

ALTERNATE BINAURAL LOUDNESS-BALANCE TEST

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Introduction and Definition of the ABLB Test

The Alternate Binaural Loudness-Balance Test, commonly abbreviated as the **ABLB Test**, stands as a foundational diagnostic tool within the field of clinical audiology, specifically utilized for the assessment of abnormal growth of loudness perception, a phenomenon known as **recruitment**. This procedure is meticulously designed to compare the intensity perception between a patient's two ears, particularly when one ear exhibits normal hearing sensitivity while the other presents with some degree of sensorineural hearing loss. Unlike standard pure-tone audiometry which merely identifies the threshold of hearing, the ABLB test provides crucial insight into the suprathreshold processing capabilities of the cochlea and the auditory nervous system. The test is predicated on the presentation of two distinct auditory stimuli--typically pure tones of an identical frequency--delivered alternately between the ears. This alternating presentation is essential as it requires the patient to make a direct, subjective judgment comparing the perceived volume of the tone in the impaired ear relative to the reference volume established in the normal or less-impaired ear. The results derived from the ABLB test are highly significant for differential diagnosis, helping clinicians distinguish between cochlear (sensory) pathologies, which are typically associated with recruitment, and retrocochlear (neural) pathologies, which often yield results indicative of loudness adaptation or decay.

The primary utility of the ABLB test lies in its capacity to identify irregular vulnerability to sound intensity, serving as a critical indicator of damage within the peripheral auditory system, specifically the hair cells of the organ of Corti. When recruitment is present, the dynamic range of hearing--the difference between the hearing threshold and the uncomfortable loudness level--is compressed. Consequently, sounds that are only slightly above the patient's elevated threshold are perceived as disproportionately loud, approaching the volume levels perceived by the normal ear at much lower intensity increments. The procedure involves setting a reference tone in the normal ear at a fixed suprathreshold level, often 20 decibels (dB) sensation level (SL) above its threshold, and then adjusting the intensity of the tone in the impaired ear until the patient reports subjective equivalence in loudness. The comparison of the intensity levels required to achieve this balance across various frequencies and intensity points provides a characteristic loudness function profile. It is this systematic comparison that allows audiologists to quantify the degree of recruitment present, thereby aiding in the accurate localization of the auditory lesion, a process vital for determining appropriate rehabilitative strategies, including the selection and fitting of hearing aids.

Historically, the ABLB test emerged during the mid-20th century as part of a battery of specialized tests designed to move beyond simple threshold measurement, focusing instead on the qualitative aspects of sound perception. It represented a crucial advancement in understanding the physiological changes associated with sensorineural hearing loss. While often categorized alongside other tests of auditory behavior, such as the Monaural Loudness-Balance Test (MLB) or the Short Increment Sensitivity Index (SISI), the ABLB specifically requires binaural comparison,

making it uniquely sensitive to asymmetric hearing loss profiles. The foundational principle remains that if an impaired ear requires significantly less intensity increment than anticipated based on its threshold shift to match the loudness of the normal ear, **recruitment** is confirmed. This finding is considered strongly correlative to a distinct variation of the same core auditory phenomenon measured by parallel forms of loudness testing, justifying the historical reference to it sometimes being described as an alternate test form or parallel form test. The robust data generated by this test informs not only the physiological understanding of the impairment but also guides clinical decisions regarding dynamic range management.

The Physiological Basis: Understanding Auditory Recruitment

Auditory recruitment, the core physiological phenomenon the ABLB Test is designed to measure, is defined as an abnormally rapid growth in the perception of loudness as the intensity of the stimulus increases. This condition is almost exclusively linked to damage within the **cochlea** itself, specifically affecting the outer hair cells (OHCs) which are responsible for the active mechanical amplification of low-level sounds entering the inner ear. In a healthy ear, the OHCs amplify soft sounds, effectively lowering the hearing threshold. When these OHCs are damaged or dysfunctional, the amplification mechanism fails, resulting in an elevated threshold for soft sounds. However, the inner hair cells (IHCs), which are responsible for transducing mechanical energy into neural signals, often remain relatively intact. Crucially, the IHCs respond primarily to high-intensity stimulation, which bypasses the need for OHC amplification, leading to the disproportionate growth of perceived volume once the elevated threshold is surpassed.

