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Original articles

Consonant correlation model: implications to clinical practice

Modelo de correlações entre consoantes: implicações para a prática clínica

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ABSTRACT

Purpose: creating a consonant correlation model, considering the syllabic structure of each consonant and showing likely statistical correlations among them. This model will be based on Implicational model of Feature Complexity (IMFC) and it will consider data of typical phonological acquisition.

Methods: the phonological systems of 186 children were analyzed. They were students of public kindergarten schools and were aged between one year, six months to five years, eleven months, and had typical language development. The complexity levels of the model were based on the sounds acquired in each age. After, the correlations among the consonants were analyzed, using the statistical significance and the power of correlations as the criteria to create the model.

Results: the consonant correlation model was created with nine levels of complexity. The model shows that the less complex sound is /t/ and the more complex is /l/ in the complex onset position. Many strong and moderate correlations were found among the consonants, except for /ʒ/. The sound with highest number of correlations was /l/ in the simple onset position.

Conclusion: the created model pointed many similarities with MICT. It describes details in the typical phonological acquisition and can be a guide to the choice of target sounds in therapy.

Keywords: Infant; Preschool; Language Development

RESUMO

Objetivo: construir um modelo de complexidade entre consoantes conforme a estrutura silábica de cada uma, evidenciando possíveis correlações estatísticas entre elas, baseando-se na estrutura do Modelo Implicacional de Complexidade de Traços (MICT) e utilizando dados de aquisição fonológica típica.

Métodos: analisaram-se os sistemas fonológicos de 186 crianças estudantes de escolas municipais de educação infantil com idades entre um ano e seis meses e cinco anos, 11 meses e 29 dias, e desenvolvimento típico de linguagem. Com base nos fonemas adquiridos em cada faixa etária determinaram-se os níveis de complexidade. Após, buscaram-se as correlações entre os fonemas, utilizando como critérios a significância estatística e a força das correlações para criar o modelo.

Resultados: o modelo de correlações entre consoantes foi construído com nove níveis de complexidade. O modelo mostra que o fonema menos complexo é o /t/ e o mais complexo é o /l/ na posição de onset complexo. Há várias correlações moderadas e fortes entre os fonemas, exceto para /ʒ/. O fonema com maior número de correlações foi o /l/ na posição de onset simples.

Conclusão: o modelo criado evidenciou muitas semelhanças com o MICT. Ele descreve detalhes da aquisição fonológica típica e pode ser um guia para a escolha dos sons alvo na terapia fonológica.

Descritores: Lactente; Pré-Escolar; Desenvolvimento da Linguagem

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INTRODUCTION

The acquisition of language as a research topic has its first reports in the years between 1876 and 1926 on the basis of dairy notes in which linguists used to write up all the words spoken by their children[1]. Since then, the interest for research in the topic has grown.

After the year 1926, studies with large samples started to become more popular. In these studies, linguists aimed to describe some standard behaviors for language[1]. However, the research methods were still quite rudimentary and several important information was overlooked.

Thus, from the 1980s, the researchers started to use audio recordings and later video, which allowed more detailed analysis and transcription of speech data, providing more scientism to language studies.

Over the years and the creation of professions such as Speech Therapy, greater attention was given to child language, looking for typical and deviant standards, as well as the therapy for these cases. In this context, this article is about the typical phonological acquisition of Brazilian Portuguese.

Many studies have been carried out in order to describe the phonological acquisition[2,3]. These works are extremely important to the clinical practice of speech therapists, as they can help in the diagnosis of phonological disorders and other related diseases, in addition to guiding the sequence of target sounds to be used in therapy.

At this point, it is crucial to mention the dissertation that inspired this research[2]. That dissertation aimed to explain the segmental acquisition of Brazilian Portuguese. In order to achieve this goal, the phonological systems of 25 children with phonological disorder were analyzed, determining the markedness implicational relations of distinctive features and, from there, the implicational model of segmental complexity was constructed. Thus, the Implicational Model of Feature Complexity (IMFC) explains the segmental acquisition of consonants through implicational relations between features, which provides different possibilities for the phonological development, as illustrated in Figure 1.

