LATE AUDITORY EVOKED POTENTIALS TO SPEECH STIMULI PRESENTED WITH DIFFERENT TRANSDUCERS IN HEARING CHILDREN

Potencial evocado auditivo de longa latência para estímulo de fala apresentado com diferentes transdutores em crianças ouvintes

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ABSTRACT

Purpose: to analyze, in a comparative manner, the influence of the transducer on the recordings of P_1, N_1 and P_2components elicited through speech stimulus, as to the latency and amplitude in hearing children. **Method:** the sample was comprised of 30 hearing children aged 4-12 yrs, both genders. The long latency auditory evoked potentials were researched by means of transducers, insertion phone and speakers, elicited through speech stimulus /da/ presented with interstimuli interval of 526ms, the intensity of 70dBNA and presentation rate of 1.9 stimuli per second. Whenever present, P_1, N_1 and P_2 components were analyzed as to latency and amplitude. **Results:** it was found a strong level of agreement between the researcher and the judge. There was no statistically significant difference when comparing the values of latency and amplitude of the P_1, N_1 and P_2 components, when considering gender and ear, as well as the latency of components when considering the types of transducers. However, there was a statistically significant difference for the amplitude of the P_1 and N_1 components with greater amplitude for the speaker transducer. **Conclusion:** the latency values of the P_1, N_1 and P_2 components and P_2 amplitude obtained with insertion phone may be used as normal reference independent of the transducer used for the recording of auditory evoked potentials of long latency.

KEYWORDS: Evoked Auditory Potentials; Transducers; Child

INTRODUCTION

The literature in this area shows that the central auditory system undergoes marked changes on the auditory deprivation in the first years of life[1]. Thus, intervention for hearing loss should be as early as possible so that the maturation of the auditory system by acoustic or electrical stimulation through electronic devices applied to deafness occurs.

In order to obtain an audiological diagnosis in the first months of life, the auditory evoked potentials (AEPs) are fundamental, since at this age, the child has no motor, cognitive and language skills needed to precisely answer to behavioral methods. In clinical practice, the psychoacoustic thresholds are determined by electrophysiological audiometry performed by means of brainstem auditory evoked responses (BAER) or auditory steady state evoked potentials (ASSEP).

In the posterior stage of the audiological diagnosis, regarding the indication of an individual hearing aid (HA), the information obtained through the AEPs are also fundamental, not only for verification of the electroacoustic parameters of hearing aids, but also for the validation step, or in other words, evaluating the benefits and limitations of

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the electronic device. At this stage, it is analyzed whether the amplification offered enabled speech perception for the child through procedures usually performed with an acoustic transducer box.

In recent years, long latency auditory evoked potential (LLAEP) has been used for this purpose by representing the electrical activity that occurs in the central auditory system and the ability to be elicited by speech stimuli, such as vowels and even sentences, a condition of special interest in audiological research.

The source generating these potentials involves the region of the auditory cortex, mainly from structures of the thalamocortical and cortico-cortical auditory pathways, primary auditory cortex and associated cortical areas[2]. Thus, the P_1, N_1, P_2, N_2 and P_3 components reflect the neural activity of the dendrites involved in the skills of attention, discrimination, memory, integration and decision making, the P_3 being considered a cognitive potential [3-7, 8].

Specifically, the P_1-N_1-P_2 complex signals the neural processing of the acoustic signal in the auditory cortex, typically elicited in response to clicks, tones and speech. The morphology of the components is similar to each record and its presence indicates that a speech stimulus was encoded in the auditory cortex, on the other hand, their absence suggests that the speech was not encoded[7].

LLAEPs occur between 50 and 750ms post-stimulus, with a wide variability in the values considering the studies performed, as shown in Figure 1 [18,18-23,25,28-30].

Although the results obtained so far show that it is possible to capture the LLAEP reliably, with children making use of hearing aids, it was not found in the literature researched, that the study had as an objective to analyze the transducer used to somehow achieve stimulation influences of the record obtained.

So the question arose: if the amplitude and latency of the P_1, N_1 and P_2 components can be influenced by the transducer speaker, once the verification of hearing aids is obtained, does the procedure have to be performed in the free field?

