SciMedCentral

Journal of Ear, Nose and Throat Disorders

Original Research

Central Auditory Processing in Hearing Aid Users: Pre- and Post-Acclimatization Results

Mariana Silva Freitas*, Adriana Neves de Andrade and Daniela Gil

Departmento de Fonoaudiologia, Universidade Federal de São Paulo, Brazil

***Corresponding author**

Mariana Silva Freitas, Departmento de Fonoaudiologia, Universidade Federal de São Paulo, Botucatu Street, 802 – Clementino Village – São Paulo, Brazil, ZIP Code 04023-900; Tel: 55 11; Email: marianafreitasfono@yahoo.com.br

Submitted: 25 May 2020

Accepted: 17 February 2020

Published: 19 February 2020

ISSN: 2475-9473

Keywords

- Hearing loss
- Sensorineural
- Speech discrimination tests
- Hearing tests
- Auditory perception
- Hearing aids

Abstract

To analyze and compare the performance of new users of behind-the-ear hearing aids in auditory processing behavioral tests in the pre- and post-acclimatization period.

Materials and methods: This study was attended by 20 individuals aged between 45 and 67 years old (both genders); with mild to moderately severe sensorineural hearing loss acquired in the post-lingual period; new users of bilateral digital hearing aids with minimum reported use of hearing aids of at least eight hours a day. They were subjected to duration and frequency pattern tests, memory for verbal and non-verbal sounds in sequence and sound localization, one week after adaptation (pre-acclimatization) and 12 weeks after amplification adaptation (post-acclimatization).

Results: The average performances in the duration and frequency pattern tests were less than 52% correct in the pre- and post-acclimatization moments, with improved performance in more than 50% of the sample. Regarding the tests of memory for verbal and non-verbal sounds, we found average performances less than 64% and 69% correct responses. The average performance for the sound localization test was less than 76% of correct responses, without changes after acclimatization in 85% of the evaluated sample.

Conclusion: The performance in the duration and frequency pattern recognition tests was better after 12 weeks of the use of amplification. The other behavioral tests presented similar results one and twelve weeks after use, thereby showing that acclimatization is not generalized for all hearing skills, therefore central auditory processing deficits should be taken into consideration during the period of amplification adaptation.

ABBREVIATIONS

Hz: Hertz; Db: Decibels; HL: Hearing Level; SL: Sound Pressure Level; CANS: Central Auditory Nervous System; DPT: Duration Pattern Test; T1: Pre-Acclimatization Time; T2: Post-Acclimatization; FPT: Frequency Pattern Test; VSM: Verbal Sequential Memory; NSVM: Non-Verbal Sequential Memory; SLT: Sound Localization Test.

INTRODUCTION

The acquired hearing loss can may impact the quality of life and the integration of the individual into society. In order to try to minimize these impacts, one of the rehabilitation proposals is the use of hearing aids. After the evaluation with the otorhinolaryngologist, the process of selection and adaptation of hearing aids in adults and elderly individuals is extensive [1], and requires the active participation of the individual in all necessary stages.

The main stages of this process are: audiological evaluation (audiological anamnesis, pure tone audiometry - air and bone conduction, speech audiometry, tympanometry, acoustic reflexes measures and discomfort threshold determination); selection, verification and validation of hearing aids using objective (verification of different input signals for pure tone and visible mapping of amplified speech) and subjective (free field thresholds, speech recognition tests in silence and noise, self-assessment questionnaires for analysis of quality of life, satisfaction, social relationship, and perception of the benefit of hearing aids) measures [2]. Throughout this process, we also include patient and family counseling.

In clinical practice, we usually note a time gap among the diagnosis of the hearing loss, the indication of the use of sound amplification and its effective adaptation. If this context remains for some time, even without the progression of hearing loss, there may be a change in the processing of sound information, due to

sensory deprivation, with impairment in one or more hearing skills [3,4].

The use of hearing aids, after a prolonged time of sensory stimulation, promotes structural and temporal changes in responses obtained in auditory evoked potentials in individuals with hearing loss [5], and in the performance in speech in noise tests [4,6]. In this study, it is hypothesized that these changes may also be found in other hearing skills after a period of effective use of hearing aids (acclimatization).

Accordingly, the objective of this study was to compare the performance of new users of behind-the-ear hearing aids in auditory processing behavioral tests that evaluate the auditory skills of temporal ordering and auditory pathway sound localization in the pre- and post-acclimatization times.

