Chapter

Otitis Media, Behavioral and Electrophysiological Tests, and Auditory Rehabilitation

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Abstract

For speech and language to develop, an intact and active auditory system is of fundamental importance. The central auditory nervous system (CANS) can be hampered by several occurrences, including otitis media (OM) originating from inflammation in the middle ear and which is often associated with the accumulation of infected (or sometimes noninfected) fluid. OM can have a diffuse effect on cognitive and linguistic abilities, affecting both speech and phoneme perception through a failure to discriminate, store, and reproduce the acoustic contrasts necessary for comprehension. It is especially common in the first years of school. In addition, OM can generate internal noise from the presence of middle ear fluid near the cochlea, which can lead to changes in speech perception, distortion in acoustic images, and a reduction in the speed and accuracy of decoding speech. Evaluating the effectiveness of the CANS is recommended in cases where there have been repeated episodes of OM. Very useful information can be gained from behavioral and electrophysiological tests. The tests allow functional diagnoses to be made and can also reveal clinical and subclinical changes. In this way, they allow information to be collected, which can help in making a prognosis and planning intervention strategies.

Keywords: otitis media, auditory processing, electrophysiology, frequency following response, evoked auditory potential; long latency auditory evoked potential

1. Introduction

Otitis media (OM) is a common childhood disease. Research has shown that recurrent episodes can induce changes or delay the development of the central auditory nervous system, leading to central auditory processing disorder (CAPD). In this chapter, we present results obtained in the behavioral and electrophysiological evaluation of the auditory processing of children and adolescents with OM over the first few years of life. In addition, we discuss aspects of the auditory rehabilitation process itself.

2. Auditory system and otitis media

Language plays an essential role in perceptual organization, including the reception and structuring of information, learning, and social interactions. Language

enables us to communicate with each other and acquire and transmit experience and knowledge. The development of speech and language requires a functional auditory system capable of detecting sound, paying attention, remembering, discriminating, and perceiving location. Any interruption to development will lead to significant functional impairments, not only in language but also in cognitive, intellectual, cultural, and social development [1, 2].

Central auditory processing (CAP) is defined as the efficiency and effectiveness with which the central auditory nervous system uses auditory information. It refers to the perceptual processing of auditory information and to the neurobiological activity underlying this processing that gives rise to electrophysiological auditory potentials [3, 4]. The efficient analysis and interpretation of normal auditory information involves several subprocesses and skills, and includes neural mechanisms underlying a range of auditory behaviors such as sound localization and lateralization; auditory discrimination; recognition of auditory patterns; temporal aspects of the hearing (integration, discrimination, resolution, temporal masking); auditory performance in the presence of competing acoustic signals (which includes dichotic listening); and decoding degraded acoustic signals [5, 6].

This whole process involves a complex system of neurons located in several stations of the auditory system. The initial analysis of the stimulus occurs in the peripheral auditory system, constituted by the external and middle ear, responsible for the capture, transduction, and processing of the sound stimulus. The stimulus arrives first at the cochlear nucleus and encephalic trunk, followed by the upper olivary complex, lateral lemniscus, inferior colliculus, and medial geniculate body, and finally reaches the primary area of auditory reception in the temporal lobe of each hemisphere. From the primary auditory cortex of each hemisphere, the signals travel to other regions of the brain-the association areas-both in the same hemisphere and in the opposite hemisphere. As the auditory information travels by ipsi- and contralateral routes, it undergoes increasingly complex levels of processing. This processing occurs both hierarchically and serially, as well as in parallel or overlapping. The result of combining serial and parallel processing makes the system highly efficient and redundant. In addition to ascending pathways, there are also descending pathways that can moderate the response to a received acoustic stimulus [7–8].

Central auditory processing disorder (CAPD) is a dysfunction of the central auditory nervous system that leads to hearing difficulties. It can lead to, or be associated with, changes in language, learning, cognition, or other communicative functions [3–5, 9]. In the pediatric population, there are several possible causes of the disorder, among them otitis media [10, 11].

Otitis media with effusion (OME) is a clinical entity characterized by the presence of effusion in the middle ear, without perforation of the tympanic membrane, but with an acute infection that lasts for a period of at least 3 months. The condition is common enough to be called an "occupational hazard of early childhood" [12] because about 90% of children have OM before school age and they develop, on average, four episodes of OM per year. OM may occur during an upper respiratory infection or occur spontaneously because of poor Eustachian tube function or an inflammatory response following a previous OM, most often between the ages of 6 months and 4 years [13, 14]. In the first year of life, 50% of children will experience OM, increasing to 60% by age 2. When primary school children aged 5–6 years were screened for OM, about 1 in 8 was found to have fluid in one or both ears [15] **Figure 1a–d**.

