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Original articles

Temporal resolution and cortical potential in different levels of English proficiency

Resolução temporal e potenciais corticais em diferentes níveis de proficiência da língua inglesa

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ABSTRACT

Purpose: to investigate and compare hearing abilities in normal hearing bilingual students, at different levels of English proficiency (basic, intermediate and advanced), using behavioral testing and electrophysiological testing.

Methods: this study is descriptive, quantitative and transversal. The sample consisted of 60 subjects (language schools students at different English proficiency levels: 20 at advanced level (AG); 20 at intermediate level (IG); 20 at basic level (BG)) with normal hearing and no complaints about auditory processing abilities, aged 18-35 years. They were subjected to behavioral test: Random Gap Detection Test (RGDT) that assesses ability of temporal resolution; and electrophysiological test Long Latency Auditory Evoked Potential (LLAEP) with verbal stimuli (syllables /ba/ - frequent stimulus and /di/ - rare stimulus) evaluating memory, attention and auditory discrimination.

Results: it was noticed a statistically significant difference between ears for: BG, to amplitude of N1 and P2, with higher values for left ear; IG to amplitude of P1, N1 and P2, with higher values for left ear; AG to latency of N1, with higher values for left ear, and amplitudes of components P2, N2 and P3, with higher values for left ear. Between groups, RGDT showed lower values of AG, and latency of N1 component, with higher values for BG.

Conclusion: there were significant differences in temporal resolution ability, better for students in advanced level of English and also to the latency of evoked cortical N1 with higher values for students at a basic level.

Keywords: Hearing; Bilingualism; Electrophysiology; Event-Related Potentials, P300; Adult

RESUMO

Objetivos: investigar e comparar as habilidades auditivas entre normo-ouvintes bilíngues estudantes de diferentes níveis de proficiência do inglês por meio de teste comportamental e eletrofisiológico.

Métodos: este estudo tem caráter descritivo, quantitativo e transversal. A amostra foi composta por 39 sujeitos (alunos de escolas de idiomas: 13 no nível avançado (GA); 13 no nível intermediário (GI); 13 no nível básico (GB)), com idade entre 18 a 35 anos, limiares auditivos tonais dentro dos limites da normalidade e sem queixas de habilidades de processamento auditivo. Foram submetidos aos testes comportamentais: teste de detecção de gap (RGDT); e ao teste eletrofisiológico potencial evocado auditivo de longa latência (PEALL), com estímulos verbais (sílabas /ba/ – frequente – e /di/ – raro)

Resultados: verificou-se diferença estatisticamente significante entre as orelhas para: o GB, para a amplitude de N1 e P2, com maiores valores para a orelha esquerda; o GI, para a amplitude de P1, N1 e P2, com maiores valores para a orelha esquerda, o GA, para a latência do componente N1, com maiores valores para a orelha esquerda, e, para as amplitudes dos componentes P2, N2 e P3, com maiores valores para a orelha esquerda. Entre os grupos, o teste RGDT mostrou menores valores para GA e para latência do componente N1, com maiores valores para o GB. **Conclusões:** pode-se concluir que o nível de proficiência avançado da língua inglesa estimula a velocidade de conexões neurais desencadeando a ocorrência mais rápida do potencial N1, assim a habilidade de resolução temporal é significantemente melhor à medida que o tempo de estudo aumenta.

Descritores: Audição; Bilinguismo; Eletrofisiologia; Potencial Evocado P300; Adulto

INTRODUCTION

In Brazil, the bilingual population is constantly increasing, to the point that, if those who learn a second language in school are considered bilingual, certainly the number of monolingual turn out to be quite inferior to bilingual Brazilian population. Such a scenario is consistent to what occurs in the international prospect, in which it is estimated that more than half of the population use two or more languages to interact in society[1].

Currently 6,909 languages are identified, used by 5,959,511,717 speakers[2]. These figures reflect the diversity of the cultures to which they are exposed and the importance of understanding and to be clearly understood in the society which one lives in. In addition, all societies, regardless of their level of development, recognize the importance of the teaching of a second language[3]. It is proof that, increasingly, it is necessary to know how the brain processes and organizes information in bilingual individuals, as well as become aware of that exposure to a second language can change the auditory processing skills.

The information processing is called auditory processing, which refers not only to the perception of sound, but also to the efficiency and effectiveness with which the central nervous system uses the auditory information, including a set of specific skills, of which the individual relies on to understand what happened, as the ability of identification, analysis, storage and retrieval of auditory information[4], which can be evaluated behaviorally or electrophysiological (objective).

Behavioral assessment of auditory processing is done with several tests that usually combine the evaluation of more than a skill, such as, for example, the detection test or Random Gap Detection Test – RGDT, which consists of a recent procedure of clinical evaluation of the ability of temporal resolution, which has a goal to determine the detection threshold of the gap[5].

The research aims of the auditory processing is made by the long latency auditory evoked potentials (LLAEP) and consists in capturing potential, in order to reflect cortical activity involved in attention skills, selection, discrimination, memory and decision[6]. Part of the positive and negative waves LLAEP, subdivided into potential exogenous or cortical evoked potentials (P1, P2, N1, N2), which are influenced by the physical characteristics of the stimulus, such as intensity, duration and frequency, and the endogenous or cognitive potential (P3), predominantly influenced by events related to cognitive skills[7].

Currently, it is known that the advantages associated with bilingualism are evident, especially when they concern the settlement of conflicts and to improve the executive functions. Exposure to two different languages can facilitate significantly the cognitive differentiation in bilingual subjects, which extend their verbal skills. Besides being easier to take ownership of the differentials, bilingual people tend to perform better on tasks of warning, monitoring and exchange of tasks, whereas the regular use of two languages requires greater control to use attention and selection of language[8].

