Aplicação do teste de lateralização sonora em idosos***

Application of the lateralization sound test in elderly individuals

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Abstract
Background: the ability to determine the direction of a sound source is based on the fact that sounds reach both ears at different times, phase, intensity and/or frequency. The perception of a sound source favors speech intelligibility in noisy environments. Aim: to identify the minimum time of interaural delay - produces lateralization to the ear which the stimulus reached first - through ascendant and descendent techniques, using the Sound Lateralization Test in elderly individuals with normal hearing thresholds in the frequencies which are most important for speech comprehension. Method: the Lateralization Test was used in 30 individuals with ages above 60 years, who presented hearing thresholds up to 25 dBHL in 500, 1000 e 2000Hz and with no air-bone gap. Results: mean times of interaural delay in sound lateralization were: a) ascending technique: 125.56sec. (female) and 83.61sec. (male); b) descending technique: 95.06sec. (female) and 61.68sec (male). Conclusion: there is no difference between the mean time of interaural delay in sound lateralization obtained with the ascending or descending technique regarding the variable initial tested ear (right or left ear); the mean time of interaural delay in sound lateralization is smaller in males, when considering both ascendant and descendent techniques; the mean time of interaural delay in sound lateralization obtained with the descendent technique is smaller than that obtained with the ascendant technique; individuals who present hearing losses beginning at 3000Hz have smaller mean times of interaural delay in sound lateralization than normal hearing individuals in both techniques.
Key Words: Hearing; Elderly; Sound Perception.

Resumo
Tema: a habilidade de determinar a direção da fonte sonora está baseada no fato de que os sons chegam às duas orelhas em tempo, fase, intensidade e/ ou freqüência diferentes. A percepção da direção da fonte sonora favorece a inteligibilidade de fala em ambientes ruidosos. Objetivo: identificar o menor tempo de atraso interaural, que é capaz de produzir lateralização para a orelha em que o estímulo chegou primeiro, por meio das técnicas ascendente e descendente, utilizando-se o Teste de Lateralização Sonora, em indivíduos idosos, com audição normal nas freqüências mais importantes para a compreensão da fala. Método: foi aplicado o Teste de Lateralização Sonora em 30 indivíduos acima de 60 anos de idade, que possuíam limiares de audibilidade até 25dBNA nas freqüências de 500, 1000 e 2000Hz, sem gap aéreo-ósseo. Resultados: os tempos médios de atraso interaural de lateralização sonora foram: a) técnica ascendente: 125,56s (sexo feminino) e 83,61 s (sexo masculino); b) técnica descendente: 95,06 s (sexo feminino) e 61,68s (sexo masculino). Conclusão: não há diferença entre o tempo médio de atraso interaural de lateralização sonora, obtido com a técnica ascendente e descendente segundo a variável lado de início do teste (orelha direita ou orelha esquerda); o tempo médio de atraso interaural de lateralização sonora é menor nos indivíduos do sexo masculino, em ambas as técnicas, descendente e ascendente; o tempo de atraso interaural médio obtido por meio da técnica descendente é menor que o obtido na técnica ascendente; os indivíduos que apresentam perda de audição à partir da freqüência de 3000Hz têm tempo médio de atraso interaural de lateralização sonora menor que os indivíduos com audição normal, tanto na técnica ascendente quanto na técnica descendente.
Palavras-Chave: Audição; Idoso; Percepção Sonora.

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Introduction

Hearing is an ability that depends on the individual's born biological capacity and environmental experience. This process becomes important to language learning and when there is any handicap on learning ability there may be also receptive or expressive language deficits.

Auditory processing is the term used to refer to a series of processes that involve mostly the central nervous system structures: auditory pathway and cortex. Auditory processing involves the detection of acoustic events, the ability to discriminate them according to placement, spectrum, amplitude and time (Pereira and Schochat, 1997; Ziliotto and cols, 2002).

