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Unilateral hearing loss: benefit of amplification in sound localization, temporal ordering and resolution

Perda auditiva unilateral: benefício da amplificação na ordenação e resolução temporal e na localização sonora

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Keywords

Hearing Aid
Unilateral Hearing Loss
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ABSTRACT

Purpose: To assess the hearing abilities of temporal ordering, temporal resolution and sound localization before and after the fitting of a hearing aid (HA) in individuals with unilateral hearing loss (UHL). **Methods:** There were evaluated 22 subjects, aged 18 to 60 years, diagnosed with sensorineural or mixed UHL, from mild to severe degrees. The study was divided into two stages: the pre and post-adaptation of HA. In both phases, subjects performed an interview, application of Questionnaire for Disabilities Associated with Impaired Auditory Localization, auditory processing screening protocol (APSP) and Random Gap Detection Test (RGDT). **Results:** This study found no statistically significant difference in sound localization and memory evaluations for verbal sounds in sequence, in RGDT and Questionnaire for Disabilities Associated with Impaired Auditory Localization. **Conclusion:** With the effective use of hearing aids, individuals with UHL showed improvement in the auditory abilities of sound localization, ordering and temporal resolution.

Descritores

Auxiliares de Audição
Perda Auditiva Unilateral
Adulto
Localização
Habilidades

RESUMO

Objetivo: Verificar as habilidades auditivas de ordenação temporal, resolução temporal e localização sonora, antes e após a adaptação do aparelho de amplificação sonora individual (AASI) em indivíduos com perda auditiva unilateral (PAUn). **Método:** Foram avaliados 22 indivíduos, com idades de 18 a 60 anos, com diagnóstico de PAUn sensorioneural ou mista, de graus leve a severo. O estudo foi dividido em duas etapas: a pré- e a pós-adaptação do AASI. Em ambas as etapas, os indivíduos realizaram anamnese, bem como a aplicação do Questionário de Habilidade Auditiva da Localização da Fonte Sonora (QHALFS), avaliação simplificada do processamento auditivo (ASPA) e *Random Gap Detection Test* (RGDT). **Resultados:** O presente estudo encontrou diferenças estatisticamente significantes nas avaliações de localização sonora e memória para sons verbais em sequência, no RGDT e no QHALFS. **Conclusão:** Com o uso efetivo do AASI, indivíduos com PAUn apresentaram melhora nas habilidades auditivas de localização sonora, ordenação e resolução temporal.

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INTRODUCTION

Changes in the abilities of the central auditory function in individuals with unilateral hearing loss (UHL) have been documented because they present damages in the efficiency and effectiveness by which the central nervous system uses the auditory information. The location of the sound source, the understanding of speech in noise, the processing of one or more signals over a period, and the perception of intervals between these signals are among the auditory abilities commonly encountered in these individuals. Therefore, UHL can be indicated as a risk factor for changes in central auditory processing due to sensory deprivation and consequent lack of auditory stimulation[1].

Adults with UHL often demonstrate decreased localization of sound and report that situations requiring spatial hearing are especially challenging. The sound localization is affected by the loss of the binaural hearing benefit. For this ability to occur without impairment, the effective functioning of the auditory pathways of the central nervous system and the cortex are necessary, as well as adequate hearing sensitivity in both ears[2,3].

The auditory abilities of ordering and temporal resolution directly interfere in the processing of sounds, which are fundamental for the perception of speech sounds and music. Temporal ordering is the auditory ability to perceive one or more sound signals without changing order over a period and process those changes; capable of identifying the time interval between sounds and their alterations[4,5].

Auditory perception results from the analysis of constant and progressive sound stimuli that contribute to verbal and nonverbal sound comprehension, as well as suprasegmental speech information, which gives rise to a relationship directly with the temporal auditory aspects. A deficit in one of the ordering or temporal resolution skills alters the perception of sounds, and consequently, the message[6].

