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Original articles

Temporal auditory processing and the distinctive features of children with phonological disorder

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Conflict of interests: Nonexistent

ABSTRACT

Purpose: to assess whether there is a relationship between temporal auditory processing skills and altered distinctive features in cases of phonological disorder.

Methods: 18 children aged between 6 and 8 years, diagnosed with phonological disorders participated in the research. All children underwent speech-language screening, phonological assessment and the assessment of temporal processing skills through the GIN – Gap in Noise Test, TPF – Frequency Pattern Test and TPD – Duration Pattern Test. The numbers of altered phonemes and distinctive features and the level at which they were in the Implicational Model of Features Complexity were compared with those of the GIN, TPF and TPD tests. The significance level adopted for all statistical tests was 5% ($p<0.05$).

Results: in no comparison and correlation was there statistical significance, but the subjects evaluated showed low performance in temporal auditory processing tasks, according to normative testing standards.

Conclusion: in the general analysis, there was no relationship between temporal auditory skills and distinctive traits in the population assessed, even though they had difficulties in temporal auditory processing tasks.

Keywords: Speech; Speech Perception; Auditory Perception

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INTRODUCTION

Considering the normal development of language, it is through the perception of speech sounds that children learn the rules of the linguistic system to which they are being exposed to and, thus, organize the phonological system of their language[1].

When the correct appropriation of this system does not occur, the phonological disorder (PD) is established. It consists of a developmental feature that corresponds to a speech difficulty which is characterized by the inappropriate use of the contrastive sounds of the language, according to age and regional variations[2,3].

The production of intelligible speech depends both on programming and motor execution capabilities, as well as on the ability to process the paradigms of the acoustic spectrum. Then, there is a close relationship between temporal acoustic perception and speech perception. For this reason, it is understood that changes in central auditory processing (CAP), and even the delay in the stages of maturation of auditory skills, may be a predictive factor of disorders in the development of speech and oral and written language[1,4-7].

In PD, production of speech of each child, when analyzing the distinctive features that make up the difficulties of this production, may show greater difficulties in the spectral or temporal decoding of sounds. In this sense, some studies have verified the importance of evaluating auditory discrimination in cases of PD, verifying the influence of all auditory skills in cases of phonological disorders[8,9]. In addition, several studies have already related PD and CAP, demonstrating, in general, that children with PD present alterations in auditory skills[4-7,10-14].

Among the altered skills, investigations into temporal auditory processing skills1[1,6,7,15-17] can be observed. A possible justification for the implication of this skill in speech production is that temporal resolution is the skill that contributes to the detection of small acoustic variations in time. In this way, it is fundamental in the detection and auditory recognition of all sound elements, constituting a prerequisite for language skills. This statement is justified because, in order to correctly discriminate and produce phonemes, it is necessary to know how to identify and discriminate small acoustic alterations, such as the perception of sound intervals, subtle alterations in duration and frequency. It is considered that deficits in temporal auditory ability generate difficulties in sound discrimination, and this difficulty has already been verified in children with PD[1,13,15].

Although some studies indicate the importance of temporal processing for phonological acquisition, in most of them the temporal processing skills (temporal resolution and temporal ordering) were investigated using only one test to assess only one of these skills, that is, they made use of the test that evaluates the perception of temporal gap or the test that evaluates temporal ordering, through the frequency or duration pattern tests or simplified assessment of central auditory processing. However, in this study, a test was used to assess temporal resolution and another test to assess temporal ordering, thus enabling a complete analysis of temporal auditory processing.

Based on these data, it is important to verify whether there is a relationship between auditory temporal processing skills, both temporal resolution and temporal ordering, with altered distinctive features in PD cases, which is the aim of the present study.

METHODS

This research was developed as part of a larger project entitled: “The study of different perceptual skills in children with typical and atypical speech development”. This study is characterized by being transversal and quantitative. The research was developed in the clinical school of the Speech, Language and Hearing Sciences Major at *Universidade Federal de Santa Maria (UFSM), Brazil,* according to rules regulated by Resolution 196/1996 (BRAZIL Resolution MS/CNS/CNEP nº.466/2012). Ethics in Research with Human Beings from UFSM, Brazil, with registration number 046/2011 and CAAE 0202.0.243.000-11.

Participants were selected through a speech screening, carried out in two schools in a city in southern Brazil. Subjects were also elected through the analysis of the screenings carried out in the Clinical Practice of Speech Therapy and Public Health I and II, which are attended by students of the fourth year of Speech, Language and Hearing Sciences Major at the home institution where the study was carried out.