The localization of sound source is one of the most important preventing factors for working accidents, specialy to workers using hearing aids or ear noise protectors (Inoue, 2001).

Human beings are capable of discriminating a sound source located in the front that is only two degrees off the horizontal line. The ability to determinate the sound source location is based on the fact that the sound reaches both ears at different times, phases, intensity and/or frequency.

The major clue to location of horizontal (left-right) continuous sounds of frequencies below 1500Hz is the interaural time difference, presented in both ears. While the major clue for high frequencies is the interaural intensity difference and spectral clues (Babkoff and cols, 2002).

When both sound clues favor the same ear (time and greater intensity), the image fuses and is easily located. When clues are opposed (faster in one ear and more intense in the other) the hearer may hear two sounds, one intensity-dependent and other time-dependent (Ballachanda and Moushegian, 2000).

Sounds whose source is located in front or behind, but with right or left deviations reach the ears with small time differences or latency because the sound travels different distances to arrive to each ear. It is possible to detect latencies of 10 to 20 milliseconds.

The head may also act as sound attenuator or amplifier, resulting in a better perception of the source direction (if intensity difference is between 5 and 15 dB at 2k Hz). It happens because the head works as an obstacle to the sound arrival to one of the ears, arriving at a lesser intensity (shadow effect), while the other ears will receive the sound without the barriers and with reflection, resulting in increased sound (illusory effect). These effects are more common in frequencies above 500 Hz (Bento, Miniti and Marone, 1998).

The correct location of the sound source requires that the hearer's auditory system is able to perceive very small time and intensity differences between ears (Ungan, Yagcioglu and Goksoy, 2001). These differences may improve significantly the speech intelligibility in noisy environments.

As audition is a bilateral process, the brain must compare both auditory inputs, solve acoustic complexities, determining the sound direction and optimizing a relevant signal among other sound and noises (Schweitzer, 2003).

The superior olival complex represents the first step of the auditory pathway which is composed by afferent lines coming from both ears, playing a functional role in sound source localization and in bilateral hearing. The bilateral hearing is done by the analysis of time and intensity differences between the sounds detected on both sides and by reinforcing the information transmission system by bursts in determined time periods. Its lesions distort expressively the localization of sounds. In the olivar complex are the origins of the most peripheral fibers of the efferent auditory system (Munhoz and cols, 2000).

When the sounds are presented by earphones, the sound source, or sources, may be placed, without exception, inside the individual's head. The intracranial (localization inside the head) is called lateralization, opposed to localization, which is perceived outside the head, according to the direction and distance of the sound source.

Precise localization and lateralization of sound source depend on intact central and peripheral auditory processing that is able to use small differences of time and intensity between ears (Babkoff and col., 2002; Lewald and Karnath, 2002; Lewald and Karnath, 2001).

Sound lateralization and speech discrimination abilities are closely related to the central auditory system function (Kubo and col., 1998; Kaizer and Lutzenberger, 2001). On the other hand, the study of lateralization contributes to the evaluation of the Central Nervous System (CNS) because it allows the stimulus control, a task difficult to perform in the open field. To understand the several kinds of peripheral or central auditory disorders many times it is necessary to relate them to the region or place where the disorder occurs (Schochat and Musiek, 2002).

The physical separation between ears imposes an interaural time delay to the stimulus that arrives to the tympanic membrane from a sound source that localized at some point is not equally distant from both ears. When the binaural signal is presented to a hearer and a small time difference (<500 µs) is introduced, the perception is of a sound source located on the side of the head favored by the interaural difference. For example, left side to a stimulus in which the the left ear signal preceded the right one. This auditory illusion is called precedence effect (Musiek and Lamb, 1999). If the interaural time difference is gradually reduced the sound image is directed to the central line (Tedesco, 2002).

