Phonological measures in children with phonological disorders

Medidas fonológicas em crianças com transtorno fonológico

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ABSTRACT

Purpose: To compare and correlate the performance of children with and without phonological disorders (PD) according to phonological awareness (PA) abilities, Percentage of Consonants Correct – Revised (PCC-R) and Speech Inconsistency Index (SII). **Methods:** Participants were 36 children with ages between 5 and 7 years divided into: Research Group (RG) – 18 children with PD; and CG – 18 typically developing children. The PCC-R was calculated, and the SII and the Phonological Sensitivity Test – Visual mode (PST-V) were applied. The PST-V consists of six tasks: equal and different alliteration (EA and DA, respectively), total alliteration (TA), equal and different rhyme (ER and DR, respectively), and total rhyme (TR). Results were statistically analyzed. **Results:** Differences were found between groups in all indexes, with better performances of the CG. In this group there were negative correlations between SII and all PA abilities and between SII and PCC-R, except for the ER. There were positive correlations between all PST-V subtests. On the RG, positive correlations were observed between PCC-R and alliteration abilities; no correlations were found between SII and PCC-R nor between SII and PA subtests. There were correlations between PST-V abilities: EA and TA; DA and TA; DA and DR; ER and TR; DR and TR. **Conclusion:** Children with PD had worse performances. CG children develop rhyme and alliteration abilities as they stabilize their speech production. RG children are more inconsistent and tend to develop PA abilities in a more disorganized manner.

Keywords: Language development disorders; Language arts; Severity of illness index; Language tests, Child; Child language

INTRODUCTION

Speech Sound Disorders (SSD) are a frequent speech and language disorder in pediatric population. The main characteristic of children with SSD is attributed to the speech sound errors present. Children with speech difficulty are a heterogeneous group and many studies point out to the influence of environmental and genetic factors[1-3].

Speech disorders presented by children with SSD are identified during the diagnostic process, when language and speech tests are applied. After diagnosis, complementary tests on phonological measures have to be applied in order to establish subgroups of speech difficulty.

Phonological measures

A determinant factor for both diagnosis and treatment planning for children with SSD is the severity classification of the disorder, which may be different from one child to the other indicating different intelligibility levels among speakers[1,4].

The quantitative index Percentage of Consonants Correct – Revised (PCC-R)[5] is quite used to classify the severity of the SSD. This index computes the percentage of consonants correct considering both omissions and substitutions as speech errors.

Another very important aspect for the classification of SSD is speech intelligibility, which can be influenced by several factors such as speech inconsistency (SI), characterized by multiple productions of a word in the same context[6-9]. SI is observed by a picture naming task with 25 pictures in which the child is asked to name the pictures three times, each time separated by a distracter activity. Based on the picture naming task, the authors considered a word as consistent when production was always the same and as inconsistent when multiple

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productions of the same word was observed each time[6].

A big challenge for researchers in the Speech-Language Pathology area still is to determine the SI value that separates normal from disordered speakers. Some studies indicate that speech variability (accepted as a normal variability) in typically developing children is of 13%[7]. Another research suggested that a speech production with SI≥40% is indicative of an inconsistent speech disorder, which would be a marker for SSD[6].

Children whose speech is characterized by inconsistent errors may have difficulty selecting and sequencing phonemes for the production of a phonological structure, which suggests a phonological planning deficit that has effects over the phonetic planning[8].

The Speech Inconsistency Index (SII) was developed for Brazilian Portuguese (BP) with the purpose to detect children who present inconsistent speech[9]. That study verified that children in the control group (SII=9.8%) were more consistent than children with SSD (SII =27.4%), and that group and gender effects influenced the results. Such effects were considered for determining the cut off values for SI (ROC curves) as well as its sensitivity and specificity values. Hence, results indicated that for girls aged between 5 years and 7 years and 6 months the cut off value for SI was 21.5%, and for boys at the same age range this value was 31.9%. Cut off values for girls over 7 years and 6 months was 14.5%, and for boys it was 17.6%. The study also detected that, from the 101 evaluated children, 38 (38%) presented SI values above the established cut off values (four children from the control group – CG, and 34 from the research group – RG). Amongst the inconsistent children from the CG (8%), there were two boys aged between 5 years and 7 years and 6 months, and two girls aged above 7 years and 6 months. Inconsistent children from RG (67%) were ten boys aged between 5 years and 7 years and 6 months, 11 boys aged above 7 years and 6 months, seven girls aged between 5 years and 7 years and 6 months, and six girls aged above 7 years and 6 months.