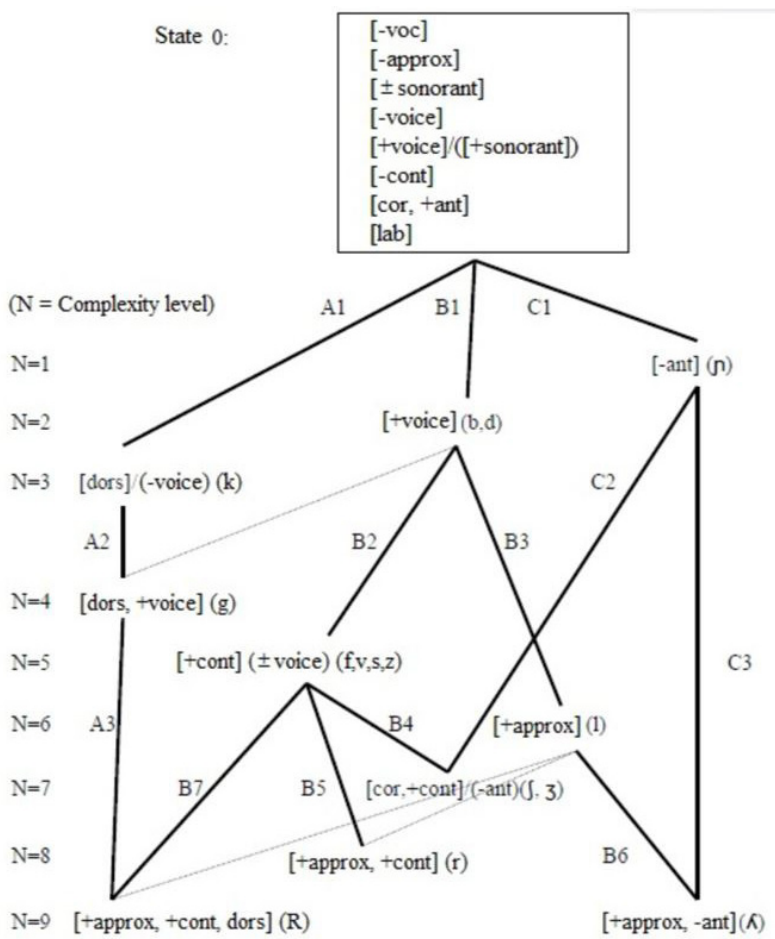


Figure 1. Implicational Model of Feature Complexity (IMFC) proposed by Mota (1996, p. 154).

In order to come to the exposed tree structure, the analysis of the author consisted of determining the sounds that were absent in each system by establishing a complex segment hierarchy in terms of presence and absence of the phonological systems of 25 subjects, in addition to the type of existing substitutions. After using the theory of markedness, it was performed the determination of markedness implicational relations of the distinctive features in the systems of these children. The analysis was qualitative and it followed the formula:

"X subjects present A and B;

Y subjects present A but they do not present B;

Z subjects present B but they do not present A;

Then: B is more marked (complex) than A if Y > Z".

The levels indicate the order of acquisition of the segments and the lines, the implication relations between the features, the darker ones indicate strong implicational relation and the lighter ones indicate poor implicational relation.

Even being created from the speech data of only 25 subjects with phonological disorder and without statistical processing of data, IMFC is mentioned in research up to the present day[4 - 6], which shows its importance. However, these aspects have been highlighted as limitations to its application. Furthermore, the fact that the phonemes have been considered only in simple onset position also limits the use of this model in the choice of target segments for phonological therapy and to determine the severity of phonological disorders, as observed in other studies[4,5].