In the area of School and Educational Psychology, a similar study to the one presented here was found, regarding the levels of learning in a private educational institution of the English language, which aimed to study the relationship between creativity, intelligence and self-concept in monolingual students (Portuguese) and bilingual (Portuguese/English). The sample was composed of 269 students, with an average of 22.41 years of age, ranging between 14 and 57 years. They considered 190 bilingual students participating on the last semester of advanced English course, with proficiency in written and oral skills, and considered the other 79 students, monolingual. These were selected in the first and second semester of English course, for presenting little or no knowledge of the English language. As a result, the students presented higher scores in bilingual of figurative and verbal creativity and intelligence when compared to monolingual students[9].

Only one national study in the area of speech therapy that related basic-level students of the English language was found, in order to verify that the previous contact with the English phonetic system favored general language learning in Portuguese speakers. The sample was comprised of eight students who had studied the English language only in high school. They were separated in the control group (participants of English course only) and experimental group (participants of phonetic classes prior to English) and, later, submitted to RGDT processing test and oral test in English before and after school. As a result, there were no differences in the tests between the groups; however, the scores indicate better performance of the control group by answering the questions in English in oral evidence, in addition to better performance of the experimental group in the RGDT test. Thus, the authors concluded that prior knowledge of the English language did not favor general learning (improves the pronunciation) of the second language of the group as a whole, but has improved its ability of temporal processing[10].

Considering the above, the objective of this study was to investigate and compare auditory skills in normo-listeners language schools students at different levels of English proficiency (basic, intermediate and advanced) through behavioral and electrophysiological test test.

METHODS

The present study was a survey of quantitative approach of transversal character, which compares the auditory findings in bilingual Portuguese/English individuals' students of language schools. Search procedures were performed individually in Audiology outpatient clinic of a teaching Hospital in the State.

This study was registered in the Project Office, under the number 036184, and approved by the Research Ethics Committee, with certificate number 29325714.1.0000.5346, on April 8th, 2014.

The sample was divided into three groups of adults normo-listeners aged 18 to 35 years, with 13 individuals each: Advanced Group (GA), which includes speakers of Brazilian Portuguese and in process of late English language bilingualism (fluent) (advanced level students of language schools); Intermediate Group (GI), composed by Brazilian Portuguese speakers in process of late English bilingualism (students of intermediate level of language schools); and Basic Group (GB), including speakers of Brazilian Portuguese and in process of late English bilingualism (students of basic level of language schools). This distribution in learning levels comply with the criteria used by the schools in their defined curriculum guidelines that direct the learning and development of the student in the standardized levels.

Inclusion criteria: tone hearing thresholds within the limits of normality; Type A tympanogram and contralateral acoustic reflexes present; be a student of a language school in basic, intermediate or advanced level of English language; not have fluency in speaking and understanding of any language other than Portuguese and English; being right handed and have, at least, incomplete higher education.

Exclusion criteria: subject older than 35 or younger than 18 years of age; with hearing loss; with updates to the middle ear; with complaints of difficulty to understand speech in quiet and noisy environments; with memory and attention difficulties; play any musical instrument; they are left handed or have become right handed throughout life; they are early bilingual (before the six years of age[11]); and are multilingual.

The individuals who fit the criteria for inclusion were given a full explanation on the nature of the research, its objectives, its procedures, the risks and benefits and the secrecy about the identification. Those who agreed to participate in the research voluntarily signed an informed consent.

The participants were subjected to the following evaluations: initial history, visual inspection of the external acoustic meatus, pure tone audiometry (PTA), speech reception threshold (SRT), percentage index of speech recognition (PISR), random gap detection test (RGDT) and long latency auditory evoked potential (LLAEP).

For the PTA, the SRT and the PISR, a two-channel audiometer was used, brand Fonix Hearing Evaluator, FA 12 model type I, and headset type TDH-39 p, from Telephonics, through which were surveyed hearing thresholds of airway in the frequencies of 250 to 8000 Hz, monaural form. The technique used was descended-and the upward normal criterion was of hearing thresholds to 25 dB, as the average tritonal (MTT) of frequencies of 500, 1000 and 2000 Hz[12].

The SRT and PISR were surveyed and the monaural form SRT with two syllable word lists, and the PISR with monosyllabic word lists. The SRT was researched through downward-upward technique. For the PISR, 40 dB were added to the average frequencies of 500, 1000 and 2000 Hz, beyond the conforto level search[13].

The RGDT has been performed the dBNS 40 added to the MTT, to evaluate the ability of temporal resolution. The subjects were instructed to respond verbally to the appraiser if you were listening to one or two sounds.

In LLAEP, individuals had to remain on alert and tell rare stimuli (20% of the total stimulus) that appeared randomly, ignoring frequent stimuli (80% of the total stimulus). The electrodes were attached to the skin of individuals with conductive electrolyte folder in the vertex (Cz), left mastoid (A1), right mastoid (A2) and control on their forehead. The equipment used was the SmartEP model, Intelligent Hearing-branded Systems (IHS). The electrode impedance was less than 03 Kohm.

Through the use of verbal stimuli, it is possible to obtain additional information about the biological processes involved in speech processing, which are of great value to the clinical practice: they provide complementary information to the one obtained by behavioral standard assessment, whether by auditory and/or cognitive lingiustic reasons[14]. Therefore, this study was directed to the influence of learning a second language through auditory processing, since the use of non-verbal stimuli would entail in result bias.

