White Paper

Revision 1.0 : July 21, 2020

The SAMBA 2 Audio Processor – Technical Facts and Initial Audiological Results

Postert B., Bicego L., Lochner J., Mojallal H. [1]
[1] Applied Hearing Science, MED-EL, Business Unit Vibrant, 6020 Innsbruck, Austria

Correspondence should be addressed to Benno Postert; AppliedHearingScience@medel.com

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Keywords: Speech in noise, listening effort, SAMBA 2, BONEBRIDGE, VIBRANT SOUNDBRIDGE

The SAMBA 2 Audio Processor – Technical Facts and Initial Audiological Results

1. Summary

MED-EL launched the new SAMBA 2 audio processor on July 8, 2020. Including the latest technology, this audio processor (AP) is designed to be used in combination with the VIBRANT SOUNDBRIDGE or BONEBRIDGE hearing implants. Since all MED-EL APs are backwards compatible, upgrading from a previous AP such as SAMBA or Amadé is possible.

This document focuses on the technical facts of the new SAMBA 2 in comparison to its predecessor, SAMBA, and presents initial audiological measurement results.

2. The SAMBA 2 Audio Processor

SAMBA 2 is the successor device of SAMBA and intended to be used as external part of the VIBRANT SOUNDBRIDGE or BONEBRIDGE system. Three variants are available and differ with respect to the maximum gain and the maximum output levels. The SAMBA 2 BB audio processor is used with the BONEBRIDGE implant, whereas two options can be used with the VIBRANT SOUNDBRIDGE (VSB) implant, SAMBA 2 Hi or SAMBA 2 Lo. The processor runs on one off-the-shelf 675 Zinc Air battery (size PR44) and is held in place over the implant by magnetic attraction. The attachment magnet comes in six different strengths and can be exchanged at the bottom of the AP using the Magnet Exchange Tool. The audio processor is comprised of two microphones, a sound processing circuitry, and a digital compression processor.

SAMBA 2 features the same basic functionality and design as SAMBA with the exception of the following modifications:

- Six instead of five **programs** are programmable.
- The number of **frequency and compression bands** has increased from 16 (48 channels in the background) to 18 (48 channels in the background).
- The existing **noise reduction** features have been supplemented with a Directional Speech Enhancement feature, and the **acoustic classifier** is now capable of identifying 6 instead of 5 different acoustic environments (see 3.2.1. for more details).
- SAMBA 2 comes with a **revolving battery door** instead of a sliding battery door.
- The **magnet** can now be exchanged from the outside of the AP, thus reducing the number of steps needed to change the magnet when compared to SAMBA.
- **Ingress protection** (IP) against intrusion from objects and moisture increased from IP32[1] to IP54. The AP is now protected against dust and water splashing from any direction, according to the international standard IEC 60529 [1].

