

# The new Harmony Soundprocessor - Outcomes with the HiRes 120 Speech Coding Strategy

*Brendel M<sup>1</sup>, Buechner A<sup>1</sup>, Krueger B<sup>1</sup>, Frohne-Buechner C<sup>1,2</sup>, Lenarz T<sup>1</sup>*

<sup>1</sup>Medical University of Hanover, Department of Otolaryngology, Hanover, Germany

<sup>2</sup>Advanced Bionics GmbH, Hanover, Germany

## Keywords

HiRes 120, Harmony Soundprocessor, Speech Coding Strategy

## Introduction

Current speech coding strategies are based on a number of stimulation sites, which is equivalent to the number of physical contacts. The independent current sources in the Advanced Bionics' HiRes system allow stimulation current to be shared between two contacts. This "current steering" technique creates additional pitch percepts as shown by Koch et al. [2007] and Downing et al. [2005]. A new speech coding strategy implementing the current steering technique, the so called HiRes 120 (or HiRes Fidelity120™), offers up to 120 different stimulation sites to the cochlear implant user. HiRes 120 is supported by the new ear level sound processor Harmony™ HiResolution® Bionic Ear System of Advanced Bionics.

## Material and Methodology

The European multicentric study protocol contains speech perception tests and perceptual channel tests over the course of five months, using HiRes on the patient's own processor (CII BTE, Auria or PSP) and HiRes 120 on the Harmony processor. As an extension to the multi-centric protocol, HiRes was also tested on the Harmony as an additional condition. The test battery consisted of HSM sentence tests in several conditions: in quiet, in speech shaped noise at 10dB S/N and with a single competing talker at 10dB S/N. Subjective data were collected by questionnaires concerning general sound quality, music perception as well as comfort and handling of the processors. During the course of the study a perceptual channel test was performed twice: after using HiRes at the beginning of the study and after the three months of using HiRes 120. For this test, stimulation was delivered to pairs of adjacent electrodes at three sites (apical, medial, basal). Following an adaptive adjustment of the proportion of current delivered simultaneously to both electrodes of the test pair, the smallest audible pitch difference was found [Koch et al. 2007]. From this, the total number of perceptual channels of the whole electrode array was derived.

Eleven adults participated in this study. They all used a HiRes90K or CII implant system and had more than nine months experiences with the HiRes strategy. Three of them used a CII BTE, five an Auria, and three the bodyworn PSP. They had a mean age of 58.1 years (38.2 to 79.3 years) and a mean duration of deafness of 5.1 years (0 to 25.3 years).

A second study group consisted of 14 adult subjects who previously had participated in an eight months study on different speech coding strategies including current steering implementations. They were tested with the Harmony for one month using both strategies (HiRes and HiRes 120). At the end of the study the "best condition" was selected defined as the condition that yielded best results in the HSM sentence test with competing talker. They had an averaged experience with HiRes of more than two years, a mean age of 58.8 years (25.1 to 76.2 years) and a mean duration of deafness of 5.0 years (0 to 26.0 years). Five of them used the CII BTE, three the Auria and six the PSP.

A statistical analysis was performed using a paired sample two-tail Student's t-test. Throughout the diagrams significance level is indicated as follows: \*\*) highly significant with  $p < 0.01$ , \*) significant with  $0.01 < p < 0.05$ .

## Results

Figure 1 shows the results from the HSM sentence test in different conditions for the first study group. The bars arranged in a chronological order show HiRes on their own processor at the beginning of the study, HiRes 120 on the Harmony after one month and three months respectively, HiRes on their own processor again for one month, and HiRes on the Harmony as the last condition. In quiet a ceiling effect could be observed for all conditions. The results after using HiRes 120 on the Harmony for three months were better than with HiRes on any of the two processors in the HSM sentence test with CCITT noise as well as with competing talker. Both speech coding strategies on the Harmony resulted in significantly better results than HiRes on the own processor at the four month appointment in the HSM sentence test with competing talker.

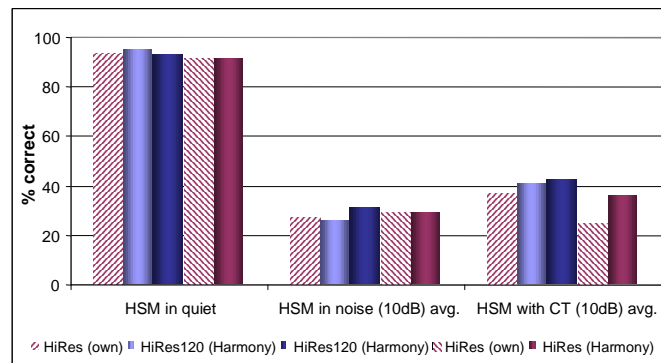


Figure 1: Group results of the HSM sentence test for different conditions;  $n = 9$  (first study group)

The subjective rating (Figure 2) showed the improved results for the Harmony processor in all items concerning clarity, pleasantness, quality, hearing in background interference and naturalness

of different voices with both strategy. The overall mean score using the Harmony with any strategy was significantly higher compared to the subjects' own processor.