For children to be included in the sample, the following inclusion criteria were observed: age between 6:0 and 8:0; be monolingual speakers of Brazilian Portuguese; be right-handed; present a diagnosis of phonological disorder; present hearing thresholds better than 15 dBHL bilaterally from 250 to 8000 Hz; parents or guardians sign the Free and Informed Consent Term (FICT); and the children themselves consent to their participation. As exclusion criteria, the following aspects were considered: having received or being receiving speech therapy; having difficulty concentrating; be a practitioner of activities with musical instruments; present other speech-language disorders that interfere with speech production, such as voice alterations, orofacial motricity, hearing, other language levels, in addition to the phonological component, and present evident neurological, cognitive or psychological alterations.

Thus, for the selection of the sample, an initial interview with the parents or guardians, speech screening and phonological assessment were carried out. In the initial interview, data on pregnancy and childbirth, motor and linguistic development, breastfeeding and current diet, aspects related to sociability, sleep, general health and schooling were investigated.

In the speech therapy screening, aspects of the stomatognathic system were observed - through the application of the MBGR protocol (Marchesan, Berretin-Felix, Genaro, Rehder)[18], in which aspect, posture, muscle tension and mobility of phonoarticulatory organs and their functions are observed - breathing, phonoarticulation, mastication and swallowing. Language aspects were also analyzed, through spontaneous speech obtained in the description of a logical sequence; voice, through the glottic source perceptual assessment scale – RASATI (Hoarseness, Roughness, Breathiness, Asthenia, Tension, Instability)[19], and hearing, through hearing assessment performed at the Audiology Laboratory of the HEI (Higher Education Institution).

To carry out the hearing assessment, according to the ANSI S3.21-1978[20] standard, a properly calibrated Fonix audiometer, model FA-12 and type I, was used. First, the external acoustic meatus of both ears was inspected with the aid of an otoscope, in order to verify the accumulation of cerumen or the presence of foreign objects in the region. Afterwards, the audiological assessment itself was carried out, being investigated the auditory thresholds, of the airway, between the frequencies of 250 and 8000 Hz, being considered normal thresholds of up to 15 dBHL for each tested frequency. Observing that no subject presented conductive problems, all had symmetry[21] between the ears in terms of auditory acuity and it was the first time that they underwent CAP assessment.

The assessment of the phonetic and phonological system of the children aimed to identify cases of phonological disorder and was performed using the Child Phonological Assessment (CPA) instrument. To this end, the child was asked to spontaneously name the items contained in the five figures of the instrument and this speech sample was recorded. After the phonetic transcription, the contrastive analysis was carried out in order to establish the phonetic and phonological systems. This instrument was also used in order to calculate the degree of severity of the phonological disorder and to carry out the analysis of distinctive features and phonetic-phonological inventory, observed in cases of speech disorder.

When necessary, complementary exams were performed, such as: otorhinolaryngological, neurological and psychological assessment, in order to confirm the exclusion or inclusion of the subject in the research.