Thus, there is a need to use a larger number of subjects, considering the syllabic structure in which the phoneme is. The use of a large sample and statistical analysis for determining the correlation between consonants result in a reliable model with application chance of further research and typical deviant acquisition and therapy.

Based on the above, the aim of this article is to construct a model of complexity between consonants, showing possible statistical correlations between them based on the IMFC[2] structure and using typical phonological acquisition data.

METHODS

This article presents the data collected for a thesis dissertation[6], which were stored in the home institution database. This database was constructed with spontaneous speech filming at the time of interaction of 186 children aged from one year and six months to five years, 11 months and 29 days, members of a monolingual family (speakers of Brazilian Portuguese), with typical language development. We did not include children with hearing loss, neurological and/or cognitive impairment (declared or detectable through observation); with presence of oral motor or organic changes, or who had participated of/were participating of phonotherapy sessions.

The database is part of a project approved by the Ethics Committee of the institution of origin under the number 0219.0.243.000-11. The authorization of the guardians for the research participants was requested by clarification, reading and signature of the Informed Consent Form, an indispensable requirement for the participation in the study.

As one of the initial research aim was to analyze the typical phonological acquisition, the subjects were divided by age of three months each, except the children of one-year-old, who were included in a single group of six months due to the low number of analyzed subjects. Figure 2 shows the distribution of children per group.

Age	Number of children
1;6 – 1;11	9
2;0 – 2;3	13
2;4 – 2;7	13
2;8 – 2;11	16
3;0 – 3;3	15
3;4 – 3;7	15
3;8 – 3;11	15
4;0 – 4;3	15
4;4 – 4;7	15
4;8 – 4;11	15
5;0 – 5;3	15
5;4 – 5;7	15
5;8 – 5;11	15

Figure 2. Number of children by age

The data collection procedures were carried out in Early Childhood Education public schools in Santa Maria – RS. The evaluation consisted of a questionnaire for parents or guardians, orofacial and oral praxis evaluation, evaluation of oral language and evaluation of phonetic and phonological aspects of speech, in addition to hearing screening.

Children who answered adequately to the mentioned evaluations carried out the phonological evaluation. This was performed by means of spontaneous speech and naming of objects and miniature toys, from a pre-prepared list, selected from the Phonological Evaluation of Children (PEC) [7]. This instrument allows to evaluate the possibilities of occurrence for each consonant of Brazilian Portuguese in every possible position.

All interactions, which lasted 20 minutes, were videotaped by using a Samsung camcorder, SMX-C200 model. The material was stored in external HD for broad speech phonetic transcription of the children. Then, we used the consensus method[8] for children up to 3:3;29. For this method two judges worked independently in the transcript; after the transcripts were compared and discrepancies were heard again by a third judge until they reached the agreement in all statements/words/sounds produced by the child. If there were no agreement between at least two judges, the segment was deleted. Thus, the reliability of the transcriptions was guaranteed, preventing the exclusion of a large number of words, since young children, who present typical development, have greater variability in their production.

On the other hand, for the children of other age groups, who present the most stable production, the following method of reliability of the transcriptions was used: all samples were transcribed by experienced judges in child language. A second judge with the same experience transcribed independently 20% of the same sample to certify the reliability[9]. Thus, the mean of agreement achieved a percentage of 79.6% for the groups of three years; 81.9% for the groups of 4 years and 80.1% for the groups of 5 years.

The speech evaluations were initially analyzed by using the Contrastive Analysis. For performing this analysis, four file cards were used: Phonetics Description 1 - recording of the production of consonantal segments; Phonetics Description 2 – recording of the phonetic inventory according to the categories of point, mode and sonority and the productions of consonant clusters; Contrastive Analysis 1 - recording of the events and possibilities of substitutions and omissions performed by the child, with the calculation of percentages; and Contrastive Analysis 2, which presents the phonological system used by the child, recording the contrasts, substitutions and the omissions which were produced by the subject[7].