Most episodes of OM resolve spontaneously within 3 months, but about 30–40% of children have repeated OM episodes and 5–10% of episodes last 1 year [13]. At least 25% of OM episodes persist for 3 months and may be associated with hearing

loss which is usually noticed by parents or teachers as inattention, needing to ask several times, disinterest, and poor school achievement.

OM impairs sound transmission to the inner ear by reducing mobility of the tympanic membrane and ossicles, thereby reflecting acoustic energy back into the ear canal instead of allowing it to pass freely to the cochlea.

Diagnosis is performed by otoscopy and confirmed by a basic audiological evaluation. Under otoscopy, a retracted, opaque tympanic membrane with reduced mobility is seen. In the vast majority of cases, a yellowish liquid line, sometimes with air bubbles, is visible through the tympanic membrane. In the audiological evaluation, the result can range from normal hearing to moderate conductive hearing loss (HL of 0–55 dB) [16]. The mean hearing loss associated with OM in children is 28 dB, while a lesser proportion (~20%) exceeds 35 dB, with a type B tympanometric curve characteristic of effusion. Auditory losses are characterized by being fluctuating, temporary, and asymmetrical [17]. The mild degree of loss is sufficient to impair certain auditory functions, and the fluctuating nature (which may change to periods of normal hearing) leads to variable stimulation of the central auditory nervous system. The effect is to make it difficult to perceive sounds, and leads to diffuse cognitive and linguistic abilities affecting both speech and the perception of phonemes; school performance also suffers [18]. In addition, the fluid in the middle ear can cause noise near the cochlea, producing a distorted perception of sounds.

Depending on the clinical history and functional conditions of the child's middle ear, treatment involves either clinical or surgical management. In small children with OME, the most common surgical procedure is tympanotomy with ventilation tube placement, which drains fluid from the middle ear and thus restores hearing. Diagnosis and treatment is essential, since in an acute episode of OM fluids can remain in the middle ear for 3–12 months; in 10–30% of children, the fluid remains for 2–3 months. Thus, a child who has had three to four OME episodes before the

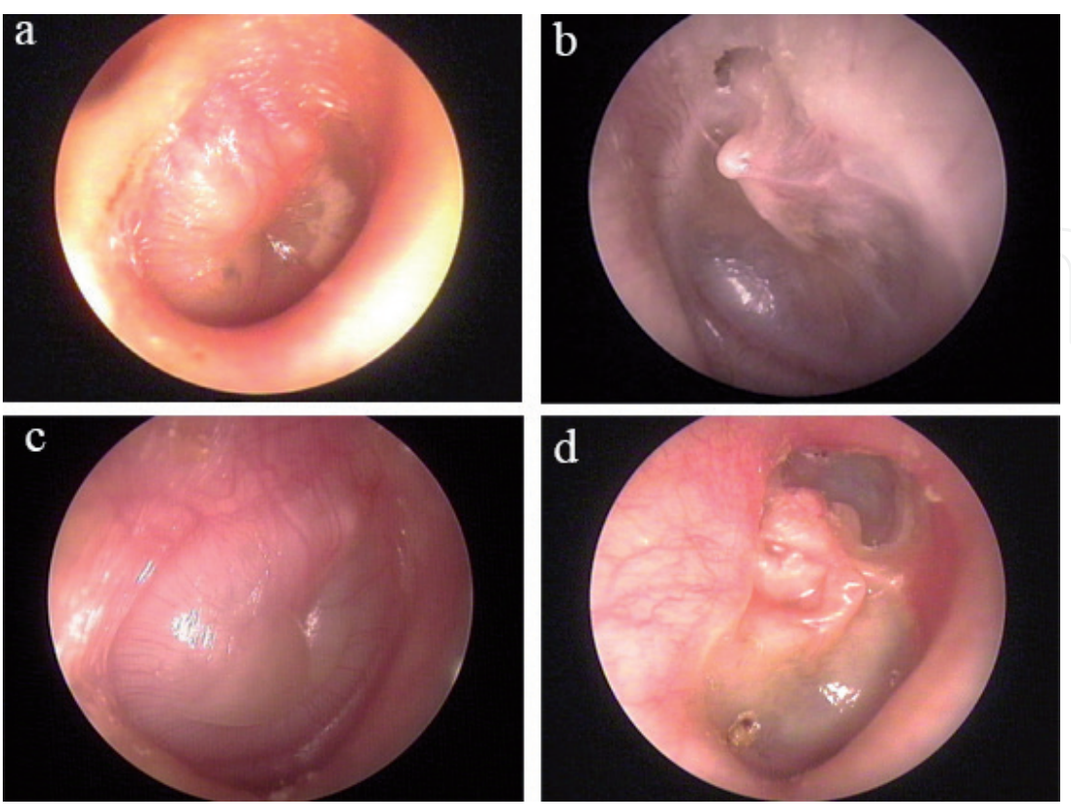

Figure 1
(a–d) Otitis media with effusion (OME). Personal collection.

age of three can have had 12 months of conductive hearing loss, which is a third of the period considered critical for development and learning [19]. The periods of auditory deprivation during the active periods of OME over the first years of life can delay the maturation of the structures in the CANS and consequently impair auditory abilities associated with central auditory processing.

