WHITE PAPER

Signia IX enhances the brain’s response to speech sounds in noise and reduces neural signatures of listening effort

Two peer-reviewed studies published in Ear & Hearing and the American Journal of Audiology examined how RealTime Conversation Enhancement (RTCE) on Signia’s Integrated Xperience (IX) hearing aids impacts brain activity in wearers listening to a simulated group conversation taking place in a loud complex background noise. Compared to our previous generation of directional microphone technology, RTCE was found to enhance the brain’s ability to automatically detect small acoustic contrasts that help listeners differentiate between speech sounds. In turn, RTCE also reduced neural signatures of effortful listening in noise. These results expand on existing reports of RTCE benefits in group conversations in noise by demonstrating that such benefits influence brain activity in a way that should make listening feel easier. Supported by advanced sound scene analysis and a unique multi-stream architecture, Signia IX empowers wearers to follow and contribute to conversations in dynamic and challenging situations.

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Take-away messages

- Contrast underlies clarity. Two peer-reviewed studies found that RealTime Conversation Enhancement (RTCE), which enhances the contrast between speech and noise in dynamic group conversations, has significant positive effects on how listeners’ brains process speech in complex background noise.
- Signia IX hearing aids enhance the brain’s ability to rapidly and automatically detect small acoustic differences between speech sounds heard in a background noise by 80%.
- Brain activity associated with listening effort was reduced by 50% when listeners wore hearing aids with RTCE while following simulated group conversations in noise.
- The benefits of Signia IX with RTCE can offer valuable support to patients who wish to follow and contribute to dynamic group conversations in challenging acoustic environments.

Introduction

Conventionally, hearing aids have relied on unilateral beamformers to enhance the signal-to-noise ratio (SNR) for talkers situated directly in front of the wearers. While the speech-in-noise (SiN) benefits of unilateral directional microphones (DMs) are well documented (Bentler, 2005), their region of directional sensitivity can be so broad as to include off-axis noise sources, which are typical in complex acoustic environments. Bilateral beamformers improve on this approach by integrating microphone arrays across bilaterally fitted hearing aids to narrow the region of directional sensitivity and provide enhanced SNR benefits relative to unilateral beamforming DMs (Picou et al., 2014). However, bilateral beamforming DMs risk attenuating or otherwise distorting important speech information in group conversations when talkers are located outside of the relatively narrow focus beam (Best et al., 2015).

Signia's Integrated Xperience (IX) platform recently introduced an innovative approach to improving clarity for SiN called Real Time Conversation Enhancement (RTCE). This technology uses a new Multi-Stream Architecture to provide the SNR benefits associated with bilateral beamforming, while overcoming the technology's limitations in group conversations. RTCE works by analyzing the incoming sound stream to detect different talkers and determine talker locations and turn-taking dynamics. The system then selectively enhances different talkers by deploying appropriate combinations of front-facing bilateral and unilateral beams. The RTCE system builds upon Signia's existing split-processing technology (Branda, 2021; Jensen et al., 2021), which allows speech signals to be processed using a separate signal processing pathway (NR, compression, etc.) from that used to process the surrounding scene. In this way, RTCE allows split-processing to be more selective of which regions in front of the listener should be assigned to the hearing aid's "speech" pathway versus its "surroundings" pathway.

Behavioral testing in hearing aid wearers has already observed significant SiN benefits of 1.1 dB SNR at speech-reception thresholds of 80% (estimated 20% improvement in intelligibility). These benefits were measured in multi-talker situations when wearers were tested with Signia IX devices where RTCE was enabled (i.e., RTCE-ON) compared to the same hearing aids where RTCE was disabled (i.e., RTCE-OFF; Jensen et al., 2023). Another study involving group conversations in a real-world food court setting found that listeners reported stronger preferences based on the criteria of understanding, clarity, focus, and reduced background noise when wearing hearing aids with RTCE-ON compared to RTCE-OFF (Folkeard et al., 2024). The efficacy of RTCE in dynamic multi-talker environments has also been compared against key competitor products featuring technologies like Deep Neural Network (DNN)-based noise reduction. In the first such study, Jensen et al. (2024) measured an acoustic SNR advantage of 3.2 dB for RTCE over the best performing competitor hearing aid with DNN-based noise reduction. A follow-up study showed that RTCE provided listeners with an average SiN advantage of 2.8 dB at a speech reception threshold of 90% understanding (SRT-90) over the same key competitor hearing aid with DNN-based noise reduction (Korhonen et al., 2024). These benefits were replicated by an external study conducted at Hörzentrum Oldenburg (Germany) which showed that 86% of listeners achieved better SiN performance with RTCE compared to competitor with DNN-based noise reduction (Jensen et al., 2025).

