WHITE PAPER - PRIMO 2013

Alta Core Features

Introduction

Oticon's new Alta product line introduces new features as well as revisions to previous features to maximise listening performance and client satisfaction. Satisfaction is experienced as a meeting of expectations, as a change in abilities, and as a reduction or elimination in the problems that drove the user to seek treatment. The key cornerstones that guide Oticon solutions are **performance, sound quality**, and the **effort** to listen with a hearing loss – in a **personalised** perspective. If a hearing aid user, with the hearing loss, auditory and perceptual system he or she has, can hear and understand in noise, listen to sound that is natural and comfortable, and do so for long periods of time without noticing fatigue and exhaustion, we have met our target. A new digital platform, named Inium, was developed to support the new and improved features that work towards our targets. These features include YouMatic Premium, Speech Guard E, Inium feedback shield, Spatial Sound Premium, and Free Focus Premium.

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PEOPLE FIRST

Inium, Oticon's 3rd generation wireless platform

Our new quad-core signal processing platform, Inium, delivers the unique combination of exceptional performance, incredibly small size and ultra low power consumption. Inium includes additional memory and processing power compared to the previous platform, which was necessary to offer the new and improved features found in Alta. Moreover, the wireless near field magnetics in Inium consume up to 10 times less energy than ear-level radio frequency technology used by other manufacturers, depending on signal complexity, range and required frequency bandwidth.

Speech Guard E

Did you know that hearing loss is experienced as a loss of clarity of sounds, especially in noisy environments, rather than an inability to hear? Even if you can hear the sounds, it is much more work to extract the message when you have a hearing loss. Hearing devices must make sure sound is audible, but also clear, natural, and easy to listen to. The standard method in all modern hearing devices of providing audibility for a broad range of inputs is compression. Compression provides audibility of soft sounds, while preventing loud sounds from becoming too loud. Sound quality can be compromised with compression, either because sound gets distorted, or because information is lost at the output because of prolonged extensive compression, (drop-outs due to long release times).

One method of avoiding the problems associated with compression is to use two sets of time constants, as found in Speech Guard. When sound inputs are relatively constant, the system can go very slowly and act like a linear system, which preserves important auditory cues and speech characteristics used to help speech segregation and localisation. When the input levels change by larger amounts, the system will react quickly to reset this linear-like window and set the system to a new steady gain level until the input levels change by a larger amount again.

Speech Guard E in Alta uses the exact same principles as the Speech Guard introduced in Agil. In this revision to Speech Guard, the goal was to increase the ability to segregate sounds. This was accomplished with an optimisation of the linear-like behaviour of the compressor. It's all about how much and how fast we change the gain as the input changes. Within specific sound events (such as the noise in a car), the gain is kept steady to facilitate the use of auditory cues. Between specific sound events, when the overall level changes dramatically, the system reacts quickly to optimise audibility and comfort.

Figure 1 represents the strategy of Speech Guard on an input/output curve. The diagonal line shows sound that passes through the system without amplification. Shifting the line above the diagonal makes the output louder than the input (which is amplification). The slope of the lines show either expansion (steeper than the diagonal) or compression (shallower than the diagonal) as found in wide dynamic range compression systems.

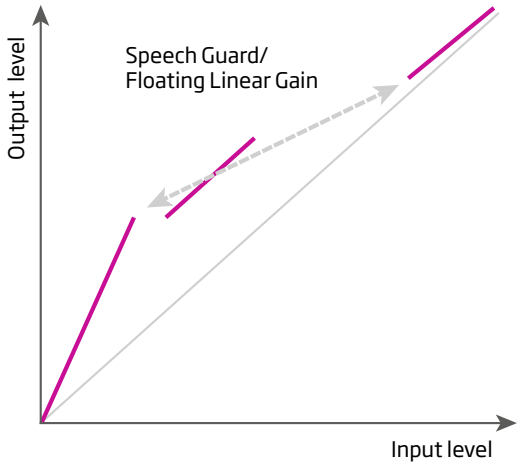

Figure 1: *Speech Guard applies gain based on a short linear segment that slides along the typical compression function when input levels change.*

