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Case reports

Phonological disorders treatment effect with a stimulability and segment complexity strata model with speech intervention software (SIFALA)

Efeito do tratamento do desvio fonológico pelo modelo de estratos por estimulabilidade e complexidade dos segmentos com software de intervenção para fala (SIFALA)

Ana Rita Brancalioni[1]
Márcia Keske-Soares[2]

[1] Universidade de Passo Fundo – UPF, Passo Fundo, RS, Brasil.

[2] Universidade Federal de Santa Maria – UFSM, Santa Maria, RS, Brasil.

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ABSTRACT

This paper focuses on the effect of the Strata Model based on Stimulability and Segment Complexity combined with the use of Speech Intervention Software on phonological disorders treatment. A case study was conducted with four subjects aged between 4:10 and 6:7, both males and females, with phonological disorders. All subjects were assessed for phonological system, stimulability, stomatognathic system and hearing screening. The therapeutic model was based on a mixed approach, wherein different models, procedures and strategies were combined, adapted and created. Each subject was treated with one of the four strata proposed in the model. The use of Speech Intervention Software was aimed at motivating the children by means of an interactive, lively and playful code. An analysis was made of data on subjects' phonological system and number of correctly produced consonants, both before and after therapy. The Chi-square test was used with a level of significance at 5% ($p < 0.05$). There were changes in the sound system for all treated subjects: segments were established in their phonetic inventory and acquired in their phonological system. The subjects treated by the strata that were focused on greater complexity of the Implicational Model of Feature Complexity showed more therapeutic improvement. However, because there was a reduced number of subjects, greater effectiveness cannot be attributed to any of the strata at this point. In conclusion, the Model and the use of Speech Intervention Software had a positive effect, contributing to the planning and treatment of phonological speech disorders. However, further studies should be conducted with larger samples to confirm the findings.

Keywords: Speech-Language Pathology; Rehabilitation of Speech and Language Disorders; Software; Computer-Assisted Instruction; Speech; Child

RESUMO

O tema desse artigo aborda o efeito que o Modelo de Estrato por Estimulabilidade e Complexidade e o uso do Software de Intervenção para Fala resulta no tratamento do desvio fonológico. Realizou-se estudo de caso de quatro sujeitos com idade entre 4:10 a 6:7, de ambos os gêneros, com desvio fonológico. Todos os sujeitos foram submetidos a avaliação da fonologia, estimulabilidade, sistema estomatognático e triagem auditiva. O Modelo terapêutico baseou-se em uma abordagem eclética, na qual diferentes modelos, procedimentos e estratégias foram unidos, adaptados e criados. Cada sujeito foi tratado por um dos quatro estratos propostos no Modelo. O uso do Software de Intervenção para Fala teve como finalidade despertar a motivação da criança a partir de um código interativo, animado e lúdico. Analisaram-se os dados da avaliação fonológica e o número de consoantes produzidas corretamente, pré e após período de terapia. Utilizou-se o teste Qui-Quadrado, ao nível de significância de 5% ($p<0,05$). Verificou-se mudança no sistema de sons para todos os sujeitos tratados, na qual segmentos foram estabelecidos no inventário fonético e adquiridos no sistema fonológico. Os sujeitos tratados por estratos direcionados para maior complexidade do Modelo Implicacional de Complexidade de Traços apresentaram melhor avanço terapêutico. Entretanto, devido ao número reduzido de sujeitos não é possível fazer afirmações quanto ao estrato de maior eficácia. Conclui-se que o Modelo e o uso do Software de Intervenção para Fala resultam efeito positivo, contribuindo com o planejamento e o tratamento do desvio fonológico. Contudo, há necessidade de realização de outros estudos com ampliação casuística para confirmação dos achados.

Descritores: Patologia da Fala e Linguagem; Reabilitação dos Transtornos da Fala e da Linguagem; Software; Instrução por Computador; Fala; Criança

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Mailing address:
Ana Rita Brancalioni
Longino Zacarias Guadagnin, nº 322, apto 202
Ibiraiaras – RS
CEP: 95305-000
E-mail: fonoaninha@yahoo.com.br

INTRODUCTION

Phonological disorder is characterized by substitutions, transpositions, insertion and/or deletions of sounds in children during the process of language acquisition, with no detectable organic cause. According to the literature, children with speech disorders present, in most cases, a delay in the acquisition of the sound system of their own language, with speech patterns similar to those ones verified in normal children, but in older subjects[1].