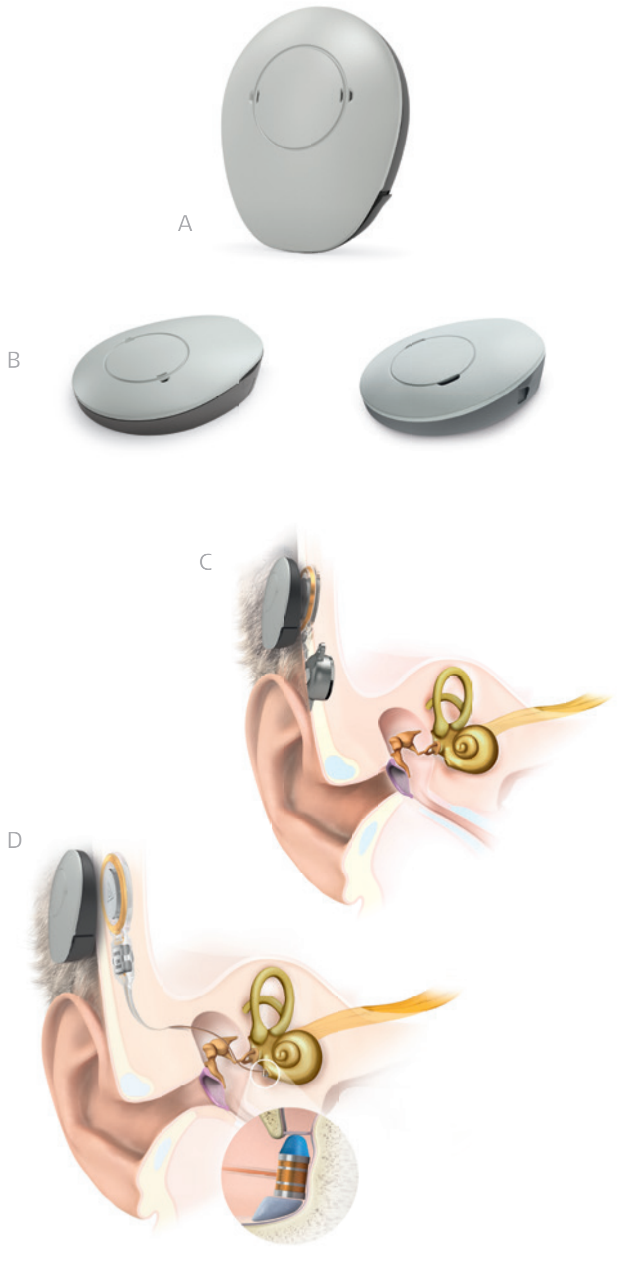

Figure 1: A) The SAMBA 2 audio processor. B) SAMBA 2 (left) compared to SAMBA (right). C) SAMBA 2 on BONEBRIDGE. D) SAMBA 2 on VIBRANT SOUNDBRIDGE.

[1] IP32: Protected from objects with a size > 2.5 mm and vertically falling water drops when AP is tilted up to 15 degrees.

3. Initial Audiological Results

3.1 Objective

The aim of this in-house test was to evaluate the audiological performance with SAMBA 2 in the universal program. The test was conducted on subjects with normal hearing by simulating hearing loss and evaluating speech understanding in quiet, speech understanding in noise and subjective listening effort for both SAMBA Hi and SAMBA 2 Hi.

3.2 Methods

20 normal hearing subjects (11 left and 9 right ears; 9 males and 11 females; average age: 37.8 years) were tested. Mild-to-moderate hearing loss was simulated by occlusion of both ears (unaided PTA4: 45 dB HL). By using a VSB implant simulator, subjects were able to perceive the VSB signal via air-conduction via an ER3-C insert earphone. Only one AP variant could be chosen due to the timeframe of this test. Therefore, the more frequently used AP variant, SAMBA 2 Hi, was tested. However, all available variants use the same front-end processing technology. Testing of the left or right ear was randomized. The hearing performance was tested with and without the APs in free field.

The word recognition score (WRS) in quiet was tested using the Freiburger monosyllable word test at 55 dB SPL. This level was chosen to provide sufficient attenuation through the ear plugs. Speech in noise was evaluated using the German matrix test OLSA at a fixed and continuous noise level of 65 dB SPL and adaptive speech (S) level with a male voice in two settings: S0°; Olnoise120°; ISTS180°; Olnoise240° (see Figure 4) and S0°; Olnoise120°; Olnoise180°; Olnoise240° (see Figure 5). Olnoise is speech-shaped stationary noise (environment noise), while the International Speech Test Signal (ISTS) is a non-stationary speech noise that consists of sentence fragments from multiple languages (a single female voice as the interferer). Subjective listening effort was examined using the Adaptive Categorical Listening Effort Scaling test (ACALES) [2]. After presentation of three OLSA (matrix test) sentences in noise, participants were asked to rate listening effort on a scale of 14 answers from "no effort" to "only noise". Each round of three sentences were presented at a different signal-to-noise ratio. Software calculated regression lines were used to describe subjective listening effort as a function of signal-to-noise ratio (SNR). The SNR rated with moderate listening effort by the participant (SNR-cut at seven effort scale categorical units (ESCU) in dB) was used for data evaluation. The desired speech signal was presented from the front loudspeaker (S0°), the level was adaptive. The female voice as the interferer using the International Speech Test Signal (ISTS), was presented from the back (ISTS180°), continuously at 65 dB SPL.