The mechanism of recruitment can be understood through the concept of the cochlear input-output function. When OHCs are damaged, the function is shifted upwards, meaning soft sounds are not perceived. Yet, once the input intensity reaches a certain high level, the response growth rate of the surviving IHCs and the corresponding neural fibers becomes steeper than normal. Because the auditory nerve fibers connected to the remaining healthy IHCs are stimulated directly by loud sounds, they reach saturation (maximum firing rate) at intensity levels that are far lower than those required in a healthy ear. This compression of the dynamic range means that while the patient requires a high intensity to even perceive the sound (elevated threshold), only a small increase in intensity beyond that threshold quickly results in the sensation of excessive loudness. The ABLB test capitalizes on this unique physiological alteration by comparing the intensity required to achieve equivalent loudness between the recruiting (impaired) ear and the non-recruiting (normal) ear. The finding that the recruiting ear requires a smaller intensity differential to match the perceived loudness confirms the hyperactivity of the surviving IHCs and their associated neural pathways.

It is important for clinicians utilizing the ABLB test to differentiate cochlear recruitment from loudness summation or other central auditory processing issues. True recruitment, as assessed by

the ABLB, is a peripheral phenomenon indicating sensory damage. Conversely, the absence of recruitment, particularly in cases of significant sensorineural hearing loss, is often a strong indicator of a **retrocochlear pathology**, such as an acoustic neuroma or other eighth cranial nerve (vestibulocochlear nerve) lesions. In retrocochlear disorders, the auditory nerve itself is compromised, leading to auditory fatigue or decay rather than the accelerated growth of loudness. Therefore, the presence or absence of a recruitment pattern revealed by the ABLB test is a fundamental diagnostic piece that guides the subsequent imaging and neurological evaluations required to accurately locate the source of the patient's hearing impairment. The test provides quantifiable evidence of the pathological alteration in the peripheral auditory system's response to suprathreshold stimuli.

Detailed Methodology of the ABLB Procedure

Executing the Alternate Binaural Loudness-Balance Test requires specialized equipment, typically a two-channel clinical audiometer capable of delivering independent stimuli to each ear via calibrated headphones, and a highly structured procedural approach. The foundational requirement for performing the ABLB is an asymmetrical hearing loss, where one ear possesses a hearing threshold that is at least 20 dB better than the contralateral ear at the test frequency, or where one ear is confirmed to be entirely normal. The first step involves determining the pure-tone thresholds for both ears at the specific frequency targeted for testing, usually starting at 1000 Hz or 2000 Hz, as these frequencies often yield the most reliable results regarding recruitment. Once thresholds are established, the clinician selects a reference ear, which is typically the normal or better-hearing ear, and sets the intensity of the reference tone at a specific suprathreshold level, commonly 20 dB sensation level (SL) above its established threshold. This fixed reference tone serves as the constant against which the variable tone in the impaired ear will be judged.

The core of the procedure involves the alternating presentation of the test tone. The audiometer delivers the tone first to the reference ear, then immediately switches to the impaired ear, and then rapidly switches back again. This back-and-forth presentation, usually lasting approximately 500 milliseconds per ear with a minimal interval between presentations, ensures the patient retains a strong auditory memory of the reference volume, facilitating a direct comparison. The patient's primary task is to indicate whether the tone in the impaired ear is louder, softer, or equal in volume to the tone heard in the reference ear. The clinician begins by setting the test tone in the impaired ear near its threshold and gradually increases its intensity across successive alternating trials. The patient provides feedback, and the clinician adjusts the intensity of the test tone until the patient confidently reports that the two tones, heard sequentially, possess **identical volume levels**. This intensity level in the impaired ear is then recorded as the first loudness balance point, meticulously noting both the Hearing Level (HL) and the Sensation Level (SL) for both the reference and the test tone.

To generate a comprehensive loudness function profile, this balancing procedure is repeated at multiple sensation levels in the reference ear. For instance, after achieving balance at 20 dB SL, the reference tone might be increased to 40 dB SL, 60 dB SL, and perhaps 80 dB SL, and the balancing process is repeated for each step. Plotting the intensity levels required in the impaired ear versus the corresponding intensity levels in the reference ear reveals the characteristic pattern of recruitment. If the impaired ear demonstrates recruitment, the intensity required to achieve loudness balance will be significantly lower than what would be predicted based on a simple linear threshold shift. For example, if the normal ear is presented with a tone at 60 dB Hearing Level (HL), and the impaired ear, despite having a 40 dB HL threshold, only requires 70 dB HL (a 30 dB SL) to achieve equal loudness, this marked compression indicates significant recruitment. A complete ABLB test typically involves repeating this detailed process across several key frequencies, usually 1000 Hz, 2000 Hz, and 4000 Hz, ensuring a thorough evaluation of the patient's suprathreshold auditory processing capabilities across the crucial speech range.

