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A Brief Overview of Amblyaudia

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Abstract

Amblyaudia, a recent subcategory of auditory processing disorder, is characterized by asymmetrical auditory processing of an individual's ears. Amblyaudia can result in speech comprehension difficulties, reading difficulties, information processing deficits, and inattention. These difficulties can be mistakenly attributed to Attention Deficit Hyperactivity Disorder (ADHD), Specific Learning Disorders (SLD), depression, anxiety disorders, and communication disorders. Unfortunately, traditional hearing tests do not place the two ears in competition and cannot detect asymmetry. Therefore, students who exhibit these difficulties and have normal performance on traditional hearing tests should be also evaluated for amblyaudia with dichotic listening tests. Amblyaudia can be addressed through dichotic listening tasks that strengthen the non-dominant ear, as well as minor adjustments to the classroom environment. This paper will examine the current literature on amblyaudia and provide a brief overview of the causes, diagnosis, treatments, and prognosis.

Keywords

Amblyaudia, Auditory Processing Disorder, Otitis Media

1. Introduction

Amblyaudia is a new diagnostic category within Auditory Processing Disorders (APD) [1] [2]. When one ear is developmentally deprived it causes the other ear to compensate and leads to weaknesses in the listener's binaural processing of auditory information [2]-[4]. Children who experience temporary hearing loss, most commonly from ear infections, are at an increased risk of developing amblyaudia [5] [6]. Characteristics of amblyaudia include speech comprehension difficulties, reading difficulties, information processing deficits, poor verbal working memory, poor adaptive skills, and inattention [7] [8].

2. Auditory Processing Disorders

Children who perform below average on two different tests of auditory ability meet the criteria for an auditory

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processing disorder [9]. An auditory processing disorder is the breakdown in auditory abilities, such as auditory discrimination, binaural listening, and temporal processing, that can lead to the reduced acquisition of knowledge from auditory input. Auditory discrimination is the ability to process the frequencies, phonemes, words, and noise level present in acoustic input. Binaural listening is the ability to integrate, separate, and locate sources of acoustic input. Finally, temporal processing is the ability to resolve, integrate, and recognize patterns in the acoustic input [2]. Auditory processing disorder is estimated to affect between 2 and 5 percent of school-aged children [10].

A recent diagnostic category of auditory processing disorder, amblyaudia, is characterized by an abnormally large performance discrepancy between the individual's two ears [11]. The asymmetrical processing abilities lead to weaknesses in the binaural processing of auditory information, much in the same way as lazy eye (amblyopia; [2]-[4]). Approximately 12 percent of children less than 5 years of age are at risk for amblyaudia [1] [2]. Of the individuals diagnosed with auditory processing disorder, 55 percent of them met diagnostic criteria for amblyaudia [5]. Therefore, children who are at risk for academic hearing difficulties should be screened for amblyaudia [5] [6].

3. Testing and Assessment

Amblyaudia cannot be identified by traditional hearing tests because there are no current tests that place the two ears in competition [1]. Instead, dichotic listening tests are used for screening and diagnosis because they put stress on the binaural auditory system and reveal any asymmetry between the auditory pathways [2] [5]. Some of the tests used are the Competing Words subtest of SCAN, staggered spondaic words test and the randomized dichotic digits test [1] [12]. Dichotic listening tests provide the listener with two monosyllabic words or digits simultaneously and is expected to repeat the words presented in each ear [13]. By placing the ears in competition, the child serves as his or her own control during testing [1]. Following testing, if the child has poor performance, he or she should be referred for further testing to rule out retrocochlear disorder, confirm the weaknesses, and receive a final diagnosis [2] [5]. The follow-up appointment can also rule out language and attention disorders if the dominant ear performs within normal range [1].

4. Diagnosis

The diagnosis of amblyaudia should address the nature of the processing weakness, which ear it affects, and the severity. Suggested severity criteria for amblyaudia is based off of interaural asymmetry. Borderline amblyaudia would have an interaural asymmetry of 10 - 19 percent, 20 - 29 percent would be the mild range, 30 - 39 percent would be moderate range, and 40 - 49 percent would be the moderately severe range. An interaural asymmetry of more than 50 percent would result in a severe amblyaudia diagnosis [5].

