

# ELECTROPHYSIOLOGY ASSESSMENT OF AUDITORY SYSTEM IN INDIVIDUALS WITH DEVELOPMENTAL PERSISTENT STUTTERING

## *Avaliação eletrofisiológica do sistema auditivo em indivíduos com gagueira desenvolvimental persistente*

Simone Fiuza Regaçone<sup>(1)</sup>, Mariana Banzato Stenico<sup>(1)</sup>, Ana Cláudia Bianco Gução<sup>(1)</sup>,  
Ana Cláudia Moraes Rocha<sup>(1)</sup>, Ana Carla Leite Romero<sup>(1)</sup>,  
Cristiane Moço Canhetti de Oliveira<sup>(1)</sup>, Ana Claudia Figueiredo Frizzo<sup>(1)</sup>

### ABSTRACT

**Purpose:** to describe the findings of electrophysiological examinations of individuals who stutter and compare with typically developing individuals. **Methods:** 34 subjects participated in this study, both genders, aged between 7 and 31 years. The research group consisted of 13 children (G1a) and 4 adults (G1b) diagnosed with stuttering and the control group of 13 children (G2a) with good academic performance and 4 fluent adults (G2b). The auditory potentials assessment was performed on frequency and duration discrimination tests. **Result:** when compared groups of stuttering children and control group, it was observed that the stuttering children had the scan frequency, increased latencies of P2, N2 components at Cz in the right ear and N2 and P3 at Fz in the left ear, and the difference amplitude P2 and P3 in the right ear Cz. In the scan duration, decreased the amplitude of the N2 and P3 components in Cz Fz in the right ear. In the group of adult stutterers was observed in the frequency sweep, increased latency P3 component at Cz and Fz in the right ear and reduced P3 amplitude at Cz in the left ear, and scan duration, increased latency of N2 Cz and P3 in the right ear and N2 at Cz in the left ear, when compared to the control group. **Conclusion:** there are differences between the electrophysiological examinations of individuals who stutter compared with those with typical development. However, further studies in this area are still needed for the findings presented here can be confirmed.

**KEYWORDS:** Evoked Potentials, Auditory; Stuttering; Auditory Perception

### ■ INTRODUCTION

Stuttering is a speech disorder that may be related to several factors, such as genetic predisposition, oral motor skills, linguistic, cognitive, emotional and environmental factors<sup>1</sup>.

A fluent speech involves both organic aspects and a healthy nervous system. Stuttering may occur during the developmental process of children, when related to physical stressors, as early brain

injury, trauma or diseases at birth<sup>2</sup>, in addition, it may even present different hearing development in comparison to fluent individuals<sup>3,4</sup>.

Proper neurophysiological processing of speech requires temporal coordination between the execution of motor skills and the cognitive processing performance<sup>5</sup>; and stuttering individuals subjected to tests that assess neurological processing showed changes in auditory, temporal, linguistic and motor aspects<sup>6-8</sup>.

The neuroaudiological processes involved in fluency processing can be investigated through the evaluation of central auditory processing<sup>9</sup>, which is related to a series of processes that predominantly involve the central nervous system structures

<sup>(1)</sup> Universidade Estadual Paulista- Júlio de Mesquita Filho-UNESP/ Marília-SP, Brasil.

Conflict of interest: non-existent

(auditory cortex and pathways). The central auditory processing assessment enables the diagnosis of the auditory gnosis process of an individual and it is performed through the application of tests that show the individual's performance before the solution of a difficult task.

Long Latency Auditory Evoked Potentials (LLAEP) or Cognitive Potential (CP) are electrophysiological tests that evaluate the cortical activity involved in discrimination, integration and attention skills<sup>10</sup>. They also reveal the integrity and capacity of the central auditory nervous system (CANS)<sup>11,12</sup>, therefore these tests have been increasingly used in the investigation of the auditory pathway of individuals with stuttering.

Despite the P300 does not accurately identify the brain activation sites, research results have showed, to some extent, that differences in interhemispheric activation patterns can be measured pre and post treatment. In addition to issues related to the possibility of differentiating individuals for whom therapy proves more effective<sup>13</sup>.