Phonological awareness

Phonological awareness is defined as the capacity of a child to consciously identify and manipulate speech segments. It is considered one of the instances of phonological processing, which is defined as the use of phonological information in the processing of oral and written language[10,11].

SSD can have an effect both on the production and the mental representation of speech sounds and, therefore, may affect both the articulation and the internal knowledge of the language. In the last case, SSD is characterized by a phonemic deficit, which affects the way the sound information is stored and represented on the mental lexicon. This occurs when the cause of SSD has a linguistic or cognitive basis. Hence, SSD may affect the awareness of speech segments as well as the use of phonological information, affecting the metaphonological abilities[12]. Thus, children with SSD are considered to be at risk for alterations in the development of reading and writing[13,14].

There are many tests adopted and developed for Brazilian Portuguese in order to analyze phonological awareness abilities. One of them is the Phonological Sensitivity Test presented in both visual form (PST-V) and auditory form (PST-A)[14,15]. This test assesses the abilities of alliteration and rhyme, which correspond, respectively, to the initial and final segments of words. Literature points out that, in preschool children within typical speech and language development, metaphonological abilities involving initial segments of words are easier than those with target-segments in the word final position[11,15].

The aim of this study was to compare and correlate the performance of children with and without Speech Sound Disorders regarding phonological awareness abilities, PCC-R index on the picture naming task, and Speech Inconsistency Index (SSI).

METHODS

This study was approved by the Ethics Commission for the Analysis of Research Projects (CAPPesq) of the Clinical Board of the General Hospital and School of Medicine of the Universidade de São Paulo (nº 0958/08). All legal guardians signed the free and informed consent term.

Participants were 36 children of both genders, aged between 5 years and 2 months and 7 years, 18 with no complaints of speech and language disorders (Control Group – CG), and 18 diagnosed with Speech Sound Disorders (Research Group – RG).

The CG consisted of children selected from schools in the city of São Paulo, Brazil – nine female and nine male – who compose the database of the Investigation Laboratory in Phonology (LIF-Fonologia). Inclusion criteria in the research were: absence of complaints of language and speech disorders, according to parents and teachers, and adequate performance on the Phonology Test[16] of the Teste de Linguagem Infantil – ABFW.

The RG was composed of children who were enrolled for treatment at the LIF-Fonologia, with the following inclusion criteria: ages between 5 years and 7 years and 11 months; speech sound errors in the Phonology Test – ABFW; age adequate performance in other aspects of language; normal results in the audiological evaluation; no previous speech-language therapy; and monolingual Portuguese speakers. The RG was composed by eight female and ten male subjects.

All subjects underwent the following experimental tests: naming test of the ABFW[16], Inconsistency Speech Test[9], and Phonological Sensitivity Test – visual mode (PST-V)[14,15]. The Percentage of Correct Consonants – Revised (PCC-R) was calculated from the answers obtained on the naming task. The tests were applied in two sessions of approximately 45 minutes each. For the CG children, the tests were applied in a silent room at the school, and for the RG children, tests were recorded in a sound-treated room at the LIF-Fonologia.

Data analysis followed the established criteria for each test. For the Phonological Sensitivity Test – Visual mode (PST-V), besides the subtests of equal and different Rhyme and Alliteration, the total score for alliteration and rhyme abilities were also computed. Thus, Total Alliteration (TA) is the sum of Equal Alliteration (EA) and Different Alliteration (DA) scores. The same was done for Total Rhyme (TR), which is the sum of Equal Rhyme (ER) and Different Rhyme (DR) scores.

Regarding the SII, we used the cut off values for Brazilian Portuguese[9], as it follows: 12.5% for girls and 31.9% for boys aged between 5 years and 7 years and 6 months; and, for children over 7 years and 6 months, 14.5% for girls and 17.6% for boys.