Differences in SiN performance, such as between two hearing aids or hearing aid features, have been commonly interpreted to imply differences in the effort required to process speech. If a hearing aid feature improves a listener's SiN intelligibility, then it is presumed to also make listening feel easier. However, this would require that listeners always exert as much effort as needed to perform the SiN test, and no more, so long as the test conditions are not too difficult (or too easy), and optimal task performance is considered a worthwhile goal (Gendolla & Richter, 2010). A growing body of work challenges this assumption by showing that both behavioral and physiological measures of listening effort can behave differently than expected from SiN intelligibility (for a review, see Francis & Love, 2020). Hence, evaluating whether hearing aid technologies are likely to make listening to speech in background noise feel easier requires the integration of behavioral outcome measures, such as SiN intelligibility, with more objective measures of effortful listening.

Fortunately, a listener's brain generates many signals that can provide more objective insights into how automatically and effortlessly the auditory system is able to process speech sounds. Moreover, these signals can be measured non-invasively through recording of the listener's electroencephalogram (EEG).

The mismatch negativity (MMN) is one such brain signal that appears in the EEG when the auditory system detects an unexpected sound (Näätänen et al. 2007). The MMN has been theorized to result from neural mechanisms responsible for making predictions about the auditory scene and supporting the maintenance of distinct auditory objects (Friston et al., 2021). Such processing binds together predictable spectral, temporal, and spatial features of certain sounds into a single coherent percept of an auditory source, like the voice of a friend or family member. Maintaining percepts of separate auditory objects in the world is considered critical to supporting our ability to selectively focus attention on a single auditory source and tune-out competing sounds in the environment.

The MMN allows us to evaluate how well hearing aids might help the brain to form and maintain predictions about the auditory world by giving us a way to measure how strongly the brain reacts when those predictions are contradicted. In a typical MMN experiment, two or more sounds are presented in a so-called "oddball" sequence. One of these sounds, known as "the standard," occurs frequently in the sequence and sets up the brain's prediction about future sounds. The other sound, known as "the deviant," occurs infrequently and at random to contradict the prediction set up by the "standard" sound. The MMN signal then appears as the difference in brain activity evoked by "standard" and "deviant" sounds (Figure 1).

The magnitude of the MMN increases when the difference between standard and deviant sounds becomes easier for the listener to detect (Paavilainen, 2013). Critically, the MMN does not require listeners to pay attention to the sound sequence. In this way, the magnitude of MMN responses, such as those evoked by two different phonemes (/ba/ vs /da/), can be used to compare how strongly different hearing aids support the "bottom-up" or automatic encoding of those speech sounds.

The MMN: Capturing Contrast in the Auditory Brain

Acoustically speaking, there is very little that differentiates the phoneme /ba/ from the phoneme /da/, and yet these small acoustic contrasts are all that separate hearing the word “bad” from hearing the word “dad.”

Properly understanding a spoken message relies on resolving many such small acoustic details. When these acoustics are faithfully transduced by the ear and encoded by the brain, in a so-called *bottom-up* manner, then hearing the correct phoneme and properly interpreting the message should *feel easy*. But, when the bottom-up encoding of speech is distorted, the brain needs to engage *top-down* cognitive repair processes that rely on our language abilities and context to make sense of what was heard. It is this use of top-down processing that is thought to result in feelings of greater listening effort and fatigue.