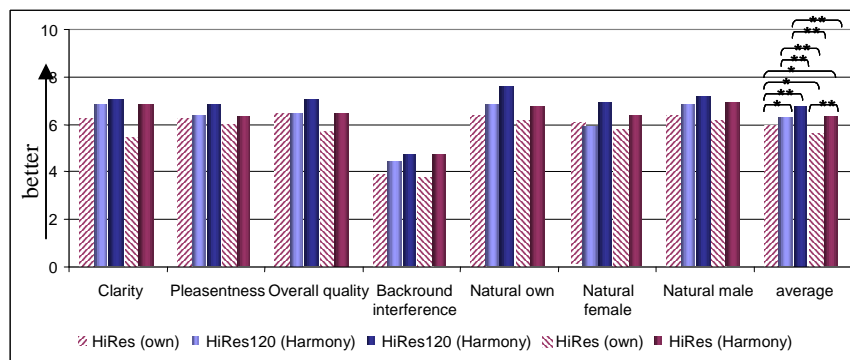


Figure 2: Group results of the sound quality questionnaire;  $n = 9$  (first study group)

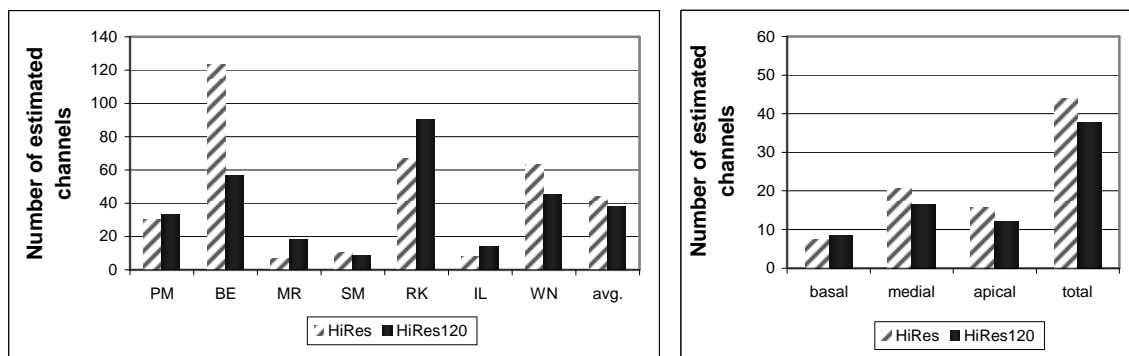


Figure 3: Perceptual channel test;  $n = 7$  (first study group); left: individual results, right: averaged results broken down by stimulation site.

For the perceptual channel test, no significant differences were found between the tests after using HiRes or HiRes 120 (Figure 3).

For the second study group - similar to the first group - clear differences among the strategies were

only found in the HSM sentence test with competing talker. Both Harmony conditions yield significantly better results compared to HiRes on the subjects' own processor (figure 4). The improvement of HiRes 120 over HiRes on the subjects' own processor is even highly significant.

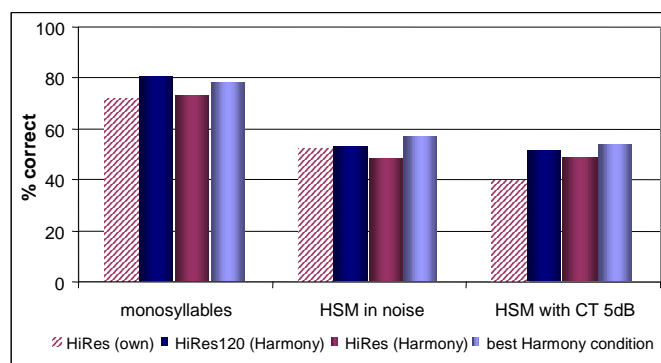


Figure 4: Speech perception tests in different conditions;  $n = 14$  (second study group)

Figure 5 shows results of the questionnaire reflecting subjective rating of the second study group for HiRes on the PSP as well as HiRes and HiRes 120 on the Harmony. The rating was noticeably higher for the Harmony, but especially clarity, overall quality and listening with

background interference is significantly better, again with a slight advantage for HiRes 120. Subsequently, even better results can be achieved when the best strategy is selected on the Harmony processor.

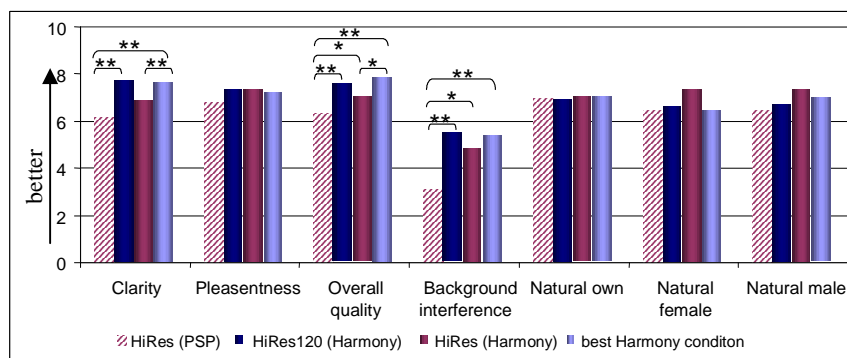


Figure 5: Results of the sound quality questionnaire;  $n = 13$  (second study group)