MATERIALS AND METHODS

This study was registered at *Plataforma Brasil*, with Certificate of Presentation for Ethical Appreciation nº 18756913.8.0000.5505, and then analyzed and approved by the Research Ethics Committees of Universidade Federal de São Paulo and Universidade Federal de Uberlândia.

We held a longitudinal, observational and inquiry study in an Auditory Health service at Universidade Federal de Uberlândia, where all individuals followed the regular flow of care with otorhinolaryngological evaluation, basic audiological evaluation pre-molding for the design of ear molds and adaptation of bilateral hearing aids (followed by adjustments, monitoring and verification of hearing aids).

In order to include participants in this research, we adopted the following inclusion criteria: ages between 45 and 67 years old (both genders); mild do moderately severe sensorineural hearing loss (pure tone average 500, 1000 and 2000 Hz up to 55 dB HL) [7], acquired in the post-lingual period; without history of otological and/or neurological surgeries; absence of middle ear, emotional, cognitive and/or neurological changes; minimum performance of 72% of correct responses on the Word Recognition Score, first adaptation of digital behind-the-ear hearing aids in both ears for a week and minimum reported use of at least eight hours a day (we used the mentioned use as criterion, since not all devices had a tool to verify the use by means of visualization in the software).

One week after adaptation, volunteers were recruited for the behavioral evaluation of auditory processing including the following tests sound localization test, memory for verbal and nonverbal sounds in sequence, and frequency and duration pattern tests – Musiek version [7]) (pre-acclimatization – T1 time). After 12 weeks (post-acclimatization – T2 time), the individuals were reevaluated with the same procedures.

In order to perform the evaluations, we used the following instruments: AC40 Interacoustics audiometer, sound field, musical instruments), compact disc with frequency and duration pattern tests (Musiek version) [7].

The memory for verbal and non-verbal sounds in sequence and sound localization tests were applied and analyzed according to the guidelines of the Behavioral Auditory Tests for the Evaluation of Central Auditory Processing [8]. Duration and frequency pattern recognition tests were presented in a sound field, at 50 dBSL, and the patients had to label the sequence heard. The percentages of correct responses equal to or greater than 76% were considered adequate for the analysis of the frequency aspects [9], and ≥ 83% of correct responses for the analysis of the duration aspects [9].

Data were stored in Excel 2010 spreadsheets, and then descriptive and inferential analyzes were performed. In order to perform the inferential analysis, we used Student's t-test. In all conclusions obtained through inferential analyzes, we used the significance level α equal to 5% (*p*-value 0.05 or 5%). Values considered statistically significant were written in bold and marked with the asterisk symbol (*).

RESULTS AND DISCUSSION

The sample selected in this research was composed of 20 patients who used hearing aids, with 07 (35%) men and 13 (65%), women. The average age of these patients was 59.55 years, ranging from 45 to 67 years old, with a standard deviation of 5.76 years. We did not perform comparisons of results between the different genders, since there is evidence that there are no differences between the performances in the behavioral auditory tests according to this variable [4].

The descriptive analyzes and comparisons of the results of the auditory processing behavioral tests, performed pre (T1 time), and post-acclimatization (T2 time) are presented in Table 1 and the individual performance in each auditory test, pre- and post-acclimatization (T1 and T2 times, respectively), were plotted on dispersion diagrams (Figures 1-4).

The inferential analysis of the results allowed us to envision that the performance of the surveyed individuals in the duration pattern pattern test is not good either in the pre-or post-acclimatization periodo, with 40.62% of correct responses and 44.95% of correct responses, respectively, but, in the comparison between the evaluations, there was a statistically significant difference with better results post-acclimatization (Table 1). The qualitative analysis of the results shows that none of the individuals achieved a performance equal to or higher than the normality criterion established for individuals in the pre-acclimatization time; and, in the post-acclimatization, only one individual was able to achieve the normality criterion. Comparing the moments individually, 50% of the sample showed improvement in performance, 45% maintained the results and 5% obtained worse results in the post-acclimatization evaluation (Figure 1).

