

**Speech Guard
In Oticon Agil
- A Whitepaper**



Improved **Speech
Understanding**
and reduced
Listening Effort



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Speech Guard Improves Speech Understanding and Reduces Listening Effort in Noise

For individuals with significant hearing loss, the use of wide dynamic range compression (WDRC) in hearing instruments is the only viable solution to achieving maximal audibility. However the use of WDRC has a downside that is well recognized but yet ignored by hearing instrument developers; audibility is only achieved at the expense of signal fidelity. Souza (2009) aptly referred to this trade off as the balance between audibility and distortion. In order to achieve maximal speech audibility and understanding with minimal distortion, the real challenge for hearing instrument manufacturers is to achieve optimal signal audibility with minimal or no distortion. To meet this challenge, gain adjustment systems would need to act fast enough to maximize speech audibility and understanding, yet slow enough to preserve the subtle details and fidelity of the speech signal.

At Oticon, an amplification strategy known as Speech Guard was developed in the newest generation wireless instrument Oticon Agil to achieve just that (Simonsen & Behrens, 2009). Speech Guard endeavors to keep the gain adjustment linear (i.e., within a “floating” linear gain window) whenever possible with slow compression speed (or longer time constants). When the input signal level is steady and stable, Speech Guard responds slowly. When abrupt loudness changes occur, Speech Guard responds quickly, bringing the input signal to a new level of audibility and assuring comfort. Thus, in situations that require protection against sudden increases in loudness level, Speech Guard responds almost instantaneously and provides protection from these unexpected increases. Conversely, when there is a significant reduction in input level, Speech Guard swiftly turns up the gain bringing the soft sound to a new level of audibility at which the “floating” linear

gain maintains a natural and distortion-free sound. Conventional slow-acting WDRC compressors effectively “shut down” during the release period causing the end-user to lose valuable speech information. Speech Guard’s fast release time allows the wearer to focus on the speech event itself rather than the artifacts a conventional compressor may present. The attack and release times of Speech Guard are controlled by the dynamics of the input signal and can vary from a few milliseconds to a second.

The effectiveness of Speech Guard in various signal conditions has been clearly revealed in a two-site study that was completed at Oticon’s international headquarters in Denmark and at Hörzentrum, Oldenburg, Germany. In this study, a total of 39 experienced hearing instrument users (29 males and 10 females) with a flat to sloping hearing loss underwent speech intelligibility and listening effort evaluations in noise. The age of the participants was between 20 and 80 years with a mean of 67.5 years. Each of these participants used Agil Pro and an advanced hearing instrument. Using a balanced cross-over design, half the participants began the study with Agil and the other half with the advanced hearing instrument. After two weeks of using either Agil or the advanced hearing instruments, participants’ speech intelligibility was evaluated before switching to the other instrument.

The set up used to evaluate speech intelligibility in noise is illustrated in Figure 1. Two configurations were used: a spatial and a co-located configuration. In the spatial configuration, un-modulated noise was presented at 70 dB SPL from 3 speakers placed at +110°, 180° and -110° azimuths. Speech was presented at 0° azimuth. In the co-located set up, noise and speech were presented at 0° azimuth. Noise in this set up was a white noise impulse occurring every 200ms. This set up was specifically designed to test the performance of Speech Guard to transient noise. The speech stimuli were derived from the Dantale II test (Danish speech intelligibility in noise test) and ►►



the OLSA test (German speech intelligibility in noise test) and the signal to noise ratio at which 50% correct score was attained was taken as the speech intelligibility score.

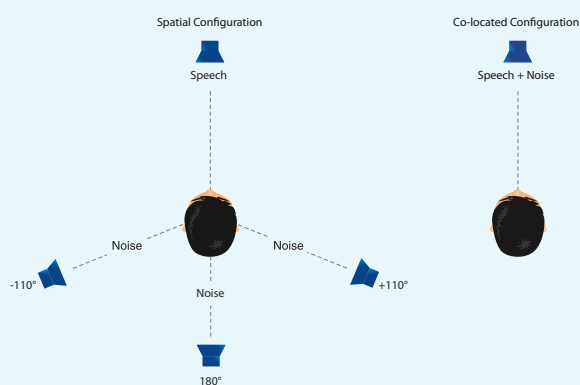


Figure 1. Schematic drawing of the two test configurations used in the speech intelligibility and listening effort tests. In the spatial configuration, speech was presented from the front speaker and un-modulated speech-shaped noise was presented at 70dB SPL from the three rear speakers. In the co-located configuration, 20 ms long white-noise pulses occurring at 200ms intervals were presented at 60dB SPL from the same front speaker speech stimuli were presented.