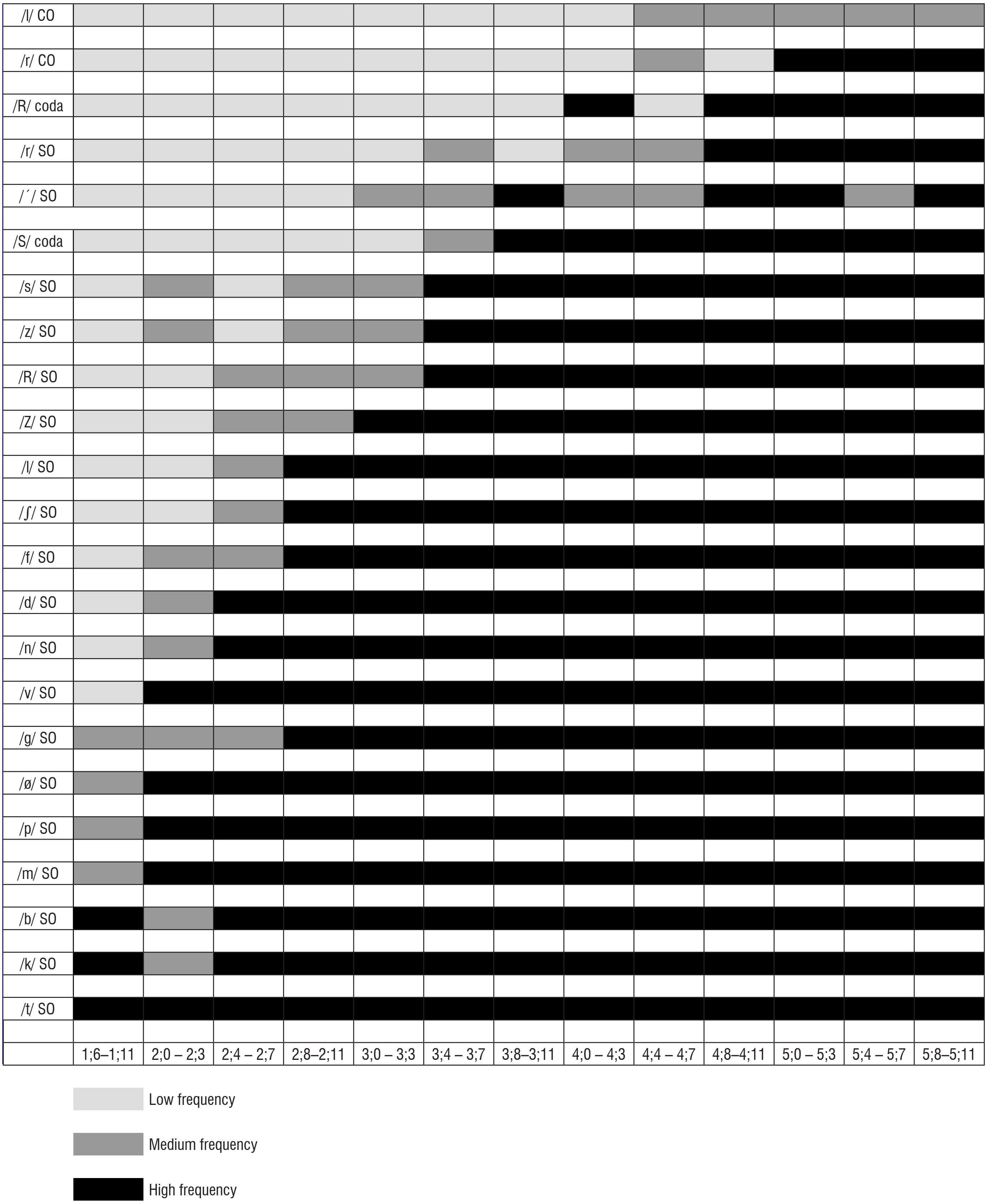
From this, in order to establish the phonological inventory, the following criteria were used: occurrence from 0 to 39% indicates that the phoneme is not acquired; if the occurrence is between 40% and 79%, the phoneme is partially acquired; and occurrence equal to or higher than 80% indicates that the phoneme is acquired. To determine the characteristics of the phonological system of the subjects and each sound production probabilities, the general phonological system of subjects was considered, by analyzing the consonants /p, b, t, d, k, g, f, v, s, z, Σ, Z, m, n, ɲ, λ, ×, r, R/ in simple onset positions, /l, r/ in the second position of complex onset and /s, r / in coda position.