It was presented a serie of 300 stimuli (240 frequent and 60 rare) with verbal stimuli (/ba/ syllables – frequent stimulus – and /di/– rare stimulus) to an intensity of 75 dB. The latency and amplitude values of the potential are expected, respectively: in P1, between 50 and 80ms; in N1, with latency between 80 and 150 ms and range of 5 to 10 μV; in P2, with latency between 145 and 180ms and range of 3 to 6 μV; in N2, with latency between 180 and 250ms and range of 8 to 15 μV; in P3, with latency between 220 and 380 ms[15], and minimum amplitude of P3 of 3 μV[16]. These values of standardization were made for the tone burst stimulation. There is a recent study conducted with values for the speech stimuli of /ba/ and /di/, which were: P1 (OD: ms 65.5; OE: 67.2 ms), N1 (OD: 107.8 ms; OE: 109, 3ms), P2 (OD: 182.7 ms; OE: 187.1 ms), N2 (OD: 251.6 ms; OE: 261.4 ms), P3 (OD: ms 324.2; OE: 329.9 ms) and amplitude of P3 (OD: 6.3 μV; OE: 6.7 μV)[17].

To the exogenous complex, the first peak, trough, peak, trough was considered. For the P3 component, the first positive peak after exogenous complex was considered and it was expected at the circuit of the rare stimuli, where the tagging was made[15]. For marking of the amplitude of the waves, for the components P1, L1, P2 and N2, the offset of the cursor in the previous sense was considered until the next peak latency, and so on. For marking of the amplitude of the P3 component, the offset of the cursor was to the posterior sense up to the closest trough. There was no record of wave playback, since collecting replication could cause fatigue and jeopardize the outcome of the evaluation, as this depends on the attention. There was no subtraction of the waves, which were used in the initial record.

After gathering the data, all results have been prepared in a Microsoft Excel spreadsheet for further analysis and comparison. The statistical analysis was carried out by a professional, through the SAS System computer program for Windows (Statistical Analysis System), version 9.2 SAS Institute Inc., 2002-2008, Cary, NC, USA.

To compare performance in tests between the ears (RE and LE), McNemar's test was used for categorical variables, for related samples and the Wilcoxon test, for samples related to numeric variables.

To compare performance in tests between the groups, we used the Fisher exact test, for expected values less than five. For comparison of the numerical variables between groups, it was used the Mann-Whitney test, due to the absence of normal distribution of the variables. The tests were considered significant with confidence level above 95% ($p < 0.05$).

RESULTS

Descriptive analyses related to age and genre are described in table 1. In which there was no statistically significant difference for age and gender among the three study groups.

Initially, an analysis was carried out by ear in each group, to identify potential differences between them due to the hemispheric dominance (tables 2 to 4). The RGDT test will not be quoted in the analysis by ear because it was held binaurally.

For GB, there was a statistically significant difference between the ears for the amplitude of N1 and P2 with higher values for the left ear.

For the GI, there was a statistically significant difference between the ears for the amplitude of P1, L1 and P2, with higher values for the left ear.

For GA, there were statistically significant differences between the ears to the latency of the N1 component, with higher values for the left ear, as well as the amplitudes of the P2 components, N2 and P3, with higher values for the left ear.

In table 5, the comparison between the groups in the RGDT test is shown, in addition to the values for each age group. A significant difference was detected between the groups with the RGDT test, showing smaller values for the GA (table 5 and Figure 1).

According to the results, a statistically significant difference was found for N1 latency to the right ear, with higher values for the GB (Figure 2).

Table 1. Description in percentage about gender and age groups

	Age			Gender	
	<20	20-29	≥30	Female	Male
GB	7.69 %	76.92%	15.38%	46.15%	53.85%
GI	15.38 %	69.23%	15.38%	46.15%	53.85%
GA	15.38%	69.23%	15.38%	46.15%	53.85%
P- Value		P=1.000		P=1.000	

Legend: GB = Basic Group; GI = Intermediate Group; GA = Advanced Group
Exact age test by Fisher and gender test chi-squared.

Table 2. Analysis by ear of latencies and amplitudes of the test long-latency auditory evoked potential to the basic group

VARIABLE	N	AVERAGE	D.P.	MIN	Q1	MEDIAN	Q3	MAX	VALUE-P*
P1_OD	13	55.38	9.36	42.00	48.00	58.00	62.00	72.00	P=0.250
P1_OE	13	59.38	10.34	44.00	52.00	58.00	60.00	84.00	
Dif_P1	13	-4.00	9.49	-26.00	-10.00	0.00	2.00	8.00	
AmpP1_OD	13	4.49	2.41	2.38	2.88	3.72	5.44	11.10	P=0.078
AmpP1_OE	13	4.97	2.97	1.72	3.45	3.87	5.86	13.01	
Dif_AmpP1	13	-0.48	0.82	-1.91	-1.17	-0.51	0.06	0.88	
N1_OD	13	103.85	9.98	90.00	100.00	104.00	108.00	130.00	P=0.461
N1_OE	13	104.92	9.65	88.00	102.00	104.00	108.00	128.00	
Dif_N1	13	-1.08	3.62	-10.00	-2.00	0.00	2.00	2.00	
AmpN1_OD	13	7.54	2.85	3.20	5.74	6.57	9.38	13.33	***P=0.040**
AmpN1_OE	13	8.17	3.18	2.68	6.90	7.26	9.53	14.76	
Dif_AmpN1	13	-0.63	0.90	-2.24	-1.14	-0.46	-0.15	0.63	
P2_OD	13	181.38	21.98	154.00	166.00	172.00	202.00	218.00	P=0.397
P2_OE	13	182.31	20.48	154.00	168.00	178.00	196.00	218.00	
Dif_P2	13	-0.92	5.27	-12.00	-4.00	-2.00	2.00	8.00	
AmpP2_OD	13	5.62	2.75	1.52	4.31	4.96	8.62	10.18	***P=0.028**
AmpP2_OE	13	6.08	2.85	1.00	4.50	5.70	8.49	10.75	
Dif_AmpP2	13	-0.47	0.65	-1.61	-0.99	-0.57	-0.19	0.57	
N2_OD	13	262.62	30.05	196.00	248.00	262.00	286.00	304.00	P=0.584
N2_OE	13	264.00	31.23	190.00	242.00	270.00	286.00	302.00	
Dif_N2	13	-1.38	6.08	-16.00	-4.00	0.00	2.00	6.00	
AmpN2_OD	13	3.45	1.98	0.34	2.17	3.95	4.69	6.17	P=0.685
AmpN2_OE	13	3.57	2.25	0.54	2.19	3.93	5.15	6.84	
Dif_AmpN2	13	-0.12	0.61	-1.20	-0.39	-0.11	0.37	0.71	
P3_OD	13	328.15	29.10	286.00	306.00	330.00	340.00	392.00	P=0.768
P3_OE	13	327.08	31.49	272.00	296.00	340.00	346.00	386.00	
Dif_P3	13	1.08	7.73	-10.00	-8.00	2.00	6.00	14.00	
AmpP3_OD	13	6.86	2.95	3.34	4.93	5.35	9.87	11.64	P=0.216
AmpP3_OE	13	6.53	2.81	1.81	4.50	6.31	9.26	10.52	
Dif_AmpP3	13	0.33	1.38	-3.28	0.42	0.68	1.24	1.65	