Whereas the phonological disorder can bring some harm to the communication of the child and also for the literacy process, the therapy for speech disorders should be efficient and fast. In order to meet this need, the way how the target segment and the target words is presented and trained with the child is the base for the therapeutic success.

The theories of language acquisition theories state that the child learns from the interaction with each other and also through interaction with the object. Thus, the more significant is the interaction and/or more attractive and stimulating is the object, more enriching the learning can be. In this context, the use of computers can be an object capable of favoring the process of teaching and learning, as it has shown to be an attractive potential for children. In addition, the use of computers helps and enhances the development of multiple experiences and possibilities, which promote socio-cognitive advantage[1].

Consequently, the different pedagogical software and the specific ones on speech seem to be an attractive proposal, as well as a learning proposal. Several software products have been developed with phonotherapeutic purposes. For the treatment of phonological disorder, in speakers of Brazilian Portuguese, the FonoSpeak software and, more recently, the Speech Intervention Software (SIFALA)[2] are the most used ones. The last one allows selecting target segments according to the Strata Model, based on the level of production of the segment and on the complexity of distinctive features, from the analysis of the sound system of the child and also from predicted generalizations. Besides, it also aims at the treatment of speech disorders, by selection of stimulus words in more favorable environments and ludic activities with the help of the computer for the correct production of the target segment in the words stimulus, promoting the generalizations of segments[2].

Stimulability, the measure that identifies whether the absent sounds of the phonetic inventory of the child can be produced through imitation[3], has been one of the criteria used to select target sounds for therapy, for explaining the patterns of generalization and predict prognosis of the treatment[4-8].

According to the literature, the generalization, the expansion and the correct use of target segments stimulated in therapy for other contexts or untrained environments, is the main aim to be achieved in therapy and the criteria used to measure the therapeutic progress[9,10]. In addition to the generalization, the effect of therapy can also be evaluated by the acquisition of segments in the phonetic inventory and the phonological system, since the main purpose of speech therapy intervention is to induce or facilitate the reorganization and/or alterations in the sound system of the child[11]. Thus, the aim of this study was to determine the effect that the Strata Model for Stimulability and Complexity[2] and the use of the Speech Intervention Software (SIFALA)[2] results in the treatment of phonological disorders.

CASE REPORT

This exploratory and comparative case study with qualitative and quantitative approach was carried out from the speech data of four subjects (S1, S2, S3 and S4) - aged from four years and ten months to 6 years and seven months, diagnosed with phonological disorder[12]. Data were collected in the research project that was approved by the Committee on Ethics and Research of Universidade Federal de Santa Maria, in its ethical and methodological aspects in agreement with the guidelines established in the Resolution 196/96 and complementary to the National Health Council. It is registered at the *Conselho Nacional de Ética e Pesquisa (CONEP)* - National Council of Ethics in Research (NCER), under the number 612.815. The schools, selected by criteria of convenience to participate in the study, authorized the collection in the institution, by signing the Institutional Authorization term of the Place of Research.

In addition, prior to the participation of children in the study, their parents and/or guardians signed the Informed Consent - IC, authorizing the participation of the child in the study. Besides, all children accepted freely to participate in the research, for such, their consent was obtained through the Consent Term for Children, whose purpose was to inform aims, methods, risks and benefits of the study to the children, and also to invite them to participate – they were free to participate of it. Due to the age of the children, the consent was given orally and signed by the guardian.

The study was developed in two preschools of the public system and in one elementary school, also of the public system. These schools are located in two cities of the northeast region of Rio Grande do Sul, with less than 10,000 inhabitants and Municipal Human Development Index (MHDI - 2013) of 0.70 and 0.72 with the economy based on agriculture and support in rural activity.

The recruited sample consisted of 45 subjects of both genders aged from four to eight years. All subjects were submitted to speech and hearing screening which included a speech and language assessment, in order to identify children with phonological disorders. The speech assessment was performed from spontaneous naming through thematic figures, used in other studies[8-10,13-17].

On the other hand, the assessment of the receptive and expressive language was performed by means of interaction and informal conversation, in which we observed the lexical, syntactic, morphological and pragmatic components, especially the logical organization of thought, the speed, the rhythm and fluency of speech, adequacy of responses and implementation of simple and complex orders.

