Acoustic characteristics of the phonemes [s] and [ʃ] of adults and children without phonological disorders

Características acústicas dos fones [s] e [ʃ] de adultos e crianças com desenvolvimento fonológico típico

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ABSTRACT

Purpose: To compare the productions of [s] and [ʃ] of adults and children with typical phonological development considering the following acoustic parameters: duration of fricative noise, frequency band of higher concentration of noise, cutoff frequency of friction noise, and values of formant transition of the following vowel. **Methods:** Participants were 26 subjects, divided into two groups: Adults group (AG) – composed of 17 young adults (mean age: 23.61±3.44 years) without phonological disorders; and Typically developing children group (TDCG) – composed of nine children (mean age: 7.12±0.74 years) with typical phonological development. Subjects underwent speech-language pathology and audiology screening, and then data collection for acoustic analysis. For acoustic analysis, pseudowords in carrier phrases were used. We analyzed 624 productions from the subjects, and the results were statistically analyzed. **Results:** The parameters frequency band of higher concentration of noise and formant transition of the following vowel presented differences between groups. In the comparison between word positions, the parameters duration and cutoff frequency of fricative noise, and formant transition of the following vowel presented differences. The parameters frequency band of higher concentration of noise, cutoff frequency of friction noise, and formant transition of the following vowel showed statistical differences in the comparison between the points of articulation of [s] and [ʃ]. **Conclusion:** For most of the studied acoustic parameters, children's and adults' productions were similar. However, for some parameters, differences were observed between groups, word positions, and pois of articulation of the phonemes [s] and [ʃ].

Keywords: Speech acoustics; Adult; Child; Speech; Phonetics; Verbal behavior

INTRODUCTION

The fricative consonants are produced by a narrowing of the vocal tract, causing, by the passage of air in a narrow space, a characteristic noise of these sounds. The phonemes /f, v, s, z, ʃ, ʒ/ are part of the third class of Brazilian Portuguese (BP) consonants to be acquired by individuals, between 1 year and 8 months and 2 years and 10 months[1,2]. The phoneme /s/ is acquired at 2 years and 6 months, and the /ʃ/ at 2 years and 10 months; the /ʃ/ is the last in the class to be produced correctly by speakers with typical phonological development (TPD). Subjects with TPD have their phonological system complete around 5 years old, as most BP speakers[3].

In terms of phonological description, it is possible to differentiate fricatives by voicing (voiced or voiceless) and by point of articulation ([coronal, +-anterior] and labial). The fricatives /s/ and /ʃ/ are voiceless and they differentiate from each other by the place of articulation where they are produced. The phoneme /s/ has the [coronal, +anterior] features, and the /ʃ/, [coronal, -anterior], differing only by the value of the trait ([anterior]).

According to the articulatory phonetics, it is possible to consider that the sound [ʃ] is a palato-alveolar fricative, i.e., produced using the palate as passive articulator and the tongue as active articulator. The sound [s] is also produced with the tongue as active articulator, however, the passive articulator,

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in this case, is the alveolar region; hence, it is considered an alveolar sound.

With respect to acoustic phonetics, the fricatives [s] and [ʃ] are described as aperiodic, noisy sounds, produced from the passage of air through a narrowing of the vocal tract. This kind of analysis allows more objectivity and reliability of data when compared to the perceptive-auditory analysis[4-6].

Speech-language pathology clinic still does not use acoustic analysis of speech as a usual procedure. Rather, auditory-perceptual analysis is constantly used to assess patients' speech. Thus, the present study intends to show how the use of acoustic analysis can make the description of speech more reliable and objective.

In order to know how oral myofunctional develops and mature and how phonological stabilization occurs, it is important to compare the speech of children and adults. Acoustic analysis allows these data to be controlled and quantified.

Thus, this study had the aim to compare the production of [s] and [ʃ] in adults and children with TPD, considering the following acoustic parameters: duration of fricative noise, frequency band of higher concentration of noise, cutoff frequency of friction noise, and values of formant transition of the following vowel. In addition, it was aimed to know the possible effects of the acoustic parameters in different word positions – initial onset (IO), and medial onset (MO) – regarding the sounds [s] and [ʃ], and the possible differentiation of the point of articulation of the fricatives [s] and [ʃ] by using the same parameters.

METHODS

This study was approved by the Ethics Committee of the Universidade Federal de Santa Maria (UFSM), under number 23081.008948/2009-01.

