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The development behind Oticon MyMusic

ABSTRACT

Different characteristics between speech and music make it less optimal to listen to music through a hearing aid programme that is optimized for speech understanding. Oticon MyMusic is a hearing aid programme dedicated for music listening, no matter if music is played in the surroundings or streamed directly to the hearing aids. The development of Oticon MyMusic is based on external research on reference curves for different speaker setups and headphones used for music listening, and research on music listening with hearing aids. The result is a completely new music programme with a unique compression scheme and standard settings optimized for music listening. The listening experience using the music programme has been tested on hearing-impaired listeners to make sure to deliver an outstanding music listening experience.

EDITOR OF ISSUE

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When a person acquires a hearing loss it affects speech understanding which in turn makes it more difficult to communicate and participate in daily activities. Hearing aids are designed to help users overcome problems in speech understanding. Hearing aids have steadily gotten better at this task over the years (Santurette, Ng, Juul Jensen, & Man, 2020). But what about other important activities we use our hearing for? Listening to music, for instance, has long been a challenge for hearing aid users – not only professional musicians, but also people listening to music for pleasure. Oticon MyMusic meets this challenge and delivers an outstanding music listening experience to the users for both music in the surroundings and streamed music.

Differences between music and speech

To understand why a normal hearing aid programme, designed for speech amplification, is not all that good for amplifying music we need to look at some characteristics for both speech and music.

Over the years, a lot of research has been done on speech characteristics. One result of this research is the Long-Term Speech Spectrum. It is possible to derive this because the variations in the vocal tract where speech is produced are fairly limited between different people, and across languages (Chasin, 2003). The Long-Term Speech Spectrum makes it easier to know where to focus the amplification in a hearing aid to best optimise speech audibility.

Music, on the other hand, is much more unpredictable and the variations much larger. Depending on the instrument or the mix of instruments used in the piece of music, both frequency and intensity ranges are much wider than for speech (see figure 1) and the emphasis within the ranges can vary much more (Chasin, 2003; Limb, 2010). Sometimes music can be speech-like but most often it is not. This makes it more difficult to know how to amplify music to make the experience just right.

Reference curves for best music listening experience

When music is produced it is optimised to be played and listened to through good loudspeakers in a good listening room at a certain distance to achieve the experience the producer wanted to create. Sometimes though, music is not listened to through loudspeakers but through speakers close to the head or in the ear canal (like headphones) where the good listening room is not adding its response and thereby colour to the sound. While the delivery medium is different, the producer's intended listening experience remains the same. Thus, a lot of research was done on music listening through different types of headphones and in-ear products. The goal of this research was to ensure that the intended experience was recreated and good sound quality maintained, despite the very different listening conditions. Measurements of music with an artificial head in both free-field (anechoic room) and diffuse free-field (very reverberant room) were made to find a reference curve that could be used when evaluating the output from headphones (Olive, Khonsaripour, & Welti, 2018).

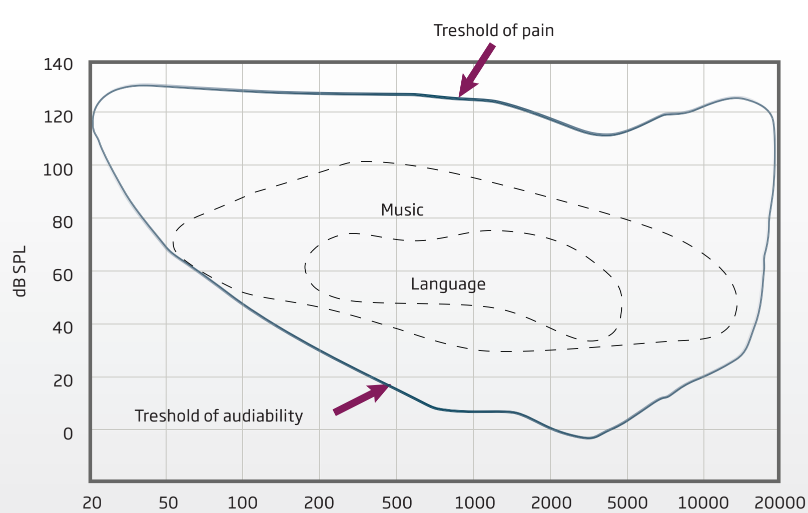

Figure 1: The frequency-intensity visualization of the human audible range with plots for speech and music areas. Image adapted from Limb (2010).