Aging may affect hearing in several ways. Presbiacusis is a neuro-sensorial hearing loss associated to age related degenerative changes. The degenerative effects may involve the internal ear as well as the CNS. The presbiacusis is described by a constant decline of the sensibility to pure tons, especially those with high frequencies. The decrease on speech discrimination is also described. The decline of other auditory functions is also related to aging, as changes on auditory fusion thresholds and on perception of binaural differences that may result on a functional loss of elder's ability to localize sound sources and understand speech in unfavorable - noisy - hearing situations (Babkoff and col.,2002).

The interest in examining the relation between aging and temporal auditory processing has been increasing in the last years due to the existence of elders that complain of speech understanding difficulties that are not related to the hearing loss they present. That means, while some elders with few trouble to detect low intensity sound report difficulties understanding speech specially in situations where there is noise or reverberation, others with evident hearing losses do not have the same complaints. Recent studies have shown that these difficulties with speech recognition may be related to losses in temporal sound processing associated to the aging process (Neves and Feitosa, 2003).

The present work has the objective to identify the smaller interaural delay time that result id lateralization to the ear to which the stimulus got first, by means of ascendant and descendant techniques using the Sonora Lateralization Test (Tedesco, 2002) in elder individuals wich normal hearing in the most important frequencies to speech understanding.

Method

This study was approved by the Ethics Committee for Research of the Federal University of Sao Paulo/ Hospital Sao Paulo, with the number 0955/02. All volunteers read and signed the consent form.

The inclusion criteria adopted to the participants selection were:

- Individuals with ages above 60 years.
- Realized audiologic evaluation (tonal audiometry and acoustic imitance measures).
- Audibility thresholds above 25dB AL in the frequencies of 500, 1000 and 2000 HZ without air-bone gap.
- Timpanometric curve type A bilaterally and acoustic estapedic reflexes present in the frequencies of 500, 1000 and 2000 Hz.

This way, 36 volunteers were invited to participate in this study as soon as they ended their audilogic evaluation. The Sonora Lateralization Test was performed with them.

1) Procedure Description

The Teste de Lateralização Temporal (Temporal Lateralization Test) elaborated by Tedesco (2002) was recorded in CD and consists in binaural presentation of the word "paca", with interaural delay time between 0 and 500 microseconds (s).

The CD has three tracks where the first is the drill one and the others are the test itself:

1st Track: Drill - contains 15 binaural presentations of the word "paca" with time differences of 0 s to 500 s delay to the right (R) and 500 s delay to the left (L) randomly distributed.

2nd Track: contains 20 differences of presentation time (between 454 and 23 s) to the right and left, totalizing 40 presentations decreasing in time but randomly distributed.

3rd Track: contains 20 differences of presentation time (between 454 and 23 s) to the right and left, totalizing 40 presentations increasing in time but randomly distributed.

2) Test Application

Subjects were taken to an acoustically treated room in the Hearing Disorder ambulatory of the Hospital Sao Paulo (UNIFESP-EPM). The test was conducted using a compact disk (CD) and a AIWA-CD player. The intensity level used was the one referred to as the most comfortable by the subject, adjusted in the volume control of the CD player itself.

The subjects were told to respond as soon as they detected the stimulus by pointing in themselves the sound source: right side, left side or center of the head.

First the drill test was conducted (track 1 of the CD). Among all the volunteers, six could not complete the drill and were eliminated from the present research sample.

This way, the 30 subjects that performed the drill correctly were then presented with the test itself (tracks 2 and 3 of the CD, always with this presentation order).

Finally, this research sample was of 30 subjects, 16 female and 14 male, with ages ranging between 61 and 76 years (means 66.46) - appendix 1.

Each individual answer was recorded on a specific protocol also proposed by Tedesco (2002) using the symbols D, when the sound was lateralized to the right side, E when it was lateralized to the left side and C when the sound was perceived in the center of the head, that is, when the sound was centralized.

The side to which the sound arrived first was named the start side or the ear that started the test.

Statistic analysis:

To this paper the statistical test of Analysis of Variance (ANOVA) was used. Is it a parametric test that supposes that , which means that the errors in each observation must have a normal distribution with zero mean and constant variation.