These data originated Figure 3[6], which is exposed hereinafter.

Based on Figure 3[6], the complexity levels of the model were established, in other words, the order of consonants acquisition.

For the analysis of the correlation between phonemes, the Statistica 9.1 software was used, calculating the Pearson coefficient, seeking the statistical significance of the correlations with level established at 5%. Besides significance, there was also the coefficient of correlation[11], considering:

- 0.9 either more or less indicates a very strong correlation.
- 0.7 to 0.9 positive or negative indicates a strong correlation.
- 0.5 to 0.7 positive or negative indicates a moderate correlation.
- 0.3 to 0.5 positive or negative indicates a weak correlation.
- 0 to 0.3 positive or negative indicates a negligible correlation.



Captions: SO = Simple onset; CO = Complex onset

Figure 3. Consonant frequency acquisition according to age (WIETHAN, 2015, p. 39).

RESULTS

First, the complexity levels of the model were established based on Figure 3, already exposed. Thus, the order of consonants acquisition was considered according to the high frequency of the phonemes in each age group. For example, the phoneme /t/ is present with high frequency since the first age group, being acquired in 100% of the research children. Thus, it was established in the Condition 0.

It is important to emphasize that the presence of the phoneme at some level depended on the fact that it continued with high frequency in the following age groups. For example, the phoneme /×/ showed high frequency in the age group of 4:8 - 4:11, but regressed in the following two age groups. Thus, it was only considered acquired at the age group of 5: 8 - 5:11.

Then, there was the analysis of correlations between the phonemes. This analysis resulted in the correlation matrix which is exposed in Table 1.

Table 1. Matriz de correlações entre os percentuais de produção correta por sujeito