Based on the described, the goal was to analyze, in a comparative way, the influence of different transducers in the record of the P_1, N_1 and P_2 components elicited by speech stimuli, as well as the latency and amplitude in hearing children.

METHOD

For the casuistry, invited to participate in the study, were children aged four to 12 years with normal hearing checked by means of the audiological evaluation, including anamneses with the parents or guardians, tonal injunction or conditioned audiometry, according to age, extent of acoustic impedance and research of otoacoustic evoked emissions by transient stimuli.

The Fisher Auditory Problems Checklist questionnaire (1997) was applied to the parents of children aged seven to 12 years, with the aim of discarding those with complaints related to auditory processing disorders. This questionnaire consists of 25 items, where the children's parents were asked to mark the complaints with an X, if present. The score was done by counting the number of unmarked items and multiplied by four [9].

Inclusion criteria:

- Pure tone thresholds within normality [10-11];
- Tympanometry type A curve, presenting normal mobility of the tympanum –ossicular system[12];
- Stapedial reflex present at normal levels, ie, triggered between 70 and 100 dB above the threshold track area[13-14];
- Presence of otoacoustic emissions evoked by transient stimuli;
- Children aged from seven to 12 with more than a 72% score on the Fisher questionnaire [9].

Regarding the exclusion criteria, were considered:

- Tonal thresholds below the normality standards;
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- Absence of ipsilateral and contralateral acoustic reflexes in one or more frequency;
- Absence of otoacoustic evoked emissions;
- Less than a 72% score on the Fisher questionnaire;
- Lack in schedules or inability to finish the review.

Of the total of 53 children invited to participate in the study, 23 (43%) were excluded for the following reasons:

- Two children did not return to complete the evaluation;
- Three children with a score less than 72% in the Fisher questionnaire;
- Four children had absent acoustic reflex;
- Five children did not allow the completion of the review;
- Nine children missed the evaluation, even after two summonses.

Thus, the casuistry was comprised of 30 children, 20 females and 10 males, ranging in age from four to 12 years.

For the LLAEP research, the Smart EP device USB Jr Intelligent Hearing Systems offering two recording channels was used. Thus, the electrodes were inserted for recording of auditory evoked potentials occurring on channel A and the recording of eye movements and blinking on the B channel [15].

On channel A, the active electrode was placed at Cz connected to the input (+) of the pre-amplifier, and the reference electrode placed on the mastoid of the stimulated ear and connected to the input (-). The ground electrode was placed on Fpz connected to the ground position.

On channel B, the active electrode was placed on the supraorbital position contralateral to the ear stimulated connected to the input (+) of the pre-amplifier, and the reference electrode on the infraorbital position on the same side connected to the (-) input. With this arrangement of electrodes, we sought to establish the amplitude of the eye movement and previous blink and research potentials in order to delimit the level of rejection that was used in each test. With this procedure, the interference of the eye movement artifact is minimized, since this rejection limit was adopted for channel A so that, consequently, eye movements were not captured by it, not interfering in the LLAEP record.

To record the auditory evoked and ocular potentials, disposable MEDITRACETM 200 brand ECG electrodes were used, with Ten 20TM brand conductive gel for EEG that was inserted after cleaning the skin of individuals with Nuprep brand abrasive gel for ECG / EEG. The impedance level was kept between 1 and 3 kohms for the electrodes.

The evaluation parameters used were bandpass filter from 1 to 30 Hz, gain of 100,000 K on both channels, averaging 512 stimuli and the analysis window response of –100ms pre-stimulus and-500ms post-stimulus.

The speech stimulus / da / produced in an anterior study [16] was presented with 526ms of interstimulus interval in an intensity 70dBNA and presentation rate of 1.9 stimuli per second.

The auditory stimulation occurred in two ways for further comparative analysis, through the EAR TONE3A earphone, Biologic 300ohm and RMS 50 Watts speaker box positioned at 90 ° azimuth, 40 cm away from the stimulated ear. The side of stimulation was randomly defined, as well as the transducer order type, starting at one time by the earphone and the other by the speaker.