The result of each comparison has a statistic value called p-value. This value contributes to the conclusion about the test conducted. If this value is higher than the significance level adopted (error or), we then conclude that the null hypothesis (H0) is the true hypothesis. Since the significance level adopted is generally 0,05 (5%) we may say that if the p-value is over 0,05 (5%) the conclusion points to the null hypothesis. If the contrary occurs the conclusion will favor the alternative hypothesis H1. The statistically significant values are assigned in the tables with *.

Another descriptive statistical technique called confidence interval was also used to verify how much a mean can vary within a certain confidence probability.

Results

Results are divided in two parts:

a) Part 1: Study of the time of interaural time delay of sound lateralization according to the variables: start side, gender and techniques.

b) Part 2: Study of the time of interaural time delay of sound lateralization according to the audiogram

PART 1:

Based on data (appendix 2) a general descriptive analysis of the answers of the 30 subjects on the Sound Lateralization Test in relation to the start side (right of left) and to the ascendant or descendant techniques (charter 1).

1.a) Study of the minimum interaural delay to sound lateralization according to the variable start side.

The comparative study of the results obtained with the 30 subjects according to the variable start side (left or right ear) with both techniques used in this research (ascendant and descendant) is presented bellow.

To this study the analysis of variance (ANOVA) was the statistical technique applied.

Base don this study it can be stated that there is no statistically significant difference between the interaural time delay related to the left or right start side in neither of the techniques used in the test. This way the results of both ears - right and left - were considered together to the other analysis.

1.b) Study of the minimal interaural time delay to sound lateralization according to the variable gender

The comparison between male and female subjects on interaural time delay to sound lateralization with the ascendant and descendant techniques is presented in Table 2. The ANOVA test was also used to this study.

These results show that the interaural time delay for sound lateralization is significantly smaller in the male subjects in both ascendant and descendant techniques.

1.c) Study of the minimal interaural time delay to sound lateralization according to the variable technique

The results of the 30 subjects (male and female together) on a comparative analysis of both techniques are presented in Table 3.

The statistical analysis shows that there is a statistically significant difference between the mean interaural time delay to sound lateralization determined by the ascendant and descendant techniques. The descendant technique presented a smaller time than the ascendant technique.

PART 2:

Presents a complete descriptive analysis about the comparison of the performance on the Sound Lateralization test of the seven subjects that presented normal audiometric results in all frequencies (250 Hz to 8k Hz) and of the 23 subjects that presented normal hearing on the frequencies of 500 Hz, 1 and 2 kHz, but with threshold droppings on the frequencies above 3 kHz.

According to the statistical analysis there is a statistically significant difference between groups. The group of subjects with thresholds dropping since the frequency of 3000 Hz produced smaller times than the group with normal audiometric thresholds in both ascendant and descendant techniques.

Charter 1: Descriptive analysis of interaural time delay of sound lateralization according to side and technique.

Descriptive Analysis	Descendant (µs)		Ascendant (µs)	
	RE	LE	RE	LE
Mean	69,67	89,30	94,67	117,30
Standard deviation	50,45	49,01	73,64	74,29
Sample size	30	30	30	30
Minimum	23	23	23	23
Maximum	181	204	363	295
Inferior limit	51,61	71,76	68,32	90,72
Superior limit	87,72	106,84	121,02	143,88

Table 1: Comparative study of the interaural time delay to sound lateralization according to the start side on ascendant and descendant techniques.

Ears	Descendant (µs)		Ascendant (µs)	
	RE	LE	RE	LE
Mean	69,67	89,30	94,67	117,30
Standard deviation	50,45	49,01	73,64	74,29
Sample size	30	30	30	30
p-value	0,132		0,241	

Table 2: Comparative study of the interaural time delay to sound lateralization according to the variable gender

Gender	Descendant (µs)		Ascendant (µs)	
	Female	Male	Female	Male
Mean	95,06	61,68	125,56	83,61
Standard deviation	55,32	37,40	82,81	56,47
Sample size	32	28	32	28
p-value	0,009*		0,028*	

Table 3: Comparative study of the interaural time delay to sound lateralization according to the variable technique (ascendant and descendant).