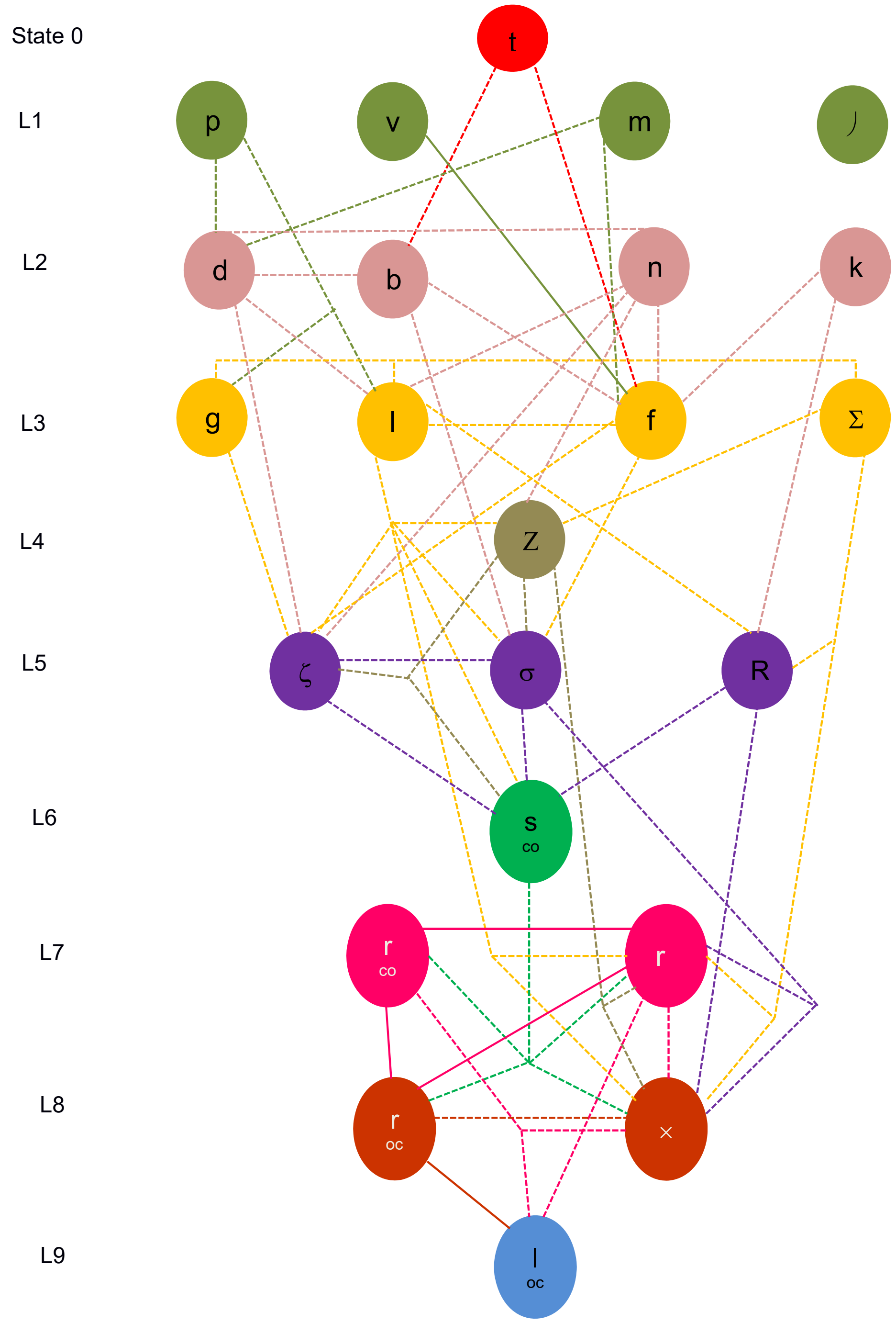
Cons.	t	p	v	m	ø	b	k	n	d	g	f	S	l	Z	R	s	z	/s/ Coda	r	/r/ coda	´	/r/ OC	/l/ OC
t	1,000																						
p	0,044	1,000																					
v	0,184*	0,366*	1,000																				
m	0,087	-0,010	0,022	1,000																			
ø	0,096	0,450*	0,228*	0,120	1,000																		
b	0,522*	0,181*	0,444*	,1744*	0,131	1,000																	
k	0,215*	0,062	0,109	,3470*	0,379*	0,393*	1,000																
n	0,122	0,464*	0,458*	,4325*	0,489*	0,418*	0,311*	1,000															
d	0,262*	0,617*	0,208*	,6832*	0,274*	0,578*	0,276*	0,552*	1,000														
g	0,392*	0,506*	0,282*	0,092	0,306*	0,373*	0,455*	0,387*	0,485*	1,000													
f	0,517*	0,366*	0,733*	,5223*	0,431*	0,652*	0,532*	0,616*	0,465*	0,391*	1,000												
S	0,355*	0,359	0,249*	,2984*	0,145	0,493*	0,463*	0,436*	0,354*	0,551*	0,329*	1,000											
l	0,329*	0,559*	0,359*	,3598*	0,427*	0,588*	0,492*	0,658*	0,680*	0,548*	0,519*	0,657*	1,000										
Z	0,174*	0,306*	0,338*	,2855*	0,416*	0,386*	0,312*	0,598*	0,297*	0,337*	0,447*	0,629*	0,590*	1,000									
R	0,191*	0,353*	0,415*	,2111*	0,244*	0,396*	0,507*	0,432*	0,267*	0,444*	0,365*	0,529*	0,663*	0,483*	1,000								
s	0,290*	0,211*	0,463*	,3172*	0,351*	0,409*	0,390*	0,381*	0,367*	0,363*	0,579*	0,343*	0,595*	0,589*	0,488*	1,000							
z	0,273*	0,498*	0,429*	0,116	0,441*	0,398*	0,353*	0,602*	0,666*	0,508*	0,516*	0,242*	0,570*	0,573*	0,401*	0,587*	1,000						
/s/ coda	0,353*	0,307*	0,390*	,2882*	0,335*	0,525*	0,386*	0,377*	0,495*	0,477*	0,436*	0,491*	0,665*	0,587*	0,513*	0,575*	0,602*	1,000					
r	0,291*	0,234*	0,274*	,2426*	0,219*	0,358*	0,373*	0,299*	0,366*	0,347*	0,330*	0,509*	0,538*	0,533*	0,473*	0,597*	0,485*	0,690*	1,000				
/r/ coda	0,206*	0,181*	0,190*	,1614*	0,165*	0,281*	0,291*	0,233*	0,266*	0,253*	0,261*	0,404*	0,446*	0,434*	0,456*	0,493*	0,345*	0,575*	0,755*	1,000			
´	0,211*	0,221*	0,220*	,3037*	0,276*	0,383*	0,457*	0,403*	0,328*	0,354*	0,322*	0,554*	0,626*	0,617*	0,599*	0,560*	0,366*	0,630*	0,696*	0,614*	1,000		
/r/ OC	0,197*	0,158*	0,182*	,1589*	0,149	0,260*	0,263*	0,236*	0,251*	0,238*	0,242*	0,370*	0,395*	0,406*	0,412*	0,450*	0,345*	0,543*	0,788*	0,786*	0,567*	1,000	
/l/ OC	0,178*	0,133	0,138	0,151	0,144	0,234*	0,241*	0,218*	0,218*	0,194*	0,212*	0,344*	0,341*	0,346*	0,369*	0,373*	0,301*	0,471*	0,601*	0,677*	0,481*	0,799*	1,000