Interpreting ABLB Results and Clinical Classifications

The interpretation of the ABLB results relies on plotting the measured loudness balance points onto a graph, comparing the intensity required in the impaired ear (y-axis) against the intensity in the reference ear (x-axis). There are four primary outcomes or classifications derived from the ABLB test, each correlating to a distinct underlying auditory pathology. The most common and clinically significant outcome is **Complete Recruitment**, where the loudness growth function of the impaired ear converges with that of the normal ear. This means that while the threshold is elevated, the maximum loudness level (or uncomfortable loudness level) is achieved at roughly the same intensity as the normal ear, indicating severe compression of the dynamic range. Complete recruitment is the classic signature of a **cochlear lesion**, specifically involving OHC dysfunction, and is typically seen in conditions such as Meniere's disease or significant noise-induced hearing loss.

The second outcome is **Partial Recruitment**, where the loudness growth in the impaired ear is steeper than normal but does not fully converge with the normal ear's function at the highest test levels. This suggests sensory damage that is not as severe or localized as in complete recruitment. Partial recruitment still points toward a cochlear etiology, but perhaps one that affects the OHCs less dramatically or is complicated by some mild neural involvement. The third, and equally critical, outcome is **No Recruitment**, also known as Decruitment. In this scenario, the impaired ear requires an intensity level proportional to or even greater than the normal ear to achieve loudness balance across all suprathreshold levels. The loudness function parallels the normal ear's function but is shifted upwards according to the threshold loss. The absence of recruitment, particularly in the presence of a significant sensorineural loss, is the hallmark finding for **retrocochlear lesions**, such as tumors affecting the auditory nerve, indicating neural pathology rather than purely sensory damage.

The fourth, less common but theoretically possible, outcome is **Hyper-Recruitment**, where the loudness perception grows even more rapidly than in complete recruitment, requiring significantly less intensity in the impaired ear than the normal ear at higher levels to achieve balance. While often considered a variant of complete recruitment, hyper-recruitment suggests an unusually heightened sensitivity within the surviving auditory neurons. Clinically, the ABLB test offers a quantifiable measure of the subject's vulnerability to volume. If the subject perceives two noises, one set 20 dB above the threshold of the normal ear, and the other adjusted accordingly in the impaired ear, as having identical volume levels, it strongly demonstrates that one of their ears is significantly more vulnerable to volume. The resulting loudness contour map is invaluable for determining the appropriate compression characteristics needed in hearing aid fitting, ensuring that soft sounds are amplified without making loud sounds uncomfortably intense, thereby optimizing the patient's residual dynamic range.

Clinical Applications and Target Populations

The ABLB Test holds significant clinical value, primarily serving as a differential diagnostic tool to assist audiologists and otologists in distinguishing the site of lesion within the auditory pathway. Its primary application lies in differentiating between sensory (cochlear) hearing loss and neural (retrocochlear) hearing loss when pure-tone audiometry results alone are ambiguous or insufficient. Identifying the exact location of the pathology is paramount because the treatment protocols and prognoses differ vastly between cochlear damage and nerve damage. For instance, a confirmed cochlear lesion (recruitment present) allows the clinician to proceed confidently with hearing aid fitting, focusing on wide dynamic range compression algorithms designed to manage the compressed dynamic range. Conversely, a confirmed retrocochlear lesion (recruitment absent) necessitates immediate referral for neurological investigation, typically involving magnetic resonance imaging (MRI), to rule out serious conditions like acoustic neuromas, which require surgical or radiological intervention.

Furthermore, the ABLB test is particularly useful when screening specific target populations that exhibit symptoms related to altered loudness perception. One prominent example is the screening of children who experience pain or discomfort associated with normal environmental noises, a condition often termed **hyperacusis** or severe sound sensitivity. While hyperacusis is a complex central processing disorder, it often co-occurs with, or is exacerbated by, the recruitment associated with mild sensorineural hearing loss. Children who experience pain associated with normal noises are sometimes screened using the alternate binaural loudness-balance test. Assessing the presence and degree of recruitment in these children helps inform management strategies, distinguishing between true hyperacusis and the extreme discomfort caused by a compressed dynamic range. In this context, the ABLB provides objective data supporting subjective reports of volume distress, guiding the design of sound therapy or the use of specialized amplification devices.