* Value-P refers to the Wilcoxon test for samples related to the comparison between the ears LE and RE.
Median legend: LLAEP latencies (ms) and amplitude (μV).

Table 3. Analysis of latencies and amplitudes of the test long-latency auditory evoked potential by ear for the intermediate group

VARIABLE	N	AVERAGE	D.P.	MIN	Q1	MEDIAN	Q3	MAX	VALUE-P*
P1_OD	13	50.15	14.46	20.00	38.00	52.00	62.00	66.00	P=0.965
P1_OE	13	48.62	15.22	22.00	42.00	56.00	60.00	68.00	
Dif_P1	13	1.54	10.01	-8.00	-6.00	-2.00	4.00	30.00	
AmpP1_OD	13	4.54	2.40	0.49	3.12	4.21	7.04	7.83	***P=0.022**
AmpP1_OE	13	5.21	2.51	1.15	3.48	4.94	7.29	8.90	
Dif_AmpP1	13	-0.67	0.98	-3.50	-0.76	-0.60	0.03	0.21	
N1_OD	13	101.69	9.72	84.00	96.00	102.00	110.00	118.00	P=0.266
N1_OE	13	103.38	9.11	88.00	96.00	102.00	112.00	114.00	
Dif_N1	13	-1.69	5.34	-10.00	-6.00	-2.00	0.00	10.00	
AmpN1_OD	13	6.82	2.57	1.87	5.71	7.49	8.57	11.48	***P=0.048**
AmpN1_OE	13	7.23	2.89	2.65	4.66	7.55	9.39	12.27	
Dif_AmpN1	13	-0.42	0.71	-1.52	-0.79	-0.49	0.07	1.10	
P2_OD	13	169.85	17.16	138.00	160.00	170.00	176.00	200.00	P=0.734
P2_OE	13	170.46	17.59	142.00	164.00	168.00	172.00	202.00	
Dif_P2	13	-0.62	5.38	-8.00	-6.00	-2.00	4.00	8.00	
AmpP2_OD	13	4.06	2.00	0.24	2.67	4.38	5.34	6.92	***P<0.002**
AmpP2_OE	13	4.75	2.33	0.48	3.39	5.08	6.10	7.83	
Dif_AmpP2	13	-0.69	0.62	-1.77	-0.93	-0.67	-0.24	0.16	
N2_OD	13	259.23	36.77	174.00	256.00	268.00	284.00	288.00	P=0.952
N2_OE	13	259.38	36.85	180.00	258.00	272.00	278.00	294.00	
Dif_N2	13	-0.15	10.47	-22.00	-6.00	0.00	8.00	18.00	
AmpN2_OD	13	3.26	2.56	0.77	1.50	2.79	3.79	8.58	P=0.893
AmpN2_OE	13	3.32	2.65	0.40	1.39	3.38	3.77	9.12	
Dif_AmpN2	13	-0.06	0.57	-1.00	-0.53	0.18	0.40	0.65	
P3_OD	13	325.23	28.09	254.00	316.00	320.00	338.00	366.00	P=0.083
P3_OE	13	322.31	28.06	250.00	316.00	320.00	346.00	354.00	
Dif_P3	13	2.92	5.75	-8.00	-2.00	4.00	8.00	12.00	
AmpP3_OD	13	5.62	2.81	2.15	3.34	5.82	7.69	11.44	P=0.839
AmpP3_OE	13	5.88	2.63	2.07	4.16	6.10	8.05	9.48	
Dif_AmpP3	13	-0.26	1.64	-4.62	-0.80	-0.07	0.85	1.96	

* Value-P refers to the Wilcoxon test for samples related to the comparison between the ears LE and RE.
Median legend: LLAEP latencies (ms) and amplitude (μV).