For the rehabilitation of individuals with UHL, auditory stimulation through the adaptation of hearing aids (HA) is the way to activate auditory plasticity, that is, to reorganize the auditory system after injury, rescuing impaired auditory abilities. Among the advantages of HA adaptation, restoration of the binaural summation phenomenon decreases auditory effort, since the stimulus presented to the two ears is perceived with greater intensity in relation to the unilateral presentation[7]. The immediate effect of this phenomenon is to improve speech recognition in a noisy environment, a situation considered difficult for individuals with UHL[3].

The central auditory system has the capacity to reorganize after an injury, suggesting that hearing loss adaptation may stimulate auditory plasticity[8]. The importance of binaural hearing has been emphasized, thus supporting the indication of HAs for UHL[9-11]. The benefits of binaural hearing are widely advocated since listening with both ears improves speech comprehension in environments where there is competitive noise or reverberation, and the location of the sound source is dependent on the perception of sound simultaneously by the ears[12].

Surveys conducted with children with UHL have demonstrated that they are subject to numerous difficulties that may affect normal language development, auditory perceptual abilities and school learning[7,13], but similar data from studies with the adult population with UHL are scarce. Therefore, the knowledge of the auditory performance of adult individuals with UHL is of great importance to provide better assistance to this group. The hypothesis of this research was that the use of hearing aids could help in the performance of auditory skills tasks.

Thus, the objective of the present study is to verify the auditory abilities of sound localization, temporal ordering and temporal resolution before and after the adaptation of hearing aids, regarding the gender, the affected ear and the type of auditory deficiency of UHL individuals.

METHODS

The study design consisted of a prospective non-randomized cohort clinical trial performed with ethical approval (1.455.011), patient science for voluntary participation in the study, and publication of the data, confirmed with the signing of the Term of Free Consent and Enlightened.

The composition of the sample, considering the eligibility criteria, was by pre-selections in a hearing health service totaling 22 volunteer individuals from 18 to 60 years of age, of both genders (13 men and 9 women), with unilateral acquired sensorineural or mixed hearing loss and without experience with HA, indicating a device complying with the SAS/MS 587 Ordinance. Subjects with neurological alterations were not included.

The methodology consisted of two phases: pre- and post-adaptation of hearing aids, respecting a three-month period between them. The following procedures were performed: audiological anamnesis, Localization Disabilities and Handicaps Questionnaire (LDHQ), Simplified Evaluation of Central Auditory Processing (SECAP), and Random Gap Detection Test (RGDT).

Through the anamnesis, we sought to ascertain the abilities of sound localization and speech perception both in situations of silence and in situations with competitive noise in the pre- and post-adaptation of HAs.

The LDHQ[14] translated into Portuguese[11] was applied, which, although not validated, makes it possible to investigate the patient's perception of the possible difficulties imposed by UHL. It consists of 14 questions about locating the sound source in activities of daily living with four choices of answers: "never", "sometimes", "usually" and "always". Each answer is assigned the value of 1 to 4 points. For the alternative number 1, weight one was adopted, weight two for number 2, weight three for number 3 and weight four for number 4. Thus, the value four was indicative of a lower degree of difficulty in locating the sound source. The value equal to or less than three was a parameter for the inclusion of participants.

The SECAP is composed of three dichotic tests, performed without visual clues. The Sound Localization Test (SLT) with the presentation of the rattle sound in five directions, in which the individual must point the place from where the sound is coming, aiming to verify the ability of sound localization; for this procedure, it is expected that the individual will point to at least four of the five directions presented, provided that the left and right directions were indicated correctly. The Memory Test for Verbal Sounds in sequence (MTVS) with the oral presentation of verbal sounds (pa, ta, ca, fa) in three different sequences, with the individual having to repeat the correct sequence. The Memory Test for Sounds non-Verbal in sequence (MTSnV) with an agogô, rattle, bell and coconut performed in three different sequences. The individual must point to the instruments in the order presented. These tests evaluate the auditory ability of temporal order and the physiological mechanism of temporal processing of discrimination of the sounds in sequence. The normality criterion for the ability to order verbal and non-verbal sounds was two or three hits in a sequence[15].