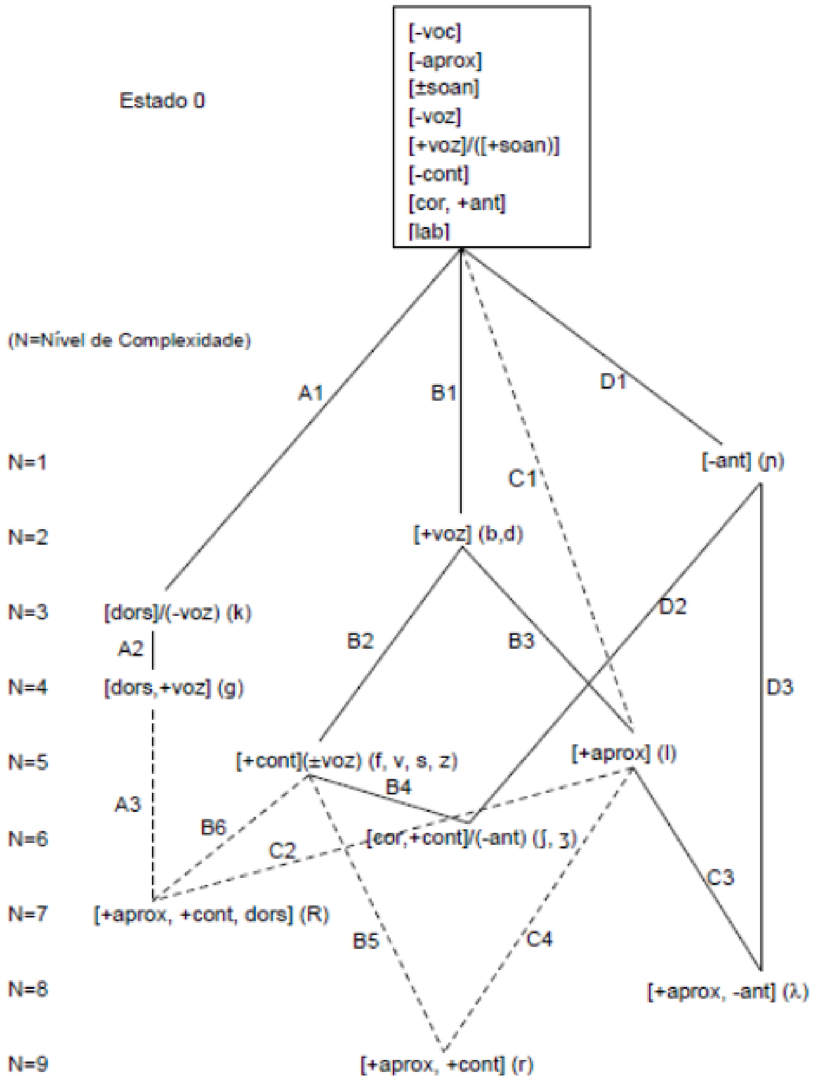
Then, after the assessments, the research sample consisted of 18 subjects aged between 6 and 8 years, diagnosed with phonological disorder. With these subjects, the analysis of the phonetic-phonological systems was performed, based on the results of the CPA instrument previously applied. The phonological inventory was described by the verification of acquired phonemes (correct production equal to or greater than 80%), partially acquired (40% to 79% of production) and non-acquired (equal to or less than 39% of production)[22].

In addition, the analysis was performed using the Implicational Model of Trait Complexity - IMTC[23], modified[24] as shown in Figure 1. The distinctive features or combinations of distinctive features that make up the phonemes considered absent or partially acquired were identified in the analysis of distinctive features. IMTC represents the relationship of implication between the distinctive features, forming paths to be followed during phonological acquisition. The lines drawn in the model represent the paths, establishing the relationship of implication between the distinctive features (the presence of a feature at a lower/marked/complex level implies the presence of another feature at a higher/unmarked/less complex level). Solid lines establish stronger relationships, while dotted lines denote weaker relationships.

The author[23] of this model affirms that, during the acquisition process, the child presents a basic representational structure (unmarked distinctive features) and, as the acquisition takes place, the input and the cognitive and articulatory abilities themselves will influence the specifications of other traits. (marked distinctive features) that were not present in the initial basic representation. On the other hand, the increase in complexity does not occur in the same way for all children, as they do not follow the same route of acquisition, they can go through different paths to reach the adult target.

In this way, it was possible to perceive the paths already covered by each subject in the modified IMTC and in which maximum level of development each subject was. For that, the percentages of alterations of distinctive features or combinations of distinctive features were used according to the possibilities of each level of complexity, considering the total number of occurrences of each phoneme and its corresponding level in the assessment of each child.

For the analysis of IMTC, it was decided to categorize the subjects in three levels, because, of the eighteen subjects evaluated, all were concentrated in four levels of the IMTC, therefore, the levels were categorized in level 5 plus level 7 (L5 + L7), level 8 (L8) and level 9 (L9).



Source: Rangel (1998)
Captions: N: Complexity Level; Voc: Vocalic; Approx: Approximant; Soan: Sonorant; Voz: Voiced; Cont: Continuant; Cor: Coronal; Ant: Anterior; Lab: Labial; Dors: Dorsal.

Figure 1. Implicational Model of Trait Complexity with alterations proposed by Rangel (1998)

The duration pattern and frequency pattern tests[25] and the Gap in Noise test (GIN)[26] were applied in the assessment of temporal auditory processing. CAP tests were performed in the Audiology Sector of the Speech Therapy Service (SAF) of the institution of origin, in a soundproof booth, using the following materials: two-channel digital audiometer, Fonix, model FA-12 and type I; Telephonics earphones, model TDH-39P and MX-41 cushion and Sony CD-player, model D-11, coupled to the audiometer.