Table 4. Analysis of latencies and amplitudes of the test long-latency auditory evoked potential by ear for the away team

VARIABLE	N	AVERAGE	D.P.	MIN	Q1	MEDIAN	Q3	MAX	VALUE-P*
P1_OD	13	45.69	13.71	20.00	36.00	52.00	56.00	64.00	P=0.370
P1_OE	13	48.77	11.12	26.00	44.00	52.00	56.00	62.00	
Dif_P1	13	-3.08	9.33	-26.00	-6.00	-2.00	4.00	8.00	
AmpP1_OD	13	3.88	1.10	1.65	3.24	3.83	4.07	6.17	P=0.425
AmpP1_OE	13	4.09	1.33	2.26	3.09	4.04	5.05	6.93	
Dif_AmpP1	13	-0.21	0.92	-1.93	-0.76	-0.31	0.43	1.49	
N1_OD	13	95.69	7.11	80.00	94.00	96.00	98.00	108.00	***P=0.047**
N1_OE	13	100.00	8.49	82.00	98.00	102.00	104.00	114.00	
Dif_N1	13	-4.31	6.97	-18.00	-6.00	-2.00	0.00	6.00	
AmpN1_OD	13	6.88	3.05	2.86	5.38	5.87	8.86	14.32	P=0.127
AmpN1_OE	13	7.63	4.06	3.49	4.86	7.03	9.58	18.87	
Dif_AmpN1	13	-0.74	1.63	-4.55	-0.75	-0.33	0.07	1.48	
P2_OD	13	176.92	26.14	146.00	158.00	168.00	196.00	226.00	P=0.375
P2_OE	13	174.77	23.13	148.00	158.00	166.00	190.00	226.00	
Dif_P2	13	2.15	6.71	-6.00	0.00	0.00	4.00	20.00	
AmpP2_OD	13	4.81	2.78	0.48	2.22	4.98	6.65	9.55	***P=0.048**
AmpP2_OE	13	5.39	3.02	0.81	3.82	5.66	6.41	10.68	
Dif_AmpP2	13	-0.58	0.87	-2.12	-1.11	-0.85	0.24	0.58	
N2_OD	13	259.54	41.49	188.00	240.00	278.00	280.00	300.00	P=0.629
N2_OE	13	264.52	34.04	188.00	262.00	278.00	286.00	296.00	
Dif_N2	13	-5.08	23.00	-74.00	-8.00	0.00	2.00	28.00	
AmpN2_OD	13	2.55	1.91	0.55	1.14	1.83	3.86	6.69	***P=0.042**
AmpN2_OE	13	2.92	2.01	0.43	1.42	2.75	3.45	7.27	
Dif_AmpN2	13	-0.37	0.68	-1.88	-0.65	-0.52	0.12	0.50	
P3_OD	13	328.00	17.46	306.00	316.00	324.00	338.00	370.00	P=0.308
P3_OE	13	325.54	17.42	298.00	316.00	324.00	338.00	364.00	
Dif_P3	13	3.23	8.96	-8.00	-4.00	0.00	10.00	22.00	
AmpP3_OD	13	4.24	1.78	0.71	4.08	4.23	4.96	6.92	***P=0.040**
AmpP3_OE	13	4.81	2.01	1.18	4.15	5.26	5.98	8.25	
Dif_AmpP3	13	-0.57	0.85	-1.72	-1.22	-0.66	-0.14	1.11	

* Value-P refers to the Wilcoxon test for samples related to the comparison between the ears LE and RE.
Median legend: LLAEP latencies (ms) and amplitude (μV).

DISCUSSION

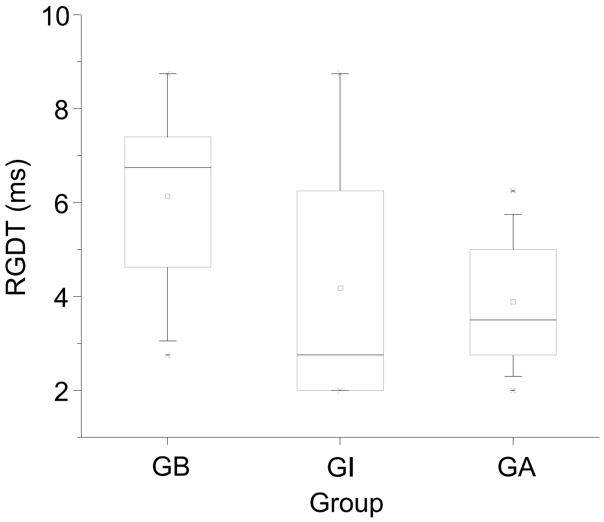
The comparative discussion between the values obtained with the results of previous studies is imprecise because there are no studies showing the differentiation between the ears to the exogenous LLAEP's potential; the parameters of analysis of records only for the endogenous potential converge P3 regarding to latency and amplitude. Few studies have focused on other components of LLAEP. Therefore, you cannot argue with studies of bilingualism, as there is no research with the same focus. The discussion will be made by exploiting what has already been vetted potential exogenous to the moment your order of latency (P1, P2, N1, N2 and P3), showing the importance of studies which deepen in this investigation.

Through the use of verbal stimuli, it is possible to obtain additional information about the biological processes involved in speech processing. Thus, such stimuli are of great value to the clinical practice, since

Table 5. Comparison between groups, by ear, to the Random Gap Detection Test and for each age group values

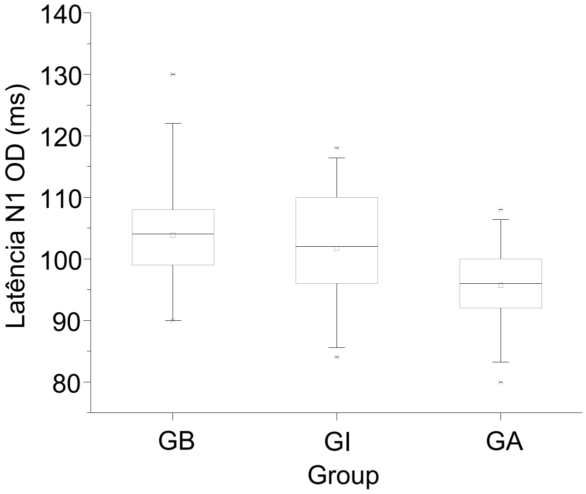
Group	VARIABLE	N	AVERAGE	D.P.	MIN	Q1	MEDIAN	Q3	MAX	VALUE-P*
GB	Age	13	23.54	4.35	18.00	21.00	22.00	25.00	32.00	P=0.993
	RGDT	13	6.14	1.86	2.75	5.0	6.75	7.30	8.75	***P=0.011(A)**
GI	Age	13	23.77	4.19	19.00	20.00	23.00	27.00	31.00	
	RGDT	13	4.17	2.61	2.00	2.00	2.75	6.25	8.75	
GA	Age	13	24.08	5.06	18.00	20.00	23.00	27.00	35.00	
	RGDT	13	3.88	1.21	2.00	2.75	3.50	5.00	6.25	