From the speech and hearing screening 14 subjects were identified with phonological disorders. These subjects had their speech reviewed by the phonological assessment (INFONO)[18]. This instrument, which is a software product of easy application, enables the collection of a corpus of speech, phonetically balanced, its phonetic transcription, as well as its analysis and results of the phonetic inventory and the phonological system. After this, the severity of phonological disorder through the Percentage of Correct Consonants-Reviewed (PCC-R)[19] was ranked.

Then, we evaluated the stimulability of the segments which were absent in the phonetic inventory, with the help of a computer, as proposed in another study[2]. Furthermore, the subjects were submitted to speech and hearing screening by the scanning technique to 20dB and the assessment of the stomatognathic system, in which we observed the aspects related to shape, tone, mobility, positioning and function of speech organs.

As inclusion criteria the subjects must present, besides the phonological disorder, a system of sounds that would allow the selection by one of the strata of treatment, proposed by the Strata Model for Stimulability and Complexity of Segments[2]. In addition, they had to demonstrate the understanding adequate to their mental age, appropriate intellectual capacity for language development, and they had to be a member of a family of monolingual speakers of Brazilian Portuguese. Besides, the subjects would not present anatomical or physiological abnormality of the production mechanism of speech and/or signs of neurological dysfunction and consistent responses at the level of 20 dB for frequencies which were tested at the speech and hearing screening.

The exclusion criteria of the study were the indicative signs of Attention Disorder and Hyperactivity Disorder (ADHD) or syndromes, organic commitment of speech organs (such as cleft lip and palate, short lingual frenulum), as well as behaviors that would be an indicative of intellectual deficit or language retardation. In addition, the sound systems with all segments present in the phonetic inventory and few changed segments in the phonological system (less than four segments: two non-acquired and two partially acquired[20] in the phonological system).

Considering all inclusion and exclusion criteria, four subjects - S1, S2, S3 and S4, took part of the sample of this study. Figure 1 shows the characterization of the subjects, regarding gender, age, severity[19] and general phonological system. In relation to the condition of the segments, we considered, according to a study[20], for acquired segment a correct production of at least 80%, for partially acquired segment a correct production between 40 and 79% and, finally, for non-acquired phoneme, we considered a correct production when it was less than 40%.

It is possible to observe that the difficulty of S1 is centered mainly on the establishment of the features [color + cont] (-ant) that lead to the specification of palatal fricatives /ʃ/ and /ʒ/. In addition, the subject presents difficulty in acquiring the complex onset, with /l/, a syllabic structure that is more complex. S1 presents a process of anteriorization of palatal fricatives, semivocalization and replacement of liquid consonant and reduction of consonant cluster.

According to the literature, the characteristics presented by S1 express a delay in phonological acquisition, which is verified by the presence of addressed processes in typical phonological acquisition between four and five years of age, that is, the final acquisition of the liquid consonant /r/, omission of /s/ and /r/ in coda, consonant cluster reduction and anteriorization of palatal fricatives. According to the classification of phonological disorders, the one presented by S1 is characterized as delayed[13].

Subject	Age	Gender	PCC-R Index (%)	Severity	General Phonological System			Phonetic Inventory	Selected stratum (target segment)	Number of sessions
					Acquired Segments	Partially acquired segments (replacement)	Non-acquired segments (replacement)	Absent sounds		
S1	5y 4m	F	89	MD	/m/, /n/, /ɲ/, /p/, /b/, /t/, /d/, /k/, /g/, /f/, /v/, /s/, /s/coda, /z/, /l/OS, /R/, /r/OS, /r/ coda, /r/OC	/ʎ/ ([l;j], /l/OC (REC)	/ʃ/ ([s]); /ʒ/ ([z])	/ʃ/, /ʒ/	Low Segment Production directed to the Higher Complexity of IMFC (/ʒ/, /ʃ/, /ʎ/, /l/OC)	06
S2	4y 10m	M	77	MMD	/m/, /n/, /ɲ/, /p/, /b/, /t/, /d/, /f/, /v/, /s/, /s/ coda, /z/ /ʃ/, /ʒ/, /l/OS, /r/OS, /r/ coda	/ʎ/ ([j]); /r/OC (REC)	/k/ ([t]); /g/ ([d]); /R/ ([l;r]), /l/OC (REC)	/g/	Low Segment Production directed to the Higher Complexity of IMFC (/g/, /k/, /l/OC, /R/, /ʎ/, /r/OC)	06
S3	5y 11m	M	49	SD	/m/, /n/, /ɲ/, /p/, /b/, /t/, /k/, /l/OS	/d/ ([t]); /g/ ([k])	/f/ ([p;t]); /v/ ([p;t]); /s/OS ([t]); /s/coda (ø); /z/ ([d]); /ʃ/ ([t]); /ʒ/ ([d]); /R/ ([l]); /ʎ/ ([j;l]); /r/OS ([l]); /r/coda (ø); /l/OC (REC); /r/OC (REC)	/f/, /v/, /z/, /ʃ/, /ʒ/, /R/, /ʎ/, /r/	High Segment Production directed to the Higher Complexity of IMFC (/g/, /d/, /l/OC, /ʎ/, /s/, /s/coda, /v/, /f/, /R/, /r/coda, /r/, /r/OC, /ʒ/, /ʃ/, /z/)	28
S4	6y 7m	M	48	SD	/m/, /n/, /ɲ/, /p/, /b/, /t/, /d/, /f/, /v/, /l/ OS, /R/	---	/k/ ([t]); /g/ ([d]); /s/OS ([t]); /s/coda (ø); /z/ ([d]); /ʃ/ ([t]); /ʒ/ ([d]); /ʎ/ ([j;O]); /r/OS ([O,j]; /r/coda (ø); /l/OC (REC); /r/OC (REC)	/k/, /g/, /s/, /z/, /ʃ/, /ʒ/, /ʎ/, /r/	High Segment Production directed to the Lower Complexity of IMFC (/l/OC, /k/, /ʎ/, /g/, /ʃ/, /s/, /s/coda, /z/, /ʒ/, /r/coda, /r/, /r/OC)	32