Neither the free-field or diffuse free-field reference curves worked optimally, though, so a new idea was proposed by Sean Olive, currently a Senior Fellow at Harman International.

The hypothesis proposed by Olive was that none of the previous ways of measuring provided an optimal reference curve. He hypothesized this was because the existing setups were not sufficiently like those in daily life or the environment in which the music was created. So, he performed measurements in a listening room with 'normal' reverberance closer to what is seen in a music production room. The frequency response was measured using an artificial head and sounds played from loudspeakers. A room like this provides a slight boost to low frequency sounds due to the reverberation absent from high frequency sounds. To know whether the response curve measured based on his hypothesis was right, he asked a test group of experienced listeners to rate several different headphones on the market on sound quality. The best rated products all had a frequency response similar to the shape of the curve measured in the test setup (Olive & Welti, 2012; Olive, Welti, & McMullin, 2013a; Olive, Welti, & Khonsaripour, 2017).

The reference curves, called Harman targets, are created for in-room (for room correction systems), in-ear, on-ear, and over-ear headphones (Olive, Welti, & McMullin 2013b; Olive, Welti, & Khonsaripour, 2016; Olive, Khonsaripour, & Welti, 2018; Jaakkopasanen, 2019). Over the last several years, the Harman curves have been used in HIFI products as reference curves (Butterworth, 2019).

The in-room and in-ear targets have formed the basics for the development of the new Oticon MyMusic (see figure 2).

Oticon MyMusic

Over the years different researchers have investigated how music experience could be improved for hearing aid users. The improvements for the music experience were created by tweaking both hardware and software for existing hearing aids. These investigations led to some fitting tips and some recommendations for gain prescription (Crook, Greasley, & Beeston, 2018; Crook, Beeston, & Greasley, 2018). This research has also been considered together with the Harman targets when developing Oticon MyMusic. This paper will not go more into the fitting tips, but you can read more about these in the Fitting Series paper from Oticon (Gade & Løve, 2021).

The general recommendations for how to prescribe amplification and the Harman targets have led to a list of design principles used for Oticon MyMusic.

1. Apply a basic hearing loss compensation

The hearing loss needs to be compensated for to make sure sounds are audible.

2. Gain knee points frequency shape should follow a music signal profile

The knee point levels are selected based on knowledge about comfortable music listening levels and on

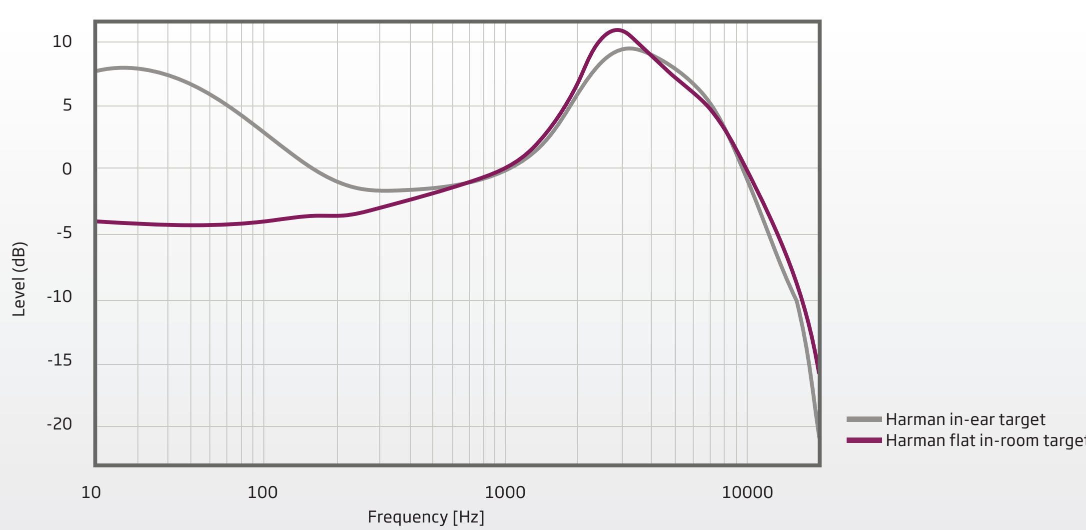

Figure 2: Harman targets for in-ear headphones and loudspeaker in-room flat. Image adapted from Olive, Welti, & McMullin (2013b) and Jaakkopasanen (2019).

dynamics in music. The broadband knee point levels used are 40dB SPL for soft, 65dB SPL for moderate, 90dB SPL for loud and 105dB SPL for very loud. Knee point levels are frequency dependent.