In the application of all tests of temporal auditory processing, the tritone mean of the frequencies of 500, 1000 and 2000 Hz was used, based on the values found in the pure tone audiometry of each child per ear. This mean was added to 50 dB HL. The PPS and DPS tests were applied binaurally and the GIN test in monaural mode.

The Pitch Pattern Sequence (PPS) test used in this study was developed by Auditec, as it presents a children's version, which consists of the presentation of 60 sequences of three pure tones each, which differ from each other. in relation to the frequency of stimuli: fine/high (1430 Hz) and coarse/low (880 Hz). Of the 60 sequences, 30 are answered in the form of a murmur and 30 in the form of naming. The expected response norm is, between 6 and 7 years old, 60%, and between 7 and 8 years old, it is 76%.

The Duration Pattern Sequence (DPS) test is similar to the PPS[25], however, in this one, the frequency is kept at 1000 Hz and the duration of the tones is varied (250 ms - short; and 500 ms - far away). Even though this test does not present a normal pattern for the age group analyzed here, it is known that it is closely related to learning[27], being used as a parameter for comparing pre and post-therapy. In the same way as the PPS, in the DPS 60 sequences are presented, 30 must be answered in the form of a murmur and 30 in the form of naming. In adults, the expected percentage of correct answers is greater than 70%, and at 9 years of age children already present results similar to those of adults. Younger children needed longer duration patterns to perform the task, considering that at 7 years old the expected is around 9% of correct answers and at 8 years old the percentage of 13% naming and 15% mumbling[27].

The GIN Test (Gap in Noise) was developed[28] and its objective is to determine the gap detection threshold, in other words, silence interval detection. To be able to detect the intervals, it is necessary to be able to solve aspects related to the time of the acoustic event. The name given to the auditory behavior that characterizes this kind of ability is temporal resolution. The test consists of four tracks, each one consisting of several six-second segments of white noise, five seconds apart. Inserted in the noise stimuli, there are gaps in different positions and duration, however, for this research, a band was applied to each ear (lanes 1 and 2). The duration threshold was considered to be the smallest time gap detected from four of the six presentations. For children, the expected result is a threshold lower than 6 ms[29], however, at 7 years old the children presented responses close to those obtained by adults, which would be 5 ms[30]. The results of the GIN test, in this study, for better analysis, were categorized into normal and altered, being considered a normal response when the child obtained a result between 2 and 6 ms (milliseconds), which is the test normative, and it was considered altered when the score was greater than 6 ms or when the child was unable to perform the task.

After carrying out all the assessments, the results of the tests that assess the temporal auditory processing ability (GIN, PPS and DPS) were correlated with the absent distinctive features.

For this purpose, the profile of the sample was described according to the variables under study from frequency tables with absolute (n) and relative (%) frequency values of the categorical variables and descriptive statistics of the numerical variable (GIN, PPS and DPS tests) , with mean values, standard deviation, minimum values, maximum values and median. Pearson's chi-square test or Fisher's exact test was used to compare categorical variables in the presence of expected values lower than 5. In order to compare numerical variables between groups, the Mann-Whitney (2 groups) and Kruskal-Wallis (3 or more groups) tests were used, due to the absence of normal distribution. In order to analyze the relationship between numerical variables (distinctive features, number of altered distinctive features and number of altered phonemes) the correlation coefficient of Spearman was used. It was adopted for all statistical tests the significance level of 5% ($p<0.05$).

RESULTS

In this session, the results of the comparisons between the temporal auditory processing tests and the different levels of the IMTC will be presented; the correlation of temporal processing results with the number of altered phonemes and the number of altered distinctive features of the 18 evaluated subjects.

Table 1 shows data from the comparison of the results of PPS and DPS tests, naming and murmuring, in the different IMTC groupings. As can be verified, there was no significant difference in the performance of the temporal tests by the children according to the IMTC levels in which they were.

However, when analyzing the means of PPS test, it is noted that the subjects who are in the last level (L9) obtained higher values than the others. On the contrary, N8 children presented lower responses than L5+L7 subjects. In the analysis of the results of DPS test, it is possible to observe a better performance of the subjects who are in L8, followed by L9 and, finally, in L5+L7. Thus, when comparing the means of correct answers in the two tests, a worse performance in the performance of the DPS test compared to the PPS test is observed, even though DPS test normative is lower than that of PPS test.

