Neuro users say it: the everyday sounds better with speech-omni

– A subjective preference evaluation of omni options in the Neuro System

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BrainHearing™ is Oticon Medical's guiding star in the development of cochlear implant (CI) systems that help the brain make sense of sounds with less cognitive effort. The goal is to help users preserve their mental resources for understanding, remembering, interacting, and enjoying, rather than 'just' hearing (Hoen et al., 2018).

One key aspect of BrainHearing™ is a focus on listening situations that users spend most of their time in, also referred to as ecological listening situations. Oticon Medical's aim is to address CI users' needs and preferences in these real-life situations and provide tailor-made technological solutions to improve the users' listening experience in those situations that matter most.

Recent studies indicate that difficult listening situations are not necessarily characterised by high levels of noise, but can also be experienced at positive signal-to-noise ratios (SNR), and with low levels of noise (Wu et al., 2018). In these low-noise environments, CIs favour omnidirectional microphone modes, sampling sounds equally from all directions in space. However, CI users may benefit from some listening support also in these situations and omnidirectional modes could be further improved with the aim of reducing listening effort and easing access to speech cues.

With that in mind, the speech-omni mode was introduced as the default setting of the FreeFocus directionality system in the Neuro 2 sound processor. Speech-omni is an omnidirectional microphone mode, with a particular emphasis over the high frequencies, offering a spatial highlight on speech cues. This feature uses the principle of directional microphones to amplify the sound-shaping effect of the external ear, thereby, delivering a more natural and clearer sound experience.

After a brief introduction of speech-omni, we review key elements of everyday listening situations that cochlear implant users encounter. We then report the first clinical observations on the preferences of new and experienced Neuro CI users for the speech-omni mode.

FreeFocus in Neuro 2 sound processor and the speech-omni mode

FreeFocus is Oticon Medical's adaptive directional microphone system, based on the Inium Sense platform (see Segovia-Martinez et al., 2016 for a full description).

Neuro 2 offers two different omnidirectional solutions amongst which audiologists and users can choose:

Opti-omni mode: This mode is a more traditional implementation of the omnidirectional mode. All spatial directions are equally picked up, with the exception of the front-back axis. Sounds coming from the front are slightly amplified (+3-5 dB) and sounds coming from the back are slightly attenuated (-3-5 dB) to reduce front-back confusions (Figure 1 – Left).

Speech-omni mode: This newly introduced mode is designed to provide a crystal clear sound and provide some emphasis on speech cues above 1880 Hz. This mode exacerbates the natural sound-shaping effect of the outer ear and provides some highlight on high-frequency speech cues, while preserving a very natural and omnidirectional sensation for sounds in the low frequencies (Figure 1 – Right).

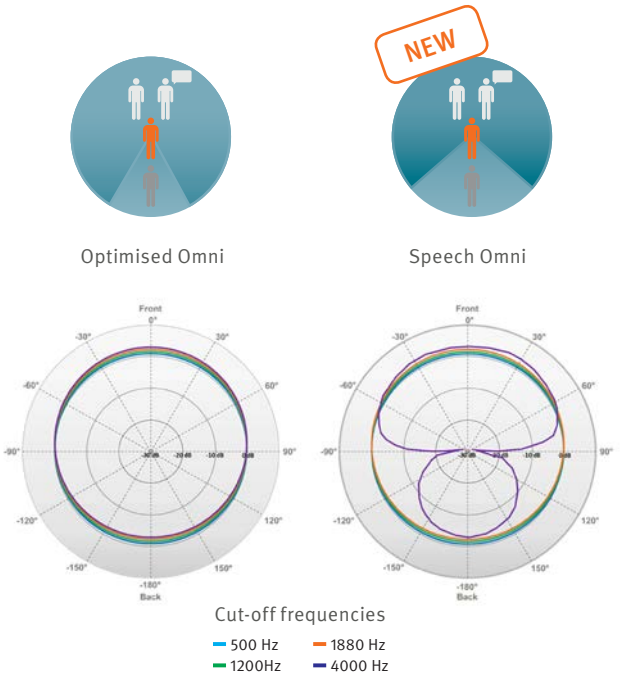

Figure 1.
The omnidirectional microphone choice in Free Focus for Neuro 2. Left: Opti-omni. Right: Speech-omni mode, default setting in Neuro 2.

