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White Paper

A Study on the Benefits of Optimizing Active Noise Reduction Technology with Auditory Masking Characteristics in Hearing Test

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This paper optimizes active noise cancellation (ANC) technology based on auditory masking principles, focusing on the center frequencies of hearing assessment tones. Four scenarios were designed to assess the benefits of using this technology for hearing tests in different noise environments. Experimental results, derived from objective sound measurements and subjective clinical hearing tests, show consistent outcomes across the four ANC-assisted hearing test scenarios. In high-noise environments, a higher maintained signal-to-noise ratio in the pure-tone signals corresponds to a stronger correlation between clinical hearing test thresholds and standard hearing test thresholds. The proposed optimized ANC technology outperforms both generic ANC and "ANC off" settings, regardless of whether the assessments are conducted in typical or noisy environments. Clinical experiments reveal a high degree of covariance between the measured thresholds using optimizing ANC technology and standard hearing test thresholds in everyday noise conditions.

Furthermore, the proposed method demonstrates close alignment between the average audiograms obtained from individuals with hearing impairments and the results from standard hearing tests, with differences within 10 dB at various frequencies. This indicates that the proposed method, utilizing a Hearing test APP combined with TWS earphones, is feasible for independent at-home hearing assessments, providing reliable results across diverse user profiles (participants ranged from 20 to 70 years old) in everyday or noisy environments. Consequently, this technology is suitable for home-based self-monitoring of hearing health.

In a high-noise environment (at 65 dB(A)), despite the challenging conditions, individuals using optimizing ANC technology demonstrated a higher number of pass results at 25 dB HL compared to those using generic ANC technology. However, there is room for improvement in achieving pass results at 500 and 1000 Hz at 25 dB HL for both ANC technologies. Future enhancements can focus on refining the headphone cavity design to improve the fit and alignment with the ear canal, expecting to enhance the signal-to-noise ratio at 500 and 1000 Hz and subsequently improve pass rates at 25 dB HL thresholds. In summary, optimizing ANC technology based on auditory masking principles effectively maintains a better signal-to-noise ratio in noisy environments. The proposed optimizing ANC hearing test, performed independently by participants using the provided Hearing test APP and TWS earphones, demonstrates a moderate to high correlation with standard hearing tests. This implies that the operational mode of the designed hearing assessment device can overcome user diversity and provide trustworthy results in everyday and noisy environments, serving as a tool for self-monitoring of hearing abilities.

While the optimizing ANC technology, designed based on auditory masking principles, outperforms generic ANC in noisy environments, there is still room for improvement at 500 and 1000 Hz. The development of optimizing ANC technology is time-consuming, involving manual adjustments of ANC parameters and verification through sound measurements. Additionally, adjustments need to consider both the amplitude and phase of acoustic responses while minimizing side effects like the occlusion effect. To address these challenges, artificial intelligence and considerations of individual ear canal acoustic resonance differences can be utilized for rapid calculation of filter coefficients closely matching the target curve. This would enhance the flexibility of ANC in adjusting its frequency range according to noise volume or specific bandwidth requirements. Referring to the design of the hearing assessment device presented in this paper, individuals can independently perform hearing tests without professional assistance, with results highly consistent with standard hearing assessments. This technology can be used as a self-fitting over-the-counter hearing aid selection tool, promoting easy and accessible hearing health management. By optimizing ANC technology based on auditory masking principles, the core objective of enabling hearing tests to move beyond clinical settings can be realized.