Similarly, in the frequency pattern test, individuals showed average performance indexes of 45.29% in the pre- (T1), and 51.94% of correct responses in the post-acclimatization period (T2), with statistically significant difference when comparing the averages (Table 1). By visualizing the individual results (Figure 2), we can note that 95% of the sample performs below the reference patterns established in the pre-acclimatization and 100% of the sample has reduced performance in the post-acclimatization period (T2). When the moments are compared, 25% of the individuals maintained their performance between the evaluations, 60% increased their results and 15% worsened their performance.

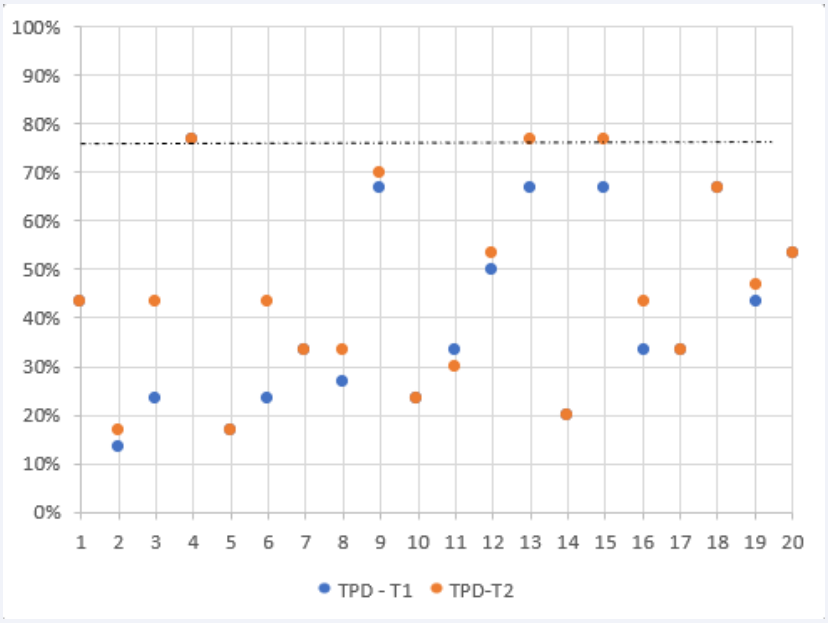

Figure 1 Dispersion diagram of the performance of each individual in the duration pattern test in the pre- and post-acclimatization period.

Table 1: Descriptive measures of the performance patients in pre- and post-acclimatization in auditory processing tests.

		average	median	minimum	maximum	standard deviation	*p*-value
DPT	T1	40.62	33.30	13.32	76.59	19.11	
	T2	44.95	43.29	16.65	76.59	19.46	**0.0084***
	difference	4.33	9.99	3.33	0.0	0.35	
FPT	T1	45.29	43.29	16.65	96.57	23.20	
	T2	51.94	44.95	16.65	96.57	22.42	**0.0254***
	difference	6.65	1,66	0.00	0.00	-0.78	
VSM	T1	56.66	49.99	0.0	100.00	30.00	
	T2	63.33	66.66	0.0	100.00	31.44	0.1628
	difference	6.63	16.63	0.00	0.00	1.44	
NVSM	T1	68.33	66.66	33.33	100.00	26.82	
	T2	66.66	66.66	33.33	100.00	27.89	0.7895
	difference	-1.67	0.00	0.00	0.00	-1.07	
SLT	T1	73.00	80.0	20.0	100.0	23.04	0.1625
	T2	75.00	80.0	20.0	100.0	23.55	
	difference	2.00	0.00	0.00	0.00		

Abbreviations: DPT: Duration Pattern Test; FPT: Frequency Pattern Test; VSM: Verbal Sequential Memory; NVSM: Non-Verbal Sequential Memory; SLT: Sound Localization Test.

In order to verify a possible difference in results due to the type of stimulus used, the performances between duration and frequency pattern tests were compared and there was no statistically significant difference between pre-acclimatization (*p*-value = 0.2225), and post-acclimatization (*p*-value=0.0504) periods.

The reduced performance of individuals with sensorineural hearing loss may occur due to difficulties in temporal encoding related to cochlear injuries, resulting from the hearing loss itself, and these changes may reverberate throughout the auditory system, justifying it, since the temporal encoding occurs in the peripheral auditory system and is represented at various levels in the CANS [10,11].