During data collection, a subject from the CG could not complete any of the PST-V tasks, and a subject from the RG did not understand the execution of the DA and DR tasks of the PST-V, resulting in sample loss.

In order to compare the performance between groups on the tests, the t Student test was used. The association between tests in each group was verified using the Spearman correlation coefficient, with signi1ficance level of 5%.

RESULTS

The analysis of the SII indicated more inconsistent subjects in the RG than in the CG (Table 1). In the CG, all children were consistent; in the RG, on the contrary, 56% were consistent and 44% inconsistent. Differences were found in the comparison between the means of the groups in each task, with better performance from the CG (Table 1).

Another aspect observed was that in the CG the PCC-R values were higher and the SII values were lower. In the RG, the opposite was found, as children presented lower PCC-R values and higher SII values (Figure 1).

The Spearman correlation coefficients indicated that, in the CG, the SII was significantly (negatively) correlated with all phonological awareness abilities and with the PCC-R, except for the ER. The PCC-R did not show significant correlations with the other phonological awareness abilities. Regarding the subtests of the PST-V, this group showed positive significant correlations between them (Table 2).

In the RG, significant positive correlations were found between PCC-R and alliteration tasks, but not between SII and PCC-R, rhyme and alliteration tasks. Results of the PST--V presented the following significant correlations: 1) EA and TA; 2) DA and TA; 3) DA and DR; 4) ER and TR and, 5) DR and TR (table 3).

DISCUSSION

This study evidenced differences in all aspects analyzed (PCC-R for the naming test of the ABFW, SII and subtests of the PST-V), suggesting that the tasks used were effective and efficient in the identification of the SSD. Regarding the comparison between groups, CG presents better performance than the RG, showing that children with SSD present several levels of phonological alterations and inconsistency of speech, as well as impairments in rhyme and alliteration abilities.

The RG presented lower PCC-R values than the CG, as well as higher standard deviation, confirming the impaired and varied phonological performance of children with SSD. The PCC-R is a measured used to quantitatively classify SSD that has been indicated consistent results in several languages[2,5,17-19].

The fact that all CG children demonstrated consistent speech, considering the standard values established for Brazilian Portuguese, reinforces the fact that children under 5 years acquire the stability of the phonological system, differently from SSD children, among which 44% presented speech inconsistency. The higher inconsistency in these children

Table 1. Comparison between control and research groups

Task	Group	n	Mean	SD	T test	p-value
PCC-R	CG	18	0.983	0.024	(34) 6.797	≤0.001*
	RG	18	0.742	0.148		
SII	CG	18	0.067	0.083	(34) -3.944	0.001*
	RG	18	0.239	0.165		
PST-V EA	CG	17	9.59	1.91	(33) 3.119	0.004*
	RG	18	7.56	1.95		
PST-V DA	CG	17	9.35	2.26	(32) 5.338	≤0.001*
	RG	17	4.76	2.73		
PST-V TA	CG	17	9.471	2.027	(33) 4.759	≤0.001*
	RG	18	6.278	1.942		
PST-V ER	CG	17	8.94	2.08	(33) 6.986	≤0.001*
	RG	18	4.28	1.87		
PST-V DR	CG	17	9.47	2.03	(32) 6.635	≤0.001*
	RG	17	4.47	2.35		
PST-V TR	CG	17	9.206	1.953	(33) 7.761	≤0.001*
	RG	18	4.361	1.739		

Qualitative analysis and Student's t Test

* Significant values (p≤0.05)