The study sample included 26 individuals divided into two groups:

- Adults group (AG): comprising 17 young adults with mean age of 23.61±3.445 years, five male and 12 female, without phonological disorders;
- Typically developing children group (TDCG): composed by nine children, with mean age of 7.12±0.74 years, six male and three female, with TPD.

In order to compose the sample, individuals of AG should not have a history of alterations in the phonological level, as well as any phonological alterations at the date of assessment and data collection; they must be monolingual speakers of BP (gaucho dialect), and be between 19 years and 32 years, 3 months and 29 days*. Inclusion criteria for the TDCG were: to present TPD; to be between 4 years and 7 years, 11 months and 29 days; and to be monolingual speaker of BP (gaucho dialect). Individuals who had received or were receiving speech-language therapy and those who presented other speech, hearing or language alterations that could interfere with speech production, such as hearing loss or cognitive, neurological or evident psychological alterations, were excluded from the sample.

All individuals and/or their legal guardians signed the Free and Informed Consent Term, allowing their participation in the study. Children were asked if they would like to participate in the study, and all of them agreed.

Subjects were selected at the School Clinic of the Undergraduate Program in Speech-Language Pathology and Audiology of UFSM – *Serviço de Atendimento Fonoaudiológico* (SAF), and at public schools (*Escola Estadual de Ensino Fundamental Marieta D'Ambrósio* and *Escola Estadual de Ensino Fundamental Edson Figueiredo*) in Santa Maria (RS), Brazil.

Individuals in both groups were submitted to a speech-language pathology and audiology screening, which observed the adequacy of orofacial myology, hearing, language, and voice aspects. With regards to orofacial myology, the following aspects were verified, through the application of the assessment protocol available at the School Clinic: aspect, posture, mobility and muscle tension of the speech organs and their functions (breathing, chewing, swallowing and speech articulation). A voice screening was conducted by obtaining the maximum phonation time of vowels [a] and [e], and observing aspects such as hoarseness, roughness, breathiness and instability. It was also carried out a hearing screening, with a properly calibrated audiometer (Interacoustics Screening Audiometer® AS208). The tests were performed at the Audiology Laboratory of the School Clinic or at the schools that participated in the study, in a silent environment. In the TDCG, the language aspects were analyzed by a logical sequence of four events, from which individuals were asked to tell a little story. In the AG, the assessment of language aspects was performed by spontaneous conversation, guided by the researcher through questions about the subject, such as age and occupation, among others.

In the AG, we applied the *Avaliação Fonológica da Criança* (AFC)[7], in an adapted manner. The target words were respected, but they were presented in a different way, as isolated figures, considering the age of the individuals in this group.

For the TDCG, individuals' spontaneous speech was observed to find whether they performed any substitution, omission, insertion or transposition in the phonological aspect, and the target phonemes were correctly produced in 100% of the possibilities of occurrence.

For both groups, it was considerate the normative criteria in literature regarding phoneme acquisition[8].

Speech data from all individuals were collected and submitted to acoustic analysis. For that purpose, pseudowords that contained the fricatives [s] and [ʃ] in IO and MO positions, always followed by the vowel [a], were used: *sássa* - [‘sasa]; *sassá* - [sa’sa]; *xáxa* - [‘ʃaʃa] and *xaxá* - [ʃa›ʃa]. The fricative sounds were analyzed only in tonic position. These pseudowords were inserted in the carrier phrase "*Fala ______ de novo*" ("Say ______ again"). Each carrier phrase was repeated radomly three times, in two blocks of recordings. A total of 624 productions were analyzed.

Pseudowords were used in order to control the linguistic

* According to the Health Descriptors (DeCS), individuals aged between 19 and 44 years are considerated adults.

variables present in the production of fricatives, because, in this way, the production of all individuals would have the same target[9-16]. The only exception was the variable word position, which was a target of this study.

Individuals listened to a recording made by the researcher, which contained the carrier phrase. Subjects were asked to repeat the carrier phrases in the order they were heard in the recording. Headphones (Sennheiser®, HD 280PRO) were used for this purpose. Data were recorded in a soundproof booth, using an omnidirectional microphone (Behringer® brand, model 8000 ECM) positioned at approximately four centimeters from the mouth of the subject. For the recording of speech data it was used the MATLAB software, version 7.1 SP3, of the software package MATLAB/Simulink, using the signal processing toolbox of Simulink in wave file and high resolution (24 bits and 96 kHz). An external sound card (M-AUDIO® brand, model LT FW 410) was also used, so the acoustic signal presented better accuracy. This plate was connected to a DELL® Inspiron notebook computer.