The examinations were performed in a quiet environment, with the child seated comfortably in a reclining chair and oriented to watch a video of their preference without sound.

The P_1, N_1 and P_2 components, when present, were analyzed for latency and amplitude. Such components are marked considering the largest peak amplitude. The variable amplitude was determined as the difference between the point corresponding to 0.0 µV (baseline recording) and the maximum positive value in the case of P_1 and P_2 components, and negative, specifically for the N_1 component, measured in µV and the latency measured in ms.

For the N_1 component, when observed by the double peak recording, called N_{1a} and N_{1b}, considered the first component to record the latency and amplitude.

The components were visually defined by considering the normal values reported in the literature (Figure 1).

The study was conducted at the Audiological Research Center (ARC) of the University of São Paulo (USP) with the approval of the Ethics Committee of the National Research under Case No. 181/2004.

Data Analysis

An analysis agreement was performed between the researcher and an experienced judge in the field of electrophysiology for the analysis of the records. The judge had no prior knowledge about the data of the child and on the type of transducer used, earphone or speaker.

The analysis of the variations of the results obtained by the researcher and the judge was performed with the Kappa statistical method that evaluates the correlation between the judges, by paired analysis and presents the percentage of agreement and the strength of agreement, which was interpreted by the kappa value (1.00).

To verify the systematic error and the casual error[17] of the analyzes between the researcher and the judge, the paired t test and error calculation were used, respectively. The systematic error is significant and its interpretation indicates that a judge tends to identify higher values when $p \leq 0.05$. The random error is an “average” value of error presented for marking components, considering the units of measurement used. The normality test used for the distribution of the differences was the Kolmogorov-Smirnov.

The statistical test was applied to the paired “t”, considering the following test variables: sex, ear, transducer type, amplitude and latency of the P_1, N_1 and P_2 components (Figures 2 and 3)

Author	Stimulus	Transducer	Intensity	Age	P_1		N_{1a}		N_{1b}	P_2
Ohlrich e Barnet (1972)	Click	Overhead speaker	65dBNA	1 month	63(10)		92(17)		--	220(35)
				6 months	89(39)		120(44)		--	193(29)
				12 months	66(20)		95(32)		--	170(34)
Barnet et al. (1975)	Click	Overhead speaker	108dBNPS	5 months	72(4)		97(17)		--	217(26)
				1 month	65(24)		104(34)		--	214(38)
				1½ months	59(14)		95(29)		--	201(33)
				2 months	64(32)		101(19)		--	229(55)
				3 months	72(19)		114(34)		--	219(33)
				6 months	99(27)		139(31)		--	199(28)
				9 months	66(26)		91(24)		--	176(23)
				12 months	65(11)		109(21)		--	182(31)
				15 months	66(16)		105(45)		--	158(36)
				18 months	57(19)		88(27)		--	167(20)
				24 months	76(19)		91(26)		--	151(22)
				30 months	77(19)		113(32)		--	154(24)
				36 months	67(27)		100(20)		--	153(21)
Ohlrich et al. (1978)	Click	Earphone		5 months	88		116		--	234
				36 months	71		104		--	153
Tonnquist-Uhlén et al. (1995)	Tone burst 500Hz	Earphone	75dBNA	8-16 years	--		HD	HE		
							102	100	--	--
Ponton et al. (1996)	Click	Surface headset left ear	65dBnNA	6-19 years	50.6(8.0)		--		--	--
Bruneau et al. (1997)	Tone burst 750Hz	Speaker	50 dBNPS	4-8 years	--		146(6)		--	--
			60 dBNPS		--		143(6)		--	--
			70 dBNPS		--		135(5)		--	--
			80dBNPS		--		149(7)		--	--
Sharma et al. (1997)	/ba/	Ear phone right ear	75dBNPS	6 years	87(14)		135(12)		221(15)	--
				7 years	81(10)		134(14)		220(12)	--
				8 years	79(13)		127(19)		107(20)	--
				9 years	81(5)		129(17)		203(12)	--
				10 years	74(18)		115(8)		203(21)	--
				11 years	78(11)		125(18)		202(12)	--
				12 years	74(15)		100(12)		194(21)	--
				13-15 years	68(9)		109(9)		188(16)	--
Albrecht et al. (2000)	Tom 1000Hz	Earphone right ear	86dBNPS		HD	HE	HD	HE		
				5-6 years	92(25)	106(9)	254(56)	241(47)	--	--
				7-8 years	94(11)	105(10)	229(54)	216(47)	--	--
				9-10 years	88(12)	99(13)	223(29)	211(36)	--	--
				11-12 years	80(26)	84(18)	202(49)	180(22)	--	--
				13-14 years	71(12)	74(27)	144(53)	148(43)	--	--
				15-16 years	67(21)	67(16)	172(52)	177(53)	--	--
Cunninghan et al. (2000)	/ga/	Earphone right ear	75dBNPS	5-7 years	90(13)		146(20)		--	--
				8-10 years	89(17)		133(22)		--	--
				11-12 years	88(20)		37(20)		--	--
				13-15 years	80(15)		120(13)		--	--
Ponton et al. (2000)	Click	Speaker headset left ear	65dBNS	5-6 years	85(16)		--		137	135
				7 years	79(22)		--		99(9)	136(4)
				8 years	66(13)		--		106(19)	147(15)
				9 years	68(16)		--		95(19)	136(15)
				10 years	64(6)		--		98(8)	149(15)
				11 years	61(10)		--		89(10)	142(4)
				12 years	54(16)		--		90(15)	147(12)
Ventura et al. (2009)	Click	Earphone right ear	70dBNA	3-12 years	87(25)		145(43)		---	204(57)