Speech Guard takes a linear line segment and slides it along the dashed compression curve when input levels fall outside its reach. So if the level goes up more than the linear segment covers, the whole linear segment moves up. The process is repeated in the opposite direction when the level goes down too far. This change in the linear segment happens very quickly to reset the system to a stable, linear-like mode as quickly as possible, but allowing the system to adjust to prevent gain from becoming too soft or too loud. Listening tests and sound quality ratings were used to adjust the length of this linear segment to the optimal setting, which changed it from 9 dB to 12 dB. If the preservation of envelope cues is estimated, Speech Guard E has even better preservation of the signal envelope than original Speech Guard – up to 14% better (Nilsson & Behrens, 2013, based on technique by Holube et al., 2005).

YouMatic Premium

Did you know that no two people see, hear, or feel the same way? Our perception is that we exist and operate in a world around us that is seen, heard, and felt the same by everyone. But really we are only connected to the world by the input to our senses (eyes, ears, skin, nose, etc.). We assume that the world is experienced the same by everyone, but all it really needs to be is consistent so that we can learn the association between our description (for example, the colour green) and what we detect by our eyes (stimulation of certain cells in the retina that we have learned to associate with the colour green). But every person's nervous system is unique and the actual patterns and reception of the world is also unique. We accommodate this diversity by learning common words or descriptions to relate what we see or hear to what others see and hear. Treatments that make individuals hear the same as everyone else will therefore be incomplete, inaccurate, or unnatural because it is calibrated based on one set of sensations, not on each individual's particular nervous system. To avoid the one-size-fits-all approach, we must go beyond the audiogram and begin to address the dimensions of personal sound perception and preferences.

Oticon has invested in providing variations in processing style to meet the needs and preferences of all clients without having to change devices, as has been necessary previously. This process begins with analysis of input sound signals by the instruments:

- Input level
- Type of signal (noise, speech in noise, speech only)
- SNR in input level
- Changes in the input level (short and long-term)
- Binaural level differences
- Binaural SNR differences

The process continues by adjusting how the system reacts to these inputs. These changes to how the system reacts are what helps adjust to individual differences. We have used:

- Auditory capacity (HL thresholds)
- Age
- Gender (NAL-NL2)
- Experience with wearing hearing aids

Table 1 shows the changes that occur to the 5 main profiles, demonstrating the range of adjustments made to ensure that YouMatic Premium will fit the personal needs and preferences of each listener.

Feature		LIVELY	EXACT	BALANCED	GENTLE	STEADY
Omni type	Normal	Opti Omni	Opti Omni	Opti Omni	Speech Omni	Speech Omni
	Power	Opti Omni	Opti Omni	Opti Omni	Opti Omni	Opti Omni
Dir automatics	Normal	Tri-mode	Tri-mode	Tri-mode	Tri-mode	Tri-mode
	Power	Tri-mode	Tri-mode	Tri-mode	Tri-mode	Tri-mode
Dir. w. Bass compensation	Normal	Off	Off	Off	Off	Off
	Power	On	On	On	On	On
Noise Management		12 dB 4.5 dB	12 dB 6.75 dB	12 dB 9.75 dB	12 dB 11.25 dB	12 dB 11.25 dB
Transient Management		Off	Off	On/Sit Depend.	On/Sit Depend.	On/Sit Depend.
Gain		~+3.0 dB	~+2.5 dB	~+1.5 dB		
Speech Guard E		Fast 12 dB FLG	Medium 12 dB FLG	Medium 12 dB FLG	Medium 12 dB FLG	Slow 12 dB FLG
Spatial Noise Management		Att 6 dB -10 dB SNR	Att 6 dB -7.5 dB SNR	Att 6 dB -5 dB SNR	Att 6 dB -2.5 dB SNR	Att 6 dB -2.5 dB SNR

Table 1: *Settings used in the automatic systems across the five personal profiles in Alta*

The actual listening scheme and mix of features set by YouMatic can be seen and adjusted in the YouMatic Manager as showed in Screen 1.