The RGDT random interval detection test comprises the recorded presentation of nine pure tone pairs at the frequencies of 500Hz, 1k, 2k and 4kHz, with random silence intervals, following protocols 0, 2, 5, 10, 15, 20, 25, 30 and 40 ms, in which the individual was instructed to respond if one or two sounds were heard. The RGDT was presented through headphones at a comfortable intensity of 50 dBNS, considering the threshold of each of the frequencies tested. The test analyzes the auditory ability of temporal resolution and the physiological mechanism of temporal processing. The normality criterion was less than or equal to 10 ms[16] and the criteria established by Balen et al.[17] for the RGDT were adopted.

The adapted hearing aids presented activation of a noise reduction system, feedback cancellation and *datalogging*, through which certification of effective use (eight hours per day) was obtained. The NAL-NL2 non-linear prescriptive method was used to calculate the electroacoustic characteristics. To verify the performance of the hearing aids, measurements of the external ear response were performed with and without amplification, using input intensity levels of 50, 65 and 80 dBNPS in which the results were compared to the prescribed target, considering similar responses when the difference did not exceed 10 dB[12]. Adjustments were made when necessary.

For the statistical treatment, a descriptive analysis of the qualitative and quantitative variables was used using the mean and standard deviation. To verify the normal distribution of the sample, the Kolmogorov-Smirnov normality test was performed. To compare the responses obtained in the pre- and post-adaptation study procedures, the Student paired t-test was used in the SECAP, RGDT and LDHQ between ears with hearing loss. For the hypothesis tests, a significance level of 5% was adopted.

RESULTS

Data obtained in the interview conducted in the pre-adaptation phase of the HA regarding sound localization (SL) showed that 59.1% (n = 13) of the participants reported it being a difficult and confusing act; 13.6% (n = 3) reported being difficult; 13.6% (n = 3) reported being confused and 13.6% (n = 3) reported no difficulty. When interviewed in the post-adaptation phase, one individual (4.5%) reported having continued without difficulty and another (4.5%) remained confused, however, 20 (90.9%) reported improvement in SL with HA. Regarding speech perception (SP), 20 (91%) individuals reported that it was a difficult and constant task, 2 (9%) individuals reported understand nothing in noisy environments in the pre-adaptation phase of hearing loss. It is noteworthy that in the post-adaptation phase all participants reported improved speech perception with the use of sound amplification in situations with competing noise.

Statistically significant differences were found between the mean values of the total and mean scores on the Localization Disabilities and Handicaps Questionnaire in the comparison between the pre- and post-adaptation hearing aids (Table 1).

Table 2 shows mean values and standard deviation of the SECAP procedure (SLT, MTVS and MTSnV) in the pre- and

Table 1. Mean values of the total and average scores in the Localization Disabilities and Handicaps Questionnaire pre- and post-adaptation

LDHQ	HA Adaptation Phase	Average	Minimum	Maximum	Median	Standard deviation	p (value)
Total Score	Pre	30.59	22.0	40.0	29.5	5.885	0.000*
	Post	43.5	35.0	55.0	44.0	7.327	
Average	Pre	2.18	1.57	2.85	2.14	0.421	0.000*
	Post	3.1	2.07	3.92	3.14	0.526	

*Significant
Caption: LDHQ = Localization Disabilities and Handicaps Questionnaire; HA = Hearing Aid

Table 2. Mean values of the responses and standard deviation in simplified evaluation of central auditory processing (SECAP) in the pre- and post-adaptation

SECAP	HA adaptation phase	Average	Minimun	Maximun	Median	Standard deviation	p (value)
SLT	Pre	3.32	2.00	5.00	3.00	0.995	0.005*
	Post	4.09	3.00	5.00	4.00	0.811	
MTVS	Pre	1.86	0.00	3.00	2.00	0.889	0.049*
	Post	2.18	1.00	3.00	2.00	0.664	
MTSnV	Pre	2.27	0.00	3.00	2.50	0.827	0.815
	Post	2.32	0.00	3.00	2.00	0.716	

*Significant
Caption: HA = Hearing Aid; SECAP = simplified evaluation of central auditory processing; SLT = Sound Localization Test; MTVS = Memory Test for Verbal Sounds in sequence; MTSnV= Memory Test for Sounds non-Verbal

post-adaptation hearing aids. A statistically significant difference was observed between the pre- and post-phases of the SLT and MTVS.