Thus, studies on the cognitive potential in this population should be encouraged in order to clarify possible correlations between auditory aspects and fluency. Given the above, this study aimed to describe the electrophysiological findings of the individuals with stuttering and to compare with fluent individuals.

## ■ METHODS

This study was approved by the Research Ethics Committee of UNESP Marilia, Sao Paulo under number 0731/2013. All participants and parents were informed about the methodological procedures and signed the Informed Consent prior to any procedure.

A cross-sectional, quantitative and qualitative study, analytical type was performed. The participants were 34 individuals with and without stuttering, of both genders, aged between 7 and 31 years.

The experimental group consisted of 13 children (G2a) and 4 adults (G2b) evaluated and treated at the Research Laboratory of Fluency - LAEF - at the Center for Education and Health Studies (CEES) of UNESP, Marilia. The control group was formed by 13 fluent children (G1a) and 4 fluent adults (G1b).

The inclusion requirements for the two experimental groups were: to be native speaker of Brazilian Portuguese and have good academic performance. The individuals with stuttering (G2a and G2b) must have presented: (1) stuttering complaint; (2) diagnosis of persistent developmental stuttering by a professional of the area; (3) at least 3% of stuttering disfluencies<sup>14-16</sup>; (4) disfluencies

for at least 12 months and; (5) stuttering classified as mild according to the SSI -3 Stuttering Severity Instrument<sup>17</sup>. For the control group of fluent children and adults (G1a and G1b), the inclusion criteria were: (1) no complaints of current or previous stuttering; (2) negative family history of stuttering; (3) present less than 3% of stuttering disfluencies on a evaluation.

For the control group (G1a and G1b), 17 subjects were matched according to age, gender and educational level, with good performance.

Exclusion criteria for the groups included the presence of other associated impairments, such as biological, visual, and hearing complaints, audiological risk factors and/or hearing loss. These conditions were detected by the specialized team through history with the leaders and participants, inspection of the external auditory canal, tympanometry and audiometry.

In the investigation of these audiological risk factors, changes were detected in all cases, both in history and tympanometry, with type A curve in both ears and normal hearing level<sup>18</sup>.

Initially, the audiovisual recording of the subjects' self expressive speech sample was performed both for the experimental and control groups, consisting of 200 fluent syllables, using a Sony digital camcorder and tripod.

The transcription and analysis of the speech were carried out according to the ABFW (Child Language Test - Fluency)<sup>7</sup>, which considers the types of disfluencies, speech rate and the frequency of breaks. Subsequently, the Stuttering Severity Instrument (SSI-4)<sup>19</sup> was applied to the experimental group to classify the degree of stuttering as mild, moderate, severe or very severe.

In the second stage, for LLAEP evaluation, the Biologic Navigator Pro was used and recorded using five disposable electrodes placed at Fz and Cz in reference to the right lobe (A2) and left (A1), using two recording channels of the equipment, the ground electrode was placed at Fpz. The impedance was kept below 5 KW.

For P300 recording, the components were studied in two scans, i.e., firstly, tone stimuli (tone burst) differing in frequency (standard stimulus: 750Hz and deviation stimulus: 1000Hz), and after that, stimuli differing in duration (standard stimulus: 100ms and deviation stimulus: 50ms, both at 1000 Hz).

Both stimuli differing in frequency and duration were presented randomly in oddball paradigm, at 1.1 stimuli per second with the occurrence of deviation stimulus probability in 20% out of a total of 250 stimuli. The wave analysis time was 500ms,

with 0.5 filter at 30 Hz and sensitivity of 50,000 mV and alternating polarity.

The subject was instructed to perform an active task, paying attention and discriminating the stimuli, naming them as “fine” for the frequency stimuli and “short” for the duration stimuli.

The waves N1, P2, N2 and P3 were identified through the criteria set by Junqueira and Colafêmima<sup>20</sup>, adapted.

For the statistical analysis of data, the following was performed: descriptive statistics (mean and standard deviation) of the waves as for the latency (ms) and amplitude (microvolts), and exploratory (Student t test) to compare groups using the software STATISTICA 7.0. The adopted level of significance was 5% ( $p \leq 0.05$  \*).