Captions: Cons = Consonant; OC = complex onset. The sounds that do not show the syllabic structure are in the simple onset position.
Statistical test used: Pearson coefficient. Significance Level: p ≤ 0,05.

Thus, based on the order of consonants acquisition, the levels of complexity were determined, and based on the correlation matrix, the correlation between the phonemes were determined, resulting in the Figure 4

The Condition 0 was defined as a correspondence to another author[2], since all children had the phoneme acquired in their phonological inventories. The dotted lines represent moderate correlation between a phoneme and another and the solid lines represent strong correlation between a phoneme and another. No pair of phonemes showed very strong correlation.

For didactic reasons, we chose a different color for each level and it was determined that the colored lines always departed from the phonemes located on higher levels to those ones found in the levels below in the hierarchy.



Captions: OC = complex *onset*; co = coda. The sounds that do not show the syllabic structure are in the simple onset position

Figure 4. Correlations between consonants model.

DISCUSSION

Regarding the levels of complexity, both the model presented here as the model of Mota[2] present nine levels, even though the model of Mota does not consider the different syllabic structures. Most phonemes remained at the same level or at levels close to the two proposals, except the phonemes /v, l, Σ, Z, R/, which all were in lower levels in relation to this model.

The explanation for this difference is that in the referred study[2], the author researched children with phonological disorders, while our research is about children with typical phonological acquisition in a wide age group, in addition to differences in terms of methodological issues.

In general, it was observed that the phonological acquisition occurred in an ascending way, though with some regressions, as observed in other studies[12,13]. Most regressions occurred in consonants such as /×/, /l/ and /r/ in complex onset and coda. This may have occurred because they are considered the most complex phonemes and syllabic structure of Portuguese and because they suffer a large number of repair strategies[2, 14].