Table 1. Comparative analysis of the numerical variables of the three groups of the Implicational Model of Trait Complexity in relation to performance in the Frequency Pattern Test and Duration Pattern Test

IMTC	VARIABLE	N	MEAN OF CORRECT ANSWERS	S.D.	MIN	MEDIAN	MAX	P-VALUE*
L5+L7	NAMPPS	5	35.33	38.99	0.00	23.33	80.00	p=0.949
	MURMPPS	5	38.67	41.14	0.00	30.00	83.33	p=0.877
	NAMDPS	5	16.00	16.90	0.00	16.66	40.00	p=0.929
	MURMDPS	5	18.66	19.66	0.00	20.00	46.66	p=0.929
L8	NAMPPS	8	29.98	29.53	0.00	26.67	73.33	-
	MURMPPS	8	33.75	32.09	0.00	33.33	80.00	-
	NAMDPS	8	23.74	26.68	0.00	15.00	56.66	-
	MURMDPS	8	24.17	27.12	0.00	15.00	56.66	-
L9	NAMPPS	5	36.67	37.93	0.00	43.33	90.00	-
	MURMPPS	5	40.66	40.71	0.00	46.66	93.33	-
	NAMDPS	5	20.00	28.96	0.00	0.00	63.33	-
	MURMDPS	5	22.00	31.94	0.00	0.00	70.00	-

Captions: IMTC: Implicational Model of Trait Complexity; DPS: Duration Pattern Sequence Test; PPS: Pitch Pattern Sequence Test; N: number of subjects; S.D.: standard deviation; MIN: minimum; MAX: maximum; P-value*: referring to the Kruskal-Wallis test to compare the variables between the 3 groups; L5: Complexity level 5; L7: Complexity level 7; L8: Complexity level 8; L9: Complexity level 9; NAMPPS: Named Frequency Pattern Sequence Test; MURMPPS: Murmured Pitch Pattern Sequence Test; NAMDPS: Named Duration Pattern Sequence Test; MURMDPS: Murmured Duration Pattern Sequence Test.

Table 2 shows the comparison of IMTC levels in relation to the performance in GIN test in the left ear and in the right ear. It was also not possible to observe a significant difference in the analyses. What can be noticed is that most subjects showed difficulty in performing the temporal gap perception task, regardless of phonological development, that is, of being more evolved in IMTC levels.

Table 2. Comparative analysis of the numerical variables of the three groups of the Implicational Model of Trait Complexity with the Gap-In-Noise test

	*GIN*RE		FREQUENCY		*GIN*LE		FREQUENCY
IMTC	**Altered N (%)**	**Normal N (%)**	**Total N**	**IMTC**	**Altered N (%)**	**Normal N (%)**	**Total N**
L5+L7	2 (15.38)	3 (60.00)	5	L5+L7	4 (26.67)	1 (33.33)	5
L8	7 (53.85)	1 (20.00)	8	L8	6 (40.00)	2 (66.67)	8
L9	4 (30.77)	1 (20.00)	5	L9	5 (33.33)	0 (0.00)	5
Total	13	5	18	Total	15	3	18
p=0.286				p=0.755			

Captions: IMTC: Implicational Model of Trait Complexity; *GIN: Gap in Noise*; N: number of subjects; *GIN*RE: *Gap in Noise* right ear; *GIN*LE: *Gap in Noise* left ear; L5: Complexity level 5; L7: Complexity level 7; L8: Complexity level 8; L9: Level of complexity 9. The statistical test used was Fischer's Exact Test.

Regarding the results of the correlation between PPS and DPS tests (naming and murmuring) with the number of altered distinctive features and the number of altered phonemes of the research subjects, no significant correlation was observed (Table 3).

Table 3. Correlation of the Pitch Pattern Sequence Test and Duration Pattern Sequence tests with the specific distinctive features that are altered in the studied sample