3. Compression must be kept low and remain stable across frequency

4. No compression prescribed between moderate and loud levels

One of the most important and unique elements of Oticon MyMusic compared to our normal VAC+ speech programme is the compression scheme.

When looking at the compression scheme over the input range, most compression is done between the first two knee point levels (soft and moderate). The design principle is to keep the compression ratio as low as possible while ensuring sounds are audible to the listener. The compression ratio is limited to a mean value of 2.5 with a max of 3.0 for individual bands for soft input levels to avoid artifacts and reduced sound quality.

The compression ratio is kept to 1.0 between moderate and loud knee points. This linear compression "window" is central in the design of Oticon MyMusic to ensure higher quality amplification of musical signals. This is, as mentioned, a very different approach compared to an amplification programme created for speech. Between the loud and very loud knee points the gain compression is fixed to 1.5. This limitation is provided to avoid major compression artifacts and simultaneously to prevent distortion at high input levels.

When looking at insertion gain curves the compression strategy means that the curves for moderate to loud inputs will be on top of each other (same gain applied for different input levels), whereas the curves for soft and very loud sounds will deviate with more and less gain respectively.

When looking at the simulated in situ output graph for a standard N3 hearing loss from Oticon Genie 2 (figure 3) the linear amplification between moderate and loud can also be seen. The compression stability over frequencies can be seen by the parallel equidistant curves up to around 2 kHz. This helps preserve the harmonicity of musical signals with larger dynamics and frequency span than speech.

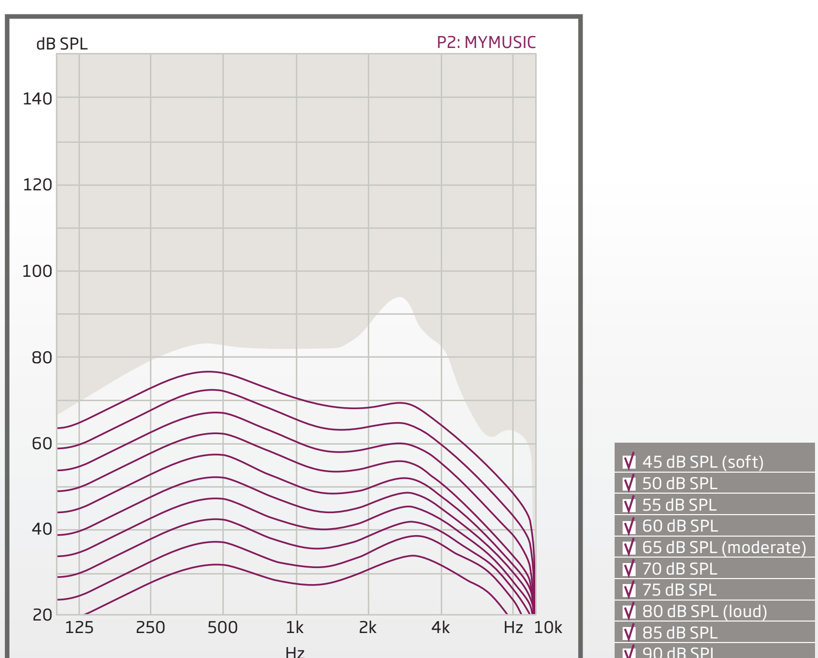

Figure 3: Oticon MyMusic simulated in situ output for ANSIs3.5 input prescribed for a standard N3 audiogram (sloping hearing loss from 35 to 65 dB HL).

5. Equalize gain so the aided response to a musical signal resembles the Harman flat in-room target response 2013 for microphone input, and the Harman target for in-ear headphones 2019 when streaming

As just described above this is used as the reference curves.

6. Adjust the loudness of the programme based on the general speech programme (P1)

The loudness of the music programme needs to provide both audibility and comfort. For this reason, the loudness of the music programme has been based on P1 at comfortable music listening input levels (~70dB SPL).

7. Settings of other features

Other features also affect the overall listening experience result. Thus, the default settings for several features differ from the normal VAC+ speech programme.