Screen 1: *The performance and behavior of the personal profile selection is shown as a mix of features. This defines how YouMatic Premium will react and respond in any listening situation.*

Our new system, called YouMatic, includes and considers auditory lifestyle and a new subjective dimension, **personal preferences** in listening style and noise tolerance. This information is used to set the speed and performance level of the automatic features in the device, which will help to match the individual system to the listener. The personal profile is selected and programmed in the fitting process and defines a detailed listening scheme. The individual listening schemes comprise a broad continuum of performance and sound variations - and these changes are not just a single change to a feature, but changes across multiple features in combinations that work together.

There are 5 personal profiles to choose from, with three sub scales of each, giving the choice from 15 various listening schemes or styles of devices. The selection by YouMatic Premium is the result of our advanced research and long experience into how different hearing aid users respond to different modes and mixture of features. These include response time, response levels, focus modes, noise management, transient management and compression speed.

The Personal Profile section implemented from Genie 13.1 helps choose between the various profiles with listening tools to compare the settings in various recorded situations. Rather than just turning on a setting and sending the patient out to return after some length of time, the system allows direct and immediate listening comparisons, which increase patient involvement in the fitting process, uncover and satisfy the personal preferences for sound and thus, reduce the chances that the hearing aid user will wear devices in sub-optimal settings.

Spatial Sound Premium

Did you know that differences in sounds at the two ears help to create the auditory world around us? Sound between the ears can differ with respect to level and timing and science shows that these interaural level differences (ILD) work primarily in the high frequencies (above 1500 Hz) while the interaural timing differences (ITD) work primarily in the low frequencies (below 1000 Hz). Onset time (which ear hears a sound first) is one of the strongest cues and can override both ILD and ITD cues. Based on such basic information, the brain creates our "perceptual world".

Taking advantage of the binaural fitting, Spatial Sound Premium is the combination of a number of device characteristics and technologies that can be used to pre-

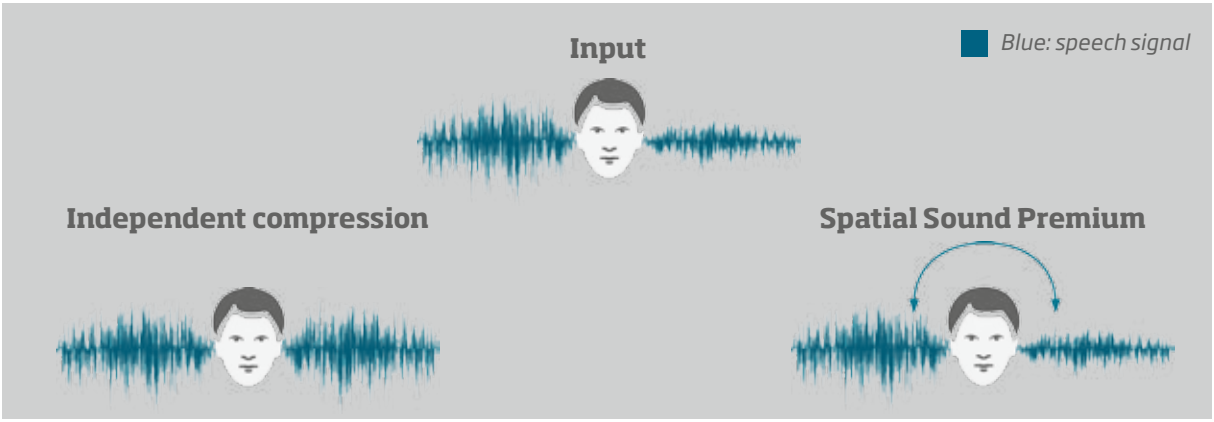

Figure 2: *Interaural level differences (ILD's) can be changed or possibly eliminated by conventional compression. Spatial Sound Premium tracks these differences in input level to preserve these useful cues. ILD's occur mainly in the higher frequencies, where short wavelengths are blocked by the head.*