Neuro 2 also offers two different directional microphone settings optimized for listening situations with higher levels of noise.

Split-directional mode: This mode is an extended omnidirectional configuration taking profit of partial directionality. The response is omnidirectional in the low frequencies, to effectively replicate the acoustic environment, while in the high frequencies, starting at 2 kHz, the microphones exhibit increased sensitivity to 0 degrees azimuth. Besides the cut-off frequency that differs somewhat, this mode will be automatically selected for noise-levels around 65 dB SPL in the automatic mode and is efficient in low to medium level noise situations.

Full-directional mode: This mode picks up sounds coming from the front and markedly reduces background noise coming from all other directions. This mode is particularly effective for speech perception in noisy environments or where there are multiple conversations in the same room. This mode is especially useful in high-level noise situations, and is automatically selected for noise levels around 75 dB SPL in the automatic mode.

At the time of fitting, audiologists can choose to offer their patients tri-mode or dual-mode automatic programs, where the system automatically selects the FreeFocus mode patients might benefit from the most according to the sound environment; among three options (one omni and two directional) for the tri-mode version or two options (one omni and one directional) for the dual-mode.

Ecological listening situations

What does our everyday sound like? Wagener et al. (2008) documented the everyday listening environments of 20 successful hearing aid users of different ages and social backgrounds. They were equipped with a recording device and spent four days recording their daily lives and sound environments. All recordings were categorised by situation and within each category a number of recordings were available and analysed. One key finding of the study was the vast variation of sound levels within a given situation (Figure 2.A). For example, a conversation in quiet occurs usually at a level of around 65 dB SPL, but the values had a large variation from 47 to 80 dB SPL.

Another aspect of importance is the signal-to-noise (SNR) ratio of the different everyday situations (Figure 2.B and see Wu et al., 2018). The striking finding in this research is that the vast majority of situations that people with hearing impairment encounter – around 70% of the time – have a positive signal-to-noise (SNR) ratio. Even situations we consider "noisy" still have a positive SNR, usually between +5 and +10 dB SNR.

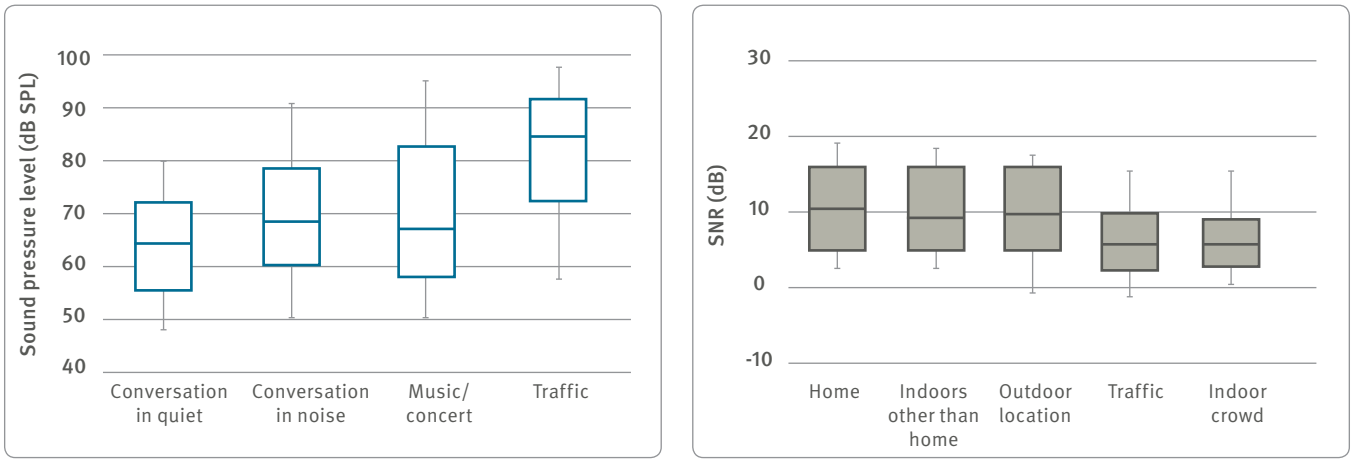

Figure 2.
Analysis of everyday listening situations as a function of listening environment. A (left): Sound levels (subset from Wagener et al., 2008). B (right): Signal-to-noise levels (Wu et al., 2018). The boundaries of the boxes represent the 25th and 75th percentile, and the line within the boxes marks the median. Error bars indicate the 10th and 90th percentile.