Techniques	Descendant	Ascendant
Mean	79,48	105,98
Standard deviation	50,30	74,22
Sample size	60	60
p-value		
	0,024*	

Table 4: Comparative study of mean interaural time delay to sound lateralization of subjects with normal audiometric results and subjects with hearing loss.

Normal X Hearing Loss	Descendant time (µs)		Ascendant time (µs)	
	Loss	Normal	Loss	Normal
Mean	69,63	111,86	91,89	152,29
Standard deviation	48,08	44,81	69,91	71,20
Sample size	46	14	46	14
p-value	0,005*		0,007*	

APENDIX I:

Charter 1: Population distribution according to the variables audiometric thresholds, values on IPRF, age and gender.

Subject	Gender	Age (years)	dB	250 Hz	500 Hz	1K Hz	2K Hz	3K Hz	4K Hz	6K Hz	8K Hz	IPRF (%)
1	M	70	OD	15	20	20	25	65	70	95	85	92
			OE	15	25	15	25	60	65	80	85	88
2	M	71	OD	25	20	25	20	30	40	50	55	92
			OE	10	15	20	25	30	35	50	55	96
3	M	64	OD	15	10	5	0	10	10	10	15	92
			OE	20	15	5	10	20	25	30	40	96
4	M	64	OD	10	10	25	20	20	30	40	55	96
			OE	20	20	15	20	20	30	50	55	96
5	M	68	OD	20	15	5	10	15	10	5	10	96
			OE	20	15	5	15	15	20	15	5	96
6	M	76	OD	30	25	20	25	15	25	50	45	88
			OE	15	20	5	15	15	15	45	55	88
7	M	62	OD	10	15	15	5	0	10	15	10	92
			OE	15	10	15	5	0	10	15	10	96
8	M	67	OD	10	10	15	20	30	40	40	55	96
			OE	20	10	10	15	30	30	45	50	92
9	M	65	OD	15	10	5	0	10	10	10	15	92
			OE	20	15	5	10	20	25	30	40	96
10	M	65	OD	10	15	10	10	15	40	35	50	100
			OE	20	15	10	0	5	30	30	25	92
11	M	64	OD	30	25	25	20	25	35	50	55	96
			OE	30	20	20	20	25	35	60	55	100
12	M	72	OD	15	15	20	25	50	60	50	55	92
			OE	20	15	15	25	35	55	55	55	88
13	M	67	OD	15	15	20	15	30	40	45	30	92
			OE	10	10	15	20	40	50	45	40	100
14	M	69	OD	25	25	20	20	20	15	25	15	100
			OE	25	25	20	15	15	20	20	15	100
15	F	62	OD	40	25	25	25	25	30	30	35	92
			OE	35	25	25	25	20	25	40	40	92
16	F	61	OD	20	20	15	10	10	15	15	15	100
			OE	20	20	20	10	15	15	15	25	96
17	F	67	OD	15	15	25	5	5	25	25	50	100
			OE	10	10	10	5	5	5	5	20	96
18	F	63	OD	30	25	15	25	40	40	50	45	88
			OE	15	15	15	25	40	40	45	40	92
19	F	68	OD	15	15	20	15	30	35	55	50	88
			OE	15	15	15	15	35	40	60	55	96
20	F	75	OD	15	15	10	10	25	25	40	30	88
			OE	25	25	15	20	20	35	35	35	88
21	F	73	OD	30	25	25	15	20	20	35	50	80
			OE	40	25	15	20	15	25	55	55	96
22	F	62	OD	30	25	20	25	40	40	50	55	96
			OE	20	25	20	20	35	30	45	55	96
23	F	65	OD	20	15	10	20	15	15	25	65	96
			OE	20	20	10	15	25	15	45	65	92
24	F	61	OD	25	25	20	20	15	10	50	50	88
			OE	30	25	20	20	20	20	40	60	88
25	F	68	OD	20	20	15	15	10	15	30	20	100
			OE	20	25	15	25	20	20	30	25	96
26	F	76	OD	20	25	25	25	25	25	45	55	92
			OE	25	25	25	25	25	40	50	45	92
27	F	61	OD	25	25	25	25	25	35	60	60	88
			OE	20	20	15	15	15	25	25	35	92
28	F	65	OD	25	20	10	15	5	15	20	20	92
			OE	25	25	10	15	15	20	10	10	88
29	F	62	OD	25	25	25	15	20	20	25	20	96
			OE	25	20	20	10	15	25	25	20	96
30	F	61	OD	20	20	10	10	10	15	25	25	96
			OE	25	25	20	15	15	15	15	15	92