* Value-P referes to the Kruskal-Wallis test for comparing the values between the three groups.
Measures ledeng: Age (years). **(A)** 'GB'≠'GI'; 'GB'≠'GA'.
GB = Basic group; GI = Intermediate group; GA = Advanced group



Legend = GB = Basic group; GI = Intermediate group; GA = Advanced group

Figure 1. Comparative Analysis of the Random test Gap Detection Test between the three groups



Legend = GB = Basic group; GI = Intermediate group; GA = Advanced group

Figure 2. Comparative Analysis of the N1 component latency between the three groups

they provide additional information to those obtained by standard behavioral assessment, whether by linguistics, auditory and/or cognitive reasons[14]. Therefore, this study was directed to the influence of learning a second language in auditory processing, using non-verbal stimuli would not affect the results, as analyzed in a recent national study that compared different verbal stimuli and tone burst. The study found that there were no statistical differences for components P1, L1 and P2 between the four stimuli used; However, there was no statistical difference for N2 and P3, with lower latency values for tone burst stimulation. These results make us think that maybe the tone burst stimulation offers low sensitivity to capture subject changed. In addition, the largest P3 latency was statistically significant with the verbal stimulus /ba/ and /ga/, and greater latency for N2 with the verbal stimulus /ba/ and /di/, there is no difference for the amplitude of P3 between the four estimuli[17].

The P1 is a positive wave component, able to reflect changes in the auditory central nervous system (ACNS), generated by the activity of Thalamic-cortical circuit in stimulation of sounds from the neuronal plasticity, a phenomenon which is essential for the development of auditory skills and language[18].

Several studies indicate that reducing the lag time of P1 is associated with improvement of communicative behaviors (vocalization)[19], the perception of speech[20] and also the skills of speech and language in children[21]. This component has been the most widely used as a biomarker of the maturation of the auditory system, mainly on research with users of cochlear implants, in which latency is less than the time of use of the device[22]. Similarly, recent studies claim that the curl P1 develops quickly after activation of the cochlear implant, reaching normal values between 3 and 8 months of device use[23,24]. However, no studies were found dealing with the extent of that potential.

In the present study, a statistically significant difference was detected between the ears for the breadth of potential P1 in the GI, with higher values for the left ear (5.21 μV) when compared to the right (4.54 μV) (table 3). This may mean that the intermediate-level proficiency in English language would cause some change in relation to communicative behaviors, featuring improved speech perception. Note that the breadth of the right ear is outside of the normal patterns of 5 to 10 μ V[15].

The exogenous component N1 has the supra-temporal auditory cortex as generator site, responsible for the attention and the initial decoding of the stimulus. It was observed, in research, greater values for the latency of N1 in school with learning complaints, showing basic changes of auditory processing in this population[25]. However, recent studies were not found on the magnitude of this potential.

In this study, statistically significant differences were noticed in the N1 component for the three groups: GB, GI and GA.

Regarding the amplitude of N1 between ears, there were higher values for the left ear in GB and GI, with averages, respectively, of 8.17 μV when compared to the right of 7.54 μV (table 2) and 7.23 μV to the left when compared to the right of 6.82 μV (table 3). It was observed that the largest amplitude values were recorded for the intermediate level of English proficiency, although all are within the normal standards of 5 to 10 μ V[15].

Regarding to N1 exogenous latency, a statistical difference was detected in GA, with higher values for the left ear, with ms 100.00, when compared to the right of 95.69 ms (table 4). Still in the comparison between groups, there was statistical difference with higher values of right ear to the GB, with an average 103.85 ms, when compared to the GI, with ms 101.69, and GA with 95.69 ms (table 6). It was observed that the GA probably has greater speed and initial decoding of the stimulus. It was also observed that both are within the normal standards of 80 and 150 ms[15].

The P2 has wave generators in various regions of the auditory cortex and primary and secondary in the reticular system, areas that are associated to the attention that the individual gives the sound stimulation and inhibition of competitive stimuli processing, which, in turn, relates and acoustic characteristics of the temporal estimuli[26]. There is a recent study in which children with attention deficit hyperactivity disorder (ADHD) presented a higher amplitude of P2 wave, which suggests that these children need greater activation of generators to ensure that sites remained attentive and, consequently, could differentiate the rare stimuli from frequent stimuli[27]. In another study, the exogenous component latency P2 had late appearance in school learning disorder showing a deficit on encoding and on characterization of information received via central hearing[25].

As a result of this study, in terms of the amplitude of P2, statistical differences with higher values for the left ear in GB, in GI and at GA, with averages, respectively, of 6.08 μV when compared to the right of 5.62 μV (table 2), 4.75 μV for left ear and right ear μV 4.06 (table 3) and 5.39 μV for left ear and right ear μV 4.81 (table 4). All range values are within the standards of normality between 3 and 6 μ V15. However, this is normative for the tone burst stimulation; There are still no studies with normality to this cortical potential.

The wave N2 is considered a mixed component for being elicited both by exogenous and endogenous factors[28]. This contributes to the potential discrimination of acoustic characteristics of the physical stimuli and also relates the endogenous factors relating to auditory sensory processing, responsible for the activities of attention, perception, discrimination and recognition of sounds. In a current study, passive and automatic pre-atentional response, elicited by a rare stimulus discrimination, amidst the frequent stimuli, during registration of LLAEP, was very deficient in schoolchildren with learning disability, being the indicator functions of discrimination and were attention altered[25].