Improving speech understanding in everyday situations

Directional microphones, or beamforming systems, are the most evidence-based methods to improve speech understanding in noisy environments. Directional microphones supress noise coming from the sides and back, while keeping good sensitivity to sounds arriving from other spatial orientations, for example the front direction. This form of signal processing improves the signal-to-noise ratio for the user, leading to easier speech understanding that releases cognitive resources for other mental processes.

Typical use time spent in directional modes

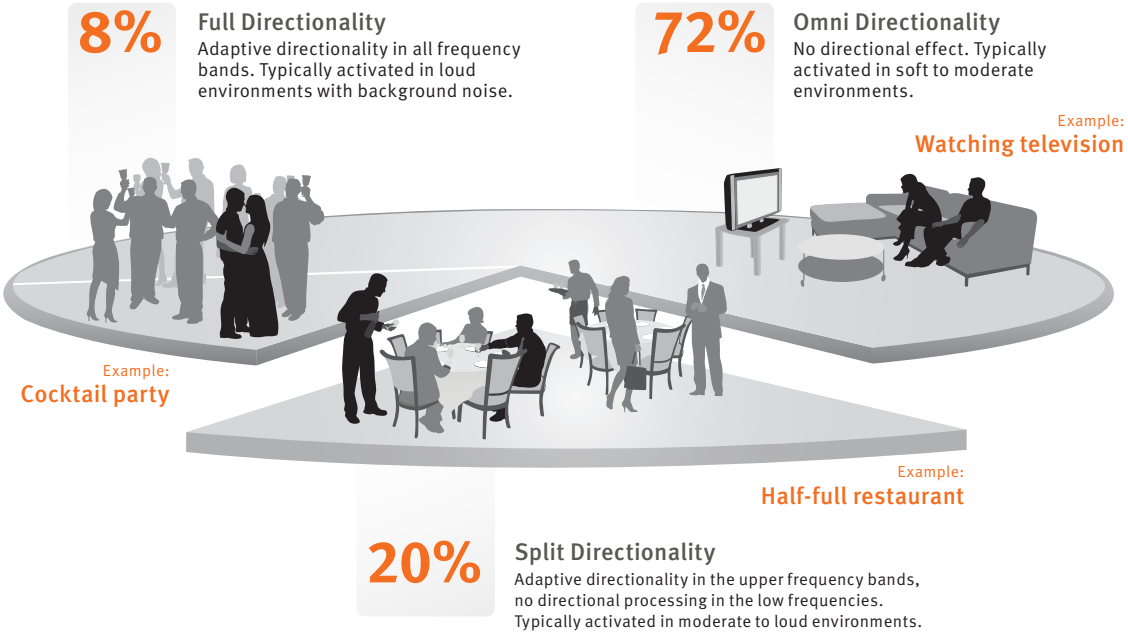

Figure 3.
A typical distribution of different directionality modes for FreeFocus users.

Why not always use a full-directional mode?

In a situation where loud background noise is present as in a crowded restaurant, a full directional microphone mode attenuates noise coming from the back and sides, while preserving good audibility of the speaker seated in front. This improves the user's understanding of speech originating from that specific direction, a real advantage in this particular listening situation. It might be obvious, but when focusing on signal-to-noise ratio and directionality systems, it would perhaps seem the easiest solution to just always use a full-directional system. However, this is not a good idea: consider instead a calm environment with several people involved in the same discussion. With a full-directional system in this situation, users would miss what the people on their sides are saying or would have to constantly turn their heads to face the person speaking at that specific moment in time. In general, a full-directional system reduces the user's spatial awareness and ability to react to sounds coming from different directions.

There are also other, more technical aspects to this. A full-directional system is much more susceptible to wind noise. Further, because of the nature of this type of signal processing, a full directionality program is less sensitive to low frequencies. This might lead users to find the sound somewhat "thin" and lacking loudness. This is why there is no "golden standard" directionality mode that fits all situations a user faces every day. To solve this, automatic directionality and transition modes, offering partial directionality, have been developed.