The MMN can be a useful tool for inferring how well the contrast between two speech sounds is *automatically* (i.e., bottom-up) encoded and resolved by the auditory brain. Consider speaking to friends in a noisy restaurant. If the background noise is too loud, then the brain might have difficulty finding the predictable patterns that define a friend’s voice from other sounds in the environment. This might then reduce the brain’s ability to detect small but important acoustic contrasts between speech sounds.

Hearing aid technologies that enhance the contrast between voices we wish to hear, and the background noise would also be expected to better preserve acoustic contrasts between different speech sounds. We can test this in an MMN experiment by presenting an “oddball” sequence of phonemes belonging to one voice in the presence of competing noise. If the technology is effective, we would expect the brain to better track the frequent phoneme (e.g., /ba/) and respond automatically and more strongly to the small acoustic difference of an infrequent phoneme (e.g., /da/) as captured by a larger MMN response.

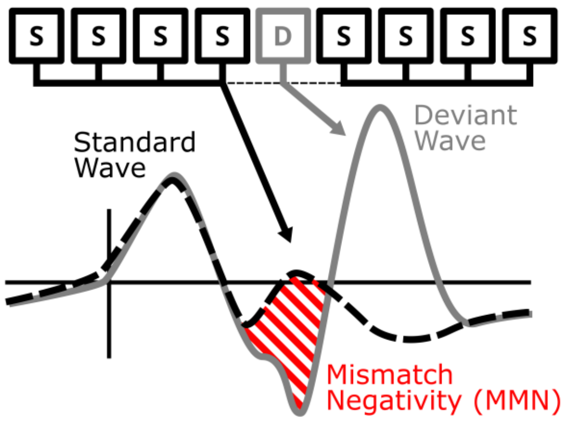

Figure 1. Example of brain activity evoked by standard (S) and deviant (D) sounds elicited in a passive oddball paradigm. The mismatch negativity (MMN) is visualized in the difference between standard and deviant responses.

Ongoing oscillations in a listener's EEG form another category of brain activity that has been linked to *effortful listening* (Dimitrijevic et al., 2019). Specifically, activity in the alpha-band (8-12 Hz) localized over parietal regions of the brain is noted to increase with the difficulty of SiN tasks at different SNRs (McMahon et al., 2016; Peterson et al., 2015) and is thought to reflect increased synchronization of neural activity that acts to functionally inhibit or "gate" processing in task-irrelevant regions of the brain (Figure 2). In this way, the strength of alpha-band activity in the EEG can provide us with a powerful and unbiased window into how much effort a listener is *exerting* while following conversations in noise.

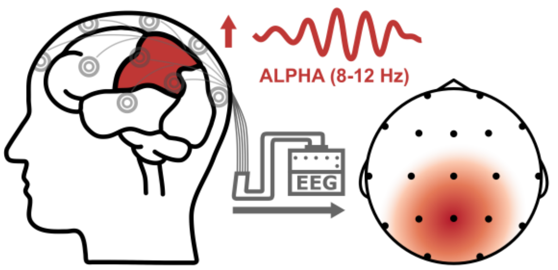

Figure 2. Under effortful listening conditions, the brain might synchronize "alpha" activity over regions that are not involved in processing auditory stimuli. Alpha activity can be measured in the EEG by looking at oscillations between 8 and 12 Hz and compared between conditions as an index of exerted listening effort.

In this paper, we review results from two peer-reviewed studies that measured the MMN (Slugocki et al., 2024a) and alpha-band power (Slugocki et al., 2024b) in the EEG of hearing aid wearers. These studies were designed to evaluate how RTCE on Signia's IX platform affects the neural processing of SiN as listeners attempt to follow talkers in a simulated group conversation. The studies hypothesized that if the behavioral benefits of RTCE reflect real "bottom-up" improvements to the encoding of speech information, compared to more traditional directional microphone systems, then RTCE processing should be associated with larger MMN responses to changing speech sounds from different talker locations, indicating more robust phoneme discrimination, which in turn should also lower neural signatures of listening effort as captured by reduced EEG activity in the alpha-band.