## Discussion

The first four months of the study protocol from the first group followed the multicentric European protocol suggested by Advanced Bionics. The major goal was to investigate the potential benefit of the currently introduced HiRes 120 sound processing option on the Harmony processor, as compared to the previous clinical system (PSP, CII BTE or Auria processor with HiRes strategy). The original protocol did not allow concluding whether any changes were related to the new strategy or the new processor. In order to get further insight into this question, without compromising the multicentric protocol, one additional month was added, in which subjects used HiRes on the Harmony.

In theory, HiRes 120 delivers an increased frequency resolution compared to HiRes. Sensitive test material is required to reveal any potential benefit. Therefore, a single competing talker was introduced for the HSM sentence test. Testing with a competing talker is more sensitive to the spectral resolution than speech shaped noise, as the subject may benefit from listening in the gaps between words [Nelson et al. 2003]. Indeed, the HSM sentence test with competing talker showed more pronounced differences than the test with only speech shaped noise. This test nicely reflected the subjective data from the sound quality questionnaire.

In both tests in noise, as well as questionnaire items, the results after three months of HiRes 120 use are better than the results after one month.

Apparently the learning process took more than one month. Experience from the introduction of HiRes has shown that only up to two weeks were required to adapt to the new strategy [Battmer et al. 2002]. Therefore it was not expected that the learning process with HiRes 120 on the Harmony was significantly longer than one month. In this case the learning process may have been longer either because the auditory system requires more time to make use of an increased spectral resolution offered by HiRes 120 or because the protocol included a change of the processor, which requires getting familiar with the handling as well as with the new front-end.

Considering only data with significant time of adaptation to the respective system (i.e. baseline with HiRes on the own processor and three month data with HiRes 120 on the Harmony) results of all tests in noise as well as questionnaire items were better with the new system. This shows the benefit of the improved front end in combination with the improved spectral resolution. The non-balanced protocol does not allow drawing a conclusive presumption, however the results indicate benefits from the improved technology of the processor's front end.

Baseline results with HiRes are mostly better than the results in HiRes after the fourth month. This may indicate that adaptation of more than one month is required also when swapping backwards from HiRes 120 to HiRes. Another sub-protocol of the European multicentric study may answer this question as it uses a balanced cross-over design with an interval of three months between the changes of the strategy.

The second group already had significant experience with strategies implementing current steering prior starting this study. Therefore it was assumed that one month of experience with HiRes 120 on the Harmony was sufficient to get an estimate of their performance. When treating HiRes 120 as a further option for the subjects to choose from, i. e. selecting the best performing strategy for each individual, the Harmony gives significant benefit subjectively as well as objectively.

## Summary

The Harmony processor introduces significantly better speech understanding compared to the forerunner system, while the improvement apparently has two causes: the improved front-end of the processor and the option for the new current steering strategy HiRes 120. Performance benefit could best be shown using the HSM sentence test with a single competing talker. Interestingly, improvements in this particular testing condition also go hand in hand with the questionnaire data,

which indicates a more life-like test situation for patients.

## Outlook

The next step will be a cross-over study with both speech coding strategies HiRes 120 as well as HiRes on the Harmony during the first year after implantation. Further evaluation of the perceptual channel test during this time for HiRes and HiRes 120 with a higher sample size will follow.

## References

- Battmer RD, Büchner A, Frohne-Büchner C, Popp P, Lenarz T. The Clarion® CII High Resolution Mode: Experience After 6 Months. Presented at Manchester 2002
- Firszt Jb, Downing M, Runge-Samuelson C, Koch Db, Litvak L (2005) Increasing spectral resolution through current steering in the HiResolution Bionic Ear®. Symposium on Cochlear Implants in Children, March 15-19, Dallas, Texas
- Gault A, Frohne-Buechner C, Delande JB, Arnold L, Miller D, Boyle P (2006) Concept and technical features of the new HiRes Auria+ processor. 9th International Conference on Cochlear Implants and Related Sciences, June 14-17, Vienna, Austria
- Downing M, Firszt Jb, Runge-Samuelson C, Koch Db, Litvak L (2005) Current steering and spectral channels in HiResolution Bionic Ear® users: Multi-center study of cochlear-implant place/pitch relationships. Assoc Res Otolaryngol Abstr, 2005;28:85
- Koch DB, Downing M, Osberger MJ, Litvak L (2007) Using current steering to increase spectral resolution in CII and HiRes90K users. Ear Hear, 2007 Apr;28 (2 suppl):38S-41S
- Nelson PB, Jin SH, Carney AE, Nelson DA. Understanding speech in modulated interference: cochlear implant users and normal-hearing listeners. J Acoust Soc Am. 2003 Feb;113(2):961-8.