Caption: M: Male; F: female; MD: Mild Deviation; SD: Severe Deviation; SO: Simple Onset; CO: complex onset; RCC: reduction of consonant cluster; *IMFC* – Implicational Model of Feature Complexity

Figure 1. Characterization of the subjects S1, S2, S3 and S4

The main difficulty presented by S2 is in the establishment of the features [dors, ± voice] that lead to the specification of the plosive segments /k/ and /g/ and in the co-occurrence of the features [+ approx, + cont, dors] to the specification of /R/. This subject presents the phonological processes of anteriorization of dorsal plosives, semivocalization of lateral liquid and consonant cluster reduction. According to the literature[13], it is possible to classify the phonological system of S2, pre-therapy, with initial characteristics, since the phonological processes of initial acquisition, involving less complex segments, have not been addressed yet.

As observed in Figure 1, S3 and S4 present changed segments in all classes of sounds, except the nasal ones. The phonological systems of these subjects are different from S1 and S2 by presenting, in addition to a greater number of changed segments, the process of systematic preference for a sound. In the phonological system of S3, the fricative segments /f, s, ʃ/ and /v, z, ʒ/ / are replaced by [t] and [d]. On the other hand, in the phonological system of S4, the segments /k, s, ʃ/ and /g, z and ʒ/ are replaced by [t] and [d]. In addition to these replacements, it occurs deletion, semivocalization or replacement of liquids, reduction of consonant cluster and also desonorization for S3.

The presence of the process of systematic preference by a sound enables the classification of these phonological deviant systems with uncommon characteristics[13] since these systems are quite lagged behind the normal phonological development, in which it is verified restricted phonetic and phonological inventory, commitment to initial levels of acquisition, with restrictions of contrasts of features, severe unintelligibility of speech and presence of many homonyms.

In Figure 1, the stratum is also described for the treatment selected and the respective target

segments as well as the number of therapy sessions. The selection of the stratum was established by the proximity between the quantity of changed segments and random selection. Thus, S1 and S2, which presented a lower number of changed segments, were included for the strata of Low Segment Production, while S3 and S4, which presented a greater number of changed segments, were included of High Segment Production. Afterwards, to set the selection regarding the complexity it was performed a random drawing, allowing the application of the four strata.

The therapy from the Strata Model for Stimulability and Complexibility[2] was based on an eclectic approach, in which different models, procedures and strategies were united, adapted and created. The use of SIFALA[2] aimed to arouse the motivation of the child from an interactive, animated and playful code. The therapist used this feature as a facilitator for intervention, in which all therapeutic activities were carried out by a speech therapist who acted as a moderator in the process of stimulation and learning.