		NAMPPS	MURMPPS	NAMDPS	MURMDPS
SOUNDING	*r	0.02411	0.02409	0.12493	0.12493
	P	0.9244	0.9244	0.6214	0.6214
APPROACHING	*r	0.02411	0.02409	0.12493	0.12493
	P	0.9244	0.9244	0.6214	0.6214
VOICE	*r	-0.20384	-0.20373	0.16864	0.16864
	P	0.4172	0.4175	0.5035	0.5035
CONTINUOUS	*r	-0.31548	-0.35559	-0.03342	-0.03342
	P	0.2022	0.1476	0.8953	0.8953
LABIAL>CORONAL	*r	-0.02411	-0.02409	0.02499	0.02499
	P	0.9244	0.9244	0.9216	0.9216
CORONAL>LABIAL	*r	-0.26517	-0.26503	0.07496	0.07496
	P	0.2876	0.2878	0.7675	0.7675
CORONAL>ANTERIOR	*r	-0.16268	-0.14682	-0.03214	-0.03214
	P	0.5189	0.5610	0.8992	0.8992
CORONAL>DORSAL	*r	0.04482	-0.00487	0.21210	0.21210
	P	0.8598	0.9847	0.3981	0.3981
DORSAL>CORONAL	*r	-0.26517	-0.26503	0.07496	0.07496
	P	0.2876	0.2878	0.7675	0.7675

Captions: NAMPPS: Named Frequency Pattern Sequence Test; MURMPPS: Murmured Pitch Pattern Sequence Test; NAMDPS: Named Duration Pattern Sequence Test; MURMDPS: Murmured Duration Pattern Sequence Test; *r=Spearman's correlation coefficient; p=p-value **>**: indicates the substitution; in the alterations of CORONAL**>**ANTERIOR were considered as well as the alterations of [+ant] > [-ant] and [-ant] > [+ant].

Table 4 shows the comparative analysis of GIN test with the number of altered distinctive features and altered phonemes. Table 5 shows the comparative analysis of GIN test with the specific distinctive features. It can be observed that there was no significant relationship between any of the variables.

Table 4. Results of the comparative analysis of the Gap-In-Noise test with the number of altered phonemes, total number of altered distinctive features

GIN	VARIABLE	N	MEAN	S.D.	MIN	MEDIAN	MAX	P-VALUE*
ALTERED RE	NO. ALTERED DISTINTIVE FEATURES	13	4.31	4.27	0.00	3.00	16.00	p=0.549
	NO. ALTERED PHONEMES	13	3.15	2.94	1.00	2.00	9.00	p=0.223
NORMAL RE	NO. ALTERED DISTINTIVE FEATURES	5	6.20	4.97	1.00	6.00	13.00	-
	NO. ALTERED PHONEMES	**5**	**5.00**	**3.39**	**1.00**	**5.00**	**10.00**	-
GIN	**VARIABLE**	**N**	**MEAN**	**P.D.**	**MIN**	**MEDIAN**	**MAX**	**P-VALUE***
ALTERED LE	NO. ALTERED DISTINTIVE FEATURES	15	4.40	4.44	0.00	3.00	16.00	p=0.368
	NO. ALTERED PHONEMES	15	3.27	3.10	1.00	2.00	10.00	p=0.143
NORMAL LE	NO. ALTERED DISTINTIVE FEATURES	3	7.00	4.36	2.00	9.00	10.00	-
	NO. ALTERED PHONEMES	**3**	**5.67**	**2.52**	**3.00**	**6.00**	**8.00**	-

Captions: *GIN: Gap in Noise*; N: number of subjects who responded to the test; S.D.: standard deviation; MIN: minimum; MAX: maximum; P-value*: referring to the Mann-Whitney test to compare the variables between the 2 groups; RE: right ear; LE: left ear; No.: number.

Table 5. Results of the comparative analysis of the Gap-In-Noise test with the specific distinctive features altered