5. Brain Physiology

In order to fully understand the effects of amblyaudia on everyday life, conventional hearing must be explained. Sound waves are collected by the outer ear and sent inward for processing. As the sound waves reach the tympanic membrane, eardrum, they are converted into mechanical vibrations. They are then amplified by the malleus, incus, and stapes and transformed into fluid waves by the oval window. In the cochlea the timing information is enhanced for sound localization [14]-[16]. The input from both ears is then transferred through the trapezoid body and superior olivary complex. The superior olivary complex measures time difference and sound intensity. The output is then sent to the inferior colliculus for integration and routing of multi-modal sensory perception through the lateral lemniscus. The medial geniculate nucleus, located in the auditory thalamus, then relays frequency, intensity, and binaural information to the auditory cortex. The medial geniculate nucleus guides direction and maintenance of attention. The output is sent to the auditory cortex within the superior temporal gyrus. From the auditory cortex the information is sent to other cortical processing areas for further processing (e.g., Wernicke's) [14] [17]. From this we gather that monaural and binaural cues are initially processed separately prior to integration at the inferior colliculus [18] [19].

6. Effects of Amblyaudia

The auditory system of a child with amblyaudia compensates for the imbalanced inputs between ears by adjust-

ing sensitivity to binaural spatial cues [18]. Because of this adjustment, amblyaudia is associated with degraded binaural spatial hearing and sound localization [20]. Binaural spatial hearing and sound localization play key roles in speech comprehension, especially in noisy environments. Difficulty with binaural spatial hearing may have secondary effects on educational development because of linguistic and cognitive difficulties [18] [21]. Linguistic difficulties result from the impairments in phonetic and phonological coding of sounds [6] [22] and articulation and syntax impairments [23]. Cognitive difficulties are closely related with linguistic difficulties. The misperception of some phonemes produces a poor semantic database, which affects reading fluency and comprehension [24] and can result in dyslexia [25]. Because of the difficulty segregating auditory information, amblyaudia has been linked to attention problems that can effect educational development [26]. Difficulties with adaptive skills and self-esteem have also been seen in children with amblyaudia [27].

Amblyaudia often presents with difficulties in attention, speech comprehension, and reading. Inattention, such as inconsistent response patterns and shorter attention spans, is common in children with amblyaudia. Additionally, speech comprehension is made difficult, especially within noisy environments, due to the decreased ability to localize sound, comprehend verbal material, and follow verbal directions with multiple steps [7] [18]. The deficits in speech comprehension also impact reading fluency and comprehension through a chain of reactions. The misperception of verbal phonemes leads to a poor semantic database, which then makes reading comprehension more tedious, decreases reading fluency, and increases the likelihood of dyslexia [8] [24].

7. Causes

Amblyaudia was initially thought to be a result of poor communication between the two hemispheres of the brain, however, more recent studies point to asymmetrical auditory input as the cause [28]. Asymmetrical auditory input during periods of auditory development leads to disruption in normal auditory development and results in neural impairment, which affects acoustic processing. Hearing loss is the primary disruption that leads to asymmetrical auditory input.

7.1. Hearing Loss

There are three types of hearing loss: Sensorineural, conductive, and mixed. Sensorineural hearing loss is related to nerve damage. This is commonly due to exposure to loud noise, head trauma, or inherited disorders [29]. Conductive hearing loss is experienced when sound waves are interrupted within the outer ear, tympanic membrane, or middle ear due to obstruction or malfunction [18]. Some causes of this type of hearing loss are earwax buildup, a ruptured eardrum and fluid accumulation. When hearing loss results from nerve damage as well as an obstruction or malfunction, it is referred to as mixed hearing loss [29]. The hearing loss associated with amblyaudia is conductive hearing loss. This is often due to fluid accumulation within the typically air-filled middle ear [2] [7] [18].

Conductive hearing loss reduces the listener's ability to segregate and locate sound sources as well as discriminate from interfering noises [30]-[32]. This is especially true with monaural hearing loss because the effects of hearing loss in one ear are typically more dramatic than those following hearing loss in both ears [7] [30] [33]-[38]. Additionally, hearing loss in one ear has profound effects on binaural spatial cues [18] [34]-[36] [39] [40].