- MoreSound Intelligence
  The directionality setting is set to 'Fixed Omni'. The prescribed setting, 'Aware', is provided by Virtual Outer Ear.

  'Neural Automatic' and 'Full Directional' can be enabled. If 'Neural Automatic' is enabled settings will be set relative to P1: 'Environment Configuration' one step towards 'Difficult' (one step to the right) and 'Sound Enhancer' one step towards 'Comfort'.

  'Neural Noise Suppression' is default prescribed 'Off'. 'Neural Noise Suppression' can be enabled. If enabled, both the trimmers for easy and difficult noise suppression will be set to one step less noise suppression compared to P1.

- Wind Noise Management
  Is default 'Off'.

- MoreSound Optimizer
  The 'Low' setting is default to avoid false positive feedback detection due to tonal input.

- Transient Noise Management
  Default is 'Off' to avoid reduction in sound level for fast attacks of the music signal.

- Speech Rescue
  Default is 'Off' to avoid getting distortion from moving sounds to different frequencies (default is the same as for a normal speech programme).

- 'Sound Control' trimmers in 'Fine-tuning' ('Brightness perception' and 'Soft sound perception')
  Default setting for both trimmers is the middle setting. There is no impact to the settings due to the replies in 'Personalisation'.

- MoreSound Amplifier
  There are no settings as such for this feature. Processing is performed in both 4 and 24 channels simultaneously as known from all other programmes based on the Polaris platform. This two-path processing allows for details to be preserved in the best way no matter the signal type.

8. Optimisation for music in the surroundings and streamed music

Oticon MyMusic has been designed differently for listening to music in the surroundings (input through hearing aid microphones) and streamed music (input through Bluetooth® Low Energy streaming). This is due to different input conditions for music in the surroundings and streamed music. Streamed music is missing the colour added to the music by the physical room. This colouring will for music in the surroundings happen before the music is picked up by the microphone and the music is amplified. To compensate for this in the streamed input the frequency response normally added by the physical room has been added to the target for streamed input – for instance more low frequency amplification.

The target for music in the surroundings is the target seen in Oticon Genie 2 whereas the target for streamed music runs in the background. Any fine-tuning done to the music programme will be applied for both targets.

How these principles have changed the prescription compared to the legacy music programme is shown in figure 4. This graph clearly shows that the output level for Oticon MyMusic in comparison to the legacy music programme is:

- Higher in low frequencies, up to about 1 kHz
- Higher in very high frequencies, above around 5 kHz
- Lower in the mid frequencies, around 1 to 5 kHz

This means Oticon MyMusic will provide enhanced audibility of the music signal outside of the medium frequencies, i.e., below 1 kHz and above 5 kHz. In addition, because gain is reduced in the mid frequencies, the overall frequency distribution of the output in Oticon MyMusic will be flatter and the amplification more balanced across frequencies.

Testing

We have tested Oticon MyMusic extensively during all phases of development. Our goal was to ensure that the sound quality perceived by hearing-impaired listeners was as we intended. The testing was done using participants who had different types of hearing loss and different relations to music – some were music lovers and amateur musicians – to make sure the music programme worked as expected for a broad range of listeners. Based on the feedback in the last round of test the target was trimmed down 1-2 dB in frequencies above 2500 Hz compared to the Harman target. This was done to achieve a better sound quality as perceived by the hearing aid users. For other listeners preferring a sound output closer to the Harman target this can easily be achieved by adjusting the 'Brightness trimmer' one step towards brighter.

A huge amount of work has been put into creating this programme for improving the music experience for hearing aid users – just as much work as when creating a new rationale for speech. Officially Oticon MyMusic cannot be called a 'rationale' but the naming does not minimize the difference perceived by the listeners. Internal preference tests were performed on the final version of Oticon MyMusic and showed a 72% higher preference for Oticon MyMusic compared to the legacy music programme. For the full description of these tests please see Man B.K.L., Garnæs M.F., Kjeldal R., Sørup Yssing M., Løve S (2021). Oticon MyMusic Clinical Evidence. Oticon Whitepaper.