Therefore, evaluation of auditory processing is fundamental in children with a history of otitis media in order to allow diagnosis, intervention, and guidance.

3. Testing the central auditory processing of children with a history of otitis media

To evaluate central auditory processing in children with a history of OM, it is recommended that a battery of test procedures be used by which the mechanisms and auditory abilities involved in the analysis and interpretation of sounds can be investigated. Due to the complexity of CANS, no single test is sufficient to explore its nature [3, 4]. Since the 1950s, numerous tests have been developed to evaluate central hearing function. These tests differ in that each presents different types of stimuli (verbal or nonverbal) and involves presentation to one or both ears (monaural or binaural). Each test is designed to evaluate a particular auditory mechanism or auditory ability and consequently probes different areas and functions of the CANS. Below the tests are divided into categories according to the way in which the stimuli are presented to the ears, the nature of the auditory tasks involved, and the method or approach used. Other currently accepted classifications involve categorizing them as binaural interaction tests, dichotic tests with verbal and non-verbal sounds (binaural integration and separation), monaural tests using low redundancy stimuli, time processing tests, and electroacoustic and electrophysiological procedures [20].

A comprehensive assessment allows for correct quantification and qualification of the various CANS mechanisms and dysfunctions and provides important information for planning and managing treatment.

3.1 Behavioral evaluation

Research by Colella-Santos et al. [11] involved 50 children (28 boys, 22 girls, mean age 11.2 years) with a documented history of bilateral SOM in the first 6 years of life and who had bilateral tympanostomy tube insertion (experimental group, EG); a control group (CG) consisted of 40 children (17 boys, 23 girls, mean age 10.7 years) with no history of otitis media. All children had auditory thresholds within normal limits on the day of evaluation and had a type A tympanometric curve. They were all evaluated with the tests described below [21–23]. The tests were the dichotic digits test, synthetic sentence identification test, gaps-in-noise test, and frequency pattern test. Details are as follows **Figure 2a** and **b**.

3.1.1 Dichotic digits (DD)

The DD test as developed in Brazil consists of four presentations of a list of two-syllable digits in Brazilian Portuguese, in which four different digits are presented simultaneously, two in each ear. The list contains 40 randomly arranged pairs of digits presented at 50 dB HL. The digits used to form the numbers are four, five, seven, eight, and nine. The participants are instructed to listen to two numbers in each ear and repeat all the numbers they hear. The order does not matter. The dichotic digits test verifies binaural integration ability [21].

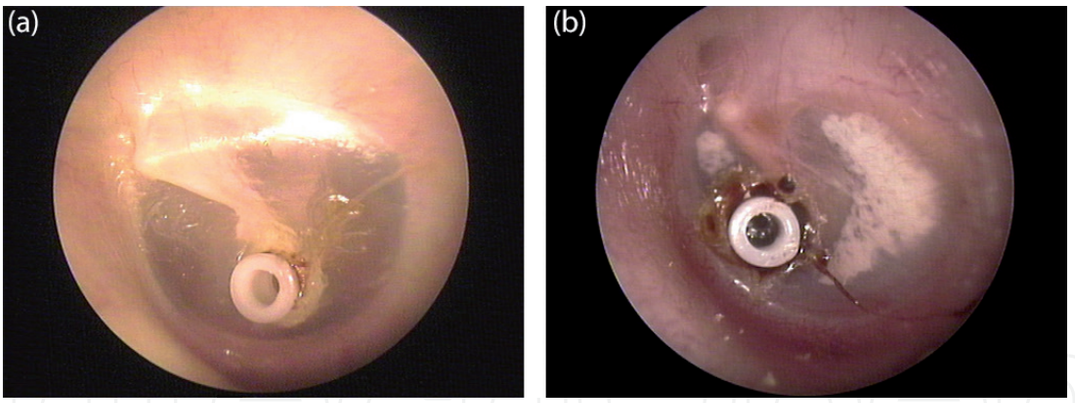

Figure 2.
(a–b) Tympanostomy tube insertion. Personal collection.