7.2. Otitis Media

Amblyaudia has been correlated with early life auditory deprivation such as otitis media with prolonged periods of temporary hearing loss [2] [7] [18]. Approximately 89 percent of cases of otitis media presenting with conductive hearing loss resulted in amblyaudia [7]. During periods of temporary hearing loss, the auditory system is unable to fully manipulate acoustical input from the affected ear [18]. When temporary hearing loss occurs during early periods of auditory experience, the central auditory circuits that support sound location may be recalibrated [41]. These adaptations may be beneficial during the period of hearing loss, however, they often become maladaptive once normal hearing is restored [4] [38] [42]-[44]. Therefore, even after normal hearing has been restored there is a possibility of long lasting auditory perceptual deficits [4] [18].

Otitis media is an infection or dysfunction that leads to the accumulation of excess fluid in the middle ear cavity [7] [45]. The excess fluid can degrade the auditory signals transmitted to the brain [7]. Roughly 80 per-

cent of children under the age of 3 experience otitis media making it the most commonly diagnosed illness among young children in the United States [7] [46] [47]. Approximately 75 percent of all infants have at least one episode during the first two years [48] [49] and 25 percent of infants develop recurrent or persistent otitis media [20]. Otitis media can often go undiagnosed given that it can occur without the presence of pain or infection [50].

8. Treatment

The processing difficulties of amblyaudia can be alleviated through interventions. Reducing the intensity of input to the dominant ear during dichotic listening tasks in order to strengthen the affected ear is usually the first part of the intervention. Then systematically increase the intensity to the dominant ear as long as the affected ear's performance remains high. This should be continued until both ears can perform more equivalently during dichotic listening tasks at equal intensity [2]. Another option is a short-term intervention program called Auditory Rehabilitation for Interaural Asymmetry (ARIA), which follows a similar progression [51].

9. Prognosis

The timing and duration of hearing loss both play key roles in the severity and prognosis of amblyaudia [18]. Abnormal acoustical experience during critical periods of development can produce profound changes in neuronal sensitivity [4] [38] [42]-[44]. These changes may help during the period of hearing loss but may be maladaptive once normal auditory inputs are available [52] [53]. Compensating for the reductions in the quality of input during those periods of development can be difficult [54] [55]. There is mixed research regarding when the changes in neuronal sensitivity dissipate. Some studies say that impairments are long lasting even after normal hearing has returned [7] [41] [56] [57]. However, other studies say that deficits largely disappear after a few years of typical auditory experience [20] [50] [58] [59]. Even if amblyaudia resolves by late childhood, there is no way to determine where the child would be without the period of asymmetrical hearing [7]. Additionally, it is hard to determine whether or not the individual will experience ripple effects on linguistic, cognitive, and social functions developed during the periods of atypical hearing.

10. Impact on School Psychologists

School psychologists should be aware of amblyaudia given that the symptoms can resemble other common disorders and traditional hearing tests do not screen for it. Children with amblyaudia can have problems with attention, reading, and speech. Amblyaudia has the potential to be misdiagnosed as Attention Deficit Hyperactivity Disorder (ADHD), a Specific Learning Disorder (SLD), Depression, an Anxiety Disorder, and a Communication Disorder [48]. Awareness is important because an accurate diagnosis means proper treatment. While the assistance provided for the other disorders would address the symptoms of amblyaudia, strengthening the non-dominant ear would address the cause.

While the non-dominant ear is being strengthened, adjustments to the classroom environment can set the child up for greater success. Directions and academic instructions should be given while facing the students instead of the board. Directions should be given with only one or two steps and should also be provided visually (*i.e.*, written on the board). After academic instructions or directions are given, additional processing time should be allowed. The seating location of the student also plays a role in his or her ability to listen. Seat the child away from common sources of noise (*i.e.*, air conditioner, window, door) as well as close to the board. Additional care should be taken in order to minimize classroom noise and distractions as much as possible. Finally, a private hand signal can go a long way for a student to communicate with the teacher about frustration or the need for assistance [60].

11. Conclusion

Difficulties in attention, speech comprehension, and reading can increase frustration as well as make processing information more challenging. Special attention should be given to students who exhibit similar difficulties and show normal performance on traditional hearing tests. A correct diagnosis of amblyaudia can lead to interventions that address the asymmetrical auditory input and alleviate some of the symptoms. Amblyaudia can be addressed by strengthening the non-dominant ear through dichotic listening tasks. Additionally, small adjustments to classroom seating and the way information is presented can set the child up for greater academic success.

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