## ■ RESULTS

Table 1 depicts the descriptive and inferential values of the variables studied in the LLAEP frequency to the experimental group of children (G2a) and the control group of children (G1a).

The results obtained in LLAEP research from children's groups (G1a and G2a) in relation to the frequency showed an increase in latency of components P2, N2 at Cz in the right ear, and N2 and P3 at Fz in the left ear, in the experimental group (G2a) in comparison with the control group (G1a). Regarding LLAEP amplitude components, a difference was

observed in P2 and P3 at Cz in the right ear, in G2a when compared to G1a (Table 1).

Table 2 shows the descriptive and inferential values of the variables studied in LLAEP duration, from the children experimental group (G2a) and the children control group (G1a).

As for the results obtained in relation to the duration test, comparing the child groups (G1a and G2a), a reduction in the amplitude of components N2 in Cz and Fz P3 in the right ear in G2a (Table 2).

Table 3 shows the descriptive and inferential values of the variables studied in the LLAEP frequency from the adult experimental group (G2b) and adult control group (G1b).

In LLAEP for the adult groups (G1b and G2b), regarding the frequency test, it was observed an increase in P3 latency at Cz and Fz in the right ear, in G2b compared to G1b. Regarding the amplitude of LLAEP components, a reduction in P3 at Cz in the left ear was observed, when comparing the two groups (G1b and G2b) (Table 3).

Table 4 shows the descriptive and inferential values of the variables studied in the LLAEP duration test from the adult experimental group (G2b) and adult control group (G1b).

As for the results obtained in relation to the duration study, when comparing the groups of adults (G1b and G2b), there was an increase in N2 and P3 latency at Cz in the right ear, in G2b group (Table 4).

**Table 1 – Descriptive and exploratory statistical analysis of the cognitive potential for the absolute amplitude and latencies of N1, P2, N2 and P3 components in ms, and the interamplitude N2-P3, for the record at Cz and Fz of G1 (a) child and G2 (a) child in the frequency test**

	PEALL	Control (G1a)		Research (G2a) n=13		Valor de p	
		Mean	SD	Mean	SD		
OD Cz	Latency	N1	104,66	16,56	113,86	22,88	0,251
		P2	163,36	31,64	192,03	33,71	*0,034
		N2	218,37	24,69	244,24	35,89	*0,042
		P3	323,04	21,09	339,61	41,36	0,210
	Amplitude	N1	-4,41	3,29	-5,26	2,70	0,474
		P2	0,76	2,21	3,33	2,41	*0,009
		N2	-5,14	3,35	-4,27	4,47	0,580
		P3	4,75	2,06	6,42	2,03	*0,049
Interamplitude	N2-P3	-8,83	6,22	-9,54	6,79	0,784	
OE Cz	Latency	N1	101,38	18,72	105,64	18,98	0,534
		P2	151,75	35,68	172,49	35,44	0,150
		N2	208,93	26,88	221,50	38,93	0,347
		P3	328,88	29,35	348,81	29,42	0,169
	Amplitude	N1	-4,10	2,30	-4,55	2,60	0,464
		P2	1,35	2,74	2,65	2,71	0,236
		N2	-5,02	3,34	-3,22	4,99	0,363
		P3	6,15	3,48	8,16	1,80	0,071
Interamplitude	N2-P3	-6,62	10,67	-11,68	5,64	0,143	
OD Fz	Latency	N1	118,28	24,98	121,88	28,37	0,734
		P2	170,89	42,65	191,47	48,19	0,260
		N2	213,17	36,83	240,96	36,92	0,066
		P3	325,04	25,54	348,90	45,66	0,113
	Amplitude	N1	-4,26	2,98	-5,15	2,38	0,408
		P2	-0,66	2,19	0,98	2,47	0,085
		N2	-4,66	3,02	-4,22	3,62	0,738
		P3	3,15	2,03	4,70	3,74	0,199
Interamplitude	N2-P3	-5,77	6,53	-8,13	7,28	0,393	
OE Fz	Latency	N1	109,63	25,34	112,84	21,24	0,738
		P2	154,47	24,70	181,38	45,96	0,051
		N2	201,00	19,90	233,17	47,50	*0,023
		P3	319,99	23,63	350,98	39,62	*0,032
	Amplitude	N1	-4,17	2,72	-6,06	3,14	0,080
		P2	-0,72	2,94	0,82	3,08	0,219
		N2	-6,04	3,61	-5,00	4,70	0,495
		P3	4,53	2,51	5,96	3,02	0,330
Interamplitude	N2-P3	-8,27	7,81	-9,04	7,38	0,798	