3.1.2 Synthetic sentence identification (SSI)

The SSI test consists of the presentation of 10 Brazilian Portuguese sentences at 40 dB HL, in the presence of a competing children's story in the same ear at a signal-to-noise ratio of 0, −10, or −15 dB. The task of the subject is to listen to the sentence and point to it in a frame. The ability analyzed in this test is figure-ground discrimination [21].

3.1.3 Frequency pattern test (FPT)

The FPT test is composed of three 150 ms tones presented at 50 dB HL and separated by 200 ms. The tones in each triplet are combinations of two sinusoids, 880 and 1122 Hz, which are designated as low frequency (L) and high frequency (H), respectively. Thus, there are six possible combinations of the three-tone sequence (LLH, LHL, LHH, HLH, HLL, and HHL). The subjects are instructed that they will hear sets of three consecutive tones that vary in pitch. Their task is to repeat the pattern by humming and verbalizing the frequency pattern (e.g., high–low–high). The FPT test checks temporal ordering ability [22].

3.1.4 Gaps-in-noise (GIN)

The GIN test consists of a series of 6-second segments of broad-band noise presented at 50 dB HL with 0–3 gaps embedded within each segment. The gaps vary in duration from 2 to 20 ms. The gap-detection threshold is defined as the shortest duration that is correctly identified at least four out of six times. The participants are instructed to indicate each time they perceive a gap. The GIN test measures temporal resolution ability [23].

To establish a difference between the right and left ears of subjects in the EG, it was necessary that there was a statistically significant difference in both the Dichotic Digits (p = 0.001) and GIN (p = 0.004) tests. No significant difference was found for gender in the behavioral tests. It was observed that the EG had lower mean responses than the CG for the DD test of approximately 5% in both ears; for the FPT 9.6% (humming) and 30% (naming); and 8% for the SSI test. For the GIN test, there was a statistically significant difference in the gap-detection threshold between the groups, with the highest threshold obtained in the EG compared to the CG (the higher the threshold, the worse the performance).

In summary, there was a negative effect of OM on the auditory skills of figure-background discrimination, resolution, and temporal ordering. The poorer results in CAP behavioral tests in the EG participants can be explained by the fact that OM,

by generating a fluctuating auditory threshold and causing temporary auditory deprivation, hampers the maturation of auditory abilities (such as binaural integration, resolution, temporal ordering, and discrimination) which are fundamental for understanding speech. During this period of auditory deprivation due to episodic OM, the CANS received inconsistent and incomplete auditory information. That is, the period between clinical assessment and the decision to perform surgery may have been too long **Table 1**.

Recent research has demonstrated associations similar to those found in the present study. Borges et al. [11] studied the effect of OM in 69 children of different socioeconomic levels who underwent surgical intervention (insertion of ventilation tubes) and observed worse performance in both the DD and GIN tests. The authors concluded that a history of OM can lead to changes in central auditory functioning, regardless of socioeconomic status.

Khavarghazalani et al. [24] evaluated 12 children with a history of OM who had undergone surgical intervention for insertion of ventilation tubes and found worse performance in the DD and GIN responses than in normals.

Gravel and Wallace [25] also found a significant increase in signal-to-noise ratio in a prospective study of children with a history of OM. There was worse performance on the SSI test (responsible for the figure-ground ability) in the OM group.

Tomlin and Rance [26] recommend that children with a history of OM undergo an evaluation of spatial processing upon entering school. They studied 35 children with a history of chronic OM and found a statistically worse performance compared to the control group in the listening in spatialized noise-sentences test (LISN-S). They concluded that these children have altered spatial processing, difficulty in focusing attention on the relevant stimulus, and difficulty in simultaneously suppressing competing stimuli coming from other directions. It is hypothesized that fluctuating access to binaural cues, caused by OM, may negatively affect the development of spatial processing in the CANS.

3.2 Electrophysiological evaluation

Auditory evoked potentials are an extremely useful instrument for the study of auditory perception and its disorders, especially when a range of stimuli are used [27].

Procedure	Ear	Control group			Experimental group			
		N	∑ (%)	SD	N	∑ (%)	SD	*p*-value
DD	R	40	98.93	1.86	50	95.40	5.16	<0.001
	L	40	97.93	4.15	50	92.55	7.95	<0.001
FPT								
Humming	B	80*	73.50	21.2	100*	42.7	22.2	<0.001
Verbalizing	B	80*	73.50	21.2	100*	42.7	22.2	<0.001
SSI	B	80*	67.5	13.9	100*	59.8	16.9	0.020
GIN	R	40	4.65	1.00	50	6.22	1.40	<0.001
	L	40	4.72	1.06	50	6.56	1.52	<0.001

*n = number, * = number of ears, B = both, R = right, L = left; ∑ = mean, SD = standard deviation, DD = dichotic digits, SSI = synthetic sentence identification, FPT = frequency pattern test, GIN = gaps-in-noise.*

Table 1.
Behavioral evaluation values of central auditory processing between control and experimental groups.