***GIN*RE**	**VARIABLE**	**N**	**MEAN**	**S.D.**	**MIN**	**MEDIAN**	**MAX**	**P-VALUE***
ALTERED	SOUNDING	13	0.08	0.28	0.00	0.00	1.00	p=0.535
	APPROACHING	13	0.08	0.28	0.00	0.00	1.00	p=0.535
	VOICE	13	0.92	1.89	0.00	0.00	7.00	p=0.495
	CONTINUOUS	13	0.92	1.19	0.00	1.00	4.00	p=0.790
	LABIAL>CORONAL	13	0.00	0.00	0.00	0.00	0.00	p=0.107
	CORONAL>LABIAL	13	0.23	0.83	0.00	0.00	3.00	p=0.535
	CORONAL>ANTERIOR	13	1.77	1.88	0.00	1.00	7.00	p=0.762
	CORONAL>DORSAL	13	0.62	1.71	0.00	0.00	6.00	p=0.367
	DORSAL>CORONAL	13	0.08	0.28	0.00	0.00	1.00	p=0.535
NORMAL	SOUNDING	5	0.00	0.00	0.00	0.00	0.00	-
	APPROACHING	5	0.00	0.00	0.00	0.00	0.00	-
	VOICE	5	1.40	3.13	0.00	0.00	7.00	-
	CONTINUOUS	5	0.80	0.45	0.00	1.00	1.00	-
	LABIAL>CORONAL	5	0.20	0.45	0.00	0.00	1.00	-
	CORONAL>LABIAL	5	0.00	0.00	0.00	0.00	0.00	-
	CORONAL>ANTERIOR	5	2.00	2.00	0.00	2.00	4.00	-
	CORONAL>DORSAL	5	0.00	0.00	0.00	0.00	0.00	-
	DORSAL>CORONAL	5	0.00	0.00	0.00	0.00	0.00	-
***GIN*LE**	**VARIABLE**	**N**	**MEAN**	**S.D.**	**MIN**	**MEDIAN**	**MAX**	**P-VALUE***
ALTERED	SOUNDING	15	0.07	0.26	0.00	0.00	1.00	p=0.655
	APPROACHING	15	0.07	0.26	0.00	0.00	1.00	p=0.655
	VOICE	15	0.80	1.78	0.00	0.00	7.00	p=0.891
	CONTINUOUS	15	1.00	1.07	0.00	1.00	4.00	p=0.249
	LABIAL>CORONAL	15	0.07	0.26	0.00	0.00	1.00	p=0.655
	CORONAL>LABIAL	15	0.20	0.77	0.00	0.00	3.00	p=0.655
	CORONAL>ANTERIOR	15	1.87	1.96	0.00	1.00	7.00	p=0.952
	CORONAL>DORSAL	15	0.53	1.60	0.00	0.00	6.00	p=0.515
	DORSAL>CORONAL	15	0.07	0.26	0.00	0.00	1.00	p=0.655
NORMAL	SOUNDING	3	0.00	0.00	0.00	0.00	0.00	-
	APROACHING	3	0.00	0.00	0.00	0.00	0.00	-
	VOICE	3	2.33	4.04	0.00	0.00	7.00	-
	CONTINUOUS	3	0.33	0.58	0.00	0.00	1.00	-
	LABIAL>CORONAL	3	0.00	0.00	0.00	0.00	0.00	-
	CORONAL>LABIAL	3	0.00	0.00	0.00	0.00	0.00	-
	CORONAL>ANTERIOR	3	1.67	1.53	0.00	2.00	3.00	-
	CORONAL>DORSAL	3	0.00	0.00	0.00	0.00	0.00	-
	DORSAL>CORONAL	3	0.00	0.00	0.00	0.00	0.00	-

Captions: *GIN*RE*: Gap in Noise* right ear; *GIN*OE: *Gap in Noise* left ear; N: number of subjects who responded to the test; S.D.: standard deviation; MIN: minimum; MAX: maximum; RE: right ear; LE: left ear; P-value*: referring to the Mann-Whitney test to compare the variables between the 2 groups; **>**: indicates the substitution in the alteration of **CORONAL>ANTERIOR** were considered as well as the alterations of [+ant] **>** [-ant] and [-ant] **>** [+ant].

DISCUSSION

The analysis of the results showed that, in the comparison between the variables, there was no statistically significant difference in all performed analyzes.

In the analysis of IMTC separated by groups (L5+L7, L8 and L9), an improvement in the results is noted in PPS test when comparing the means between the L5+L7 and L9 levels, however, when the L8 is verified, the means get worse. A similar result was found in the means of DPS test, where there is also an improvement when comparing the L5+L7 and L8 levels, but worsening when the L9 results are analyzed. However, none of the performed analyzes was statistically significant. Based on these results, it can be verified that the child presenting a less altered phonological system does not mean that he will have better performance in temporal processing tasks.

These data suggest that the temporal auditory abilities of subjects with PD would not follow the same pattern of development as the phonological acquisition, because, even the subjects with a slightly altered phonological system, presented great difficulty in performing temporal processing tasks. This fact is observed in the analysis of the averages of the temporal tests[27-29].

In a study[10], when analyzing the sequence of verbal sounds in the simplified CAP assessment, the authors observed that temporal ordering shows to be the skill that can be most compromised in children with alteration of distinctive features.

The relationship between language problems and CAP is already known, especially regarding oral language comprehension. The perceptual abilities of a child influence the development of speech. By receiving stimuli, analyzing and organizing the processing of auditory information, the child will establish a mental representation of the linguistic stimulus and store it in memory[10,31-33]. However, this finding was not confirmed in the present study, because, according to the results, the performance in temporal processing did not follow the evolution in the phonology of the evaluated subjects.