A pantonal threshold of 40 dB HL was used as a basis for fitting to account for the simulated hearing loss. The default first fitting with the fitting formulas (DSL-I/O for SAMBA, DSL-v5 for SAMBA 2) and 100% acclimatization was applied. The recommended software was used to set up each AP. SAMBA was set up using SYMFIT 7.0 in combination with CONNEXX 6 while SAMBA 2 was set up with SYMFIT 8.0. Both APs were used in the default program (universal).

For data analysis and graphs, GraphPad Prism 7.04 was used, and to test for statistical significance Wilcoxon signed-rank test was performed.

3.2.1 Technical Facts – SAMBA vs. SAMBA 2

This section provides an overview of the technical properties relevant to the design of the in-house test. In particular, the output sound-pressure-level (SPL) for 90 dB input SPL (OSPL90) and full-on gain curves for SAMBA Hi and SAMBA 2 Hi from internal technical bench measurements will be discussed. More detailed data for the other available AP variants of SAMBA and SAMBA 2 can be found on the fact sheets [3, 4].

Figure 2 shows the full-on gain curve (FOG, dashed line) and the output sound-pressure-level (SPL) for 90 dB input SPL curve (OSPL90, solid line) for SAMBA Hi (left) and SAMBA 2 Hi (right). The measurements were done in free field, input signals were pure tones, and the gain control was set to the full-on position.

The two graphs show that SAMBA 2 Hi had a similar OSPL90 and full-on gain response compared to SAMBA Hi. This is important to point out as it demonstrates that comparable fittings can be achieved with SAMBA Hi and SAMBA 2 Hi in terms of maximum output and gain.