Methods

Participants

A total of 15 older adult listeners (mean age = 72.7 years, range = 40–88 years, 8 female) with moderate-to-severe degrees of sensorineural hearing loss were recruited to participate in the two studies (Figure 3). Most listeners (11 out of 15) had more than nine years of hearing aid experience, 1 had less than one year of experience, and 3 had never worn hearing aids. All participants were native speakers of American English and passed cognitive screening. Participants gave their written informed consent prior to their participation.

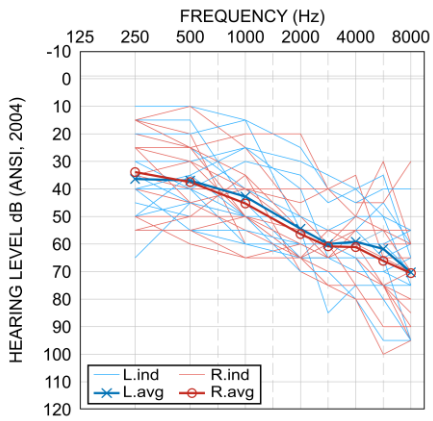

Figure 3. Individual (thin lines) and average (bold lines) audiograms for the left (blue) and right (red) ears of the participant sample.

Hearing aids

Participants were all fitted bilaterally with Signia Pure Charge&Go IX receiver-in-canal (RIC) hearing aids. The study aids were programmed for each participant's hearing loss according to Signia's fitting formula at 100% prescription gain (IXFit, experienced). The hearing aids were coupled using occluding power ear tips (closed, no venting) and feedback tests were completed for each ear using Signia's Connexx fitting software. Real-ear measures (REMs) were conducted to verify fitting from each listener using an Audioscan Verifit system with the International Speech Test Signal (ISTS; Holube et al., 2010) at levels of 65 and 80 dB SPL.

The study aids were configured with two programs. In the first program, RTCE was enabled in a fixed always-on mode (RTCE-ON). In the second program, RTCE was disabled (RTCE-OFF). Both RTCE-ON and RTCE-OFF programs featured split processing. Hence, in the RTCE-OFF program, speech and surrounding streams were separated broadly by front- and rear-facing unilateral beams, respectively. In the RTCE-ON program, the speech stream could include signals captured by a combination of multiple bilateral and unilateral beams. All additional hearing aid settings were left to the fitting software's defaults.

Test Environment

All testing took place with listeners seated in a double-walled sound-treated booth. Six identical loudspeakers were positioned in the booth at a distance of 1 m from the seated listener (Figure 4).

In both MMN and alpha-power experiments, target speech signals alternated between loudspeakers positioned at 0° and 330° in the azimuth to simulate conversation partners taking turns talking at a table seated opposite to the listener. Speech was always presented in the presence of an ongoing background noise. The noise included temporally offset recordings of the ISTS masking noise presented through each of three loudspeakers at 150°, 180°, and 210° in the azimuth. The total level of ISTS presentation was calibrated to 75 dBA SPL. In addition, temporally offset recordings of cafeteria noise were presented from each of the same three rear loudspeakers, as well as a fourth 30° loudspeaker at 10 dB below the ISTS (i.e., 65 dBA SPL). This specific mixture of louder babble and softer cafeteria noise was designed to be representative of the kind of noise that listeners might encounter in a real-world restaurant setting.

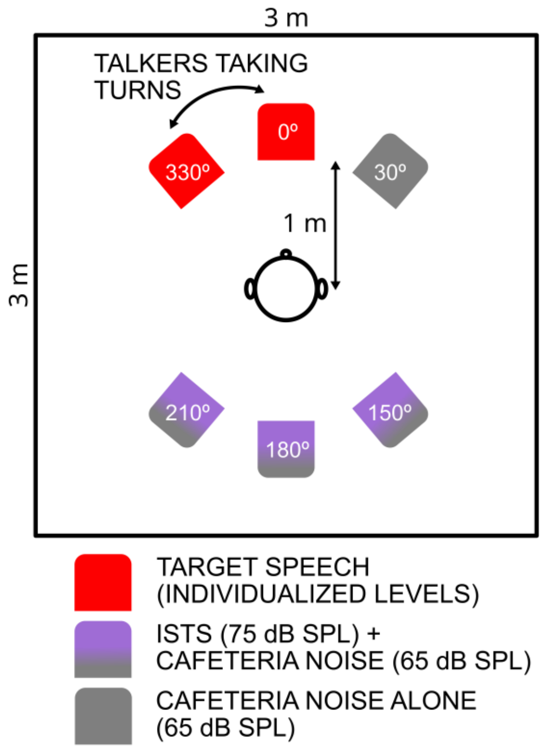

Figure 4. Schematic representation of the test environment and speech-in-noise configuration used for all phases of this study.