Legend: RH: Right Hemisphere; LH: Left Hemisphere.

Figure 1 – Mean latency values, in ms, of the $P_{1,}$ N_1 e $P_{2,}$ components in accordance with each study analyzed

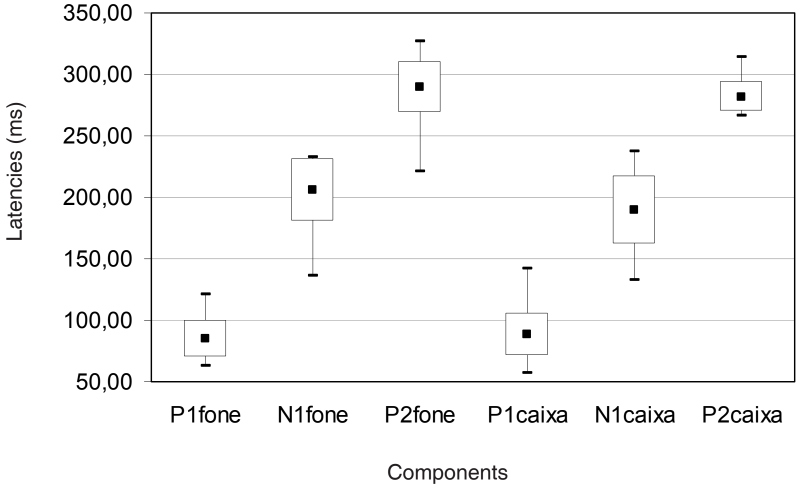

Figure 2 – Mean values, standard deviation, minimum and maximum latency values for the P_1, N_1 e P_2, components considering the types of transducers

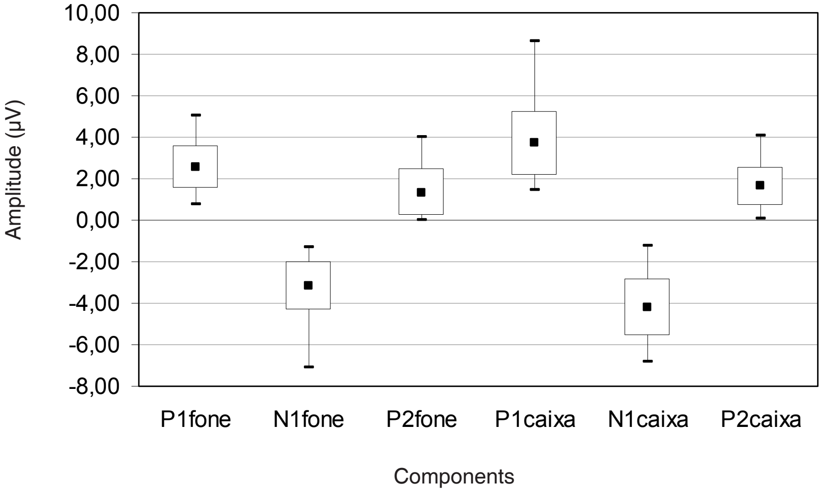

Figure 3 – Mean values, standard deviation, minimum and maximum amplitude values for the P_1, N_1 e P_2, components considering the types of transducers