Caption: CG - control group; RG - research group; SD - standard deviation; RE - right ear; LE - left ear; t test - p\* ≤0,05

**Table 2 – Descriptive and exploratory statistical analysis of the cognitive potential for the absolute amplitude and latencies of N1, P2, N2 and P3 components in ms, and the interamplitude N2-P3, for the record at Cz and Fz GI (a) child and GII (a) child in the duration test**

	PEALL	Control (G1a) n=13		Research G2a) n=13		Valor de p	
		Mean	SD	Mean	SD		
OD Cz	Latency	N1	104,42	14,00	103,54	20,29	0,898
		P2	159,84	19,06	168,08	15,78	0,241
		N2	220,62	25,09	237,59	28,56	0,120
		P3	337,69	30,13	352,11	38,18	0,295
	Amplitude	N1	-3,98	3,19	-4,78	1,67	0,430
		P2	1,47	2,76	1,90	2,85	0,700
		N2	-6,40	2,52	-4,00	2,45	*0,021
		P3	5,45	2,31	5,17	2,31	0,764
Interamplitude	N2-P3	-10,01	7,82	-8,07	4,96	0,458	
OE Cz	Latency	N1	107,47	24,38	111,20	23,38	0,791
		P2	162,72	29,86	184,76	26,36	0,082
		N2	226,54	33,14	245,49	23,73	0,148
		P3	333,69	31,00	341,17	31,69	0,720
	Amplitude	N1	-4,23	2,74	-3,85	1,06	0,663
		P2	2,09	2,92	2,26	2,35	0,944
		N2	-5,29	3,75	-14,65	64,98	0,305
		P3	5,85	2,97	5,54	3,29	0,728
Interamplitude	N2-P3	-8,85	9,43	-9,73	3,44	0,752	
OD Fz	Latency	N1	117,88	21,20	111,07	23,99	0,450
		P2	166,97	36,45	152,47	17,80	0,508
		N2	207,16	27,08	211,81	32,81	0,697
		P3	333,29	17,36	334,57	44,63	0,924
	Amplitude	N1	-5,05	3,71	-3,76	2,65	0,318
		P2	-0,31	2,41	0,12	2,51	0,843
		N2	-5,50	2,65	-5,42	2,75	0,942
		P3	5,93	2,93	3,11	1,89	*0,007
Interamplitude	N2-P3	-11,43	4,72	-7,20	5,90	0,054	
OE Fz	Latency	N1	113,39	19,92	113,80	25,09	0,870
		P2	155,75	25,38	170,79	29,96	0,232
		N2	196,27	32,68	210,53	25,09	0,214
		P3	320,23	20,61	339,53	40,59	0,428
	Amplitude	N1	-4,20	3,22	-5,48	2,05	0,342
		P2	-0,79	3,29	-1,51	2,20	0,548
		N2	-4,79	3,25	-5,41	3,04	0,753
		P3	5,11	2,54	3,92	1,54	0,173
Interamplitude	N2-P3	-7,52	8,32	-9,07	3,35	0,538	

Caption: CG - control group; RG - research group; SD - standard deviation; RE - right ear; LE - left ear; t test - p\* ≤0,05

**Table 3 – Descriptive and exploratory statistical analysis of the cognitive potential, for the absolute amplitude and latencies of N1, P2, N2 and P3 components in ms, and the interamplitude N2-P3, for the record at Cz and Fz adult G1B and adult G2B in the frequency test**