Having used both instruments for weeks, each participant's listening effort to instruments was also evaluated in the laboratory at the end of the four week trial period. This same set up that was used to evaluate speech intelligibility in noise was also used to evaluate listening effort. However, there was a slight difference in the way speech stimuli were used to assess listening effort. Five sentences from the Dantalle II and the OLSA tests were used as the speech stimuli. Participants were required to repeat each sentence, and then rate the difficulty of speech understanding with Agil and the advanced instrument being tested following the presentation of all 5 sentences. Participants were blinded to the hearing instruments and the order of presentation of sentences was randomized between the two instruments. The signal-to-noise ratio for the listening effort measurement for each participant corresponded to 80% correct speech recognition. Participants

rated the instruments on a blank but a bound visual analogue scale (see Figure 2) which was later translated into one of the seven descriptive categories of effort (Schulte et al. 2009): No effort, very little effort, little effort, moderate effort, considerable effort, much effort and maximum effort.

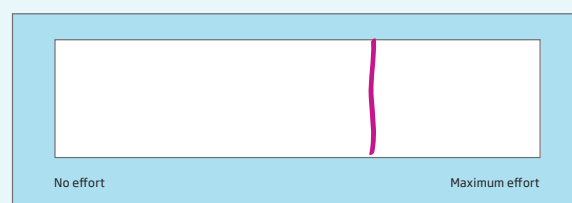


Figure 2. Example of a completed visual analog scale used in the listening effort measurement. Each participant indicated with a vertical line how effortful he or she found it to be to understand the speech.

The results of the speech intelligibility in noise test are shown in figure 3. The speech intelligibility scores for both the spatial and co-located configurations were significantly better for Agil compared to the advanced hearing instrument. A lower speech intelligibility score means better performance as the 50% correct speech recognition was attained at a poorer signal to noise ratio. An improvement of 1.0 dB and 1.5 dB was observed when using Agil compared to the advanced instrument in the spatial and the co-located configurations respectively. This represents an improvement of 13% for the spatial and 18% for the co-located configurations. In the co-located configuration, the hearing instrument would have to respond quickly to the rapid signal fluctuations in order to maintain acceptable listening comfort. When using conventional instruments, the intelligibility of ongoing speech during the noise bursts is usually compromised due to a slow release following a fast attack by the compressor. It is clear that with the fast release times used in Speech Guard, better speech intelligibility was able to be achieved. ►►

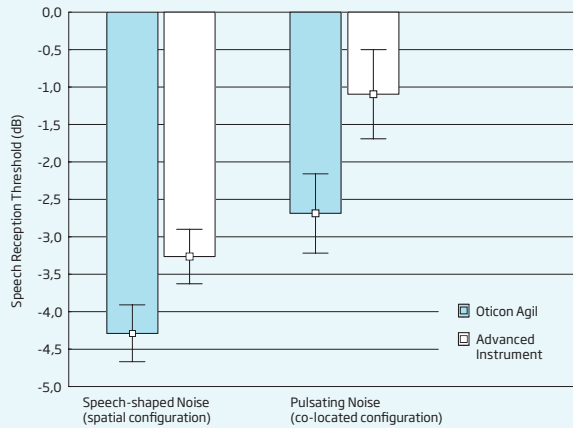


Figure 3. Speech recognition results from Dantale II and OLSA for Agil and the advanced hearing instrument for the spatial and co-located configurations (see figure 1 for the two test configurations).

The listening effort rating obtained for Agil was also significantly better for Agil than that obtained for the advanced hearing instrument. As shown in figure 4, “considerable” effort was needed to understand speech in noise when using the advanced hearing instrument. With Agil the effort expended in listening to the same speech material in noise was only “moderate”, and this represented a statistically significant reduction in listening effort ($p < 0.05$).

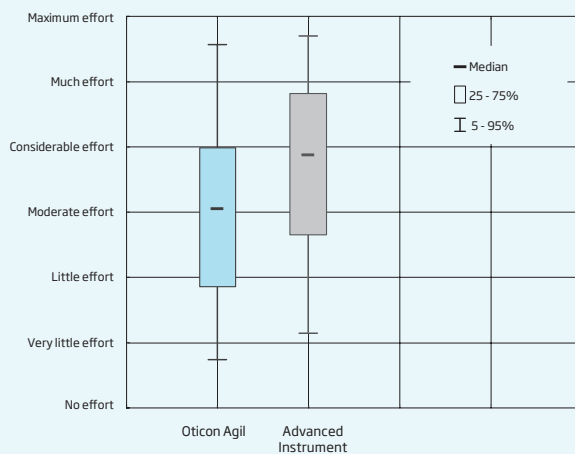


Figure 4. Median listening effort ratings with Agil (left) and the advanced hearing instrument without Speech Guard (right). The listening effort is significantly reduced with Agil.

The present study has clearly demonstrated that Oticon Agil with Speech Guard has a clear performance advantage over the advanced hearing instrument without Speech Guard in terms of speech understanding and listening effort in noisy situations. By protecting and preserving the natural details and dynamics of speech, it is possible to allow users of Agil to not only understand speech better but also to understand speech in noise with significantly less effort.

Speech Guard is available in Oticon Agil Pro and Agil.

References and Further Reading

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People First is our promise
to empower people
to communicate freely,
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