serve spatial cues. These include binaural compression (which coordinates compression ratios inter aurally, aligned with the naturally occurring intensity differences) open ear fittings (which allow low frequency ITD information into the ear undisturbed where normal hearing is often found), extended frequency bandwidth (which adds to the high frequency ILD cues that can be made audible), as well as Spatial Noise Management. In Alta, the processes that use a comparison of information from both ears can now be personalised to the individual, allowing Spatial Sound to work for a wider range of listeners than ever before.

True binaural processing, where compression is linked between the ears is one of the features of Spatial Sound Premium. Binaural compression is important to make sure that interaural level differences are preserved to the highest degree possible by compression, which amplifies soft sounds more than loud sounds. If compression is de-correlated and independently optimised, the levels at the eardrum can end up roughly equal (see Figure 2), eliminating this important cue.

Spatial Noise Management looks at asymmetrical, noisy situations and when beneficial, overrides the standard binaural compression. When there are large differences in the level of noise and the signal-to-noise ratio between ears, the Spatial Noise Management will emphasize the ear with a better signal-to-noise ratio. The extent to which the better ear is emphasized is based on the personal profile, so this processing is used more frequently for individuals that appreciate more processing to reduce noise (see figure 3).

Free Focus Premium

Did you know that one of the most challenging problems associated with hearing loss is difficulty extracting sound from background noise, not an inability to hear? Today's digital sound processing enables to remove unwanted noise - also coming from different directions. This is accomplished using directional microphones that are now capable of being tuned to vary their sensitivity based upon the direction of sound, making sounds from the front come through better than sounds from other directions.

Directional microphones (as they are called) can have some drawbacks, which is why they are not used universally in all settings. They can be noisy in quiet situations, are prone to wind noise, and rarely provide as

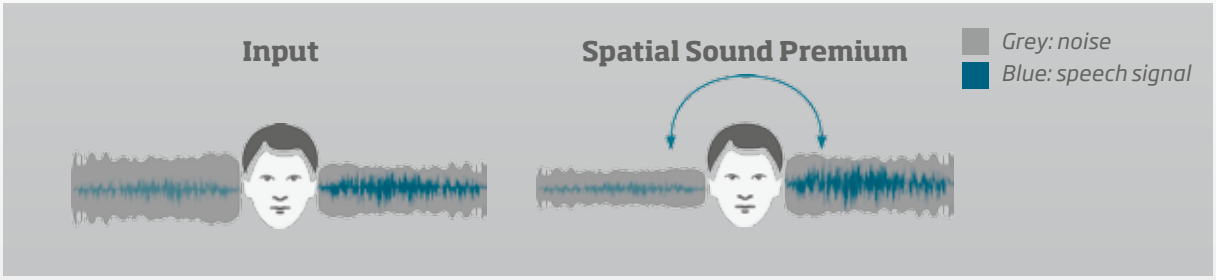

Figure 3: *In asymmetric noise conditions, Spatial Noise Management will overwrite the standard process to reduce the level of noise, helping to focus on the optimal signal to noise ratio in the ear ipsilateral to the noise.*