Experiment 1 – Phonemic Discrimination and the Mismatch Negativity (MMN)

Experiment 1 (Slugocki et al., 2024a) was conducted in two phases over the course of a single 2-hour study session.

The first phase of Experiment 1 estimated the SNRs that listeners required to perform a two-alternative force choice (2AFC) phonemic discrimination task at 75% correct performance. Target speech tokens comprised recordings of two monosyllables, /ba/ and /da/, produced by a male native talker of American English. On each trial, a pair of speech tokens was presented from a loudspeaker located directly in front (0° azimuth). Listeners were then required to indicate whether the two tokens in each pair were the "same" or "different" by pressing corresponding buttons on a touchscreen monitor. The level of the speech was varied adaptively from trial-to-trial according to a Bayesian-guided algorithm designed to estimate the SNR required for 75% correct performance. The purpose of this first phase was to individualize the SNR that should be used for subsequent measurement of the MMN. Given that the MMN is sensitive to the perceptual difference between standard and deviant stimuli (Pakarinen et al., 2013), it was important to test listeners at SNRs close to their discrimination thresholds. Listeners' phonemic discrimination thresholds were only measured for the RTCE-ON condition as this was expected to be the easier condition.

The second phase of Experiment 1 measured listeners' MMN responses to the same phonemic contrasts in the same ongoing background noise. Speech was presented at levels corresponding to the SNRs associated with each listener's phonemic discrimination threshold as measured in Phase 1. However, in this second phase, the /ba/ and /da/ tokens were presented through two loudspeakers, positioned at 0° and 330°, with presentation alternating between the two positions to simulate talkers taking turns. Listener EEG was recorded using 19 Ag/AgCl sintered electrodes positions according to the 10-20 system. High forehead was used as ground and bilateral earlobes were used as reference. For each hearing aid program (RTCE-ON *versus* RTCE-OFF), listeners were presented with a sequence of 800 speech tokens of which 85% were the "standard" /ba/ and 15% were the "deviant" /da/. The sequence of standard and deviants was pseudo-randomized so that at least three standards occurred between each deviant. The number of deviant trials occurring in each target speaker location was also balanced. Speech tokens in the sequence were separated from one another by 0.6–0.7 s. The order of hearing aid programs was counterbalanced across listeners.

Experiment 2 – Alpha-band Power

Experiment 2 (Slugocki et al., 2024b) was conducted in two phases over the course of a second 2-hour study visit. Thirteen out of the 15 recruited participants returned to participate in Experiment 2.

The first phase of Experiment 2 estimated listeners' speech reception thresholds for 50% correct performance (SRT-50) on a sentence-level SiN test. On each trial of this test, listeners were presented with sentences selected from a speech corpus developed for the Repeat-Recall Test (RRT; Slugocki et al., 2018; Kuk et al., 2021). These short sentences are designed to be syntactically valid, but semantically meaningless, so that listeners cannot use context to help "fill-in" masked speech. Listeners were required to repeat each sentence exactly as heard and pre-identified target words were scored for correct repetition. In this phase, target sentences were presented from a single loudspeaker located directly in front of the listener (i.e., 0° azimuth). The level of the target sentences was varied adaptively according to a Bayesian-guided algorithm for rapidly estimating the SNR corresponding to SRT-50. Assessment of SRT-50 was limited to the RTCE-ON condition, where performance was expected to be better.

