 2007, Sydney, Australia* **Evaluation of the Harmony processor and T-Mic in children.** Buckler L, Lewis K, Lisbona K. *Poster at 11th international Conference on Cochlear Implants in Children, April 11-14th, 2007, Charlotte, North Carolina.*

UltraZoom

UltraZoom is a monaural adaptive beamformer that focuses on sounds coming from in front of the listener while attenuating sounds originating from the rear hemisphere in a frequency-specific manner (Hehrmann et al. 2012). UltraZoom was launched for Phonak hearing instruments in 2011. The new Advanced Bionics Naída CI Q70 (Naída CI) sound processor incorporates the UltraZoom beamforming technology from Phonak.

Study Type	Summary	Presentations/Publications
Pilot Study Medical University of Hannover and Advanced Bionics European Research Centre, Germany	Feasibility study conducted by combining the UltraZoom feature of a modified Phonak Ambra hearing aid with an Advanced Bionics Harmony™ processor. Preliminary acute data were collected from ten experienced Harmony/HiRes™ Fidelity 120 implant users. Speech was presented from 0° azimuth and speech-shaped noise was presented from loudspeakers placed at ±70°, ±135° and ±180° azimuth. The Oldenburg sentence test was used to determine the signal-to-noise ratio at which subjects scored 50% correct. **UltraZoom provided significantly better speech understanding in noise than the omni-directional condition: 5.3dB ± 1.2 improvement (Büchner et al. 2014).**	**Advanced Beamformers for Cochlear Implant Users: Acute Measurement of Speech Perception in Challenging Listening Conditions.** Büchner A, Dyballa KH, Hehrmann P, Fredelake S, Lenarz T. *PLOS ONE. 2014 Apr 22;9(4);9(4):e95542. doi: 10.1371/journal.pone.0095542. eCollection 2014.* **Naída CI Q70 Beamforming Technology: Unrivalled Performance in Noise** *Advanced Bionics white paper* **Improved Speech Intelligibility With Cochlear Implants Using State-of-the-Art Noise Reduction Algorithms.** Hehrmann P, Fredelake S, Hamacher V, Dyballa KH, Büchner A. *ITG-Fachbericht 236: Sprachkommunikation• 26.-28.09.2012 Braunschweig ©VDE VERLAG GMBH Berlin Offenbach.* **Experience of CI users with an adaptive-beamformer in a challenging listening situation** Büchner A, Geißler G, Arweiler I, Dyballa KH, Fredelake S, Hehrmann P, Hamacher V, Lenarz T. *Poster at 11th European Symposium on Paediatric Cochlear Implantation, Istanbul, May 23-26th 2013.* **Advantage of a Wireless Microphone Technique on Speech Intelligibility in Noise for Bilateral Cochlear Implant Users.** Brendel M, Geißler G, Arweiler I, Dyballa KH, Fredelake S, Hehrmann P, Hamacher V, Büchner A. *Poster at British Cochlear Implant Group Annual Conference, Scotland, March 2013*

Additional References:
Hey M, Vorwerk W, Langer J, Vorwerk U, Begall K.
Vergleich von Satztests im Störschall bei Cochlea Implantat Patienten. *6. DGA Proceedings. 2003.*