These regressions can be associated with the U-shaped curve, where there is a great number of correct productions, with sudden reduction in this number and subsequent recovery. This phenomenon is quite common in phonology and vocabulary acquisition[12, 15].

The nasal and fricative phonemic classes had similar behavior to some Brazilian studies[2, 3], in addition to Spanish data[16] and English data[17]. However, the acquisition of these two classes of sounds occurred earlier in the Portuguese Language when compared to the French Language[18].

In relation to the complex onset, in our research, as well as in other studies[3, 19], it was verified that it was the last syllabic structure to be acquired. Furthermore, /l/ emerges after /r/ when it is at this position[19]. It is hypothesized that this occurs due to the fact that the frequency of words with /l/ in complex onset is lower than /r/ at the same position.

The differences between the data may be explained due to methodological differences, differences between languages and external influences.

Observing the correlation matrix which is shown in Table 1, there is high number of statistically significant correlations. This phenomenon is very common when there is plenty of analyzed data. In this case, there is a high number of investigated subjects[20]. For this reason, we decided to consider the coefficient of the correlation[11] as a way to present more reliable results.

In general, it can be said that most of the statistically significant and moderate correlations refers to phonetically similar sounds, such as: voiced sound and its corresponding voiceless sound (s X z); occlusive sounds and fricative sounds with the same articulation point (d X z); fricative sounds with very similar articulation point (f x s); the lateral sounds between themselves (l X ×); lateral sounds and tap (l X r); and other sounds with very similar articulatory features[21]. Looking from this angle, we highlight the minimal pairs v X f, which presented strong correlation between each other.

In IMFC[2] most of the implicational relations is also related to phonemes that present similar articulatory features, which reinforces the validity of both models as representatives of typical and deviant phonological acquisition.

The only sound that was not correlated with any other was /ɲ/. We expected that such sound would present the same correlations with the other nasal phonemes or other properties that were similar in terms of articulation, as /Σ/, /Z/ or /×/, which also present [coronal] and [-anterior] features[2].

Regarding the phonemes correlated with /g/, there is disagreement, as there is no correspondence with the IMFC[2] and it does not present articulatory features with /p, z, Σ, l/ [21].

The consonant /l/ in simple onset position was the one that showed more correlations with others. Phonemes correlated with /l/ have similar articulatory features[21] and/or implication relations with IMFC[2]

The phoneme /s/ in coda position showed correlations with phonemes located, most of them, in similar levels. In addition, there was a correlation with the /r/ in the same position and in complex onset, showing that both depend on the correct production of /s/ in coda with the purpose of emerging in the phonological system of the children, as an analogy to IMFC, although this does not consider the syllabic structure[2].

Tap showed strong correlations with each other in all possible positions, in other words, in coda, simple onset and complex onset positions. This indicates that in the first two positions, it is acquired simultaneously in very similar time intervals. Then, the segment seems to emerge in the most complex position. For the last one, it still showed a strong correlation with the phoneme /l/ in the same syllabic structure, which indicates a strong dependence.

Finally, the phoneme /×/ presented a great number of moderate correlations, which may indicate its dependence of acquisition of other phonemes, particularly those ones located in the superior levels since this phoneme emerges later and undergoes regressions along the process[2, 6].

In general, we found more similarities than differences between the model proposed here and IMFC[2], even with such different methodologies. This data reinforces the importance and validity of IMFC to describe deviant phonological acquisition, as well as it offers some credibility to the model that was presented here.

CONCLUSION

The aim of this paper was achieved with the construction of the Correlations between Consonant Model. This model describes details of typical phonological acquisition and it provides subsidies for speech therapy, since it can help in the choice of target sounds.

Then, it is recommended that phonemes are chosen based on their location in higher levels (located lower in the hierarchy). They should also present correlations with phonemes which were already acquired.

Therefore, it is interesting that other studies should be carried out by testing the choice of targets in speech therapy in order to verify the effectiveness of the model in deviant phonological acquisition, more specifically in the occurrence of generalizations.

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