Although the differences were statistically significant, the same cannot be stated from the clinical perspective, since the improvement noted after 12 weeks of the use of amplification corresponded to one or two more hits. The results obtained are below those found in other studies [12,13], but the differences may be justified by the age of the population (younger in previous studies [14]), the characteristics of the hearing loss of the studied

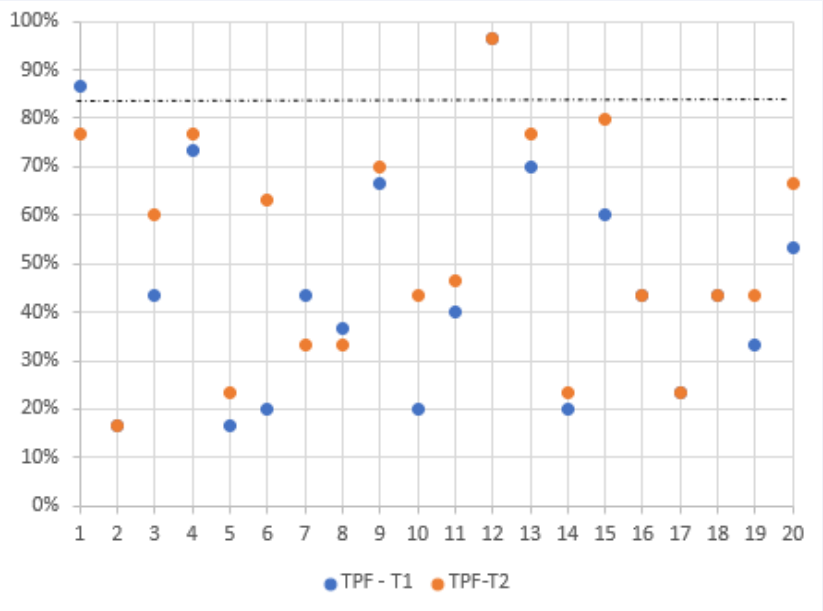

Figure 2 Dispersion diagram of the performance of each individual in the frequecy pattern test in the pre- and post-acclimatization times.

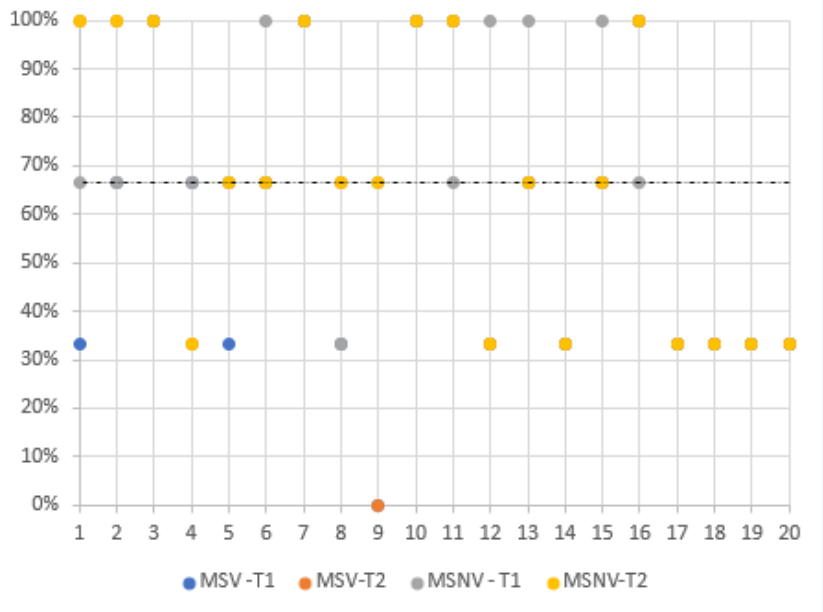

Figure 3 Dispersion diagram of the performance of each individual in memory tests for verbal and non-verbal sounds in sequence pre- and post-acclimatization.

population (restricted to high frequencies [12] , and/or the version of the applied test [13]).

The low performance of the surveyed individuals in the complex temporal ordering tests was also noted in the tests involving simple verbal and non-verbal stimuli. The average performances in the memory for verbal sounds in sequence test was 56.66% of correct responses in the pre-acclimatization and 63.33% of correct responses in the post-acclimatization (Table 1). There was no significant difference between the results in both evaluations, where 75% of the individuals maintained the scores in the comparison between the performances and only 50% of the sample presented results compatible with the normality criteria in the pre and 60% in the post acclimatization period (Figure 3).