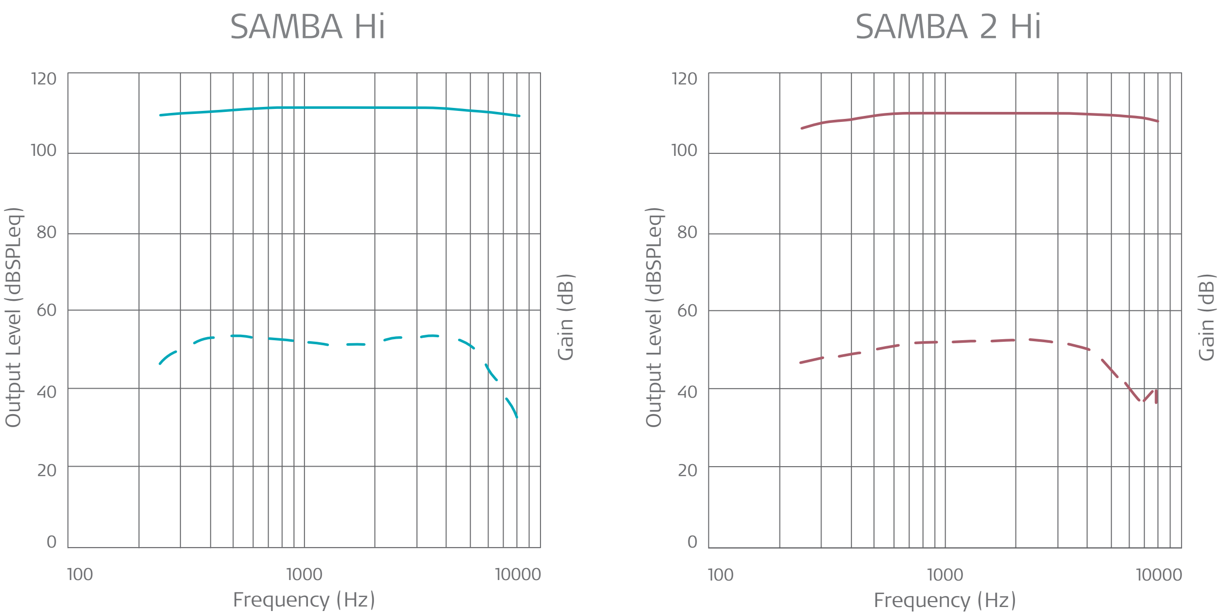

Figure 2: Technical output measurements for SAMBA Hi and SAMBA 2 Hi from 250 to 8000 Hz at 90 dB SPL input (OSPL90, solid line) in dBSPLeq and full-on gain (FOG, dashed line) in dB.

Table 1 summarizes technical data for SAMBA Hi and SAMBA 2 Hi. The frequency range from 250 to 8000 Hz, maximum OSPL90 and high-frequency average full-on gain (HFA-FOG) of SAMBA Hi and SAMBA 2 Hi are comparable. In detail, SAMBA Hi has a maximum OSPL90 of 111 dB SPLeq and SAMBA 2 Hi 110 dB SPLeq. The HFA-FOG of the frequencies 1, 1.6 and 2.5 kHz is 52 dB for both APs. SAMBA 2 offers more precise fine-tuning with two additional independent frequency and compression bands. Both AP generations come with automatic adaptive multi-channel directional microphones and offer acoustic classification based on five (SAMBA) or six (SAMBA 2) acoustical environments. For an overview of the detectable classes, see Table 1. Desired speech from behind, which was previously undetectable with SAMBA, is now in focus with SAMBA 2, for example, in a car when the user might not be able to turn their head. By recognizing the acoustic environment, settings such as adaptive noise reduction and adaptive directionality are adopted automatically. The noise reduction of SAMBA was based on the modulation properties of the incoming signals and worked well with stationary noises from any direction. The new feature, Directional Speech Enhancement, has been added to SAMBA 2's Speech and Noise Management. Using this feature, SAMBA 2 is now able to adapt noise reduction based on modulation properties and the direction of incoming signals. Thus, SAMBA 2 works well in stationary noise as well as in non-stationary noise. In the default universal program, all noise reduction features are active.

Technical Information	SAMBA Hi	SAMBA 2 Hi
Frequency range (Hz)*	250-8000	250-8000
Max OSPL90 (dB SPLeq)	111	110
HFA-FOG (dB)	52	52
Independent frequency bands*	16	18
Independent compression bands*	16	18
Microphones*	Automatic adaptive multi-channel directional	Automatic adaptive multi-channel directional
Acoustic classification*	5 acoustical environments (speech, speech in noise, non-stationary noise, stationary noise, music)	6 acoustical environments (quiet, speech in quiet, noise, speech in noise, music, car)
Noise reduction*	Based on modulation properties of incoming signals	Based on modulation properties and direction of incoming signals
Fitting software*	SYMFIT 7.0 in combination with CONNEXX 6	SYMFIT 8.0

Table 1: Technical information on SAMBA Hi and SAMBA 2 Hi.
*true for all SAMBA and SAMBA 2 variants.