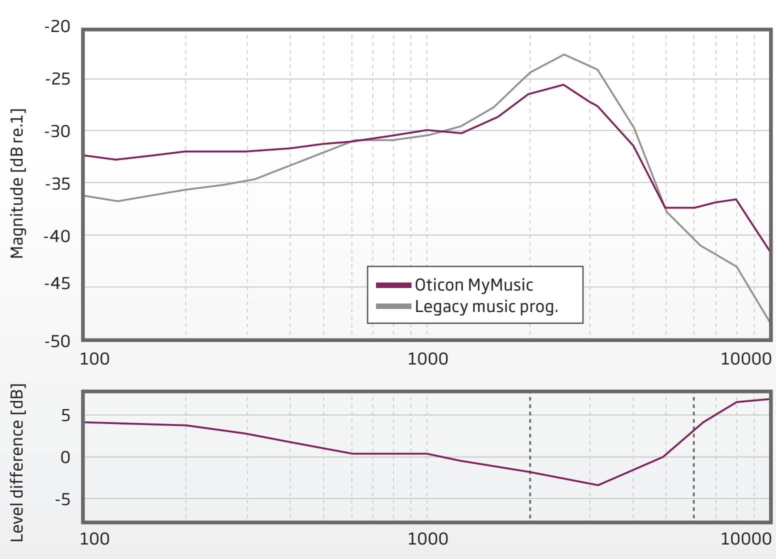

Figure 4. Top graph: Hearing aid output for both Oticon MyMusic and legacy music programme. The input signal is music shaped noise (IEC 60268-1) presented at 70 dB SPL. The measurement is made with a flat 30 dB HL hearing loss. Bottom graph: level difference for the two measurements.

References

1. Butterworth, B. (2019). Where are we at with the Harman curve? SoloStage!Solo https://www.soundstagesolo.com/index.php/features/217-where-are-we-at-with-the-harman-curve
2. Chasin, M. (2003). Five Differences Between Speech and Music for Hearing Aids. AudiologyOnline, Article 1116 https://www.audiologyonline.com/articles/five-differences-between-speech-and-1116
3. Crook, H. Greasley, A. E., & Beeston, A. V. (2018). Music counselling and fitting: a guide for audiologists. Version 1.0, dated 24 September, 2018
4. Crook, H., Beeston, A. V. & Greasley, A. E. (2018). Starting out with a music program: Quickstart clinic guide. Version 1.1, dated 24th September 2018
5. Gade, P.A. & Løve, S. (2021). Simple ways to optimize your fittings. Oticon Optimal Fitting Series No. 1 - 2021 updates.
6. Jaakkopasanen (2019). Harman In-ear 2019 v2 Target. Retrieved 30.06.2021 from: https://github.com/jaakkopasanen/AutoEq/issues/85
7. Limb, C. (2010). Your brain on improv. TEDxMidAtlantic https://www.ted.com/talks/charles_limb_your_brain_on_improv#t-6438
8. Man B.K.L., Garnæs M.F., Kjeldal R., Sørup Yssing M., Løve S (2021). Oticon MyMusic Clinical Evidence. Oticon Whitepaper
9. Olive, S.E. & Welti, T. (2012). The relationship between perception and measurement of headphone sound quality. Convention paper. Audio Engineering Society. Presented at the 133rd convention, San Francisco, CA, USA
10. Olive, S.E., Welti, T., & McMullin, E. (2013a). Listener preference for different headphone target response curves. Convention paper. Audio Engineering Society. Presented at the 134th convention, Rome, Italy
11. Olive, S.E., Welti, T., & McMullin, E. (2013b). Listener Preferences for In-Room Loudspeaker and Headphone Target Responses. Convention paper. Audio Engineering Society. Presented at the 135th convention, New York, NY, USA
12. Olive, S.E., Welti, T., & Khonsaripour, O. (2016). The preferred low frequency response of in-ear headphones. Convention paper. Presented at the Conference on Headphone Technology, Aalborg, Denmark
13. Olive, S.E., Welti, T., & Khonsaripour, O. (2017). A Statistical Model That Predicts Listeners' Preference Ratings of In-Ear Headphones: Part 1 – Listening Test Results and Acoustic Measurements. Convention paper. Audio Engineering Society. Presented at the 143rd convention, New York, NY, USA
14. Olive, S.E., Khonsaripour, O., & Welti, T. (2018). A survey and analysis of consumer and professional headphones based on their objective and subjective performances. Convention paper. Audio Engineering Society. Presented at the 145th convention, New York, NY, USA
15. Santurette, S., Ng, E. H. N., Juul Jensen, J., & Man K. L., B. (2020). Oticon More clinical evidence. Oticon Whitepaper.

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