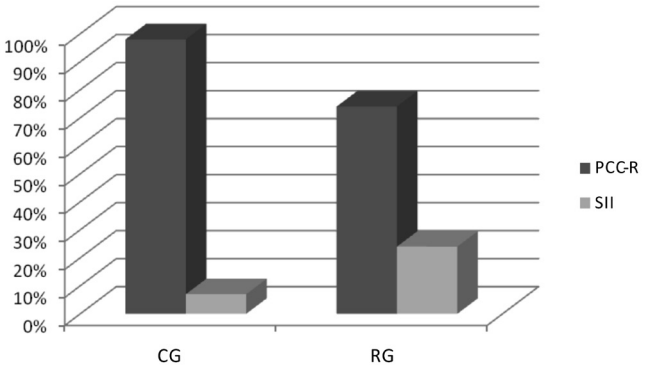
Note: SD = standard deviation; EA= equal alliteration, DA = different alliteration, TA = total alliteration; ER = equal rhyme, DR = different rhyme; TR = Total rhyme, SII = speech inconsistency index; PCC-R = percentage of correct consonants – revised; PST-V = phonological sensitivity test – visual mode; CG = control group; RG = research group

Table 2. Correlation coefficient between variables in the control group (CG)

		PCC-R	SII	PST-V EA	PST-V DA	PST-V ER	PST-V DR	PST-V TA	PST-V TR
PCC-R	Correl. coeff.	1.000	-0.599	0.292	0.164	0.051	0.222	0.228	0.175
	p-value		0.009*	0.256	0.529	0.845	0.391	0.378	0.501
	n		18	17	17	17	17	17	17
SII	Correl. coeff.		1.000	-0.704	-0.540	-0.468	-0.592	-0.630	-0.564
	p-value			0.002*	0.025*	0.058	0.012*	0.007*	0.018*
	n			17	17	17	17	17	17
PST-V	Correl. coeff.			1.000	0.888	0.702	0.759	0.958	0.772
EA	p-value				≤0.001*	0.002*	0.000*	0.000*	0.000*
	n				17	17	17	17	17
PST-V	Correl. coeff.				1.000	0.644	0.644	0.977	0.674
DA	p-value					0.005*	0.005*	0.000*	0.003*
	n					17	17	17	17
PST-V	Correl. coeff.					1.000	0.842	0.688	0.961
ER	p-value						≤0.001*	0.002*	0.000*
	n						17	17	17
PST-V	Correl. coeff.						1.000	0.711	0.951
DR	p-value							0.001*	0.000*
	n							17	17
PST-V	Correl. coeff.							1.000	0.734
TA	p-value								0.001*
	n								17
PST-V	Correl. coeff.								1.000
TR									

* Significant values (p≤0.05) – Spearman correlation

Note: SD = standard deviation; EA= equal alliteration, DA = different alliteration, TA = total alliteration; ER = equal rhyme, DR = different rhyme; TR = Total rhyme, SII = speech inconsistency index; PCC-R = percentage of correct consonants – revised; PST-V = phonological sensitivity test – visual mode; Correl. coeff. = correlation coefficient



Note: CG = control group; RG = research group; SII = speech inconsistency index; PCC-R = percentage of correct consonants – revised

Figure 1. Relation between PCC-R and SII in the control and research groups

suggests that they present more instability in phonological programming[9].

During typical phonological development, different productions of the same word occur in low frequency. These inconsistencies were found in English (around 13%)[7] and in Portuguese (9.8%)[9]. In children with SSD speech inconsistency is more frequent, and they demonstrate difficulty in programming the sequence of sounds involved in the phonological structure, that is, children select the structure using different paths, indicating phonological programming alteration with effects in the phonetic programming[8].

Inconsistency may result in different neural control strategies, in several levels of the production system, reflecting in different patterns of activation, such as pre-verbal conceptual preparation, grammar codification linking with the phonological/phonetic system, morpho-phonological codification, phonological selection, phonetic codification, articulatory selection, articulation, and manifestation of speech[20]. Hence, the findings of the present study demonstrated the negative impact of speech inconsistency in children, as it hinders the acquisition of categories needed for the development of new phonemes[6].