3.2.1 Click ABR

In the literature, there are contradictory results in Click ABR responses in individuals with a history of OM. Chambers et al. [28] and Folsom et al. [29] identified an increase in the latency of waves III and V in a group of children with a history of OM, whereas Shaffer [30] did not find a statistically significant difference in Click ABR responses in individuals with and without a history of OM. The majority of studies relating Click ABR results with OM history have investigated latency values; however, Maruthy and Mannarukrishnaiah [31] found a reduction in the amplitude of waves I and III. Sanfins et al. [32] observed statistically significant differences in the absolute latencies of waves I and V as well as in the amplitude of waves III and V from children with a history of bilateral OME compared to their healthy peers. Colella-Santos et al. [11] reported a significant increase in the absolute latency of wave III associated with a decrease in amplitude in children with bilateral OME. Finally, Sanfins [33] reported alterations in the values of waves III and V for both groups of children with a history of OME, seeing both bilateral and unilateral alterations **Figure 3**.

In animals, the effect of conductive hearing loss on CANS was studied by unilaterally removing the malleus and applying a fluid to simulate OM [34], finding a decrease in neuronal activity due to changes in various structures (wave III), upper olivary complex (wave IV), and lateral lemniscus (wave V). At the same time, based on the results of Maruthy and Mannarukrishnaiah [31], it has been suggested that the auditory nerve and cochlear nuclei are more susceptible to modifications after OM infection.

Sanfins et al. [32] suggest that different modifications may occur in CANS structures depending on the unilaterality or bilaterality of the infection. In episodes of bilateral OME, the latency values indicated that the auditory nerve (wave I, wave III) and the lateral lemniscus (wave V) were affected, whereas in unilateral OME, the cochlear nuclei (wave III) was affected. However, when the amplitudes were analyzed, the structures involved were the cochlear nuclei (wave III) and the lateral lemniscus (wave V), both for children with unilateral and bilateral involvement. It should be noted that when evaluating click ABR, the amplitude values show greater variability than the latencies. It is important to emphasize that a unilateral OM may not provide a better performance in the processing of auditory information than bilateral OM. The use of only one ear can lead to damage to the functionality of

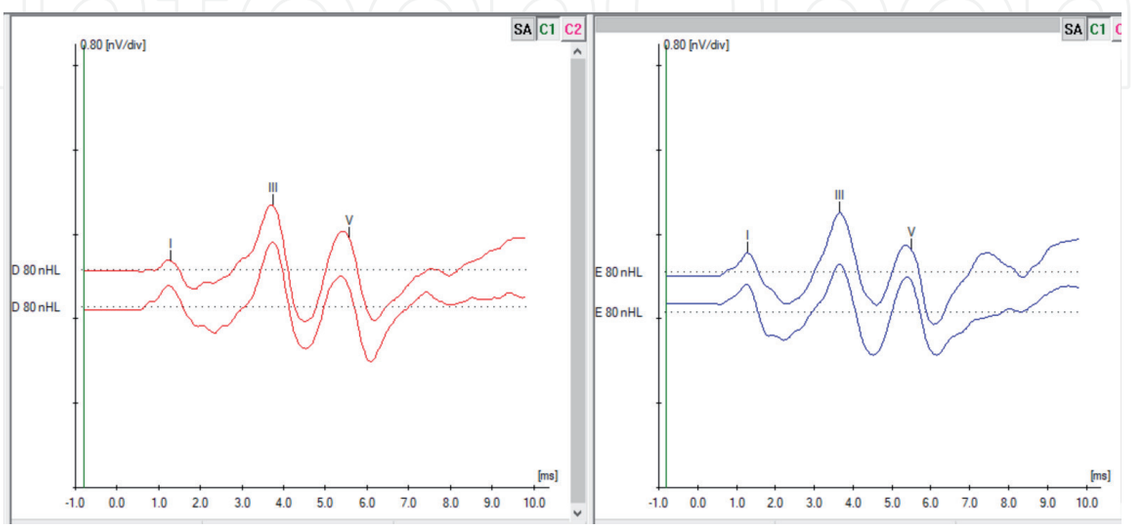

Figure 3.
Click ABR. Personal collection.

the CANS and, over time, activities that depend on binaural auditory processing (binaural interaction and binaural integration, among others) can be compromised due to the auditory imbalance arising from OM.