RESULTS

Normal distribution was observed for all variables. The analysis of agreement between the researcher and the judge, with regard to the latency and amplitude values are found in Tables 1 and 2.

There was no statistically significant difference when comparing the mean values of amplitude and latency of the P_1, N_1 and P_2 components for each type of transducer, considering gender and ear (Table 3), which allowed the analysis of data considering the group of children evaluated.

With regards to obtaining the response, there was the record of the P_1 and N_1 components in 100% of the children for both transducers, however, the P_2 component was recorded in 90% when the survey was conducted with an earphone and 83.33 % with a speaker.

The descriptive analysis (mean, standard deviation, maximum and minimum values) the latency and amplitude of the P_1, N_1 and P_2 components, when they were surveyed with transducers earphone and speaker are presented in Tables 4 and 5.

The comparison between the values of amplitude and latency of the P_1, N_1 and P_2 components, by means of the paired Student's t test, considering the type of transducer earphone and speaker is presented in Table 6.

Table 1 – Mean values and standard deviation and concordance for each measurement, such as transducer and earphone, considering the components analyzed

	EARPHONE										
	Researcher		Judge		Difference		Correlation		Casual error	Systematic error	p
	X	SD	X	SD	X	SD	R	P			
P_1 latency	84.80	14.74	85.60	14.58	0.80	20.36	0.99	0.000*	1.74	1.84	0.075
N_1 latency	205.80	25.17	204.23	24.93	-1.56	4.70	0.98	0.000*	3.45	1.82	0.078
P_2 latency	289.23	20.68	288.96	21.07	-0.03	3.31	0.99	0.000*	2.30	0.05	0.953
P_1 amplitude	2.54	1.05	2.62	1.13	0.08	0.65	0.82	0.000*	0.46	0.72	0.474
N_1 amplitude	-3.20	1.18	-3.35	1.37	-0.15	0.48	0.94	0.000*	0.35	1.68	0.103
P_2 amplitude	1.39	1.11	1.44	1.17	0.08	0.43	0.93	0.000*	0.30	1.01	0.320

*$p \leq 0.05$: statistically significant difference
Paired t Test and calculation of systemic error (t Test) and casual (Dahlberg) error
Legend: X= mean; SD=standard deviation; R=correlation; p=significance value.

Table 2 – Mean values and standard deviation and concordance for each measurement, such as transducer and speaker, considering the components analyzed

	SPEAKER										
	Researcher		Judge		Difference		Correlation		Casual error	Systematic error	p
	X	SD	X	SD	X	SD	R	P			
P_1 latency	88.40	17.38	87.66	16.85	-0.73	2.76	0.99	0.000*	1.99	1.45	0.157
N_1 latency	189.70	28.06	190.23	27.44	0.53	4.28	0.99	0.000*	3.00	0.68	0.500
P_2 latency	281.96	12.33	281.96	12.43	-0.33	1.49	0.99	0.000*	1.04	1.09	0.286
P_1 amplitude	3.69	1.58	3.78	1.66	0.09	0.77	0.89	0.000*	0.54	0.67	0.504
N_1 amplitude	-3.94	2.04	-4.07	1.50	-0.13	1.63	0.61	0.000*	1.14	0.45	0.655
P_2 amplitude	1.63	0.92	1.59	0.88	-0.08	0.27	0.95	0.000*	0.20	1.55	0.133

*$p \leq 0.05$: statistically significant difference
Paired t Test and calculation of systemic error (t Test) and casual (Dahlberg) error
Legend: X= mean; SD=standard deviation; R=correlation; p= significance value.