Another finding of the present study was the negative correlation between PCC-R and SII in the CG, indicating that, as children acquire more correct sounds, speech inconsistency decreases[9]. This correlation, although negative, was not significant in the RG, showing that phonological programming may be affected in children with SSD, regardless of severity. This result may have been influenced by children's age. In another study with Brazilian Portuguese speakers between 5 and 10

Table 3. Correlation coefficient between variables in the research group (RG)

		PCC-R	SSI	PST-V EA	PST-V DA	PST-V ER	PST-V DR	PST-V TA	PST-V TR
PCC-R	Correl. coeff.	1.000	-0.273	0.556	0.562	0.289	0.041	0.609	0.094
	p-value		0.274	0.017*	0.019*	0.245	0.676	0.007*	0.711
	n		18	18	17	18	17	18	18
SII	Correl. coeff.		1.000	-0.450	0.078	-0.263	-0.046	-0.119	-0.208
	p-value			0.061	0.767	0.291	0.861	0.638	0.408
	n			18	17	18	17	18	18
PST-V	Correl. coeff.			1.000	0.218	0.250	0.050	0.650	0.149
EA	p-value				0.400	0.317	0.850	0.004*	0.556
	n				17	18	17	18	18
PST-V	Correl. coeff.				1.000	0.186	0.530	0.862	0.285
DA	p-value					0.474	0.035*	0.000*	0.267
	n					17	16	17	17
PST-V	Correl. coeff.					1.000	0.471	0.371	0.843
ER	p-value						0.056	0.129	0.000*
	n						17	18	18
PST-V	Correl. coeff.						1.000	0.469	0.837
DR	p-value							0.058	0.000*
	n							17	17
PST-V	Correl. coeff.							1.000	0.406
TA	p-value								0.095
	n								18
PST-V	Correl. coeff.								1.000
TR									

* Significant values (p≤0.05) – Spearman correlation

Note: SD = standard deviation; EA= equal alliteration, DA = different alliteration; TA = total alliteration; ER = equal rhyme, DR = different rhyme; TR = total rhyme, SII = speech inconsistency index; PCC-R = percentage of correct consonants – revised; PST-V = phonological sensitivity test – visual mode; Correl. coeff. = correlation coefficient

years old, there was association between SII values and the severity measured by the PCC-R[21].

Regarding the phonological awareness abilities tested in this study, RG children presented worse performance than CG children, showing that SSD subjects have difficulties in phonological awareness abilities[12,14,22-24]. These difficulties may be influenced by the inner knowledge of the language, that is frequently affected in phonologically disordered children[23,24].

Another study[25] reported the importance of the development of rhyme to the literacy process, suggesting that not only the meaning of the word by itself but also the reflection regarding the its structure is fundamental for obtaining success in segmentation tasks, which are essential to the development of other phonological awareness abilities. This fact explains the difficulties of children with SSD during the literacy process.

Because of these difficulties, studies have suggested that the diagnosis of SSD is carried out as earlier as possible. These children also need adequate treatment as soon as possible, as they usually have phonological awareness difficulties that impact the learning of reading and writing[13,23,24].

The difficulties of children with SSD regarding phonological awareness abilities reflect the relation of speech perception and articulatory gestures. This is due to phonological representation failures, that may affect the use of phonological information to manipulate words segments[12,23-26].

Differences between RG and CG occurred in all tasks, although in a Brazilian study with the PST-V[14] significant differences were found between these children only in the different alliteration task. However, in all tasks, children with SSD presented worse performance. It is important to emphasize that this previous research studied children between 7 and 10 years old, which may have influenced the results.

The analysis of the correlation between tasks in each group showed that more correlations were found between tasks in the CG. In this group there was no correlation between PCC-R and PST-V, although it is important to note that PCC-R values were close to the maximum, with low variability. Hence, besides their good performance in the phonological system, they were still developing the phonological awareness abilities assessed by the PST-V[14,23,24,27].

On the other hand, for the RG, the PCC-R was significantly correlated only with alliteration abilities, but not with rhyme. The heterogeneity of the SSD may partially explain these findings, as other studies also found similar results[23,24,28]. Another point is that alliteration abilities are considered easier and are acquired earlier by children[11,15].

Moreover, the positive correlation found between PCC-R and alliteration in the RG may be explained by the fact that, as PCC-R increases, children have more options of consonants. Hence, the increase of correct consonants improves phonological representations, which are essential for manipulation of words segments. However, there is evidence that this improvement may not be enough to repair rhyme problems, since, according to the literature, this ability is more difficult than alliteration[11,15].