3.2.2 Frequency following response

Few studies have investigated the frequency following response (FFR) in cases of otitis media. A study of two groups of children with a history of bilateral OM (recent onset and long-term) showed that FFR responses were affected in a statistically significant way in the onset portions (waves V and A) and offset portion (wave O), along with reduced values of the VA complex (more specifically VA slope) when responses between the groups were compared. The findings suggest that long-term OM in children is associated with a reduced neural conduction velocity relative to the processing time of speech stimuli, either at the beginning (onset) or final portion (offset), resulting in a decrease in the coding of speech in the brainstem [35] **Figure 4**.

Sanfins et al. [32] reported that children with a history of SOM present an increase in the absolute latency of all FFR waves compared to children with no history of otological problems. In addition, children without hearing loss have more coherent responses in both ears, whereas the group of children with a history of OME has a greater dispersion of latencies in all FFR components (**Figure 5**). Colella-Santos et al. [11] also reported a decrease in VA slope in girls with OME.

3.2.3 Long latency auditory evoked potential

3.2.3.1 Tone burst

The literature reports alterations in the components of the LLAEP in children with language disorders and also in those with phonological disorders [36] changes that are frequently associated with problems arising from OM. Researchers note that OM can lead to changes in central auditory pathways [30, 37, 38]. However, there are few studies that have associated the LLAEP responses in children with a history of OM **Figure 6**.

Maruthy and Mannarukrishnaiah [31], Shaffer [30], Sanfins [33], and Colella-Santos [11] reported similar results, i.e., the presence of LLAEP changes in children with a history of OME. In the studies by Maruthy and Mannarukrishnaiah [32], all components of the LLAEP (P1, N1, P2, and N2) were significantly longer in

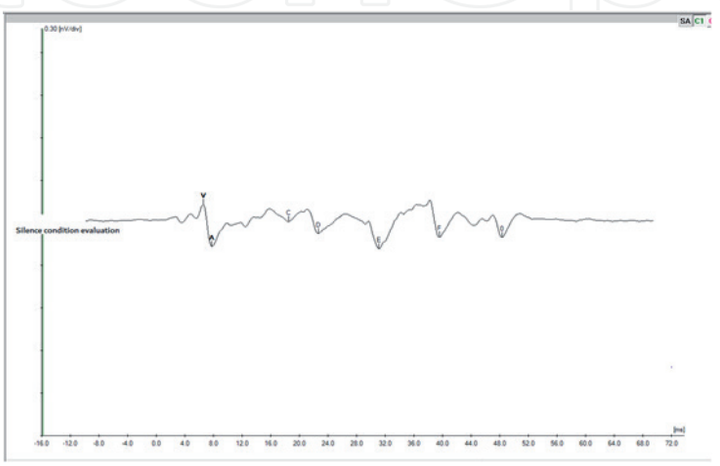

Figure 4.
FFR. Personal collection.

Figure 5.
Comparison (left vs. right ear) of absolute latency values of FFR components in children with a history of otitis media (right panel) and children with no history of otitis media (left panel), from Sanfins et al. [32].

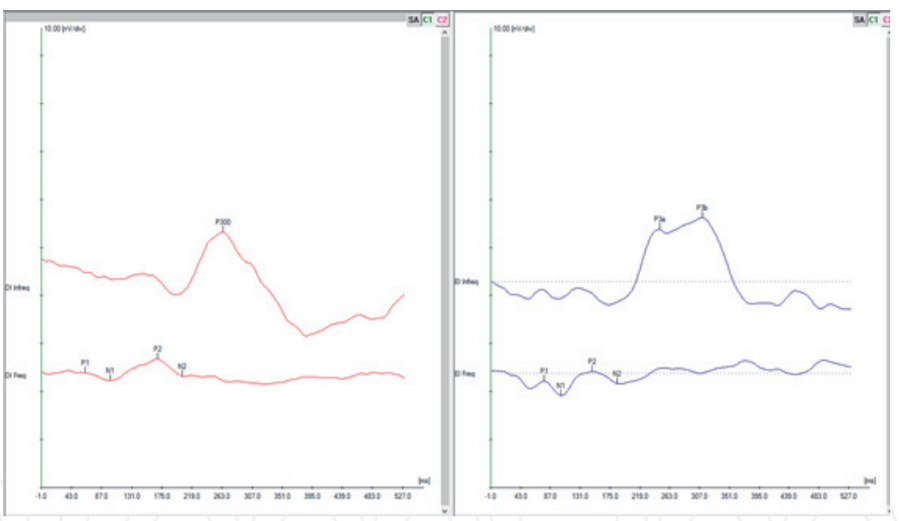

Figure 6.
LLAEP. Personal collection.

children with an SOM history. Shaffer [31] showed an increase in the latencies of N1 and P2, associated with the absence of the P300, in the majority of children evaluated. Sanfins [34] found prolongation of latencies only for P2 and N2 (for females), in comparison with the responses of children without otological alterations. Colella-Santos [11] observed an increase in P2, N2, and P300 latencies in children with a history of OME.