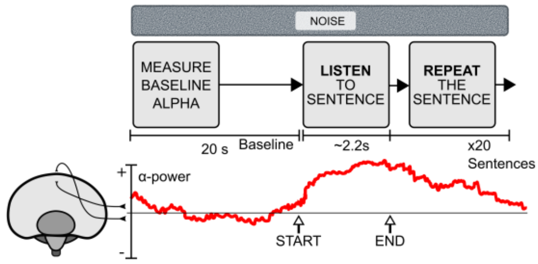

Figure 5. Schematic representation of the speech-in-noise test protocol used to measure neural oscillatory activity in the alpha band.

The second phase of Experiment 2 involved measuring ongoing neural oscillations in the alpha-band while listeners performed SiN testing at fixed SNRs corresponding to their individualized SRT-50s. In this second phase, sentence presentation alternated between two loudspeakers at 0° and 330° to simulate talkers taking turns. Listeners were again required to repeat each sentence exactly as it was heard, and pre-identified target words were scored for correct repetition. Listener EEG was recorded using the same setup as in Experiment 1. Testing was conducted in six blocks of 20 sentences each, with three test blocks used to evaluate each hearing aid program (RTCE-ON versus RTCE-OFF). Alpha-band power corresponding to sentence presentation was tracked with digital codes in the EEG recording and corrected according to baseline alpha activity (Figure 5). The order of hearing aid programs was counterbalanced across participants.

Results

Experiment 1 – Phonemic Discrimination and the Mismatch Negativity (MMN)

Figure 6 shows the average of all brain responses evoked by the standard /ba/ and deviant /da/ stimuli presented across the two loudspeaker positions in a cafeteria-like background noise. The upper panel of Figure 6 shows the brain responses collected when listeners were wearing hearing aids with RTCE processing disabled (RTCE-OFF) and the lower panel shows the same responses collected when listeners were wearing hearing aids with RTCE enabled (RTCE-ON). In both hearing aid conditions, we can see listeners' brains responding to the speech sounds with a stereotyped series of waves that involve a positive peak at around 100 ms and a negative peak at around 150 ms. These are commonly referred to as the P1 and N1 components, respectively, of the "cortical auditory-evoked potential" (cAEP) because they are the first large positive and negative peaks of EEG activity from the auditory cortices in response to sound events. Whereas the responses to the standard /ba/ sounds (black lines) are similar between the two hearing aid conditions, we can see that the negative peak evoked by the deviant (different) /da/ sounds (pink lines) appears to be larger in the RTCE-ON condition than in the RTCE-OFF condition. This suggests that listeners' brains reacted more strongly to the acoustic/perceptual features that differentiate /ba/ from /da/ when they were listening to the speech sounds in the RTCE-ON condition.

We can better analyze this effect by plotting the "difference" wave (broken gray line) which is calculated by subtracting the "standard" response from the "deviant" response. The MMN is then easily quantified by the "area under the curve" (AUC), shown by the blue hatched area in Figure 6. Statistical analysis confirmed that the AUCs of MMN responses were significantly larger, by an average of 80%, when hearing aids were in the RTCE-ON than in the RTCE-OFF program ($\chi^2(1) = 5.08$, $p < 0.05$).