APENDIX 2:

Table 1: Population distribution according to the variables gender, age and test responses on both techniques

Subject	Gender	Age (in years)	Descendant time (us)		Ascendant time (us)	
			OD	OE	OD	OE
1	M	70	23	68	91	91
2	M	71	23	23	23	23
3	M	64	23	68	91	91
4	M	64	23	68	91	91
5	M	68	91	91	91	91
6	M	76	68	91	91	159
7	M	62	68	91	68	159
8	M	67	45	68	23	68
9	M	65	23	68	23	91
10	M	65	23	91	91	91
11	M	64	23	23	23	23
12	M	72	23	68	45	23
13	M	67	45	136	23	113
14	M	69	113	159	204	249
15	F	62	23	23	23	23
16	F	61	91	159	204	249
17	F	67	159	159	91	159
18	F	63	68	91	45	91
19	F	68	23	68	23	91
20	F	75	68	136	23	91
21	F	73	159	181	91	45
22	F	62	45	68	159	159
23	F	65	91	23	113	136
24	F	61	68	68	159	159
25	F	68	159	136	136	159
26	F	76	23	23	91	23
27	F	61	159	68	363	295
28	F	65	91	68	91	91
29	F	62	181	204	159	113
30	F	61	68	91	91	272

Discussion

The same divisions used in the results presentation will be maintained in the discussion.

PART 1: Discussion about the interaural time delay to sound lateralization according to the variables start side, gender and techniques

In the Part 1 the study of the interaural time delay to sound lateralization according to the variables start side (right or left ear), gender (male and female) and techniques (ascendant and descendant).

The first analysis refers to the start side of the test and shows that the values found on the right ear were smaller than the ones obtained in the left ear, but this difference wasn't statistically significant whether the first stimulus were presented in the left or right ear. It means the subjects presented a similar performance under both conditions and with ascendant or descendant techniques used in the test (Table 1).

Tedesco (2002) applied the Sound Lateralization Test in 80 young females with ages varying between 18 and 25 years, with normal hearing and observed that left ear thresholds were significantly smaller than the ones of the right ear either in the ascendant or in the descendant technique. It disagrees with the present study, where no significant differences between ears were found.

Ballachanda e Moushegian (2000) studied eight women with normal and symmetric hearing. The stimulus presented were tone bursts, with interaural time and intensity differences. The authors observed that the curves of the right and left sides were not identical, but were very much alike. This way they concluded that there is symmetry between both sides.

Lewald e Karnath (2002) evaluated ten volunteers (with ages varying between 20 and 35 years) using pure tones (1 kHz, 100 ms duration) with interaural time difference presented by earphone while the subjects were in vertical position or inclined left or right 45º or 90º. During body inclination the head auditory medium plane, measured by psychometric functioning evaluation, was always shifted to the upward ear. It points toward a change in auditory perception of the downward ear, that is, a gravitational linear acceleration. The best value obtained with body inclination of 90º was 25 µs.