As previously discussed, in the vast majority of time, CI users are in so-called ecological situations -environments with low average noise levels and favourable SNRs – where they mostly prefer the omni-directional mode.

With that in mind, we designed our system so that it continuously analyses the overall sound level and SNR in the user's surroundings (see Figure 3), and in these specific ecological environments it automatically chooses of the omni-modes, speech omni or opti-omni.

The speech-omni mode is thought to further improve speech clarity by applying directionality advantages to an omnidirectional mode. We conducted a study to assess the quality of the listening experience associated with speech-omni compared to opti-omni and document the preferences for adult Neuro users for the speech-omni mode.

The Study

Objective

The goal of this evaluation was to document the preference of CI users for the two omnidirectional modes proposed in Neuro 2: speech-omni and opti-omni. We expected that CI users, and in particular in those users with a history of normal hearing (postlingual-deaf adults with shorter deprivation durations), would prefer the particular shaping of sounds above 1880 Hz that speech-omni offers.

Methods

The study was performed in Italian hospitals as part of the regular clinical follow-up of the patients. Their audiologists asked them to perform comparisons to provide personalised mapping parameters and usage counselling.

Description of participants

Thirty-five adult NeuroZti/Neuro One users were tested (17 women and 18 men). Patients were aged 31 to 73 years (average: 54 +/- 13 years). Most users (24) had short deprivation durations (criteria: below 10 years, average: 4 years) and 11 users had longer deprivation durations (criteria >= 10 years, average: 22 years). In Neuro One, the opti-omni mode is the default directional mode, patients were therefore used to opti-omni if they were experienced CI users. This was the case for 22 included patients who were using their device since an average of 9.5 months. The other 13 patients were tested at activation and were therefore proposed to choose between both omni modes at activation.

Description of outcome measures

The evaluation consisted in a 3-alternative forced-choice preference rating task. Participants choose between the two omni modes or a no-preference response. Patients' CIs were mapped with two different programs based on their personal mapping parameters, changing only the omnidirectional mode of FreeFocus to opti-omni in one program and to speech-omni in the other program (P1 or P2, randomly assigned across users). Patients received a list of 10 different listening situations. For each listening situation, patients indicated whether they would prefer using P1, P2, or if they would have no marked preference. The chance level was thus 33% for each possible choice. The questionnaire used in this study is summarised in Table 1.

Table 1. Sound quality evaluation

Carrier question	Listening situations	Categories
Which program do you prefer for:	the clarity of voices	Voice Quality
	the quality of voices	
	listening in noisy environments	Difficult Speech
	listening in high levels of noise	
	intelligibility of speech perceived from a distance	
	intelligibility of fast speech	
	intelligibility of soft speech	
	having a conversation on the phone	Special listening situations
	listening to music or TV	
	the perception of voice height	

Table 1.
Details of the 10 items from the questionnaire used to evaluate subjective preference. Left column: carrier sentence, middle column: end of the question and depicted listening situation, right column: grouping of the ten items in three main categories.

Results

Overall patients preferred speech-omni over opti-omni. This preference was particularly large for items questioning voice quality and speech intelligibility in low-noise situations (category "Voice Quality") where 67.1% (twice the chance-level) of preferences went to speech-omni compared to 25.7% to opti-omni and 7.2% no preference. For difficult speech perception the preference was also clear with 52% of choices for speech-omni against 19% for opti-omni.

The advantage of speech-omni was still present even if less clear-cut for particular listening tasks such as using the phone or listening to music or TV; in these situations 44% of choices went to speech-omni, double compared to the 20% given to opti-omni while 36.2% of patients encountered difficulties to perceive clear differences. The three distributions were significantly different than chance distribution (Chi2 non-parametric test).