A therapeutic intervention for S1, S2, S3 and S4 was set up as it is described below:

- Before initiating the therapeutic intervention, we performed the baseline and, always after five therapy sessions to the poll, in order to evaluate the therapeutic evolution. The baseline and the polls were performed by using five or six words for each segment that were partially acquired or non-acquired in different syllabic positions, verified in the phonological system of the pre-therapy assessment[12]. Both baseline and the polls were performed with the use of SIFALA[2] which permitted to collect, record and generate the percentage of correct answers for each segment in the different positions.
- The selection of target segments followed the order of treatment that was determined by the selected stratum. All the stratum segments were stimulated, except when the subject presented chronologically age inferior to the age of acquisition of the segment or when we verified correct production of 100% of the segment in the poll.
- All subjects were submitted to the Period 1 (P1) of stimulation, which included the stimulation of all target segments of the selected stratum (in the listed order). Therefore, the number of therapy sessions varied among subjects.
- The therapeutic intervention started with the first target segment determined by the selected stratum. When the child reached 50% or more in terms of correct production[21] or after three consecutive stimulation therapy sessions with the same target segment, the next segment stratum was selected as target.

In relation to the structure of the therapy sessions, each session was performed individually, lasting 30 minutes and with the frequency of three times a week. In all sessions, only one target segment was stimulated from the strategies, as described below:

- Auditory bombardment - carried out at the beginning and also at the end of each therapy session according to the presentation of SIFALA[2], in order to encourage and facilitate the development of new auditory images.
- Target segment imitation training - imitation of the target segment individually (sound) and at syllabic level as established in SIFALA[2], in order to check the stimulability (correct production) of the target segment.
- Practices for the target segment placing - in cases that the subject was not able to imitate the correct production of the target segment or syllable individually, a set of strategies for the production of the target segment was carried out. The performance of this activity aimed to raise awareness of the point and articulatory mode of the target segment, as well as facilitating their production. The runtime of performance of the activity had a maximum of five minutes and one small mirror, available on the table, next to the child, was used when necessary to expand visual awareness and self-control of the motor gesture. Besides the mirror, a spatula, stethoscope, powdered chocolate, *dulce de leche* and drinking straw. The visual stimulation and proprioceptive production enable the child to imitate the sound to organize the phonological information standards.
- Auditory discrimination – the subject is asked to look at pairs of syllables and identify equal syllables and different syllables, according to the ludic activity available in SIFALA[2], held in video and audio and also only in audio, in order to assist in the understanding of auditory and production differences, in relation to the target segment and its replacement or in relation to the presence or absence of the target segment.
- Target segment stimulation at the level of word and / or sentence - eight stimulus words carefully selected, based on criteria established in another study[2] were trained in ten play-training activities, available on

SIFALA[2], for encouraging the correct production of word stimuli by repetition and by spontaneous naming. The main aim of the play-training activities was to promote the correct production of word stimuli, several times, in order to facilitate the development of new auditory and kinesthetic images as well as facilitating the correct production and the self-correction[1].

Another important contribution to the treatment, also recommended in the literature and in other therapy models, is the guidance for parents and the performance of activities at home[12,13,21,22]. However, in order to avoid variables at the treatment, due to the participation/contribution of the family at the therapeutic process, we did not provide guidelines or activities to the parents.

We also carried out the analysis of reliability of the pre-therapy phonological assessment and after P1, of S1, S2 and S4, by three speech therapists, experts in speech with deviations, who were instructed to perform the broad phonetic transcription by using the Phonetic Alphabet International (IPA) from audio recordings. These recordings were edited, removing information of both subjects and assessments, being them identified by pseudonym. The words produced by the subjects were transcribed in a specific protocol, identified by the same pseudonym corresponding to the audio recording.

Afterwards, the percentage of reliability between the phonetic transcriptions performed by the researcher and by speech therapists was calculated. For that, we compared all consonant segments that occurred in the sample, the same procedure performed in another study[23]. The mean of the reliability percentage was 93.5%, ranging from 87 to 98% (standard deviation of 3.5%).

The data from the phonetic inventory and from the phonological system were analyzed pre-therapy and after Period 1 of therapy for S1, S2, S3 and S4. Finally, we compared the number of consonants produced correctly between the pre-therapy phonological assessment and after Period 1 of therapy. These data were run in Statistica program, version 9.1. We used the chi-square test, at a significance level of 5% ($p < 0.05$).

RESULTS

Figure 2 shows the results regarding the phonetic inventory, the phonological system and the assessment of stimulability pre and after Period 1 (P1) of therapy for S1, S2, S3 and S4. We verified that all of the absent segments in the phonetic inventory for S1, S2, S3 and S4 became present after P1 of therapy. Furthermore, we noted that all the subjects acquired segment P1 after therapy.