The results memory for non-verbal sounds in sequence were 68.33% of correct responses in pre-acclimatization and 66.66% of correct responses in post-acclimatization Quantitative analysis based on the reference criteria, 70% of the individuals presented adequate results in T1 and 65% in T2. When the performance change was verified, 25% of the individuals improved their

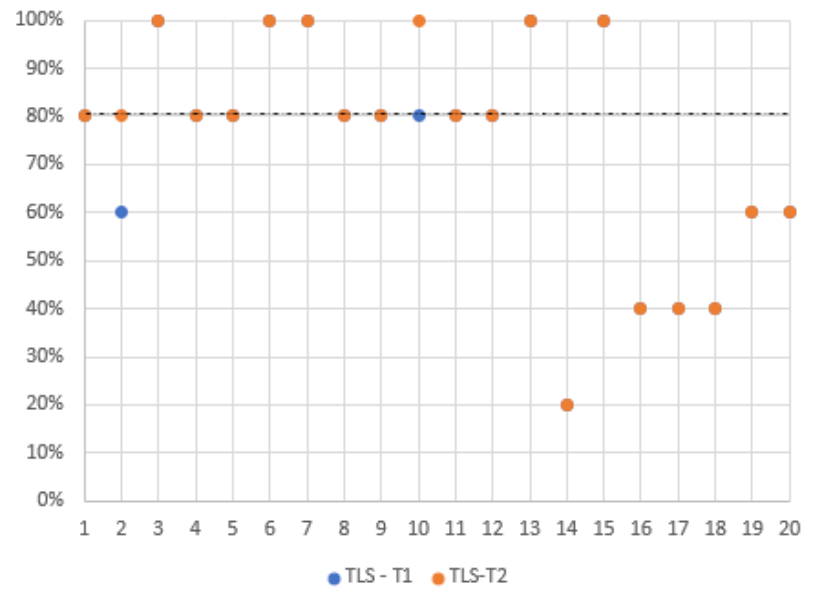

Figure 4 Dispersion diagram of the performance of each individual in the sound localization pattern pre- and post-acclimatization.

scores, 25% had worse results and 50% remained with stable values.

Although the stimuli presented were different, linguistic and non-linguistic sounds, when performing the comparison between the tests, there were no statistically significant differences in the pre (*p*-value=0.0692) or post-acclimatization (*p*-value=0.3306) times.

In general, the performance of the surveyed individuals in the four tests of temporal processing was quite reduced, when compared to the reference criteria, which highlights two scenarios: it is necessary to evaluate the auditory temporal processing skills in hearing aid users, using simple and/or complex sounds; and, in order to perform the correct analysis and interpretation and ultimately provide further intervention such as auditory training. Other studies with larger populations should be conducted, controlling other variables that were not considered here, such as, schooling, acquisition time of hearing loss, audiometric configuration and cognitive screening.

The changes in temporal processing exhibited by the evaluated population may contribute to difficulties in understanding in noisy environments and hindering the perception of supra-segmental aspects of speech (tone, intonation and reading rhythm).

Another extremely important skill for communication and with early development in the first years of life is the sound localization. The ability to localize sounds requires accurate information of clues of duration and intensity, besides requiring information received from both ears for the correct localization of the sound source. Individuals with hearing thresholds within normal limits or with symmetrical bilateral sensorineural hearing losses should not have difficulties in identifying the origin of the sound source in ideal listening situations, but, with the aging of the central nervous system, these difficulties may arise.

The evaluated population presented average performances of 73% in the sound localization test in the pre-acclimatization time (T1), and 75% in the post-acclimatization time (T2), without statistically significant differences when comparing the performances (Table 1). In the individual analysis of the performance of the study participants (Figure 4), 70% or more of the individuals had normal results in the pre- and post-acclimatization times. When comparing the evaluations, only 15% of the individuals presented improvement in sound localization performance in post-acclimatization period and 85% maintained the results. These results may have occurred due to the loss of the natural characteristics of sound acquisition when a behind-the-ear hearing aid is inserted into the ear. The situation closest to that naturally verified occurs with the adaptation of intra-channel hearing aids.