The RGDT results by frequency and for the mean of all frequencies tested in the pre- and post-adaptation hearing aid are described in Table 3. There is a statistically significant difference for all frequencies and their means.

In the comparison between the types of hearing loss of the participants of this study and the procedures performed, there was a statistically significant difference between the two phases of the study only for the MTSnV (Table 4).

In Table 5, the comparison of performances in the procedures is arranged between the ears revealing that there were no statistically significant differences.

Table 3. Mean values of the responses and standard deviation for the RGDT in the two phases of the study

RGDT	HA adaptation phase	Average	Minimun	Maximun	Median	Standard deviation	p (value)
500Hz	Pre	50.91	5.00	150	50.0	44.898	0.022*
	Post	34.18	2.00	150	17.5	34.191	
1000Hz	Pre	56.68	2.00	150	50.0	49.206	0.004*
	Post	38.50	2.00	150	15.0	38.278	
2000Hz	Pre	62.95	5.00	150	50.0	48.640	0.001*
	Post	42.68	2.00	150	20.0	49.210	
4000Hz	Pre	85.23	10.0	300	50.0	77.205	0.003*
	Post	38.95	2.00	150	15.0	44.210	
Average 500, 1, 2 and 4kHz	Pre	63.94	6.25	150	50.0	48.789	0.000*
	Post	38.58	2.00	150	16.9	39.065	

*Significant
Caption: HA = Hearing Aid; RGDT = Random Gap Detection Test

Table 4. Comparison between types of hearing loss and procedures performed in the pre- and post-adaptations

Procedures		Hearing Loss	Average	Minimun	Maximun	Median	Standard deviation	p (value)
SECAP	SLT Pre	S	3.00	2.00	4.00	3.00	0.73	0.642
		M	3.70	2.00	4.00	3.00	1.15	
	SLT Post	S	4.16	4.00	5.00	4.00	0.71	0.101
		M	4.00	3.00	5.00	4.00	0.94	
	MTVS Pre	S	1.75	1.00	3.00	2.00	0.86	0.524
		M	2.00	0.00	3.00	1.00	0.94	
	MTVS Post	S	2.16	1.00	3.00	2.00	0.57	0.910
		M	2.20	1.00	3.00	2.00	0.78	
	MTSnV Pre	S	2.58	0.00	3.00	2.00	0.66	0.050*
		M	1.90	0.00	3.00	3.00	0.87	
	MTSnV Post	S	2.16	0.00	3.00	2.00	0.83	0.287
		M	2.50	2.00	3.00	2.00	0.52	
LDHQ	Score Pre	S	31.00	1.64	2.85	2.12	7.21	0.730
		M	30.10	1.57	2.78	2.30	4.28	
	Average Pre	S	2.21	23.0	40.0	29.5	0.51	0.737
		M	2.15	22.0	35.0	30.0	0.30	
	Score Post	S	44.66	2.35	3.57	3.12	8.11	0.426
		M	42.10	2.07	3.92	3.20	6.38	
	Average Post	S	3.18	35.0	50.0	43.5	0.58	0.439
		M	3.00	39.0	55.0	45.5	0.45	
RGDT	500Hz Pre	S	43.75	5.00	150	32.5	51.57	0.425
		M	59.50	15.0	150	37.5	36.09	
	1000Hz Pre	S	44.75	2.00	150	30.0	56.08	0.220
		M	71.00	5.00	150	35.0	37.25	
	2000Hz Pre	S	52.08	5.00	150	50.0	51.80	0.260
		M	76.00	5.00	150	37.5	43.51	
	4000Hz Pre	S	75.00	10.0	300	50.0	87.56	0.509
		M	97.50	15.0	150	37.5	65.03	

*Significant
Caption: S = sensorioneural; M = mixed; SECAP = simplified evaluation of central auditory processing; SLT = sound localization test; MTVS = Memory test for verbal sounds; MTSnV = memory test for sounds non-verbal; LDHQ = Localization Disabilities and Handicaps Questionnaire; RGDT = Random Gap Detection Test

Table 4. Continued...