	PEALL	Control (G1b) n=4		Research (G2b) N=4		Valor de p	
		Mean	SD	Mean	SD		
OD Cz	Latency	N1	88,99	16,34	107,21	17,13	0,170
		P2	145,98	20,80	182,42	29,20	0,088
		N2	203,50	19,22	237,60	37,28	0,155
		P3	301,61	19,41	360,69	39,07	*0,035
	Amplitude	N1	-5,91	3,24	-4,89	2,05	0,614
		P2	2,21	0,77	3,00	2,69	0,592
		N2	-4,80	1,57	-3,70	4,73	0,672
		P3	8,55	4,00	7,14	2,39	0,569
Interamplitude	N2-P3	-13,35	5,24	-10,84	6,89	0,583	
OE Cz	Latency	N1	102,78	17,43	106,16	25,42	0,833
		P2	152,75	11,29	169,15	12,65	0,101
		N2	201,42	18,57	228,49	34,00	0,211
		P3	280,79	23,52	337,53	50,73	0,088
	Amplitude	N1	-6,77	0,81	-2,32	4,35	0,090
		P2	3,66	1,66	2,00	2,02	0,250
		N2	-4,03	1,35	-4,69	3,40	0,727
		P3	9,89	1,45	6,51	1,22	*0,011
Interamplitude	N2-P3	-13,91	2,65	-11,20	4,48	0,336	
OD Fz	Latency	N1	93,67	17,57	109,55	21,90	0,301
		P2	171,75	24,74	201,16	53,73	0,358
		N2	207,93	28,35	256,07	41,65	0,104
		P3	300,05	43,62	380,74	34,74	*0,027
	Amplitude	N1	-7,21	1,92	-5,96	2,07	0,412
		P2	-0,46	1,13	1,01	2,71	0,353
		N2	-4,21	2,75	-3,60	3,71	0,802
		P3	8,04	7,53	6,52	4,37	0,739
Interamplitude	N2-P3	-12,25	7,76	-10,12	8,01	0,715	
OE Fz	Latency	N1	113,45	22,54	107,73	19,37	0,713
		P2	172,79	17,76	197,77	20,53	0,095
		N2	178,37	106,12	235,51	20,94	0,331
		P3	290,68	47,14	353,67	50,84	0,119
	Amplitude	N1	-3,84	7,37	-5,36	1,90	0,704
		P2	1,60	2,75	0,68	1,65	0,587
		N2	-3,80	1,42	-3,25	1,67	0,631
		P3	6,03	4,11	5,10	2,62	0,714
Interamplitude	N2-P3	-9,82	4,27	-8,34	4,27	0,642	

Caption: CG - control group; RG - research group; SD - standard deviation; RE - right ear; LE - left ear; t test - p\* ≤0,05

**Table 4 – Descriptive and exploratory statistical analysis of the cognitive potential for the absolute amplitude and latencies of N1, P2, N2 and P3 components in ms, and the interamplitude N2-P3, for the record at Cz and Fz G1 (b) adult and G2 (b) adult duration test**

	PEALL	Control (G1b) N=4		Research (G2b) n=4		Valor de p	
		Mean	SD	Mean	SD		
OD Cz	Latency	N1	94,72	15,26	104,86	27,89	0,546
		P2	161,86	20,70	181,38	23,82	0,262
		N2	221,72	12,59	248,00	14,57	*0,034
		P3	319,31	29,41	384,64	12,53	*0,006
	Amplitude	N1	-4,46	1,91	-4,01	2,08	0,762
		P2	1,33	1,16	2,62	1,90	0,290
		N2	-4,43	2,32	-3,06	1,44	0,356
		P3	5,43	1,49	4,23	2,46	0,436
Interamplitude	N2-P3	-9,85	3,70	-6,52	2,15	0,171	
OE Cz	Latency	N1	96,54	24,76	101,22	17,23	0,766
		P2	162,90	21,03	182,16	18,57	0,218
		N2	220,42	11,33	237,59	7,11	*0,042
		P3	318,53	39,29	356,53	24,89	0,153
	Amplitude	N1	-4,72	1,37	-4,00	1,28	0,472
		P2	30,9	2,11	2,20	2,90	0,636
		N2	-4,95	4,01	-4,02	3,53	0,737
		P3	6,09	2,49	5,60	1,95	0,763
Interamplitude	N2-P3	-10,89	6,13	-9,61	2,68	0,715	
OD Fz	Latency	N1	112,67	28,15	98,62	34,24	0,549
		P2	182,16	32,03	166,80	29,72	0,508
		N2	218,34	44,77	220,68	43,52	0,942
		P3	322,44	59,55	395,31	42,50	0,093
	Amplitude	N1	-5,26	3,94	-4,57	1,61	0,758
		P2	-0,88	2,64	0,11	1,67	0,547
		N2	-4,54	3,17	-3,04	1,59	0,430
		P3	7,29	10,16	3,78	0,62	0,516
Interamplitude	N2-P3	-11,82	12,89	-6,82	2,07	0,472	
OE Fz	Latency	N1	102,00	30,79	126,98	17,92	0,210
		P2	176,70	34,11	192,83	27,92	0,491
		N2	202,20	36,19	221,46	31,51	0,452
		P3	315,93	48,17	350,80	48,19	0,345
	Amplitude	N1	-5,25	1,79	-4,06	1,27	0,319
		P2	-0,55	1,97	0,07	2,69	0,725
		N2	-5,20	1,82	-1,85	3,19	0,117
		P3	3,39	2,35	3,39	0,19	0,998
Interamplitude	N2-P3	-8,59	1,88	-5,24	3,15	0,118	