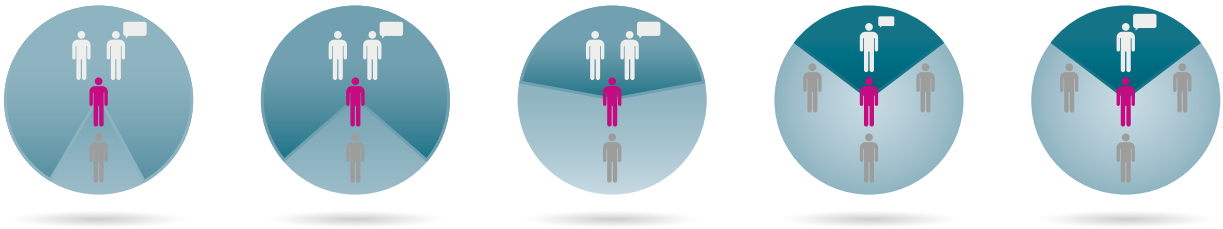

Figure 4: *Graphical representations (left to right) of Opti Omni, Speech Omni, Split Dir, Full Dir, and Full Dir with low frequency compensation.*

much benefit as expected. They are less sensitive to low frequency sounds, but that can be compensated for. It is also possible to produce polar responses for specific environments and positions on the head, whether the microphone is in the ear or behind the ear or trying to simulate the directional response of the normal ear. There are even automatic microphone modes that do not disturb or disrupt the listener, changing characteristics naturally to maximise the microphone characteristic based on the situation.

Alta has combined all the alternate microphone settings into a single feature we call Free Focus Premium This includes new directionality modes to gently provide the appropriate amount of attenuation of noise and enhancement of speech for each individual including speech understanding in groups, crowds and background noise. The system is designed to produce the best possible signal-to-noise ratio in noisy settings with as little compromise as possible to the spatial awareness and accuracy.

A range of directional settings are provided that introduce directionality from the high frequencies downward in frequency as more directionality is deemed useful. The Opti Omni and Speech Omni settings are used in quiet settings - and in situations where the signal-to-noise ratio cannot be improved - to mimic the natural frontal focus of the unaided ear. More directionality is implemented as noise levels increase and signal-to-noise ratio degrades. For severe and profound losses full directionality is only implemented with a low frequency boost, as regular directionality is not sufficiently loud to be useful for these listeners. Three of the five directional responses are used for each device, based on the personal profile and hearing

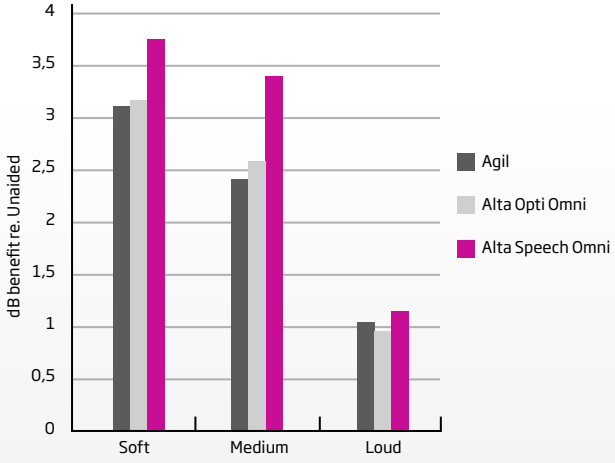

Figure 5: *Speech intelligibility with HINT, Agil vs. Alta, n=48, tested at Oldenberg and Cleveland. Soft (55 dB), Medium (65 dB), and Loud (75 dB) noise with performance expressed as benefit relative to unaided.*

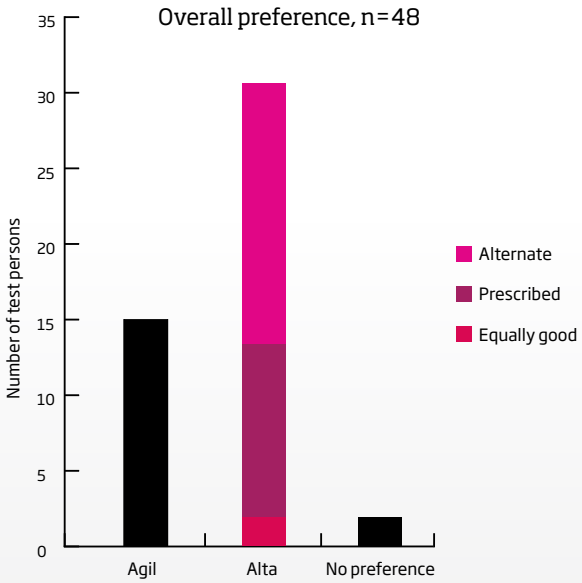

Figure 6: *Device preferences expressed when subjects were asked to choose between the three options worn during the claim study, n=48. Two profiles were evaluated, one with Opti Omni in quiet and the other with Speech Omni in quiet as default surround mode for quiet settings.*