Procedures		Hearing Loss	Average	Minimun	Maximun	Median	Standard deviation	p (value)
RGDT	Average Pre	S	53.89	6.25	150	43.1	54.97	0.301
		M	76.00	11.25	51.25	39.40	39.54	
	500Hz Post	S	29.75	2.00	90.0	32.5	39.78	0.518
		M	39.50	5.00	150	17.5	27.12	
	1000Hz Post	S	30.58	2.00	100	10.0	42.64	0.299
		M	48.00	5.00	150	17.5	31.81	
	2000Hz Post	S	37.83	2.00	150	25.0	54.04	0.624
		M	48.50	2.00	150	12.5	44.84	
	4000Hz Post	S	39.33	2.00	90.0	20.0	53.20	0.966
		M	38.50	5.00	150	20.0	33.17	
	Average Post	S	34.37	2.00	92.5	21.2	44.98	0.592
		M	43.62	6.25	150	14.4	32.17	

*Significant

Caption: S = sensorioneural; M = mixed; SECAP = simplified evaluation of central auditory processing; SLT = sound localization test; MTVS = Memory test for verbal sounds; MTSnV = memory test for sounds non-verbal; LDHQ = Localization Disabilities and Handicaps Questionnaire; RGDT = Random Gap Detection Test

Table 5. Comparison between ears in the procedures performed in the pre- and post-adaptations

Procedures		Ear	Average	Minimun	Maximun	Median	Standadr deviation	p (value)
SECAP	SLT Pre	RE	3.33	2.00	4.00	3.00	0.816	0.920
		LE	3.29	2.00	5.00	3.00	1.380	
	SLT Post	RE	4.13	4.00	5.00	4.00	0.834	0.729
		LE	4.00	3.00	5.00	4.00	0.816	
	MTVS Pre	RE	2.07	0.00	3.00	2.00	0.961	0.119
		LE	1.43	1.00	3.00	2.00	0.535	
	MTVS Post	RE	2.27	1.00	3.00	2.00	0.704	0.394
		LE	2.00	1.00	3.00	2.00	0.577	
	MTSnV Pre	RE	2.13	0.00	3.00	2.00	0.915	0.257
		LE	2.57	0.00	3.00	2.00	0.535	
	MTSnV Post	RE	2.20	0.00	3.00	2.00	0.775	0.267
		LE	2.57	0.00	3.00	2.00	0.535	
LDHQ	Score Pre	RE	31.20	23.0	40.0	30.0	5.747	0.491
		LE	29.29	22.0	35.0	29.0	6.422	
	Average Pre	RE	2.23	1.64	2.85	2.14	0.412	0.467
		LE	2.08	1.57	2.71	2.07	0.457	
	Score Post	RE	42.47	35.0	55.0	45.0	8.254	0.345
		LE	45.71	41.0	54.0	44.0	4.536	
	Average Post	RE	3.02	2.07	3.92	3.21	0.593	0.345
		LE	3.26	2.92	3.85	3.14	0.322	
RGDT	500Hz Pre	RE	48.67	5.00	150	20.0	45.177	0.741
		LE	55.71	5.00	150	50.0	47.472	
	1000Hz Pre	RE	56.80	2.00	150	50.0	48.668	0.987
		LE	56.43	5.00	150	50.0	54.292	
	2000Hz Pre	RE	63.33	5.00	150	50.0	41.819	0.959
		LE	62.14	5.00	150	50.0	64.798	
	4000Hz Pre	RE	86.33	10.0	300	50.0	78.569	0.924
		LE	82.86	10.0	200	50.0	80.304	
	Average Pre	RE	63.78	7.50	150	50.0	46.262	0.983
		LE	64.29	6.25	150	50.0	57.770	
	500Hz Post	RE	30.80	2.00	90.0	20.0	24.748	0.510
		LE	41.43	2.00	150	15.0	50.721	
	1000Hz Post	RE	36.47	2.00	100	15.0	32.439	0.725
		LE	42.86	5.00	100	15.0	51.386	

Caption: SECAP = simplified evaluation of central auditory processing; SLT = sound localization test; MTVS = Memory test for verbal sounds; MTSnV = memory test for sounds non-verbal; LDHQ = Localization Disabilities and Handicaps; Questionnaire; RGDT = Random Gap Detection Test; RE = right ear; LE = left ear

Table 5. Cotinued...