Caption: CG - control group; RG - research group; SD - standard deviation; RE - right ear; LE - left ear; t test - p\* ≤0,05

## ■ DISCUSSION

In this study, neuroaudiological processes involved in fluency processing were investigated by evaluating auditory evoked potentials. When subjected to the tests that evaluated the neurological processing in the auditory and linguistic aspects<sup>7,8</sup>, the individuals with stuttering showed neurophysiological difficulties.

The literature has described functional differences in stutterers in the pattern of hemispheric activity in response to linguistic and non-linguistic stimuli, differences in neuro-magnetic response and P300 amplitude<sup>21,22</sup>.

When the fluent children group (G1a) and stuttering children group (G2a) were analyzed, differences were observed as to P3 amplitude, regardless of the stimulated ear.

As for the fluent adult group (G1b) and stuttering adult group (G2b), differences in the P3 amplitude, shorter when right ear was stimulated, identified to capture electrical activity in the midline of the cortex (Cz). Auditory Evoked Potentials are generated from the activation of thalamic-cortical pathways, primary auditory cortex and cortex. In general, latency spikes of auditory evoked potentials of stuttering people differ from fluent ones<sup>23-25</sup>.

The P2 component is an exogenous potential and its generation is related to the central auditory system responses to physical and acoustic parameters of auditory stimuli and represent the activation of the supratemporal laterofrontal auditory cortex. The N2 component is a mixed potential that has characteristics relating to exogenous and endogenous responses involved in the reception and interpretation of the physical and acoustic information of the auditory stimulus. This component suffers influences from the task of discrimination

and state of attention and represents the activity of the supratemporal auditory cortex<sup>26-28</sup>.

In this study we found changes in the P3 and N2 components for latency and amplitude in the stuttering children group (G1b) and stuttering adult group (G2b). When studied from non-linguistic stimuli using the oddball paradigm, the electrophysiological responses reflect the attention and auditory discrimination skills.

Especially in stuttering adult patients, the perception of the acoustic characteristics is performed with less precision and a longer reaction time to the target stimulus due to an impaired non-linguistic processing, which results in abnormal waveform patterns as observed in this study in stuttering in adults and children<sup>29,30</sup>.

The P3 is generated from endogenous characteristics related to cognition, more specifically to the identification task and appointment of stimuli<sup>23</sup>. Despite the P300 does not accurately identify the brain activation sites to be related to the associative auditory cortex<sup>28</sup> and to be generated from the activation of different areas of the cortex, the results of the study show the differences in the pattern of inter-hemispheric activation between stuttering and fluent people<sup>2,25,29</sup>. Studies<sup>24,25</sup> have showed differences especially regarding the latency in P3 component in stuttering and fluent.

## ■ CONCLUSION

There are differences between the electrophysiological tests of individuals with stuttering compared to fluent ones. However, further studies in this area are still needed before the findings presented here may be confirmed and allow progress to new proposals for evaluation of stuttering.