Figure 3 illustrates the number of segments produced pre and after the P1 of therapy for S1, S2, S3 and S4. We verified that all subjects produced a greater number of correct segments after P1 of therapy, being this difference statistically significant.

		General Phonological System			Phonetic Inventory	Stimulability
		Acquired Segments	Absent sounds	Non-acquired segments	Absent sounds	
S1	Pre-therapy	/m/, /n/, /ɲ/, /p/, /b/, /t/, /d/, /k/, /g/, /f/, /v/, /s/, /s/coda, /z/, /l/OS, /R/, /r/OS, /r/coda, /r/OC	/ʎ/, /l/ OC	/ʃ/, /ʒ/	/ʃ/, /ʒ/	/ʃ/ Stimulable for isolated form; not stimulable for syllable and word /ʒ/ Non stimulable for isolated form, for syllable and word
	After P1	/m/, /n/, /ɲ/, /p/, /b/, /t/, /d/, /k/, /g/, /f/, /v/, /s/, /s/coda, /z/, /ʃ/, /ʒ/, /l/OS, /l/OC /R/, /r/OS, /r/coda, /r/OC	/ʎ/	---	---	---
S2	Pre-therapy	/m/, /n/, /ɲ/, /p/, /b/, /t/, /d/, /f/, /v/, /s/, /s/ coda, /z/ /ʃ/, /ʒ/, /l/OS, /r/OS, /r/ coda	/ʎ/, /r/OC	/k/, /g/, /R/, /l/ OC	/g/	/g/ Non stimulable for isolated form, for syllable and word
	After P1	/m/, /n/, /ɲ/, /p/, /b/, /t/, /d/, /f/, /v/, /s/, /s/ coda, /z/ /ʃ/, /ʒ/, /l/OS, /ʎ/, /r/OS, /r/ coda	/k/, /g/, /l/OC, /r/OC	---	---	---
S3	Pre-therapy	/m/, /n/, /ɲ/, /p/, /b/, /t/, /k/, /l/OS	/d/, /g/	/f/, /v/, /s/ /s/ coda, /z/, /ʃ/, /ʒ/, /R/, /ʎ/, /r/OS, /r/ coda, /l/OC, /r/OC	/f/, /v/, /z/, /ʃ/, /ʒ/, /R/, /ʎ/, /r/	/f/ Stimulable for isolated form, for syllable and word /v/ Stimulable for isolated form, for syllable and word /z/ Non stimulable for isolated form, for syllable and word /ʃ/ Non stimulable for isolated form, for syllable and word /ʒ/ Non stimulable for isolated form, for syllable and word /R/ Stimulable for isolated form and syllable and non stimulable for word /ʎ/ Stimulable for isolated form, for syllable and word /r/SO, /r/ coda, /r/ Non stimulable for isolated form, for syllable and word
	After P1	/m/, /n/, /ɲ/, /p/, /b/, /t/, /d/, /k/, /g/, /f/, /v/, /z/, /ʃ/, /ʒ/ /l/OS	/s/, /s/coda, /X/, /ʎ/, /l/OC	/r/OS, /r/coda, /r/OC	---	---
S4	Pre-therapy	/m/, /n/, /ɲ/, /p/, /b/, /t/, /d/, /f/, /v/, /l/OS, /R/	---	/k/, /g/, /s/OS, /s/coda, /z/, /ʃ/, /ʒ/, /ʎ/, /r/OS, /r/coda, /l/OC, /r/OC	/k/, /g/, /s/, /z/, /ʃ/, /ʒ/, /ʎ/, /r/	/k/ Stimulable for isolated form, for syllable and word /g/ Stimulable for syllable and non stimulable for isolated form and word /s/ Non stimulable for isolated form, for syllable and word /z/ Non stimulable for isolated form, for syllable and word /ʃ/ Stimulable for isolated form. Non stimulable for syllable and word /ʒ/ Non stimulable for isolated form, for syllable and word /ʎ/ Stimulable for isolated form, for syllable and word /r/SO, /r/ coda, /r/CO Non stimulable for isolated form, for syllable and word
	After P1	/m/, /n/, /ɲ/, /p/, /b/, /t/, /d/, /f/, /v/, /l/OS, /ʎ/, /R/	/k/, /s/OS, /s/ coda, /ʃ/, /ʒ/, /l/OC	/g/, /z/, /r/OS, /r/ coda, /r/OC	---	---

Figure 2. General phonological system, phonetic inventory and stimulability pre therapy and after period 1 of therapy for S1, S2, S3 and S4