Procedures		Ear	Average	Minimun	Maximun	Median	Standadr deviation	p (value)
RGDT	2000Hz Post	RE	44.27	2.00	150	25.0	48.928	0.831
		LE	39.29	5.00	150	25.0	53.575	
	4000Hz Post	RE	37.80	2.00	90.0	15.0	40.617	0.863
		LE	41.43	5.00	150	15.0	54.598	
	Average Post	RE	37.33	2.00	92.5	17.5	33.283	0.833
		LE	41.25	6.75	150	15	52.385	

Caption: SECAP = simplified evaluation of central auditory processing; SLT = sound localization test; MTVS = Memory test for verbal sounds; MTSnV = memory test for sounds non-verbal; LDHQ = Localization Disabilities and Handicaps; Questionnaire; RGDT = Random Gap Detection Test; RE = right ear; LE = left ear

DISCUSSION

Central auditory processing (CAP) includes the fundamental auditory mechanisms for the development of the auditory abilities of attention, memory, detection, sound localization, auditory discrimination, recognition and understanding of sound patterns, temporal aspects of hearing, and auditory performance with degraded acoustic signals. It is understood as "what we do with what we hear" and is defined as the individual's ability to perceive and interpret the sound stimuli of speech(15).

SECAP is a screening instrument for central auditory processing, it is easy and quick to use and widely used in children(18). Its use is very restricted in adults and elderly(19), with a study related to vocal(20) deafness and no record of application in adults with UHL. We believe that initiating the use of the instrument in question may assist professional conduct.

The difficulty of locating the sound source is present in day-to-day situations and has been identified as one of the greatest difficulties reported by individuals with UHL(7,21). This has repercussions not only for locating speech sounds, but especially for warning signals important to the individual's safety; in addition to these individuals demonstrating less speech intelligibility in environments with competing noise(14,22).

One of the plausible justifications for the difficulty in the ability of sound localization is the difference in the time for the perception of the sound by the ears. The first stimulated ear indicates the direction of the sound origin, that is, a sound that originates on the right side will first reach the right ear, which is closer to the sound source, and after a short time difference, will reach the contralateral ear(23). This integration between the ears contributes to the auditory localization in space(19).

In a study conducted by Mondelli et al.(11), it was observed that without the use of HAs there was a difficulty in locating for individuals with UHL. After the use of amplification, for a minimum period of six months, there was a significant improvement, regardless of the type or degree of hearing loss. The same was observed in the present study. A statistically significant improvement was found in the ability to localize sound with the use of HAs, as verified by the SLT, as well as by the Localization Disabilities and Handicaps Questionnaire (Table 1). Therefore, the binaural hearing achieved with the HA adaptation for individuals with UHL recovers the ability of sound localization.

The benefit with the use of HAs for the ability of sonorous localization, as verified in the present study, emphasizes the importance of using questionnaires as subjective tools of investigation to ascertain the improvement of hearing abilities in the period of HA adaptation(11).

Regarding the auditory ability of temporal ordering for all individuals of the present study, it was observed that there was a statistically significant improvement in the MTVS in the comparison of the pre- and post-adaptation phases. The same did not occur for the MTSnV, since this ability was already adequate according to the interpretation criteria of the test. However, there was a slight improvement in the performance of individuals with UHL, who presented a mean value of 2.27 in the pre-adaptation phase and 2.32 with the use of amplification (Table 2).