UltraZoom continued

Study Type	Summary	Presentations/Publications
Naída CI Q70 Clinical Study Medical University of Hannover and Advanced Bionics European Research Centre, Germany	Clinical study using the Naída CI Q70 speech processor in a group of 10 postlingually deafened, unilaterally implanted CI users who were experienced with HiRes™ 120 and the Harmony™ processor. The benefit of UltraZoom (with and without ClearVoice™) was compared to the omni-directional microphone using the adaptive Oldenburg sentence test. Speech was presented from 0° azimuth and speech-shaped noise fixed at 65 dB SPL was presented simultaneously from five loudspeakers positioned at ±70°, ±135° and 180° azimuth. **There was an average speech intelligibility improvement of 6 dB with UltraZoom compared to the omni-directional setting. There was an additional 0.8 dB improvement when ClearVoice was added.** For the Oldenburg sentences, psychophysical research shows that increasing the signal-to-noise ratio by 1 dB could lead to up to 15% improvement in speech understanding in cochlear implant users (e.g., Hey et al. 2003). Thus, the 6 dB improvement seen in this study may potentially translate into considerable benefit for Naída CI users when UltraZoom is enabled.	**Advanced pre-processing strategies with the new Naída CI Q70** Brendel M. *Presentation at Advanced Bionics Symposium European Federation of Audiology Societies Congress, Budapest, June 2013.* **Experience of CI users with an adaptive-beamformer in a challenging listening situation** Büchner A, Geißler G, Arweiler I, Dyballa KH, Fredelake S, Hehrmann P, Hamacher V, Lenarz T. *Poster at 11th European Symposium on Paediatric Cochlear Implantation, Istanbul, May 23-26th 2013.* **Naída CI Q70 Beamforming Technology: Unrivalled Performance in Noise** *Advanced Bionics white paper*
	Same clinical study group and setup as above but UltraZoom was compared to the T-Mic™ microphone and the omni-directional mic in more realistic noise conditions. Speech reception thresholds were measured in a moderately reverberant room using the adaptive Oldenburger sentence test. Speech was presented from the front loudspeaker at 0° azimuth and fixed masking noise was presented either simultaneously from eight loudspeakers located at 0°, ±45°, ±90°, ±135° and 180° azimuth or from five loudspeakers positioned at ±70°, ±135° and 180° azimuth. In a third test setup, an additional roving noise was added to the six-loudspeaker arrangement. **UltraZoom significantly improved the SRTs compared to the T-Mic alone in each of the test setups used.**	**Speech reception threshold benefits in cochlear implant users with an adaptive beamformer in real life situations.** Geißler et al. *Accepted, CI international*

AutoSound™

The wide Input Dynamic Range (IDR) and dual-loop Automatic Gain Control (AGC) within AutoSound automatically adapt to an AB implant user's surroundings, just like a normal-hearing ear. AB implant recipients do not need to fumble with dials or switches to make adjustments for changing sound environments.

Study Type	Summary	Presentations/Publications
Clinical Study Washington University, USA	Three programs were created with T levels set at 10% of the M level, at a 'barely audible' level and 10 current units (CU) below the barely audible level for ten adult CII/HiRes™ 90K users. FM-tone soundfield thresholds were significantly lower when T-levels were set at 10 CU below soft than when T-levels were set at 10% of Ms. Three IDR settings also were compared. Thresholds were lower with IDRs of 80 dB and 65 dB than with an IDR of 50 dB. However, this effect was mainly in the mid to lower frequencies. Scores for CNC words presented in quiet at 50 dB were better with an IDR of 65 or 80 dB compared to an IDR of 50 dB. The authors recommend setting T levels to higher than 10% of M levels and using a wide IDR, but only in patients who can reliably report sound quality issues. Otherwise manufacturer's defaults should be used.	**Optimizing the perception of soft speech and speech in noise with the Advanced Bionics cochlear implant system.** Holden LK, Reeder RM, Firszt JB, Finley CC. *Int J Audiol. 2011 Apr;50(4):255-69.*
Clinical Study Medical University of Hannover, Germany	This study explored the role of dual-loop AGC and IDR for understanding speech in realistic noise conditions. Sentences were presented at a roving level of ±10 dB or ±15 dB around a starting presentation level of 65 dB SPL. The SNR was adaptively adjusted to find a 50% speech reception threshold. Subjects included 11 Auria™ users, 11 Harmony™ users, 11 Esprit 3G users, 11 Freedom™ users and 11 Opus 2 users. The five groups did not differ significantly in age, duration of deafness or in the test scores obtained with the HSM sentence test at 10 dB SNR.	**Speech perception with cochlear implants as measured using a roving level adaptive test method.** Haumann S, Lenarz T, Büchner A. *ORL J Otorhinolaryngol Relat Spec. 2010;72(6):312-8.*