3.3 Results

Speech in quiet was tested using the Freiburger monosyllabic test. The word recognition score (WRS) improved 69% ± 12.4% with SAMBA and 72% ± 12.3% with SAMBA 2 from the unaided condition. The difference in WRS between both APs was not significant ($^{ns}p = .2903$). Speech in noise was tested using the German matrix test OLSA. The improvement for SAMBA and SAMBA 2 were both significant compared with the unaided situation, although it was even greater for SAMBA 2. The biggest difference in performance between SAMBA and SAMBA 2 was observed when both speech shaped stationary noise and interfering speech were presented simultaneously (S0°; Olnoise120°; ISTS180°; Olnoise240°), see Figure 4. In this situation, the improvement was -1.6 ± 2.4 dB with SAMBA and -5.7 ± 3.5 dB with SAMBA 2, compared with the unaided condition. The observed difference was statistically significant ($^{****}p < .0001$). SAMBA 2 was still significantly better ($^{***}p = .0009$) but the difference with SAMBA was smaller when only speech shaped stationary noise was presented (S0°; Olnoise120°; Olnoise180°; Olnoise240°), see Figure 5. In this condition, the improvement was -5.7 ± 2.2 dB with SAMBA and -6.7 ± 2.2 dB with SAMBA 2, compared with the unaided condition. The test results for subjective listening effort showed an improvement of -3.5 ± 4.7 dB with SAMBA and -5.2 ± 4.6 dB with SAMBA 2 over the unaided condition. The difference between improvements from the unaided condition with both APs was statistically significant ($^{*}p = .0246$), and SAMBA 2 demonstrated a greater improvement in subjective listening effort than SAMBA.

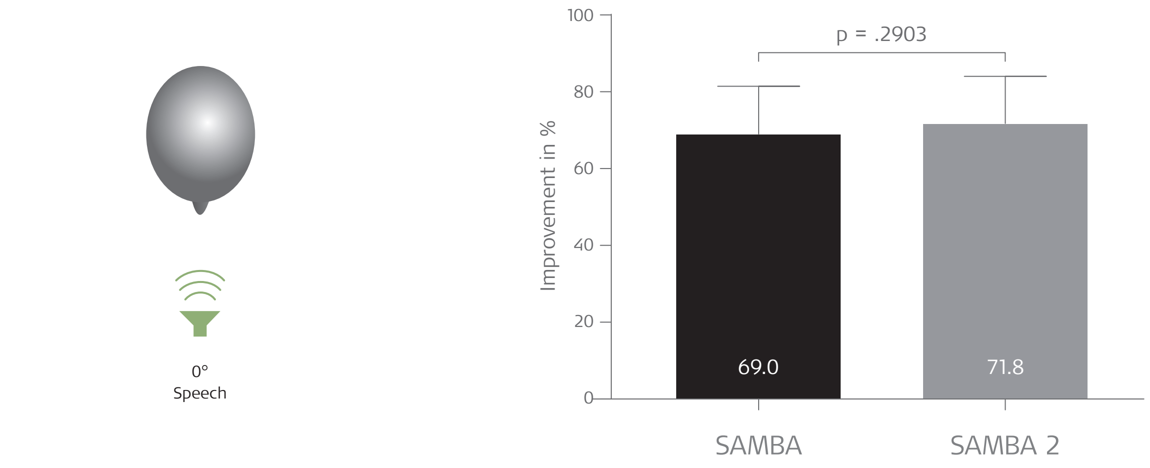

Figure 3: Speech understanding in quiet. Mean and standard deviation of the % improvement in WRS from unaided are shown for SAMBA (black) and SAMBA 2 (grey). Speech was presented from the front (S00°) at 55 dB SPL.