Individuals with UHL do not have the benefit of interaural time, understood as the time in which the brain analyzes stimuli that reach the two ears, and allows the individual to detect which direction the signal proceeds(24). Thus, for these individuals, the time to locate the sound source is greater, which consequently causes it to lose part of the message(25).

The data indicated that all individuals in the research presented a statistically significant performance in the RGDT comparing the pre- and post-adaptation situations of the HA (Table 3), showing that the effective use of the HA resulted in the benefit of the temporal resolution ability.

In the present research, individuals with sensorineural hearing loss presented better scores and mean responses than individuals with mixed hearing loss, except for the total score in the pre-adaptation phase (Table 4).

Individuals with mixed/conductive hearing loss by the application of the Localization Disabilities and Handicaps Questionnaire, in a study conducted by Mondelli et al.(11), obtained better performance than individuals with sensorineural hearing loss, both for evaluation with and without HAs. This data does not agree with the findings of the present study, in which individuals with sensorineural hearing loss presented better scores and mean responses than individuals with mixed hearing loss, except for the total score in the pre-adaptation phase (Table 4).

In the relationship between the hearing loss type and the RGDT (Table 4), it was verified that individuals presented better performance in the RGDT than those with mixed hearing loss. The degree of hearing loss was statistically significant in the performance of individuals in the frequencies of 1k, 2k and 4k Hz, as well as in the mean frequencies in the pre-adaptation phase. In the post-adaptation stage, the degree of hearing loss was statistically significant in the frequencies of 500, 1k and 2k Hz.

The absence of statistical significance (Table 5), verified in the comparison of the pre- and post-adaptation performance of the individuals with UHL in the SLT and in the Localization Disabilities and Handicaps Questionnaire between the ears affected by UHL are similar to a study[3] that evaluated the temporal ordering ability with the MTVS, where individuals with right ear involvement presented better performance in the test than those with left hearing loss.

In a retrospective study published in 2014, 489 patients with unilateral hearing loss were analyzed, being 218 male and 271 female, with a mean age of 55 years. It was found 49.5% of UHL in the left ear and 43.6% in the right without significant difference between the laterality of the hearing loss[26].

Although no statistical significance was found, it was possible to observe that individuals with right UHL presented better RGDT performance compared to the left ear, except for the 1k and 4k Hz frequencies during the pre-adaptation phase and the 2k Hz frequency in the post-adaptation phase, both for the analysis of the test frequencies and for the mean responses obtained (Table 5). Similar results are found in a survey[3] in which, when assessing temporal resolution through the RGDT, the authors observed that individuals with left UHL had higher detection thresholds than individuals with right UHL. These results corroborate with other studies[27,28] reporting an advantage of the right ear, that is, of the left hemisphere, in temporal resolution tasks. Some authors have suggested the preferential role of the left hemisphere in the analysis of the temporal aspects of the acoustic stimulus[29,30], which allows a better performance for the individuals with a HA on the right.

It was found that individuals with right hearing loss presented better performance compared to the left ear when comparing MTVS performance (Table 5). These results are similar to a study[3] that evaluated the temporal ordering ability with MTVS, in which individuals with right ear involvement presented better performance in the test than those with left hearing loss.

In the MTSnV evaluation, individuals with left UHL presented better performance in the test than subjects with right ear impairment (Table 5). The opposite is observed in another study[3], in which the performance difference between individuals with right UHL is slightly higher than the performance of those with left involvement. When correlating the hearing loss degree with the performance in the tests, there was influence of the hearing loss degree only in the MTSnV (Table 5).

The importance of binaural hearing has been emphasized, thus supporting the indication of electronic sound amplification devices. Many studies point out the benefits in daily communication situations with hearing aids[9-11].

CONCLUSION

The auditory localization, temporal ordering and temporal resolution auditory abilities were significantly improved with the effective use of hearing aids in individuals with UHL.

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Author contributions

MFCGM: study design, assistance with data interpretation, article submission and procedures, preparation, correction and final approval of the version to be presented for publication; MMS: data acquisition, aid in data interpretation and survey review; MRF: article writing, data analysis and critical review for relevant intellectual content.