To get a precise sound lateralization during movement the auditory system must consider special changes in head position specially when the sound signal is short enough and the orientation response directed to that signal can' t be performed in its presence (Lewald e Karnath, 2001). As audition is a bilateral process, the brain must compare both auditory inputs, solve acoustic complexities, determining the sound direction and optimizing a relevant signal among other sound and noises (Schweitzer, 2003). To understand the several kinds of peripheral In central auditory disorders it is important to relate them to the region or place where the disorder occurs (Schochat and Musiek, 2002). Lesions of the olival complex affect expressively the sound localization (Munhoz and col 2000). Besides, Musiek and Lamb (1999) state that the lateralization or ear effects in patients with brain disorder show a considerable variability to electrophysiological and behavioral measures.

Kaiser and Lutzenberger (2001) stated that in the language process phonetic contrasts between sounds produce an electroencephalographic asymmetry with high amplitudes and short latencies in the left side, as compared to the right side. It shows that only in electroencephalographic test the brain response to auditory stimulus changes is sensitive to left temporal cortex specialization during speech processing. Besides that, the magneto encephalography has shown that different kinds of binaural sounds increase the amplitude in the opposite side of the sound lateralization. These findings suggest that there is a hemispheric specialization to auditory events on the contralateral hemisphere that may appear very clearly as brain responses to stimulus changes.

The second analysis refers to the possible differences in performance of male and female subjects. It was observed that there is a statistically significant difference between the sound lateralization thresholds of male and female subjects once they were significantly smaller in male subjects both in ascendant and descendant techniques. The mean interaural delay was to female subjects was 95,06 s and to male subjects was 61,68 s with the descendant thechnique. With the ascendant technique the mean interaural delay was 125,56 s to female subjects and 83,61 s to male subjects. On the other hand, Tedesco (2002) found higher lateralization thresholds with female subjects, comparing with those of the present study: 201,4 s (right ear) and 154,6 s (left ear) with ascendant technique and 293,8 s (right ear) and 237,1 s (left ear) with descendant techinique. The other authors mentioned in the literature reviewed didn't investigated comparisons between sound interaural lateralization time delays according to the variable gender.

The third analysis refers to the comparative study between mean interaural lateralization time delays related to the ascendant and descendant techniques. The statistical analysis has shown that there is a significant difference between mean interaural lateralization time delays obtained with ascendant and descendant techniques. Apparently the descendant technique was easier to respond and resulted in smaller mean lateralization time 79,48 s than the ascendant technique 105,98 s (table 3). These findings disagree with the ones obtained by Tedesco (2002) that found smaller times with the ascendant technique, with mean interaural minimum difference of 201,4 s (right ear) and 154,6 s (left ear).

PART 2: Discussion about the study of sound lateralization delay time according to the audiogram:

In this phase was conducted the comparative study of the sound lateralization mean delay time between the seven subjects whose audiometric thresholds were equal or under 25dB in all frequencies (250 to 8000 Hz) and the 23 subjects whose thresholds were under 25 dB only in the frequencies bellow 2000 Hz. The aim of this comparative study was to try to verify the hypothesis that subjects with neuro-sensorial hearing loss would show bigger sound lateralization delay time than subjects with normal hearing.

The statistical analysis showed that there was a statistically significant difference between groups. The group of subjects with lower thresholds in the frequencies above 3000 Hz presented smaller times than the subjects with audiometric thresholds within the normal range, with both techniques. With the descendant technique the mean time for normal hearing subjects was 111,86 s and for subjects with hearing losses was 69,63 s. With the ascendant technique the mean time was 152,29 s to the normal hearing subjects and 91,89 s to subjects with hearing losses (table 4). These findings agree with Neves and Feitosa's (2003) statement, that the hearing loss is no always a prediction factor of time resolution loss.

Kubo and col (1998) studied the relation between sound lateralization and speech discrimitaion in subjects with neuro-sensorial hearing loss of unknown etiology or presbiacusis. Time and intensity interaural differences were measured and the maximum values for speech discrimination were determined. Subjects with good values to interaural difference perception (of time and intensity) also presented good speech discrimination and all the subjects with poor interaural difference perception also presented difficulties with speech discrimination. Besides, as in the present study, the authors state that the audiometric configuration didn't affect sound lateralization.