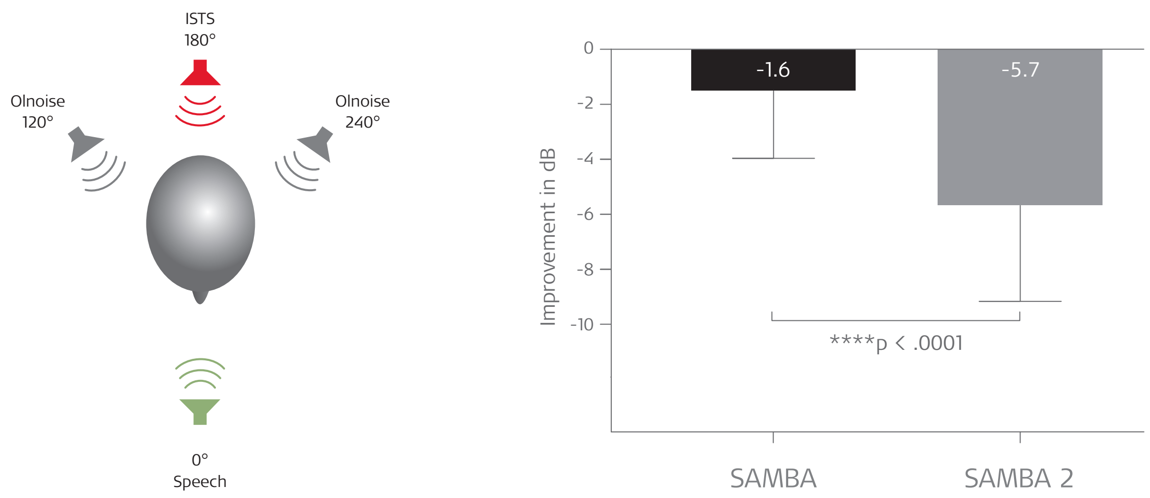

Figure 4: Speech in stationary noise and interfering speech. The speech recognition threshold at 50% speech understanding in dB SNR was tested using OLSA (matrix test). Results show the mean and standard deviation of the improvement from unaided (in dB SNR) of SAMBA (black) and SAMBA 2 (grey). Stationary Olnoise was presented from 120° and 240°, interfering speech noise was presented from 180°. All noise signals were presented continuously at 65 dB SPL. The sound level of speech from the front (S00°) was adaptive.

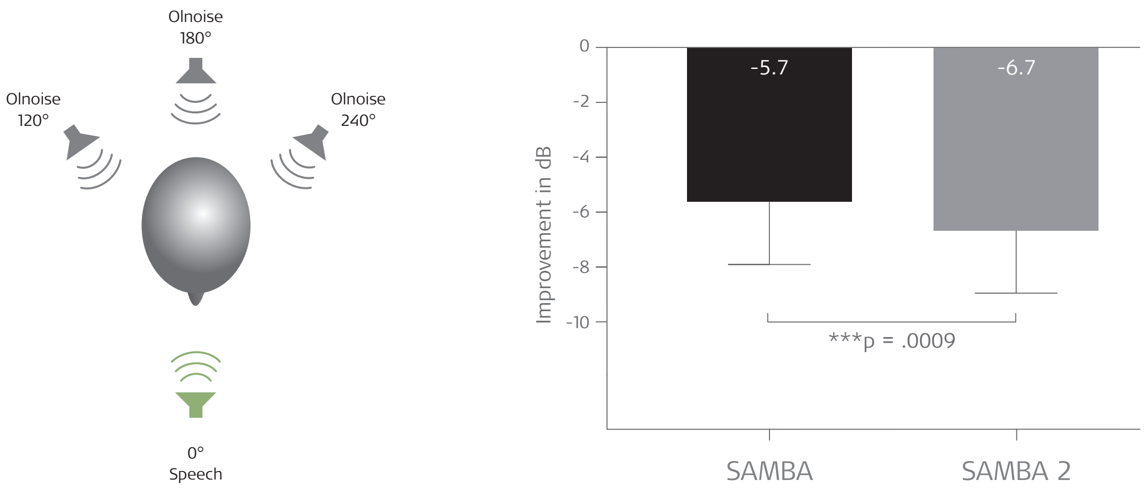

Figure 5: Speech in stationary noise. The speech recognition threshold at 50% speech understanding in dB SNR was tested using OLSA (matrix test). Results show the mean and standard deviation of the improvement from unaided (in dB SNR) of SAMBA (black) and SAMBA 2 (grey). Stationary Olnoise was presented continuously at 65 dB SPL from 120°, 180° and 240°. The sound level of speech from the front (S00°) was adaptive.