## RESUMO

**Objetivo:** descrever os achados dos exames eletrofisiológicos de indivíduos com gagueira e comparar com indivíduos com desenvolvimento típico. **Métodos:** participaram desta pesquisa 34 indivíduos, de ambos os gêneros, com idade entre 7 e 31 anos. O grupo pesquisa foi constituído por 13 crianças (G1a) e 4 adultos (G1b) diagnosticadas com gagueira e o grupo controle por 13 crianças (G2a) com bom desempenho acadêmico e 4 adultos (G2b) com desenvolvimento típico. Foi realizada a avaliação dos potenciais auditivos, na varredura de frequência e de duração. **Resultado:** quando comparados os grupos de crianças gagas e controle, foi observado que as crianças gagas apresentaram na varredura de frequência, aumento da latência dos componentes P2, N2 em Cz na orelha direita e N2 e P3 em Fz na orelha esquerda, e diferença na amplitude de P2 e P3 em Cz na orelha direita. Na varredura de duração, houve redução da amplitude dos componentes N2 em Cz e P3 em Fz na orelha direita. Já no grupo de adultos gagos, observou-se na varredura de frequência, aumento da latência no componente P3 em Cz e Fz na orelha direita e amplitude reduzida no P3 em Cz na orelha esquerda, e na varredura de duração, aumento de latência de N2 e P3 em Cz na orelha direita e N2 em Cz na orelha esquerda, quando comparados ao grupo controle. **Conclusão:** há diferenças entre os exames eletrofisiológicos de indivíduos com gagueira comparados aqueles com desenvolvimento típico. No entanto, novos estudos neste âmbito ainda são necessários para que os achados aqui apresentados possam ser confirmados.

**DESCRIPTORIOS:** Potenciais Evocados Auditivos; Gagueira; Percepção Auditiva

## ■ REFERENCES

- Smith A, Kelly E. Stuttering: A dynamic, multifactorial model. In: Curlee RF, Siegel GM. (Org) Nature and treatment of stuttering: New directions. Needham Heights: Allyn & Bacon. 1997. P. 204-17.
- Oliveira CMC, Souza HA, Santos AC, Cunha DS. Análise dos fatores de risco para gagueira em crianças disfluentes sem recorrência familiar. Rev CEFAC [online]. 2012 [acesso em 2014 abr 24]; 14(6): 1028-35. Disponível em: <http://www.scielo.br/pdf/rcefac/v14n6/212-10.pdf>
- Fox PT, Ingham RJ, Ingham JC, Hirsch TB, Downs JH, Martin C et al. A PET study of the neural systems of stuttering. *Nature*. 1996;382:158-62.
- Howel P, Williams SM. Development of Auditory Sensibility in Children who Stutter and Fluent Children. *Ear & Hearing*. 2004;25(3):265-73.
- Andrade CRF, Cervane LM, Sassi FC. Relationship between the stuttering severity index and speech rate. *Medical Journal*. 2003;121(2):81-4.
- Bosshardt HG, Ballmer W, De Nil LF. Effects of category and rhyme decisions on sentence production. *Journal Speech Language Hearing Research*. 2002;45(5):844-58.
- Andrade CRF. Abordagem neurolingüística e motora da gagueira. In: Ferreira, Ferreira, LP; Befi-Lopes, D; Limongi, SC. O Tratado de Fonoaudiologia. São Paulo: Roca, 2004. P. 1001-16.
- Biermann-Ruben K, Salmelin R, Schnitzler A. Right rolandic activation during speech perception in stutterers: a MEG study. *Neuroimage*. 2005;25(3):793-801.
- Schiefer A, Barbosa LMG, Pereira LD. Considerações preliminares entre uma possível correlação entre gagueira e os aspectos lingüísticos e auditivos. *Pró-Fono R Atual Cient*. 1999;1(1):31-7.
- Mcpherson DL. Late potentials of the auditory system. San Diego: Singular Publishing Group, 1996.
- Baran JA, Musiek FE. Behavioral assessment of the central auditory nervous system. In: Rintelmann W. F (Ed). *Hearing Assessment*. 2<sup>nd</sup> Ed. Boston: Allyn & Bacon, 1991.
- Schochat E, Matas CG, Sanches SGG, Carvalho RMM, Matas S. Central auditory evaluation in multiple sclerosis: case report. *Arquivos de Neuro-Psiquiatria*. 2006;64(3):872-6.
- Andrade CRF, Sassi FC, Matas CG, Neves IF, Martins VO. Potenciais evocados auditivos pré e pós-tratamento em indivíduos gagos: estudo piloto. *Pró-Fono R Atual Cient*. 2007;19(4):401-5.
- Riley GD. A stuttering severity instrument for children and adults. SSI-3. 3rd ed. Austin: ProEd; 1994.
- Yairi E, Ambrose N. Onset of stuttering in preschool children: select factors. *J Speech Lang Hear Res*. 1992;35(4):783-8.
- Bloodstein O. A handbook on stuttering. Chicago: National Easter Seal Society; 1995.