Beyond differential diagnosis, the ABLB contributes fundamentally to the rehabilitation process, specifically in modern hearing aid fitting. The principle of recruitment dictates that a standard linear amplification scheme would render loud sounds unbearable for the patient due to the accelerated growth of loudness. By accurately plotting the patient's loudness growth function using the ABLB, audiologists can select and fine-tune hearing aids that incorporate advanced **compression technology**. This technology ensures that the gain applied by the hearing aid is inversely proportional to the input intensity, amplifying soft sounds significantly while limiting the output for loud sounds, thereby effectively restoring the patient's perceived dynamic range. Therefore, the test moves beyond mere diagnosis; it serves as a critical mapping tool for personalized auditory rehabilitation, ensuring maximum speech intelligibility and comfort for individuals afflicted by cochlear pathology.

Comparison with Other Loudness Balance Tests

While the ABLB Test is a highly effective measure of recruitment, it exists within a larger family of suprathreshold auditory tests. Its fundamental characteristic--the use of two ears for comparison--distinguishes it from the Monaural Loudness-Balance Test (MLBT). The **MLBT** is employed when hearing loss is symmetrical (equal in both ears) or when the hearing loss is unilateral but the patient exhibits specific auditory symptoms that make binaural comparison difficult. The MLBT involves balancing loudness between two tones of different frequencies within the *same ear*, rather than comparing the same frequency between two ears. For instance, a tone at a frequency with normal hearing is balanced against a tone at a frequency with hearing loss in the same ear. The underlying principle is similar--to measure the accelerated growth of loudness--but the execution is mono-aural, making it suitable for different clinical scenarios where the ABLB cannot be performed due to symmetrical loss. Both tests aim to map the loudness function, but the ABLB offers a more direct and often more reliable comparison because the reference ear provides a genuinely normal physiological baseline for the tested frequency.

Another related diagnostic tool is the **Short Increment Sensitivity Index (SISI) Test**, which indirectly assesses recruitment by measuring the patient's ability to detect very small (typically 1 dB) increments of intensity superimposed on a continuous tone set 20 dB above the patient's threshold. Patients with cochlear damage (recruitment) often score high on the SISI (70% to 100%), demonstrating an abnormally high sensitivity to these minute intensity changes, a finding consistent with the compressed dynamic range and accelerated loudness growth observed in the ABLB. Conversely, patients with normal hearing or retrocochlear lesions typically score poorly (0% to 20%). While the SISI test is quicker to administer and does not require binaural comparison, it provides a binary or percentile outcome regarding sensitivity rather than the comprehensive loudness function map generated by the ABLB. The ABLB, by providing intensity-specific balance points, yields a richer, more detailed profile of the recruitment phenomenon across the entire suprathreshold range.

The ABLB also differs conceptually from tests designed to measure auditory adaptation or fatigue, such as the Tone Decay Test. The ABLB measures how quickly loudness grows with increasing intensity, a static measure of perception. Tone decay tests, however, measure the patient's ability to sustain the perception of a tone over time at suprathreshold levels. Significant tone decay is the classic sign of a retrocochlear lesion (neural damage), where the auditory nerve fails to maintain consistent firing rates, causing the sound to fade rapidly. In a comprehensive diagnostic battery, the ABLB (identifying recruitment/cochlear damage) is often paired with a tone decay test (identifying adaptation/neural damage) to provide a robust and highly specific differentiation between sensory and neural pathologies. Therefore, while the ABLB shares the goal of evaluating suprathreshold auditory function with these other tests, its specific methodology--the alternate, binaural comparison across multiple intensity levels--makes it uniquely suited for quantifying recruitment in asymmetrical hearing loss cases, a measure so strongly comparable to other recruitment assessment methods that they are considered unique variations of the very same exam.