3.2.3.2 Speech

The LLAEP with verbal stimuli provides additional information about the biological processes involved in speech processing, enabling the collection of information complementary to those obtained by standard behavioral evaluations [30, 39, 40].

In the studies of Sanfins [33], children with bilateral OME presented prolonged latencies for N1, P2, N2 (female), and P300, in comparison with responses of children without auditory changes. Children with unilateral OME had prolonged latencies for P2 and P300 in comparison to the responses from healthy children.

The evaluation of the LLAEP using both nonverbal and verbal stimuli seems to be able to identify neurophysiological changes resulting from OM. However, it is important to note that, in unilateral OM episodes, only verbal sound stimuli (speech LLAEP) seem to be able to differentiate groups on the basis of latency. OM impairs speech perception as a result of a failure to recognize sound signals (discrimination, storage, memory). Therefore, the more accurate identification of LLAEP changes with verbal and non-verbal stimuli may relate to underlying OM.

4. Auditory rehabilitation

It is known that hearing loss due to OM during childhood development may result in long-term changes in neural function, structure, and connectivity. The changes are associated with a series of sensory, cognitive, and social difficulties suggestive of impaired brain function [41, 42] which may culminate in central auditory processing disorder (CAPD) [11].

Intervention for CAPD should be initiated as soon as the diagnosis, made through a series of behavioral and electrophysiological procedures, demonstrates the involvement of the CANS. Early identification, followed by intensive intervention, makes best use of the brain's inherent plasticity. Successful treatment outcomes depend on stimulation and repeated practice that induce cortical reorganization (and possibly reorganization of the brainstem), which is reflected in behavioral change [43–45].

Neuroplasticity is the key to the effectiveness of repeated auditory stimulation. Through experience and stimulation it induces reorganization of the cortex and brainstem, improving synaptic efficiency and neural density, giving rise to associated cognitive and behavioral changes [46–48]. The ability of the CANS to adapt to internal and external changes has important implications for learning [49].

Auditory training (AT) is defined as a set of (acoustic) conditions and/or tasks designed to activate the auditory system and related structures in such a way that their underlying neural processes and associated auditory behavior is altered in a positive way [8]. Both formal and informal AT procedures are conducted by audiologists in clinics; the difference between them is that formal training is acoustically controlled, meaning control over stimulus generation and presentation. Combined formal and informal AT offers an approach that provides more intensive practice and leads to better treatment efficacy [8]. AT performed in an individual with CAPD should include activities that aim to improve auditory skills such as sound localization and lateralization tasks, auditory discrimination, auditory pattern recognition, temporal aspects of audition, and auditory discrimination among competing acoustic signals [4].

Donadon and colleagues [50] have studied the efficacy of AT through behavioral CAP tests in children with a history of OM who had undergone bilateral tympanotomy for insertion of ventilation tubes. The sample consisted of 34 subjects who were divided into two groups: an auditory training group (ATG) formed by 20 children and adolescents, aged 8–13 years, diagnosed with CAPD, who were given an auditory training program; and a visual training group (VTG) formed of 14 children and adolescents, aged 9–13 years, diagnosed with CAPD who were given a visual training program. All subjects underwent peripheral auditory evaluation

and behavioral evaluation of their CAP (using the dichotic digit test, sentence identification test with ipsilateral competing message, gaps-in-noise test, frequency pattern test, and dichotic vowel test). Auditory training was given through repeated verbal and non-verbal stimuli and associated tasks (available at the website www.afinandoocerebro.com.br) via headphones in an acoustic booth (the intensity was set at 50 dB HL). Each session lasted between 40 and 45 minutes and was performed once a week. The stimulation protocol was developed with the purpose of developing the auditory abilities of:

i. binaural integration-through dichotic listening exercises;

ii. temporal resolution-by means of minimum time interval perception exercises;

iii. temporal ordering-using nonverbal tasks related to frequency, intensity, and duration; and

iv. figure-background exercises with competing noise.

The visual stimulation protocol was elaborated using varied stimuli and tasks from the website via a 15″ notebook positioned in front of the subject on a table arranged in a sound booth. The stimulation protocol was designed with the purpose of stimulating the visual abilities of:

i. visual background;

ii. visual closure;

iii. perception and discrimination of sizes and formats; and

iv. visual memory.

All subjects were reevaluated after 8 weeks with the same battery of behavioral tests as performed at the initial evaluation. In the ATG the results showed a statistically significant difference in the abilities of binaural integration ($p = 0.001$), temporal ordering ($p < 0.0001$), temporal resolution ($p < 0.0001$), and bottom figure (<0.0001) in a comparison of before and after AT. These results suggest that the auditory stimulation performed during AT induced changes in the central auditory nervous system, as demonstrated by the better values recorded in the behavioral tests after intervention. Behavioral changes observed after AT in this population with a history of OM point to evidence of neuroplasticity, since auditory stimulation brought about improvements to the identified impaired hearing abilities.