Babkoff e col. (2002) also stated that hearing subjects with high frequency hearing losses are able to normally locate sound sources in the horizontal plane.

Ungan, Yagcioglu and Goksoy (2001) evaluated 13 volunteers (from 16 to 55 years of age), by dicotically presented clicks, with interaural time delays or interaural intensity differences. They concluded that interaural time and intensity differences are processed through different pathways or in different areas of the auditory cortex.

Confronting the results obtained by Tedesco (2002) that proceeded the Sound Lateralization Test with young subjects and the results of this study we may say that the elder presented a smaller mean sound lateralization time delay in both ears and with both proposed techniques (ascendant and descendant). This difference may be due mostly to the small number of elder subjects that presented lateralization thresholds exceptionally high while most hearing elders presented thresholds within the same range, whether they had hearing losses or not.

Neves and Feitosa (2003) described a research involving the auditory processing of young and old adults with and without hearing losses. They tried to investigate whether the elders would have a worse temporal resolution than the young and if this deficit would be restricted to persons with hearing losses. The diction thresholds of both groups of elders were similar and both had higher thresholds than the group of young adults, while the results' variability was larger in the group of elders than in the group of young adults. It allowed the conclusion that the temporal resolution loss is not an unavoidable consequence of aging.

Finally it is important to stress that most authors conducted comparative analysis between young and old subjects' performance in directional hearing tests because they supposed there is a decrease of the auditory system's ability to process time and intensity binaural differences associated with age. It could result in a functional loss of the ability of elder subjects to understand speech in unfavorable hearing conditions.

Babkoff e col. (2002) evaluated 78 subjects (with 21 to 88 yars of age) to compare young and elders'performance in sound lateralization to clicks. But, contrary to the present study, the authors report that old subjects presented a sound lateralization deficit to interaural time delay. The explanation to these findings according to the authors is that the decrease of temporal resolution in old subjects may affect the ability to discriminate basic stimulation features.

The central auditory processes are mechanisms and processes of the auditory system responsible for the following behavioral phenomena: sound localization and lateralization; auditory discrimination; among others (Pereira e Schochat, 1997; Ziliotto e col., 2002). The direction of the source sound may be determined based in some clues (binaural and spectral). The binaural clues are interaural time delay and intensity interaural intensity differences. The spectral clues are spectral features of sound stimulus that have different frequency components. The sound localization precision depends on how the clues are used. Subjects may use the binaural clues in the horizontal level (interaural time delay or interaural intensity differences that are different from zero), but can't use them in the medial hemispheric level. To pure tones the subjects cannot use spectral clues since they consist of only one frequency component (Inoue, 2001). It explains the fact that in this study the elders' performance was increased by the use of speech stimulus, compared with pure tones, what disagrees with the statement by

Bento, Miniti e Marone (1998), that state that the ability to discriminate the sound source is better with transitory, low frequency sounds and noises.

Conclusion

A) The smaller interaural time delays that produced sound lateralization to the side in which the sound arrived first were:

- Descendant technique: 95,06 s (female gender) e 61,68 s (male gender).

- Ascendant technique: 125,56 s (female gender) e 83,61 s (male gender).

B) There was no difference in the mean interaural time delay to sound lateralization obtained with ascendant or descendant technique related to the variable star side of the test (right or left ear).

C) The mean interaural time delays to sound lateralization were smaller in male subjects in both ascendant and descendant technique.

D) The mean interaural time delay to sound lateralization obtained with descendant technique is smaller than the one obtained with the ascendant technique.

E) Subjects that presented hearing loss from the frequency of 3000 Hz have shown smaller mean interaural time delay to sound lateralization than subjects with normal hearing in both ascendant and descendant technique.

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