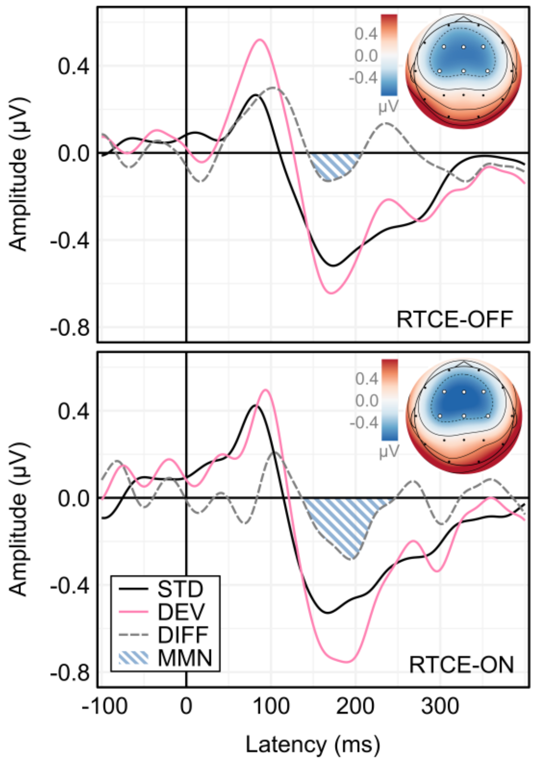

Figure 6. Grand-averaged standard (black, solid lines), deviant (pink, solid lines), and difference waves (grey, broken lines) evoked across frontocentral electrode sites (white circles in topographic plots) by the phonemic oddball sequence. Blue hatched areas represent the areas under the curves (AUCs) of the mismatch negativity (MMN) response. Topographic plots show distributed scalp activity for 50 ms region around peak of difference waves.

Because our MMN experiment did not require listeners' active participation, these results suggest that the behavioral advantages of RTCE processing reported previously for SiN tests are "bottom-up" in nature. As such, we would expect that RTCE processing should also help to reduce the effort that listeners need to exert when attempting to follow group conversations in noise. This hypothesis was addressed by Experiment 2.

Experiment 2 – Alpha-band Power

Figure 7 plots spectrograms of the oscillatory EEG activity averaged across all sentence presentations and listeners in RTCE-ON and RTCE-OFF conditions. In these plots, the time relative to sentence onsets is plotted along the x-axes and the frequency of EEG activity is plotted along the y-axes. The strength of activity is indicated by the saturation/intensity of the red color.

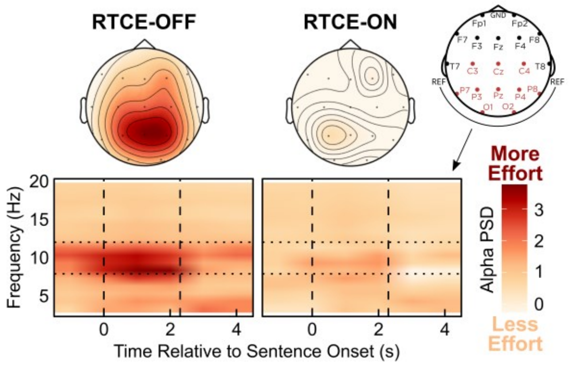

Figure 7. Spectrograms (lower panels) comparing average alpha-band activity at centro-posterior electrodes (red points on headmap in upper right) measured in RTCE-OFF and RTCE-ON conditions. Horizontal dotted lines denote frequencies in the alpha-band. Vertical dashed lines denote sentence onset and average sentence offset. Topographic maps of activity in the alpha-band averaged over the duration of a target sentence are plotted atop each spectrogram. The strength of activity is indicated by the saturation/intensity of the red color, where darker shades of red indicate greater alpha power, suggestive of greater listening effort.

In the RTCE-OFF program, we can see brain activity in the alpha-band (8-12 Hz), defined by the horizontal dashed lines, is very strong during the time period where participants were attempting to listen to the sentences presented across the two talker locations (i.e., between the vertical dashed lines). The topographic plots shown above each spectrogram further reveal that alpha-band activity was concentrated towards the back of the head (i.e., centro-posteriorly) as would be expected for listeners who are engaged in a challenging SiN task (e.g., McMahon et al., 2016; Peterson et al., 2015). On the other hand, when listeners were performing the same SiN test while wearing hearing aids with the RTCE-ON program, we can observe that alpha-band activity in the EEG was dramatically reduced. Statistical analysis confirmed that alpha-band power was significantly reduced by an average of 50% in the RTCE-ON compared to the RTCE-OFF program ($\chi^2(1) = 55.14$, $p < 0.001$).

Discussion

Modern hearing aid development is at a stage where increasingly sophisticated processing algorithms are being combined to enhance the speech-in-noise (SiN) performance of hearing aid wearers. Yet, situations involving listening to "conversations in large groups" or listening to "conversations in the presence of noise" still rank among the lowest in terms of reported hearing aid satisfaction (Picou, 2022). The results of the two peer-reviewed neurophysiological studies reviewed in this paper expand on the existing work reporting acoustic and behavioral benefits of RTCE (e.g., Folkeard et al., 2024; Jensen et al., 2023; Jensen et al., 2024; Korhonen et al., 2024) by showing how RTCE processing enhances speech processing in the brain when wearers are in noisy multi-talker scenarios.