All respondents

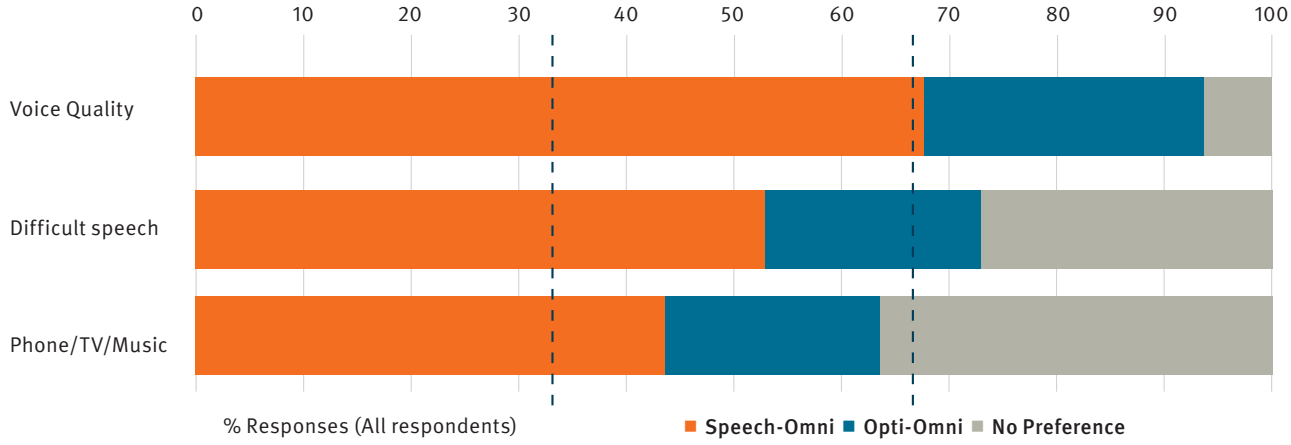

Figure 4.
Averaged results (N=35), showing distribution of preference ratings in percentage of responses, for speech-omni in orange, opti-omni in blue or no-preference in grey. The dotted lines indicate the 33% chance level.

Testing the effect of deprivation duration

Looking into the specific patterns of preference of the 24 users with shorter deprivation duration, they were slightly more likely to prefer the sound modification introduced by speech-omni than the 11 patients with longer durations. For voice quality the ratings were respectively 71% vs. 59% for speech-omni and 23% vs 31% for opti-omni. This difference did, however, not reach statistical significance (Mann-Withney U test). Duration of deprivation had therefore a negligible impact on the preference ratings for speech-omni.

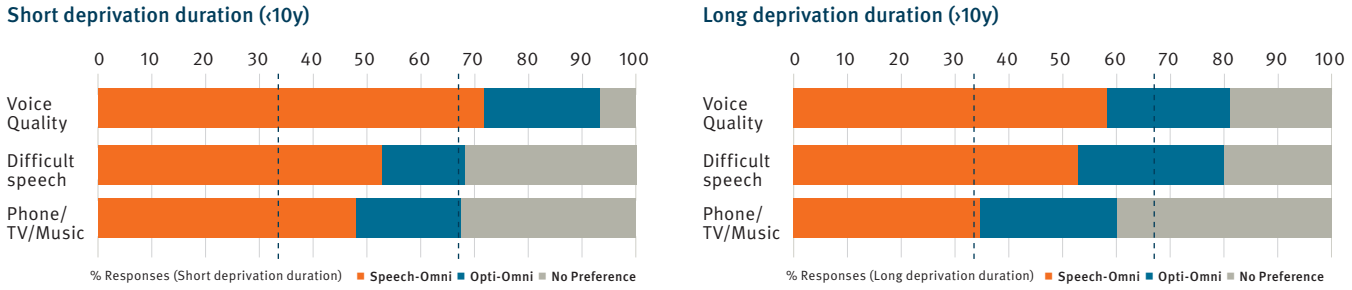

Figure 5.
Preference distribution as a function of deprivation duration. Distribution of preference ratings in percentage of responses, for speech-omni in orange, opti-omni in blue or no-preference in grey. The dotted lines indicate the 33% chance level. Patients with a short deprivation duration on the left panel and patients with a longer deprivation duration on the right panel.

Testing the effect of habituation to opti-omni

The 13 patients tested at activation day showed a pronounced preference for speech-omni, especially in the voice quality category, and this preference largely remained over time: 74% preference for speech-omni in new users whereas 63% of experienced users chose speech-omni over the opti-omni mode they were used to for 9 months on average. Again, however, this difference did not reach statistical significance, and habituation to opti-omni did therefore not interact with the preference pattern expressed in favour of speech-omni.