AutoSound™ continued

Study Type	Summary	Presentations/Publications
Clinical Study Medical University of Hannover, Germany *Continued*	Results at ±10 dB of roving showed significantly better scores for the Harmony and Opus 2 when compared to the Freedom, and the Opus 2 compared to the Esprit 3G. The Harmony, Auria and Opus 2 were better than the Esprit 3G at ±15 dB roving. **The wide IDR and dual-loop AGC in the Harmony, Auria and Opus 2 are advantageous for understanding speech in variable levels of noise.**	**Input Dynamic Range Testing** Khajehnouri Y, Lenarz T, Büchner A. *Poster at 2007 Conference on Implantable Auditory Prostheses July 15–20, 2007, Lake Tahoe, California* **Influence of the input dynamic range of cochlear implant processors on speech perception.** Haumann S, Büchner A, Lenarz T. *Poster at 2nd International Symposium of the Politzer Society on Otosclerosis & Stapes Surgery, May 8–10, Biarritz, France 2008.*
Clinical Study Hearts for Hearing, Oklahoma City, USA	Speech recognition, non-linguistic sounds identification, and preference ratings were measured for a narrow (40 dB) and wide IDR (70 dB) in seven adult CII/HiRes™ 90k users. All subjects demonstrated better speech recognition in quiet with the wider IDR. In the most difficult condition, reflecting real-world listening (AzBio sentences with +10 dB SNR), 4 subjects showed comparable performance with both IDRs, 2 subjects showed better performance with the narrow IDR, and 1 subject showed better performance with the wider IDR. **The majority of subjects preferred a wider IDR for listening to speech in quiet, for listening to speech in the most difficult noise condition, and for listening to music.**	**Effect of input dynamic range on speech recognition and music enjoyment.** Wolfe J, Mears A. *Poster at 10th International Conference on Cochlear Implants and Other Implantable Auditory Technologies* *April 10–12, 2008, San Diego, California*
Clinical Study Cambridge, UK	Six adult CII/HiRes™ 90K users were tested in a counterbalanced order with two types of AGC: the standard dual-time constant, dual loop AGC currently used in the sound processor and a fast-acting single loop syllabic compressor. **Fixed and roving level testing in noise indicated that speech perception was significantly better with the dual-time constant AGC.** There was little difference between the two AGC systems in quiet.	**Dual-time-constant and fast-acting AGC systems in cochlear implant subjects.** Boyle PJ, Stone MA, Moore BC. *Poster at 2007 Conference on Implantable Auditory Prostheses July 15–20, 2007, Lake Tahoe, California* **Comparison of dual-time-constant and fast-acting automatic gain control (AGC) systems in cochlear implants.** Boyle PJ, Büchner A, Stone MA, Lenarz T, Moore BC. *Int J Audiol. 2009 Apr;48(4):211-21*
Clinical Study Arizona State University and the Mayo Clinic, USA	A large and significant study containing three separate experiments. Experiment 1 recruited 26 CII, 32 3G and 18 Tempo+ subjects: The CII and Tempo+ groups achieved higher scores than the 3G group for sentences presented in noise (+10 and +5 dB SNR) and the CII group achieved higher scores than the 3G group for sentences presented at soft levels (54 dB SPL). It was speculated that differences in microphone sensitivity settings played a significant role in the performance of patients who use the 3G device. In experiment 2 ten 3G users were tested with the standard 30 dB IDR and the Whisper sensitivity setting with an IDR of 40 dB. An increased IDR improved performance at soft levels but reduced performance in noise. In experiment 3, the issue of why performance in noise with a wider IDR was unaffected in the CII and Tempo + devices but reduced with the 3G was explored. Ten CII users were recruited and tested. Increasing input dynamic range with the CII cochlear implant system significantly improved sentence understanding for material presented at conversational levels in quiet, conversational levels in background noise, and low input levels in quiet. **In conclusion the IDR, the setting of microphone sensitivity, and the methods for implementing compression appear to be the major factors responsible for the differences in performance between devices. The authors findings suggest a versatile speech processor would (i) use a wide IDR (55 dB or greater) and (ii) apply constant compression throughout the IDR.**	**Performance of patients using different cochlear implant systems: effects of input dynamic range.** Spahr AJ, Dorman MF, Loiselle LH. *Ear Hear. 2007 Apr;28(2):260-75.*