The fact that the SII in children with SSD until 7 years did not demonstrate significant correlation with phonological awareness abilities suggests that both phonological representation (needed for good performance in rhyme and alliteration tasks) and phonological and phonetic programming (needed to produce the same word consistently) are affected, preventing children to carry out the tasks with organization.

Several studies have shown varied results regarding the relation between severity, SII and phonological awareness abilities[23,24]. In a study with phonologically disordered children[21], it was noted that higher PCC-R values were associated with lower SII values, that is, the more severe the phonological disorder, the more difficulties in phonological programming.

A recent study[8] have pointed out that children with SSD and speech inconsistency who did not present problems with reading or alliteration and rhyme abilities showed normal phonological representation, as well as good oral-motor control. Hence, difficulty is on the selection and sequencing of phonemes (phonological programming) of a word or utterance.

In general, children with SSD are at risk for phonological awareness alterations and later for reading and writing disorders[23,24,29].

Studies have demonstrated that cognitive-linguistic, speech motor and auditory processing interacts with each other in children with typical language and speech development. In children with SSD, who might present difficulties in any of these processing abilities, this interaction reflects in deficits in several abilities, which are manifested, as in the present study, in less correct consonants, more speech inconsistency, and phonological awareness alterations, possibly leading to future academic difficulties[8,20,29].

Our results indicate that the SII and PST-V tasks and the PCC-R index are efficient to identify children with SSD. There were also evidences that these assessment procedures are complementary, providing important information to speech-language pathologists regarding the diagnosis of SSD.

CONCLUSION

Children with SSD present worse performance in PCC-R, SII and phonological awareness abilities when compared to typically developing children. Children in the CG develop rhyme and alliteration abilities as they stabilize their speech production. In the RG, more severe children are also more inconsistent and develop phonological awareness abilities in a more disorganized manner.

Positive significant correlations were found between most of the tasks in the CG, however, in RG children, few correlations were observed, suggesting that these subjects present a more heterogeneous performance on the tasks applied. Inconsistent children vary regarding severity and phonological awareness abilities of rhyme and alliteration.

The procedures used in this study are effective to indicate the difficulties of children with SSD, besides evidencing the differences between them and typically developing children.

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RESUMO

Objetivo: Comparar o desempenho de crianças com e sem transtorno fonológico (TF) quanto às habilidades de consciência fonológica (CF), índice de Porcentagem de Consoantes Corretas – Revisada (PCC-R) e Índice de Inconsistência de Fala (IIF), além de correlacionar estes resultados entre si. **Métodos:** Participaram 36 sujeitos, entre 5 anos e 7 anos de idade, divididos em: Grupo Pesquisa (GP): 18 crianças com TF; e Grupo Controle (GC): 18 crianças em desenvolvimento típico de linguagem. Foi calculado o PCC-R, aplicado o IIF e o Teste de Sensibilidade Fonológica-Visual (TSF-V): aliteração igual (AI), diferente (AD) e total (AT), rima igual (RI), diferente (RD) e total (RT). Os resultados foram analisados estatisticamente. **Resultados:** Foram encontradas diferenças na comparação dos grupos em todos os índices, com melhores desempenhos no GC. Neste, houve correlação negativa do IIF com todas as habilidades de CF e com o PCC-R, exceto com RI. Em todos os subtestes do TSF-V houve correlações positivas entre si. No GP, foram encontradas correlações positivas entre o PCC-R e as provas de aliteração; não foram encontradas correlações entre IFF e PCC-R, nem com as provas de CF. Houve correlações no TSF-V: AI com AT; AD com AT; AD com RD; RI com RT e RD com RT. **Conclusão:** Crianças com TF apresentam pior desempenho; as do GC, na medida em que estabilizam a produção de fala, desenvolvem as habilidades de rima e aliteração. As crianças do GP são mais inconsistentes e parecem desenvolver as habilidades de CF de forma desorganizada.

Descritores: Transtornos do desenvolvimento da linguagem; Estudos de linguagem; Índice de gravidade de doença; Testes de linguagem, Criança; Linguagem infantil

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