The results of the MMN study (Slugocki et al., 2024a) suggest that RTCE enhances pre-attentive (i.e., bottom-up) encoding of phonemic contrasts presented across different talker locations in a cafeteria-type noise. Previous research has already shown that use of split-processing, as first introduced in Signia AX hearing aids, enhances the MMN response to speech sounds presented from a single location compared to a more traditional "single stream" processing approach (Slugocki et al., 2021). This newer MMN study builds upon that previous work to show how the rapid and flexible deployment of front facing unilateral and bilateral beams enabled by RTCE work with split-processing to better track speech sounds from multiple talker locations and enhance the contrast between potential group conversation partners and the background noise to a greater extent than possible with split-processing alone.

Critically, because our MMN experiment did not require listeners to actively pay attention to the speech sequence, we can interpret the MMN enhancement to reflect better *bottom-up* or *automatic* processing of the speech sounds. In other words, listeners were very unlikely to invoke "top-down" processes to help repair degraded and/or distorted speech cues as might result from shortcomings of more traditional unilateral or bilateral beamforming systems. Deployment of top-down cognitive repair mechanisms is often considered to result in feelings of effortful listening and, over time, listener fatigue (Koelewijn et al., 2015; Shinn-Cunningham, 2008). Unfortunately, standard SiN tests are not well-suited for detecting when such cognitive repair mechanisms are invoked by listeners. Perhaps partly for this reason, the SiN benefits attributed to either traditional beamformer type do not always align with wearers' subjective preferences (Wu, 2010; Picou et al., 2014; Best et al., 2015). It has become increasingly important to validate that new approaches to providing hearing aid wearers with directional benefits in challenging multi-talker situations, like RTCE, actually enhance the *automatic* (bottom-up) processing of speech. This is especially the case given the degree to which contemporary models for understanding how hearing loss and cognitive resources interact in challenging listening situations (e.g., Pichora-Fuller et al., 2016; Rönnberg et al., 2013) underscore an appreciation for "being able to listen easily" as important to a listener's self-perceived success in group as well as one-on-one communication (Nicoras et al., 2023). The results of the alpha power study (Slugocki et al., 2024b) further complement the results of the MMN study by showing that enhancing the bottom-up encoding of speech with RTCE also helps to reduce brain activity associated with *effortful listening*.

Developing and reporting on more integrative and holistic hearing aid evaluations, such as those reviewed in this paper, underscores Signia's commitment to continually refining approaches to hearing health care in ways that help hearing aid wearers feel more comfortable and confident about communication and stay connected with family, friends, and the broader social world. For listeners with hearing loss, technologies that reduce the effort required to overcome challenging acoustic conditions are critical to helping prevent social isolation and loneliness (Reed et al., 2025). As such, it is essential that modern approaches to evaluating the efficacy of hearing aid technologies adapt to more carefully consider the interplay of technology and biology in hearing aid wearers.

Summary

In this paper, we have presented the results of two peer-reviewed neurophysiological studies that examined how RTCE processing provided by Signia's Integrated Xperience hearing aids impacts brain activity in hearing aid wearers listening to speech in a simulated group conversation taking place in a complex background noise.

The results of these studies showed that, compared to a more conventional directional microphone technology, RTCE was associated with an average 80% enhancement in how strongly wearers' brains *automatically* reacted to changing speech sounds and a 50% reduction in neural activity linked to listening effort.

These results suggest that the behavioral SiN benefits provided by RTCE on Signia IX hearing aids help to make communicating in noisy situations *feel easier* for wearers even when those situations involve multiple talkers.

Being able to "listen easily" is commonly acknowledged as important to a listener's self-perceived success in group as well as one-on-one communication. Signia IX could potentially offer a strong advantage to wearers who would typically struggle to participate in noisy social situations, helping them to once again be a part of the conversation.

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