Limitations and Modern Alternatives

Despite its historical significance and diagnostic power, the ABLB Test is not without limitations, prompting the development of modern alternatives that offer objective measures of auditory function. The primary limitation is its reliance entirely on the patient's subjective judgment and cooperation. The test requires the patient to accurately compare the perceived loudness of two sequential, alternating tones, a task that can be cognitively challenging, particularly for pediatric patients, the elderly, or individuals with cognitive impairments. Furthermore, the test is inherently restricted to patients with **asymmetrical hearing loss**; if the loss is symmetrical across both ears, the reference ear is also impaired, invalidating the use of the ABLB methodology and necessitating the use of the Monaural Loudness Balance Test or other techniques. The time required to meticulously plot multiple loudness balance points across several frequencies also makes the ABLB test resource-intensive compared to rapid screening tools like the SISI test.

Modern audiology has introduced objective measures that can often provide similar diagnostic information without relying on subjective patient responses. Auditory Evoked Potential (AEP) testing, such as the Auditory Brainstem Response (ABR) and the Auditory Steady-State Response (ASSR), can objectively estimate hearing thresholds and provide information about neural function, helping to differentiate between cochlear and retrocochlear sites of lesion. More directly related to cochlear function are **Otoacoustic Emissions (OAEs)**. OAEs are faint sounds generated by the healthy outer hair cells (OHCs) and recorded in the ear canal. The presence of robust OAEs strongly suggests intact OHC function, which typically rules out significant cochlear damage and the associated recruitment phenomenon. Conversely, the absence of OAEs in the presence of mild to moderate sensorineural hearing loss is a powerful indicator of OHC damage and likely recruitment, providing an objective substitute for the ABLB findings regarding the site of lesion.

However, it is crucial to recognize that objective tests, while valuable, do not always fully replace the subjective measure of loudness perception. While OAEs confirm OHC status, they do not directly measure the patient's experience of volume growth or their uncomfortable loudness levels. Therefore, even in modern clinical settings, the ABLB retains its utility, especially when precise information about the patient's uncomfortable loudness levels (UCLs) and dynamic range compression characteristics is needed for the highly individualized process of hearing aid fitting. Furthermore, the ABLB is highly sensitive to the presence of **tinnitus**, as the internal noise often complicates the perception of the quiet alternating tones, sometimes leading to unreliable balance points. Clinicians must carefully weigh the necessity of the detailed loudness mapping provided by the ABLB against the potential for confounding factors or the availability of faster, objective diagnostic pathways before administering this classic suprathreshold test.

Historical Context and Evolution of Loudness Testing

The concept of measuring the abnormal growth of loudness perception has its roots in mid-20th-century audiology, a period marked by intense research aimed at localizing auditory lesions following the development of the pure-tone audiometer. The earliest systematic observations of recruitment were made by Edmund P. Fowler in the 1930s, who recognized that patients with certain types of hearing loss complained that loud sounds were perceived as equally loud as in their normal ear, despite having significantly elevated thresholds for soft sounds. Fowler's initial work laid the conceptual groundwork for the ABLB, formalizing the idea of comparing loudness sensation between ears. His method was fundamental in establishing that the auditory system does not always scale loudness perception linearly with intensity, especially after peripheral damage.

The refinement and standardization of the ABLB Test occurred largely in the 1940s and 1950s, solidifying its place as a critical component of the "auditory test battery" alongside other site-of-lesion tests. Before the widespread availability of advanced imaging techniques like MRI and CT scans, these behavioral tests were the only non-invasive means audiologists had to distinguish between sensory and neural pathologies. The ABLB provided the necessary evidence to differentiate cochlear disorders, which were treatable with compression amplification, from potentially life-threatening retrocochlear tumors. This distinction was historically so important that the ABLB became synonymous with recruitment measurement, setting a high standard for behavioral diagnostic sensitivity. The robust correlation of ABLB findings with cochlear pathology led to its classification as a definitive measure of sensory damage, often referred to as the **alternate test form** or **parallel form** due to its relationship with other established loudness tests.

Although modern technology has shifted some diagnostic reliance toward objective measures, the ABLB Test represents a crucial evolutionary step in audiological assessment. It cemented the understanding that hearing loss is not simply a uniform attenuation of sound but a complex

distortion of auditory processing, particularly concerning intensity. The principles established by the ABLB--the concepts of dynamic range compression and differential loudness growth--continue to inform contemporary hearing science and the design of all modern digital hearing aids. The enduring legacy of the Alternate Binaural Loudness-Balance Test is its role in transforming audiology from a field focused solely on measuring hearing thresholds to one dedicated to understanding and managing the complex subjective experience of sound intensity following auditory system damage, thereby enhancing the quality of rehabilitative care provided to individuals with asymmetrical sensorineural hearing loss.

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