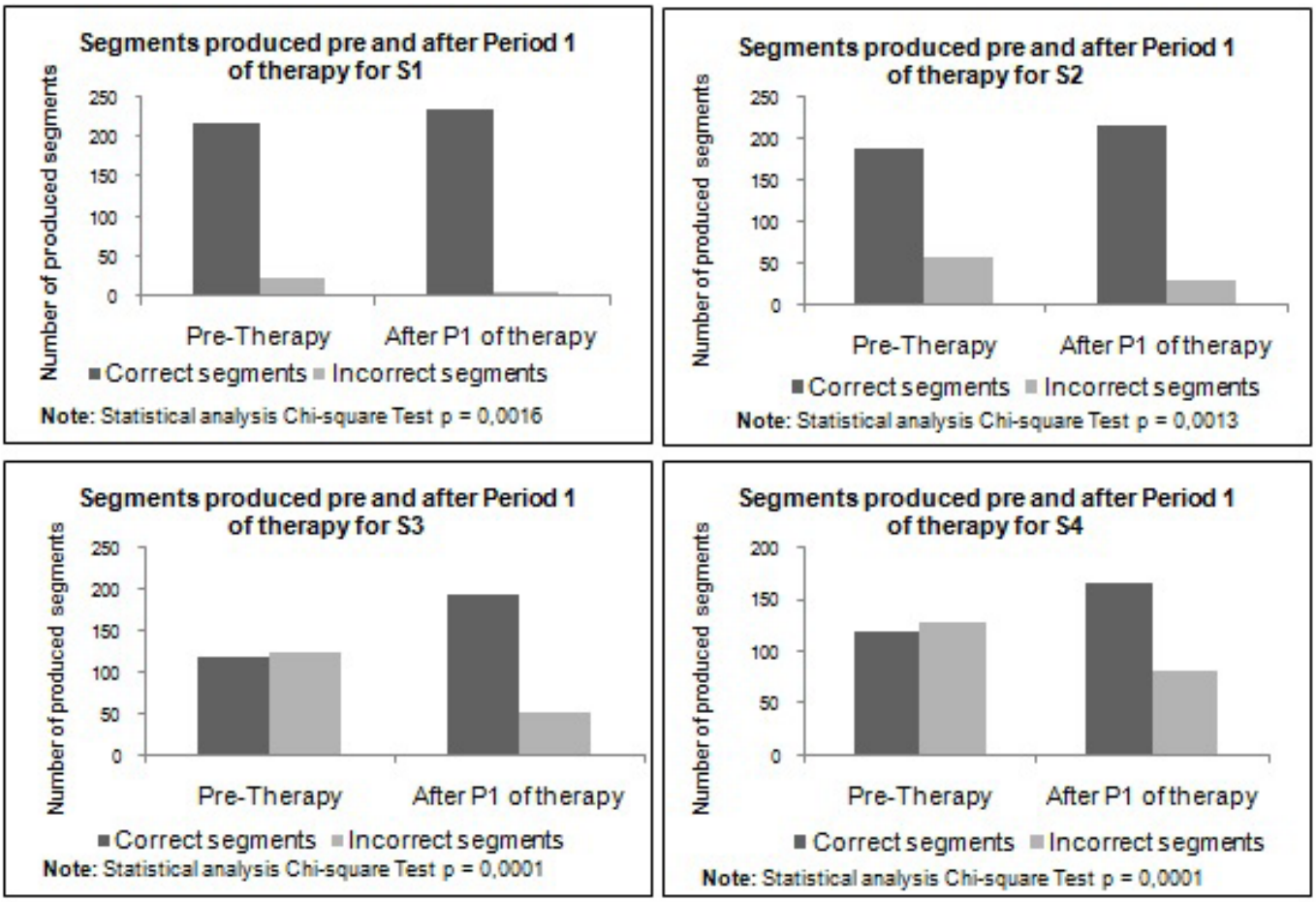

Figure 3. Number of segments and produced pre after the Period 1 (P1) of therapy for S1, S2, S3 and S4

DISCUSSION

All absent segments for S1, S2, S3 and S4 became present after the P1 therapy. This finding reveals that the subjects presented improvement regarding the ability to articulate the changed segments. Therefore, we suggest that the focus on stimulability, included by the eclectic approach, on the training of the target segment imitation and of the strategies for the segment placement contributed actively to obtain such results.