Table 3 – Comparison of latency (ms) and amplitude (μV) values for the P_1, N_1 e P_2 components performed with earphone transducers and speakers considering sex and stimulated ear

	LLAEP Components											
	Latency						Amplitude					
	P_1		N_1		P_2		P_1		N_1		P_2	
	Headset	Speaker	Headset	Speaker	Headset	Speaker	Headset	Speaker	Headset	Speaker	Headset	Speaker
Sex	0.072	0.750	0.757	0.144	0.493	0.510	0.222	0.651	0.222	0.543	0.788	0.526
Ear	0.828	0.211	0.391	0.500	0.236	0.998	0.055	0.677	0.854	0.636	0.126	0.691

*$p \leq 0.05$: statistically significant difference
Paired t Test

Table 4 – Descriptive analysis for latencies of the P_1, N_1 e P_2, components considering the type of transducer, earphone and speaker

	Long Latency Auditory Evoked Potential-latency (ms)				
	N	**Mean**	**SD**	**Minimum**	**Maximum**
P_1-earphone	30	84.80	14.74	63	121
N_1-earphone	30	205.80	25.17	136	232
P_2-earphone	27	289.23	20.68	221	327
P_1-speaker	30	88.40	17.38	57	142
N_1-speaker	30	189.70	28.06	132	237
P_2-speaker	25	281.96	12.33	266	314

Legend: n=number of children; SD= standard deviation
Descriptive analysis

Table 5 – Descriptive analysis for the amplitudes of the P_1, N_1 e P_2, components considering the type of transducer, earphone and speaker

	Long Latency Auditory Evoked Potential – amplitude (µV)				
	N	**Mean**	**SD**	**Minimum**	**Maximum**
P_1-earphone	30	2.54	1.05	0.77	5.01
N_1-earphone	30	-3.20	1.17	-7.13	-1.29
P_2-earphone	27	1.34	1.11	0.01	4.01
P_1-speaker	30	3.69	1.58	1.46	8.59
N_1-speaker	30	-4.20	1.39	-6.82	-1.21
P_2-speaker	25	1.63	0.92	0.04	4.08

Legend: n=number of children; SD= standard deviation
Descriptive analysis

Table 6 – Results of the Paired Student T test to compare the latency (ms) and amplitude (µV) values for the P_1, N_1 e P_2 components performed with transducers, earphones and speakers

	Long Latency Auditory Evoked Potential					
	P_1 latency	**N_1 latency**	**P_2 latency**	**P_1 amplitude**	**N_1 amplitude**	**P_2 amplitude**
Transducer	0.495	0.304	0.555	0.000*	0.018*	0.117

* $p \leq 0.05$: statistically significant difference
Paired *t* Test

DISCUSSION

The research of the auditory evoked potentials have been used as an objective method of evaluating individuals with normal hearing, but also in individuals with hearing impairment making use of the electronic device: HA or HF, with the goal of evaluating the effectiveness of thereof. In this context, we highlight the LLAEPs, P_1, N_1 and P_2 components, performed with the child in a state of alert, which eliminates the use of sedation, a procedure that requires an anesthesia doctor, which for many centers becomes a problem. Another important aspect is the high concordance with the psychoacoustic thresholds described in the literature.

LLAEPs evaluate the top of the signal processing in the central auditory system, including speech sounds[18]. Thus, the presence of components, especially the P_1 demonstrates that the auditory sensation occurred, which enables to make an inference about the psychoacoustic threshold of the individual.

Early diagnosis of hearing loss, brings to professionals in the intervention phase in hearing loss, concerns about the indication process and adaptation of electronic devices applied to deafness in the infant population. This is justified, initially, because the selection of electroacoustic characteristics of hearing aids considers the anatomical and acoustic conditions of each ear since it is based on electroacoustic procedures for certifying whether the given program generates the sound pressure level required to make speech audible and comfortable for the child. At this stage no behavioral assessment methods are recommended.

Already in the validation step, the effectiveness of the electronic device for the detection of sound and consequently for other auditory skills involved in the processing of speech sounds is verified with the child using the electronic device, ie, the test is carried out in the free field with the stimulus presented by the acoustic transducer box.