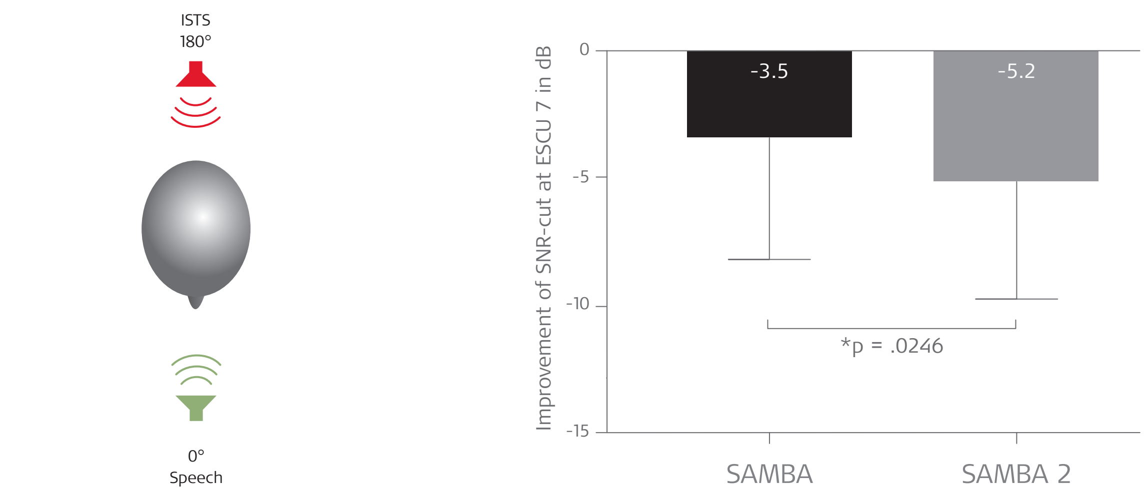

Figure 6: The subjective listening effort. Subjective listening effort was examined using the Adaptive Categorical Listening Effort Scaling test (ACALES). Results show the mean and standard deviation of the improvement from unaided of SAMBA (black) and SAMBA 2 (grey). The SNR-cut at 7 effort scale categorical units (ESCU) in dB represents the signal-to-noise ratio at which the participant rated the speech material to be understandable with moderate effort. The speech was presented from the front (S0°), the level was adaptive. Noise (ISTS180°) was presented continuously at 65 dB SPL from the back.

4. Discussion – Initial Data on SAMBA 2

The technical measurements revealed that SAMBA 2 Hi has output sound pressure levels (OSPL90) and full-on gain (FOG) values comparable to SAMBA Hi. Speech in quiet results were also similar for both APs. In the less complex speech in noise environment where only stationary noise was presented, SAMBA 2 showed slightly better performance. There was a 1 dB improvement between means. In the difficult listening environment where both environmental noise and interfering speech were simultaneously present, SAMBA 2 demonstrated a much larger improvement than SAMBA. Here the mean improved by 4.1 dB SNR over the previous generation. Thus, thanks to the advanced noise reduction features of the new SAMBA 2, speech understanding—especially in noisy environments with multiple voices in the background, such as at an airport or train station—improved significantly for users. In addition, the results of the ACALES subjective listening effort test demonstrated that less listening effort is required in noisy environments with SAMBA 2 when compared to SAMBA.

These results have provided preliminary data on the performance of the new SAMBA 2 AP. However, it should be taken into account that these measurements were performed in normal hearing subjects with simulated hearing loss. Therefore, future clinical studies are needed to test both AP variants with VIBRANT SOUNDBRIDGE and BONEBRIDGE users.

4.1 Conclusion

Preliminary results indicate that SAMBA 2 has some features that enhance hearing performance over its predecessor audio processor, SAMBA. Not only was listening effort reduced but also hearing performance improved in challenging listening environments when SAMBA 2 was compared to SAMBA. Thanks to SAMBA 2's backwards compatibility, future as well as existing VIBRANT SOUNDBRIDGE and BONEBRIDGE users will be able to benefit from the new generation AP.

5 References

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MED-EL Medical Electronics | Business Unit Vibrant
Fürstenweg 77a | 6020 Innsbruck, Austria | vibrant@medel.com