A study that compared the improvement of the phonological system of children with phonological disorder who were submitted to speech therapy, with or without stimulation of orofacial praxis abilities, found out that only the group treated with praxis abilities of language with phonological therapy acquired all the segments which were absent in phonetic inventory[24]. Other studies also reported the acquisition of sounds in the phonetic inventory after the therapy from different intervention phonological models[14-16,25].

In relation to the phonological system, we observed that all subject acquired segments after the P1 of therapy. This finding reveals that the therapy achieved the objective of promoting the acquisition of segments, making the speech the child more intelligible. In general, we observed that most of the acquisitions in the phonological system of S1, S2, S3 and S4 occurred at the changed segments that were present in the phonetic inventory and that were stimulatable in the assessment of the stimulability. This finding comes to an agreement with the literature that states that phonological systems whose changed segments are stimulatable present better prognosis[4-8].

S3, with a severe level, treated by the Low Segment Production directed to the Higher Complexity of IMFC stratum, showed the highest number of segments acquired in the phonological system. According to the literature, the treatment of more severe phonological systems, which present higher number of changed sounds, results in greater acquired segments[16].

S3 and S4 had in common, after the P1 of therapy, the segment /r/, which was not acquired in their phonological system at any of coda positions, simple and complex onset. This finding validates a study which states that no stimulable target segment is more difficult to be taught and learned[8]. Moreover, it highlights the complexity of the segment /r/ and the greatest difficulty in acquiring it due to the need for more precise and fine movements of tongue[17] and also to the fact that this segment assumes more complex positions in the syllable, being the latest phonological acquisitions evidenced by children with normal phonological development[26].

Finally, although there were important developments in the treatment of S3 and S4, after 28 and 32 therapy sessions, respectively, the data of the re-assessment point to the need for further therapy. The treatment of more severe phonological systems, due to their higher unintelligible speech and less phonological knowledge, as well as the need of a greater number of acquired segments, the subjects need a greater number of treatment sessions to have the speech therapy discharge[27].

Since the main aim of speech intervention is to induce or facilitate the reorganization and/or changes in the phonological inventory of subjects who present phonological deviation[11], it is expected to verify on the speech of the child the occurrence of more correct production of the segments with the therapy - this was achieved in the intervention of S1, S2, S3 and S4. This shows that the therapeutic intervention promoted the correct production of segments, which make the speech of the subjects more intelligible.

Furthermore, these findings reveal that treatment from the stratum and the selected words stimulus, together with the activities carried out with the help of SIFALA[2], was effective for the treatment of S1, S2, S3 and S4. This corroborates with the data in the literature that refer that the use of software in speech therapy has revealed positive results[10,28,29].

The results of therapy with the application of the software show that the use of a computer is able to offer an effective therapy, leading to acquisition of sounds. According to researchers, software help because during activities with the computer, the child engages in an interactive program with exercises based on the production and/or the perception of target sounds[29,30].

According to the literature[10,30], the use of a computer, as an intervention instrument is capable of favoring better results in relation to the development in the phonological system when compared to the standard therapy, since the specific software is a way to innovate the speech therapy in order to make it more appropriate to current interests of the child[10,29].

Furthermore, it is possible to be inferred that the positive results were achieved, since the activities of training and play-training developed and practiced with the help of SIFALA[2] allowed to explore and achieve the aims of the treatment that included teaching the correct articulation of the sounds of speech and facilitating the organization of concepts, the lexical representation and the storage of information about the system of sounds and phones of speech.

CONCLUSION

The Stratum Model for Stimulability and Complexity of the segments and the use of Speech Intervention Software (SIFALA) provided changes in the system of sounds of the treated subjects, in which segments are established in the phonetic inventory and acquired in the phonological system. We conclude that the Model and the use of SIFALA have positive effect, contributing to the planning and treatment of phonological disorders. However, there is the need for further studies with an amplification of the sample to confirm the findings.

All subjects treated by the different strata, presented gains in the phonological system. However, the subjects treated by strata directed to greater complexity of IMFC showed better therapeutic improvement, but due to the small number of subjects and due to the fact that the initial phonological systems are different, we cannot make statements about the most effective stratum.

Finally, SIFALA was used as a facilitator instrument in the therapy, and the activities play- training based on procedures, techniques or strategies associated to the literature and clinical practice. Thus, SIFALA fulfill the recommendation described in the literature, in which it is mentioned that the software can be used as a way to guide the therapy, if it is provided a theoretical basis and that clinical evidence are also considered in the process.

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