In the audiology clinical practice, there is concern about the accuracy of the results when the procedure is done this way, because many variables must be controlled, from the positioning of the acoustic boxes to the stimulus calibration, including the variability of the test-retest.

The literature search focused on the LLAEP in normal children, the population evaluated in this study, and it appears that in the literature searches were performed with a headset [8,19-28] and free field [29-33], with analysis of the age and characteristics of the stimulus used, involving the type, intensity, duration, interstimulus interval, among others. It is important to note that the diversity in the methodology used in these studies complicates the comparative analysis and may explain the variability of the latency and amplitude of the P_1, N_1 and P_2 components, as observed in Figure 1 and the results obtained in the present study (Tables 4 and 5). Accordingly, it is recommended that studies purporting to examine changes in specific groups, using the control group for data analysis.

In this context, no studies seeking to determine the influence of the transducer used for stimulus presentation in the record of the LLAEP were found. Although it is an objective test, the analysis of the components of the LLAEP has a great deal of subjectivity because it is directly related to the experience of the examiner. Thus, the concern is valid in knowing whether or not the influence of the transducer under the P_1, N_1 and P_2 components, so that the professional can consider this variable when analyzing a record, thus avoiding mistakes.

With regards to obtaining a response, the P_1 and N_1 components were recorded in 100% of the children for both transducers, however, the P_2 component was recorded in 90% when the survey was conducted with an earphone and 83.33% with a speaker, with no apparent factor to explain this finding.

In Table 6, it can be seen that there was no significant difference between the latency values of the amplitude of the P_1, N_1 and P_2 components for the record with earphones and speakers, with a similar dispersion of the latency of these components. Therefore, the latency values obtained with the transducer earphone can be used as a reference for the procedure performed with a speaker for these variables.

However, this did not occur for the amplitude of the P_1 and N_1 components, which was presented as greater when researched with the acoustic transducer speaker, which was statistically significant (Table 6). This finding is extremely important because normal values should be used according to the transducer, since changes in amplitude indicate changes in the magnitude of synaptic activity involved during the perceptual processing [34].

CONCLUSION

The results obtained demonstrated that, in the analysis of the long latency auditory evoked potentials elicited by speech stimuli, the latency values of the P_1, N_1 and P_2 components and the P_2 amplitude, obtained with headsets, can be used as a reference for the record analysis obtained with the acoustic transducer speaker. However, the amplitude values of the P_1 and N_1 components differ according to the type of transducer used and must be determined for both the transducer earphone, as well as for the speaker.

RESUMO

Objetivo: analisar, de forma comparativa, a influência do transdutor no registro dos componentes P_1, N_1 e P_2 eliciados por estímulo de fala, quanto à latência e à amplitude, em crianças ouvintes. **Método:** 30 crianças ouvintes de quatro a 12 anos de idade, de ambos os sexos. Os potenciais evocados auditivos de longa latência foram pesquisados por meio dos transdutores, fone de inserção e caixa acústica, eliciados por estímulo de fala /da/, sendo o intervalo interestímulos de 526ms, a intensidade de 70dBNA e a taxa de apresentação de 1,9 estímulos por segundo. Foram analisados os componentes P_1, N_1 e P_2 quando presentes, quanto à latência e à amplitude. **Resultados:** constatou-se um nível de concordância forte entre a pesquisadora e o juiz. Não houve diferença estatisticamente significante ao comparar os valores de latência e amplitude dos componentes P_1, N_1 e P_2, ao considerar sexo e orelha, assim como para a latência dos componentes quando analisado os tipos de transdutores. Entretanto, houve diferença estatisticamente significante para a amplitude dos componentes P_1 e N_1, com maior amplitude para o transdutor caixa acústica. **Conclusão:** os valores de latência dos componentes P_1, N_1 e P_2 e amplitude de P_2 obtidos com fone de inserção podem ser utilizados como referência de normalidade independente do transdutor utilizado para a pesquisa dos potenciais evocados auditivos de longa latência.

DESCRITORES: Potenciais Evocados Auditivos; Transdutores; Criança

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