For the visual training group, however, there was no significant difference in performance for any CAP behavioral tests when comparing pre and post interventions. Thus, auditory training appears to be effective as an intervention strategy for re-adjusting the auditory skills in subjects with a history of OM. Auditory stimulation brought about improvements in impaired hearing skills. AT was able to reorganize the neural substrate, providing appropriate experiences, shaping existing circuits in the CANS, and increasing neural density, reflected by an improvement in the behavioral evaluation **Figure 7**.

Modifications to a child's environment are also important aspects for teachers and parents to address in order to help individuals with CAPD improve access to

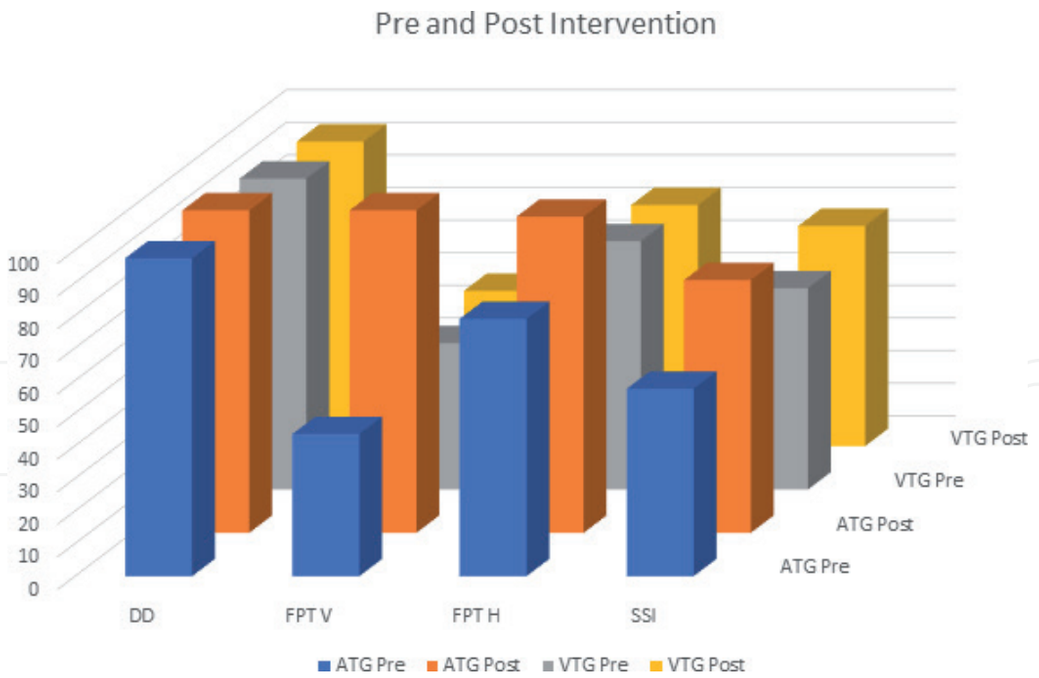

Figure 7.
Comparison of performance in behavioral evaluation pre and post intervention by groups. ATG Pre = auditory training pre intervention; ATG Post = auditory training post intervention; VTG Pre = visual training pre intervention; VTG Post = visual training post intervention; DD = dichotic digits; FPT V = frequency pattern test verbalizing; FPT H = frequency pattern test humming; SSI = synthetic sentence identification.

auditory information outside the therapy room. Some simple changes may bring many benefits to learning. Common recommendations for individuals with auditory disorders include the following:

- Preferred seating arrangements
- Addition of visual cues
- Clear language
- Making frequent checks for understanding
- Repetition or rephrasing
- Multimodality cues and hands-on demonstrations
- Preteaching of new information and new vocabulary
- Provision of a notetaker
- Recording information pictorially
- Gaining attention prior to speaking
- Positive reinforcement
- Reducing environmental noise
- FM systems

5. Summarize

- The negative effects of otitis media on the development of auditory abilities in children and the maturation of their central auditory pathways is undeniable;
- Early medical intervention in OM and family counseling is extremely important;
- The aim should be to avoid prolonged auditory fluctuation caused by OM, thereby minimizing the effects generated by fluid in the middle ear in the development of auditory abilities;
- The overall recommendation is that audiological diagnosis should include both behavioral evaluations and electrophysiological testing of auditory processing;
- In cases of auditory processing disorder, research shows that auditory training is the most effective procedure to re-adjust auditory skills.

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