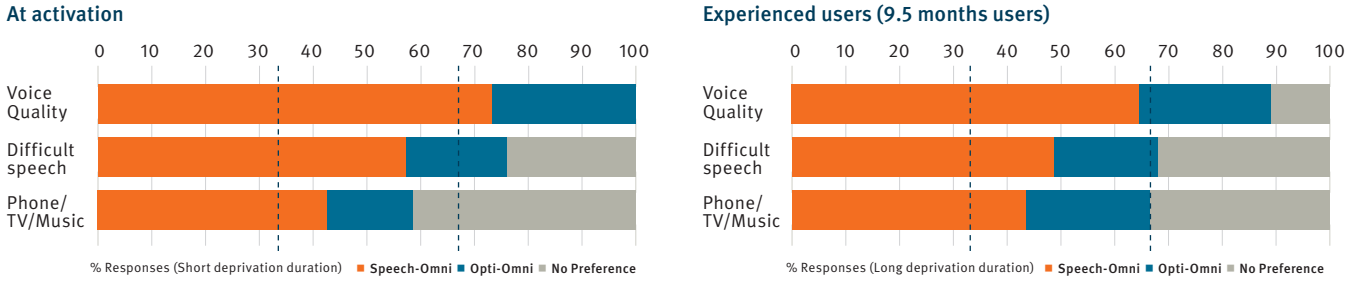

Figure 6.
Preference distribution as a function of CI experience. Distribution of preference ratings in percentage of responses, for speech-omni in orange, opti-omni in blue or no-preference in grey. The dotted lines indicate the 33% chance level. Patients tested at activation day (no CI experience) on the left panel and experienced CI users (9 months on average) on the right panel.

Discussion

This evaluation of the speech-omni mode in 35 Neuro CI users clearly demonstrates a marked preference for the speech-omni over the opti-omni mode of the FreeFocus directional system. Users preferred the speech-omni mode over the opti-omni mode in particular to preserve voice quality and to maximize, speech intelligibility in the presence of moderate noise levels, listening situations that speech-omni was designed to address. Preferences were also in favour of speech-omni for difficult speech listening situations. Even for those patients who had been using opti-omni for an average of 9 months before, showed a preference for speech omni. This indicates that during sound processor upgrade from Neuro One to Neuro 2, patients who have been using opti-omni before may benefit from a switch to speech-omni.

Conclusions

By partially reproducing the shaping of the sounds that the natural outer ear provides, causing mid-to-high frequency sounds from the front direction to be naturally amplified compared to other frequencies and other spatial directions, speech-omni offers a much more natural listening experience to Neuro CI users. Users prefer this sound to experience most of the everyday listening situations they encounter. In agreement with the promise of BrainHearing™, speech-omni is an Oticon Medical unique option offering more flexibility and providing more sound clarity and audibility in the listening situation users encounter most of the time. Further studies will confirm these results with both behavioural methods such as speech perception in spatialised noise situations and with self-reported ratings in various natural listening situations and environments.

References

Hoen M, Neel-Weile J, Holmberg M & Lunner T. (2018). Oticon Medical BrainHearingTM – Helping the brain make sense of sound. Oticon Medical White Paper. www.oticonmedical.com.

Segovia-Martinez M, Gnansia D & Hoen M. (2016). Coordinated Adaptive Processing in the Neuro Cochlear Implant System. Oticon Medical White Paper. www.oticonmedical.com.

Wagener KC, Hansen M & Ludvigsen C. (2008). Recording and classification of the acoustic environment of hearing aid users. Journal of American Academy of Audiology, 19, 348-370.

Wu YH, Stangl E, Chipara O, Hasan SS, Welhaven A & Oleson J. (2018). Characteristics of Real-World Signal to Noise Ratios and Speech Listening Situations of Older Adults With Mild to Moderate Hearing Loss. Ear & Hearing, 39, 293-304.

Because sound matters

Oticon Medical is a global company in implantable hearing solutions, dedicated to bringing the magical world of sound to people at every stage of life. As a member of one of the world's largest groups of hearing health care companies, we share a close link with Oticon and direct access to the latest advances in hearing research and technologies. Our competencies span more than a century of innovations in sound processing and decades of pioneering experience in hearing implant technology.

By working collaboratively with patients, physicians and hearing care professionals, we ensure that every solution we create is designed with users' needs in mind. We share an unwavering commitment to provide innovative solutions and support that enhance quality of life for people wherever life may take them. Because we know how much sound matters.

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