When analyzing the results of PPS and DPS tests, it is noted that the subjects presented greater difficulty with the duration pattern test. In a research[34] of literature review on the use of PPS and DPS tests in Brazil, the researchers concluded that, in most speech-language disorders, the temporal ordering ability is altered, and the most used test in Brazil to verify this ability was the of frequency pattern. However, the authors did not show differences between PPS and DPS tests in Brazil[34].

Such difference in performance between tests was reported in a study[27] which verified the performance in the frequency and duration pattern tests in children aged between 7 and 11 years, with normal speech development. When comparing the results between the frequency and duration pattern tests, the author observed a worse performance in the duration pattern test. This result is in agreement with the present research, as younger children presented lower performances in DPS compared to PPS in the Auditec test, also used in this study. It is worth mentioning that this did not aim to statistically correlate the results of the PPS and DPS tests, however, it observed, through the analysis of the results, the same pattern of responses between the tests. The aforementioned author states that the frequency pattern may have an innate determination, while the duration pattern depends on stimuli from the environment, requiring learning.

Another study[10], similar to the present work, found a weak correlation between CAP and combinations of distinctive features. This study used a different protocol, the simplified CAP assessment, however, it showed a higher correlation between the sequencing of verbal sounds and the combination of the features [+proximate, +continuous], which corresponds to the phoneme /r/. The study showed a distinct tendency for children with alterations in this combination of distinctive features to also present difficulties with the auditory ability of temporal ordering[10]. This result agrees with the findings of the present research, because, even with no significant relationship, it is possible to observe that most subjects had results well below the expected scores for the standard of each test. This finding demonstrates the difficulty that children with PD have with temporal ordering, recognition, naming and imitation of patterns of duration and frequency.

In the present study, no significant relationship was found between the CAP tests applied and the distinctive features, however, it is verified that children with alteration in the [approximate] trait show greater difficulty with the auditory skills tested by the analysis of the means obtained in the applied CAP tests.

A similar study applied PPS test to children with PD, and most subjects obtained results within the normal range in both tests[14]. This result is in agreement with some research carried out previously with children in the same age group, which presented results within the expected for the temporal ordering skills[11,35], however, both results disagree with the data obtained in the present research, which, despite not presenting statistical significance of the results, show that most subjects obtained results below expectations in all applied tests, not agreeing with the aforementioned research.

In the analysis of GIN test, it is observed that there was no correlation in the analysis of altered distinctive features, but, similar to PPS and DPS tests, most children obtained results considered altered. It is noteworthy that there are normotypic data expected for these tests in the child population from seven years old, but there is also a great variability in the performance of the GIN, PPS and DPS test in normotypic children. Of the 18 children that were evaluated, 15 presented results greater than 6 ms, in one or both ears, or were unable to perform the task proposed by the test. This result agrees with the findings of other studies that evaluated temporal resolution[11,15,36,37]. Thus, even though GIN, PPS and DPS are tests with low performance for reference of normality, it was found that the performance of the studied sample was below the normative values.

The difficulty of children with PD in performing temporal processing tests agrees with findings in the literature, some hypotheses relate speech and/or language difficulties to a deficit of perceptual origin, especially with temporal processing[38,39]. Processing speech sounds is related to the ability to perceive and process the spectral features of phonemes, including the intervals between each sound, within a time interval on the order of milliseconds, which is essential for language development. Therefore, any change or instability in the representation of phonemes can lead to difficulties in speech perception and in phonological, syntactic and semantic acquisition[37,40,41].

It is believed that the lack of a statistically significant relationship can be explained, in part, by the constitution of the group of evaluated subjects. In the sample, there was no variation in the severity of PD, with most children presenting a little altered phonological system. The age factor may have contributed, as the age group evaluated can be considered advanced to still present a PD. Around the age of nine, PD starts to be considered as residual speech errors, which also has negative consequences on the development of the child, both in speech and writing.

It is suggested to carry out further research with a greater number of subjects and to try to carry it out with children who have a more altered phonological system, using a more specific protocol for assessing temporal auditory processing, as in the present study.

CONCLUSION

No significant relationship between distinctive features and altered phonemes and temporal auditory processing tests was observed. However, the low performance in all temporal processing tests used in the research subjects was noted, indicating the difficulty that children presented with PD have with the tested auditory skills.

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