The difficulties of temporal processing and sound localization shown by hearing aid users are the issue of several studies. Several manufacturers seek technological solutions related to the structure and operation of hearing aids, with a view to improving the reception of sound information and, consequently, reducing the listening effort and maximizing the ability to recognize speeches, but, even with high-tech equipment, some individuals may be used to holding the old patterns of neural activation and, in these cases, it is also necessary to use other rehabilitation strategies with communication instructions and auditory training [15].

CONCLUSION

The performance in the duration and frequency pattern recognition tests was better after 12 weeks of the use of amplification; however, with performance below the expected from the quantitative perspective. The other behavioral tests presented similar results one week and twelve weeks of hearing aid use, thereby highlighting that acclimatization is not uniformly generalized for all hearing skills.

ACKNOWLEDGEMENTS

We thank the coordination of SASA UFU and the friends of the team of the department of speech therapy of Unifesp.

In addition, we thank the CNPq (Brazilian National Council for Scientific and Technological Development), for the scholarship and financial assistance that allowed us to achieve the full dedication to the program and the operationalization of the study.

REFERENCES

1. American Academy of Audiology (AAA). Guidelines for the audiologic management of adult hearing impairment. Reston: AAA. 2008.
2. Iwahashi JH, Jardim IS, Sizenando CS, Bento RF. Protocolo de seleção e adaptação de prótese auditiva para indivíduos adultos e idosos. Arquivos Int Otorrinolaringol (Impr.). 2011; 15: 214-222.
3. Freitas M, Naves K, Frizzo AC, Goncales AS. Aplicação do teste SSW em indivíduos com perda auditiva neurossensorial usuários e não usuários de aparelho de amplificação sonora individual. Rev CEFAC. 2013; 15: 69-78.
4. Fonseca GCR, Costa-Ferreira MID. O desempenho de idosos com perda auditiva neurossensorial nos testes de processamento auditivo: um estudo longitudinal. Rev CEFAC. 2015; 17: 809-818.
5. Leite RA, Magliaro FCL, Raimundo JC, Gândara M, Garbi S, Bento RF, et.al. Efeito do uso do AASI na decodificação do estímulo de fala por meio do Peate-fala. Braz J Otorhinolaryngol. 2018; 84: 66-73.
6. Habicht J, Finke M, Neher T. Auditory Acclimatization to Bilateral Hearing Aids: Effects on Sentence-in-Noise Processing Times and Speech-Evoked Potentials. Ear Hear. 2018; 39: 161-171.
7. Musiek FE, Baran JA, Pinheiro ML. Duration pattern recognition in normal subjects and patients with cerebral and cochlear lesions. Audiology. 1990; 29: 304-313.
8. Pereira LD, Schochat E. Processamento Auditivo Central: manual de avaliação. São Paulo: Lovise. 1997; 2: 175-176.
9. Corazza MCA. Avaliação do Processamento Auditivo Central em adultos: testes de padrões tonais auditivos de frequência e teste de padrões tonais auditivos de duração [tese]. São Paulo: Universidade Federal de São Paulo. 1998.
10. Chermak GD, Musiek FE, Craig CH. Considerations in the assessment of central auditory processing disorders. In: Chemark GD, Musiek FE, Craig CH, editors. Central auditory processing disorders: new perspectives. San Diego: Singular Publishing Group. 1998; 1: 91-107.
11. Bellis TJ. Interpretation of central auditory assessment results. In: Bellis TJ. Assessment and management of central auditory processing disorders in the educational setting: from science to practice. San Diego: Singular Publishing Group. 2003; 2: 267-313.
12. Santos RBF, Marangoni AT, Andrade AN, Prestes R, Gil D. Effects of auditory training in individuals with high-frequency hearing loss. Clinics. 2014; 69: 835-840.
13. Peixe BP, Sanguebuche TR, Malavolta VC, Garcia MV. The study of responses to auditory processing tests in the elderly. Rev CEFAC. 2019; 21: 1-10.
14. Matos GGO, Frota S. A influência das perdas auditivas sensorioneurais na ordenação temporal. Rev CEFAC. 2013; 15: 1435-1440.
15. Kuk F, Korhonen P. Localization 101: Hearing aid factors in localization. Hearing Review. 2014; 21: 26-33.

Cite this article

Freitas MS, de Andrade AN, Gil D (2020) Central Auditory Processing in Hearing Aid Users: Pre- and Post-Acclimatization Results. J Ear Nose Throat Disord 5(1): 1043.