In relation to the breadth of N2, there were statistical differences in GA, with higher values for the left ear, with averages of 2.92 μV for left ear and right ear μV 2.55 (table 4). However, the values are outside the normal patterns of 8 to 15 μ V[15].

Table 6. Comparison between groups, by ear, of long-latency auditory evoked potential test

Group	VARIABLE	N	AVERAGE	D.P.	MIN	Q1	MEDIAN	Q3	MAX	VALUE-P*
GB	P1_OD	13	55.38	9.36	42.00	48.00	58.00	62.00	72.00	P=0.173
	AmpP1_OD	13	4.49	2.41	2.38	2.88	3.72	5.44	11.10	P=0.736
	N1_OD	13	103.85	9.98	90.00	100.00	104.00	108.00	130.00	***P=0.044(B)**
	AmpN1_OD	13	7.54	2.85	3.20	5.74	6.57	9.38	13.33	P=0.755
	P2_OD	13	181.38	21.98	154.00	166.00	172.00	202.00	218.00	P=0.587
	AmpP2_OD	13	5.62	2.75	1.52	4.31	4.96	8.62	10.18	P=0.520
	N2_OD	13	262.62	30.05	196.00	248.00	262.00	286.00	304.00	P=0.922
	AmpN2_OD	13	3.45	1.98	0.34	2.17	3.95	4.69	6.17	P=0.484
	P3_OD	13	328.15	29.10	286.00	306.00	330.00	340.00	392.00	P=0.971
	AmpP3_OD	13	6.86	2.95	3.34	4.93	5.35	9.87	11.64	P=0.074
	P1_OE	13	59.38	10.34	44.00	52.00	58.00	60.00	84.00	P=0.093
	AmpP1_OE	13	4.97	2.97	1.72	3.45	3.87	5.86	13.01	P=0.505
	N1_OE	13	104.92	9.65	88.00	102.00	104.00	108.00	128.00	P=0.528
	AmpN1_OE	13	8.17	3.18	2.68	6.90	7.26	9.53	14.76	P=0.714
	P2_OE	13	182.31	20.48	154.00	168.00	178.00	196.00	218.00	P=0.300
	AmpP2_OE	13	6.08	2.85	1.00	4.50	5.70	8.49	10.75	P=0.517
	N2_OE	13	264.00	31.23	190.00	242.00	270.00	286.00	302.00	P=0.792
	AmpN2_OE	13	3.57	2.25	0.54	2.19	3.93	5.15	6.84	P=0.725
	P3_OE	13	327.08	31.49	272.00	296.00	340.00	346.00	386.00	P=0.955
	AmpP3_OE	13	6.53	2.81	1.81	4.50	6.31	9.26	10.52	P=0.307
GI	P1_OD	13	48.62	15.22	22.00	42.00	56.00	60.00	68.00	
	AmpP1_OD	13	5.21	2.51	1.15	3.48	4.94	7.29	8.90	
	N1_OD	13	103.38	9.11	88.00	96.00	102.00	112.00	114.00	
	AmpN1_OD	13	7.23	2.89	2.65	4.66	7.55	9.39	12.27	
	P2_OD	13	170.46	17.59	142.00	164.00	168.00	172.00	202.00	
	AmpP2_OD	13	4.75	2.33	0.48	3.39	5.08	6.10	7.83	
	N2_OD	13	259.38	36.85	180.00	258.00	272.00	278.00	294.00	
	AmpN2_OD	13	3.32	2.65	0.40	1.39	3.38	3.77	9.12	
	P3_OD	13	322.31	28.06	250.00	316.00	320.00	346.00	354.00	
	AmpP3_OD	13	5.88	2.63	2.07	4.16	6.10	8.05	9.48	
	P1_OE	13	50.15	14.46	20.00	38.00	52.00	62.00	66.00	
	AmpP1_OE	13	4.54	2.40	0.49	3.12	4.21	7.04	7.83	
	N1_OE	13	101.69	9.72	84.00	96.00	102.00	110.00	118.00	
	AmpN1_OE	13	6.82	2.57	1.87	5.71	7.49	8.57	11.48	
	P2_OE	13	169.85	17.16	138.00	160.00	170.00	176.00	200.00	
	AmpP2_OE	13	4.06	2.00	0.24	2.67	4.38	5.34	6.92	
	N2_OE	13	259.23	36.77	174.00	256.00	268.00	284.00	288.00	
	AmpN2_OE	13	3.26	2.56	0.77	1.50	2.79	3.79	8.58	
	P3_OE	13	325.23	28.09	254.00	316.00	320.00	338.00	366.00	
	AmpP3_OE	13	5.62	2.81	2.15	3.34	5.82	7.69	11.44	