17. Yairi E, Ambrose NG, Cox N. Genetics of stuttering: a critical review. *J Speech Lang Hear Res.* 1996;39:771-84.
18. Jerger J. Clinical experience with impedance audiometry. *Arch Otolaryngol.* 1970;92(4):311-24.
19. Riley G. Stuttering severity instrument for young children (SSI-4) (4<sup>o</sup>ed.). Austin, TX: Pro-Ed. 2009.
20. Junqueira CAO, Colafêmnia JF. Investigação da estabilidade inter e intra-examinador na identificação do P300 auditivo: análise de erros. *Rev Bras Otorrinolaringol.* 2002;68(4):468-78.
21. Salmelin R, Schnitzler A, Scmitz F, Jancke L, Witte OW, Freund HJ. Functional organization of the auditory cortex is different in stutterers and fluent speakers. *Neuroreport.* 1998;13(9-10):2225-9.
22. Morgan MD, Cranford JL, Burk K. P300 event-related potentials in stutterers and nonstutterers. *Journal Speech Language Hearing Research.* 1997;40(6):1334-40.
23. Eggermont JJ, Ponton CW. The neurophysiology of auditory perception: From single units to evoked potentials. *Audiology and Neuro-Otology.* 2002;7(2):71-99.
24. Andrade CRF, Sassi FC, Matas CG, Neves IF, Martins VO. Potenciais evocados auditivos pré e pós-tratamento em indivíduos gagos: estudo piloto. *Pró-Fono R Atual Cient.* 2007;19(4):401-5.
25. Angrisani RMG, Matas CG, Neves IF, Sassi FC, Andrade CRF. Avaliação eletrofisiológica da audição em gagos, pré e pós terapia fonoaudiológica. *Pró-Fono R Atual Cient.* 2009;21(2):95-100.
26. Hansen JC, Hillyard SA. Temporal dynamics of human auditory selective attention. *Psychophysiology.* 1988;25:316-29.
27. Oades RD, Dittmann-Balcar A, Schepker R, Eggers C, Zerbin D. Auditory event-related potentials (ERPs) and mismatch negativity (MMN) in healthy children and those with attention-deficit or tourette/tic symptoms. *Biological Psychology.* 1996;12:163-85.
28. Hall J. Handbook of auditory evoked responses. Boston: Allyn & Bacon, 2006.
29. Hampton A, Weber-Fox C. Nonlinguistic auditory processing in adults who stutter. *Journal of Fluency Disorders.* 2008;33(4):253-330.
30. Preibisch C, Raab P, Neumann K, Euler HA, Von Gudenberg AW, Gall V et al. Event-related fMRI for the suppression of speech-associated artifacts in stuttering. *NeuroImage.* 2003;19(3):1076-84.

<http://dx.doi.org/10.1590/1982-0216201517610114>

Received on: May 24, 2014

Accepted on: November 13, 2014

Mailing address:

Ana Claudia Figueiredo Frizzo

Av. Vicente Ferreira, 1278 - Bairro Cascata

Marília – SP – Brasil

CEP: 17515-901

E-mail: [anafrizzo@marilia.unesp.br](mailto:anafrizzo@marilia.unesp.br)