loss selected. Testing of the various profiles has shown the benefit of more directionality, as seen in Figure 4: The profile with more directionality in Alta showed significantly more benefit than the Agil or the Alta profile with less directionality. This also leads to increased preference for the Alta, as seen in Figure 5. By selecting the appropriate level of directionality, the performance and preference can be optimised.

Inium feedback shield

Did you know that many variables in a sound system, like distance between microphone and speaker, level of amplification, size of venting and physical characteristics of the ear all affects the feedback path and can cause instability and generate feedback? Signal processing can be used to limit feedback, but can also generate strange sounds when it is not done accurately or carefully (this is called entrainment).

Science shows that dealing with physical changes around a device is the secret to a good feedback cancellation system. Feedback can be eliminated in almost any situation if you turn down the gain, generate other annoying sounds, or distort sounds. To be effective, feedback cancellation must be provided while preserving sound quality and maintaining amplification. The secret to Inium feedback shield is to combine algorithms when they are beneficial to provide a system that controls feedback without the negative side effects.

Phase inversion **Frequency shift** **Gain manager**

Three processes are used in various combinations to give the most stable system with the fewest problems. These include:

- Phase inversion to cancel feedback
- Frequency shifting to de-correlate the input and output of the device to break the feedback path and help differentiate feedback from tones
- Careful gain control to avoid feedback conditions

These processes are used to maximise stability and sound quality while still preventing feedback from occurring. Phase inversion is the process that actually cancels feedback, as long as the feedback frequency is known and stable. This process requires time to find the feedback and cancel it, so other systems are necessary to control feedback in the short term. Frequency shift is used to decorrelate the input signal and output of the device, which helps distinguish feedback from tones in the input, but also prevents new feedback loops while the phase inversion system eliminates the present feedback. The Gain manager uses measurements of the system to determine how much gain can be expected from the system, given the ear canal, the fit of the ear mould, and the characteristics of the listener's ears. Allowing a system to try and provide gain during the short period of time where the system is not stable and prone to feedback is foolish, so we use the information we have to avoid this. All together, the system is our most stable, least likely to feedback, while still providing our world renowned sound quality and avoiding entrainment artefacts. This is a win win win situation.

Conclusion

The testing with Alta shown in the Free Focus Premium section demonstrates that hearing impaired listeners can hear a difference between the personal profiles offered in Alta. The data also shows that there is a nearly equal split in their preference between the two profiles, despite the fact that performance was better with the more directional system. This is an example where a single performance measure is not sufficient to determine the overall needs and preferences for each listener, and a system that accommodates a range of listening styles will better meet the listening needs of all patients. It is good to offer more help to those who need it or want it (as indicated by patient responses to the YouMatic Premium feature), but a system needs to adapt to the needs and situations each individual encounters throughout the day. Appropriate reactions across listening situations matching the listener's preferences and abilities will make listening as comfortable and easy as possible. It makes sense that a device that changes to work the way you listen is easier to use and adapt to than a device that requires you to change your listening style to accommodate it.

Oticon Alta is a step forward in helping to deliver on our intent to help maximize the hearing available to hearing impaired listeners and let them forget they have a hearing loss. The closer we get to allowing hearing impaired individuals to hear without limitations or extra burdens, the closer we are to delivering on our promise to give people the energy to live their life.

People First

People First is our promise
to empower people
to communicate freely,
interact naturally and
participate actively

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