Group	VARIABLE	N	AVERAGE	D.P.	MIN	Q1	MEDIAN	Q3	MAX	VALUE-P*
GA	P1_OD	13	45.69	13.71	20.00	36.00	52.00	56.00	64.00	
	AmpP1_OD	13	3.88	1.10	1.65	3.24	3.83	4.07	6.17	
	N1_OD	13	95.69	7.11	80.00	94.00	96.00	98.00	108.00	
	AmpN1_OD	13	6.88	3.05	2.86	5.38	5.87	8.86	14.32	
	P2_OD	13	176.92	26.14	146.00	158.00	168.00	196.00	226.00	
	AmpP2_OD	13	4.81	2.78	0.48	2.22	4.98	6.65	9.55	
	N2_OD	13	259.54	41.49	188.00	240.00	278.00	280.00	300.00	
	AmpN2_OD	13	2.55	1.91	0.55	1.14	1.83	3.86	6.69	
	P3_OD	13	328.77	17.46	306.00	316.00	324.00	338.00	370.00	
	AmpP3_OD	13	4.24	1.78	0.71	4.08	4.23	4.96	6.92	
	P1_OE	13	48.77	11.12	26.00	44.00	52.00	56.00	62.00	
	AmpP1_OE	13	4.09	1.33	2.26	3.09	4.04	5.05	6.93	
	N1_OE	13	100.00	8.49	82.00	98.00	102.00	104.00	114.00	
	AmpN1_OE	13	7.63	4.06	3.49	4.86	7.03	9.58	18.87	
	P2_OE	13	174.77	23.13	148.00	158.00	166.00	190.00	226.00	
	AmpP2_OE	13	5.39	3.02	0.81	3.82	5.66	6.41	10.68	
	N2_OE	13	264.62	34.04	188.00	262.00	278.00	286.00	296.00	
	AmpN2_OE	13	2.92	2.01	0.43	1.42	2.75	3.45	7.27	
	P3_OE	13	325.54	17.42	298.00	316.00	324.00	338.00	364.00	
	AmpP3_OE	13	4.81	2.01	1.18	4.15	5.26	5.98	8.25	

SIGNIFICANT DIFFERENCES BY THE MULTIPLE COMPARISONS DUNN TEST($P<0.05$):

* Value-P referes to the Kruskal-Wallis test for comparing the values between the three groups.

Measures legend: LLAEP latency (ms) and amplitudes (μV) and RGDT (ms). **(B)** 'GB'≠'GA'.

GB = Basic group; GI = Intermediate group; GA = Advanced group

The P3 component is considered a cognitive potential, unlike the others, since corresponds to the electrical activity that occurs in the auditory system when there is a breakdown of the rare among frequent stimulation related to cognition, auditory memory and attention[29]. A study investigated the interhemispheric differences related to amplitude and latency of the P3[30], however, no significant results were found, which contradicts previously published data, according to which the amplitude of P3 is significantly greater than in the right hemisphere[31].

Recent studies have demonstrated the influence of stimulus for the components N2 and P3. The difference between the stimuli was between speech consonantal contrasts (/ba/-/da/) and (/i/-/a/) vowel. Such research was conducted with 31 individuals without hearing, neurological and language impairments between the ages of 7 to 30 years of age[32]. These components are related to the processing of identification and with attention to the rare stimulus, with positive relationship between the value of your latency and the level of difficulty of the task of discriminating[33].

For GA, there was a statistically significant difference between the ears for the breadth of potential P3, with higher values for the left ear, at an average of 4.81 μV and μV 4.24 to the right ear (table 4). When comparing the present research with studies that established normative values of amplitude, amplitude of not less than 3 μ V[16] was obtained. However, these values have been obtained by means of the tone burst stimulation, for being the most widely used in clinical practice.

In this study, the best results for the left ear exogenous components make us think about what might be happening with hemispheric dominance in people at different levels of proficiency in the English language, once, for right-handed individuals, hemispheric dominance usually is left. This may indicate that the two hemispheres would be being processed, so the second language would create a greater participation of the right hemisphere, assuming that the individual who learns a second language after the complete acquisition of the mother tongue recruit more neural connections of the right hemisphere, unlike simultaneous bilingual.

Most of the researchers is consensual in the allocation, for most monolingual speakers, on the left hemisphere dominance for language. With regard to bilingual, there are controversies about its lateralization. There are proposals that there will be either a left hemisphere dominance for both languages, or a smaller left lateralization for the language in bilingual or, yet, bilingual lateralization differences for the two languages. Some studies have found differences in the direction of a greater involvement of the right hemisphere[34,35].

The RGDT test, in this study, was performed binaurally, i.e. in both ears simultaneously, which is consistent with studies that verified the absence of benefit of an ear on the other for gap detection procedures[36,37]. This test evaluates the ability of temporal resolution, which shows the frequency of the sound, as well as its emergence, and contributes significantly to the ability to represent the time of components phonetically important speech signs[38].

Therefore, a significant difference was observed between the groups with the RGDT test, showing smaller values for the GA, with averages of 6.14 ms for the GB, 4.17 ms for the GI and 3.88 ms for the GA (Figure 1) and (table 5). All groups are within the standards of normality, when considering the average of four sound frequencies less than or equal to 10ms[39].

This was probably due to the improvement of the ability of temporal resolution, due to the more advanced level of study of the English language, since it is essential for the understanding of speech in regards to the ability to represent the time of components for both phonetically important[40] Portuguese language and English. Therefore, a greater degree of proficiency in the second language is directly proportional to the best performance in the ability of temporal resolution.

The study presented important limitations regarding its population, sample and time consumed. There was great difficulty in collecting part of the population set for this study. As students of language schools, there have been restrictions in relation to the composition of the groups, because there's no way of knowing whether the level at which the student station in English really reflects your language proficiency, since each school/educational establishment has curriculum guidelines that direct the learning and development of the student in the standardized levels. The criteria used by each educational institution varies according to the interests of each Director of education and cannot be taken as a fully reliable parameter.

In addition, due to the size of the sample, which presented a high number of people, more than the time scheduled for all groups was spent.

The low number of current references can cause difficulty for publication in scientific journals, showing the need for more studies on the subject, especially on the exogenous components of LLAEP test, which were little explored. Similarly, the limitation of studies made it difficult for the the author to present a positioning of in the discussion.

From this study, it was possible to highlight the need for research that encompass the exogenous LLAEP's potential, as well as studies with individuals in the process of bilingualism in the English language to perform more extensive discussions about this subject, which can contribute even more to the evidence of the benefits of bilingualism.

CONCLUSION

It can be concluded that the level of advanced proficiency in the English language stimulates neural connections speed triggering the occurrence faster than potential N1, so the ability of temporal resolution is significantly better as time increases.

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