The analysis of the recorded data was performed on the audio processing Praat software (version 5.0.12; available at www.praat.org), at a sampling rate of 96 kHz and 16 bits, for three of the four studied acoustic parameters: duration of fricative sounds, frequency band of higher concentration of noise, and values of formant transition of the following vowel [a].

The duration of fricative noise for [s] and [ʃ] was obtained by measuring the time between the first sign of fricative noise after silence and the first pulse of the vowel [a] following the fricative or between the last pulse of the vowel [a] (of the word *"Fala"*) and the first pulse of the following vowel [a], for the cases in which fricatives were analyzed in IO position. For cases in which the sounds were in MO position, it was measured the time between the last pulse of the preceding vowel (the first [a] of the target word) and the first pulse of the following vowel [a].

The frequency bands of higher concentration of fricative noise were extracted based on visual analysis, in the spectrogram generated by the Praat software, from the frequency bands corresponding to those of higher concentration of fricative sound. It was considered that the regions of higher concentration of fricative noise were the most intense (the darkest) in the spectrogram generated by the program. The frequency values that represented the beginning and the end of the region of higher concentration of noise were extracted.

The same software was also used to measure parameter values of formant transition. This parameter represents the influence of the sounds on the following vowel; in this present study, the influence of [s] and [ʃ] on the vowel [a]. For this purpose, it was necessary to extract the values from the formants of each vowel [a] following the fricatives studied in tonic position. The first 20 milliseconds (ms) were cut out and, from that, the first three formants of the vowel (F1, F2 and F3) were calculated using a software command (formant->formant listing).

To analyze the cutoff frequency parameter, the Wavesurfer software (version 1.8.5, available at http://www.speech.kth.se/wavesurfer/download.html) was used, in a sampling rate of 16 kHz and 16 bits. Eight milliseconds were cut in the middle portion of the spectrum of each studied sound ([s] and [ʃ]). It was used the Fast Fourier Transform (FFT) technique, by manually extracting the peak of higher frequency seen in the spectrogram.

After tabulated, data were statistically analyzed by using the SPSS Statistics 17.0 program, in order to compare the results of the TDCG and AG groups for each analyzed parameter. The non-parametric Wilcoxon Signed-Rank test was used in the comparisons performed in the groups, and the Mann Whitney U test was used for comparisons between groups; a significance level of 5% ($p<0.05$) was used in both tests.

RESULTS

The median values are exposed, since data did not present a normal distribution. Mean values were also presented, complementing the values of standard deviation, variance and coefficient of variation, measures of variability, i.e., through these measures it was possible to have an idea of how the sample varied regarding a particular parameter (Tables 1 and 2).

A significant difference was observed only for the parameter band of higher concentration of frequency, in both word positions for [s] and only in IO for [ʃ]. N addition, the parameter formant transition in F2 presented significant difference for [ʃ] in both word positions. Hence, it was inferred that the parameter band of higher concentration of frequency was a primary track, that is, it was the parameter that better differentiated the sound [s] between AG and TDCG, and that the parameter formant transition in F2 was a primary track in the differentiation of [ʃ] between groups.

Analyses were also conducted in order to know the possible relationship between IO and MO positions for both analyzed sounds, in AG and TDCG, with the following cross-overs using the Wilcoxon Signed-Rank test: [s] sound in IO position *versus* [s] sound in MO position, and [ʃ] sound in IO position *versus* [ʃ] sound in MO position (Table 3).

Regarding the differences between word positions, the Wilcoxon Signed-Rank test showed significant difference in the duration parameter for both phones and both groups, demonstrating that this was a strong parameter for this differentiation. The parameters cutoff frequency and formant transition in F1 and F3 were secondary parameters for this differentiation, because they presented significant difference only for [s] or only for [ʃ], and only in the AG.

We also analyzed the possible relationship between the point of articulation of the studied sounds with the following crossings, also carried out by the Wilcoxon Signed-Rank test: [s] sound in IO position *versus* [ʃ] sound in IO position, and [s] sound in MO position *versus* [ʃ] sound in MO position (Table 4).

It was verified that the parameters cutoff frequency, frequency bands of higher concentration of fricative noise, and formant transition in F2 were more robust to differentiate the [s] and [ʃ] sounds, with regards to their points of articulation. Duration and formant transition in F1 were secondary parameters for this differentiation, presenting significant difference in only one position in the analyzed words, and only in the AG.

Table 1. Comparison between AG and TDCG regarding the acoustic parameters obtained for the [s] sound

Acoustic parameters			AG				TDCG				p-value
			Mean (SD)	Median	Variance	Variation coefficient (%)	Mean (DP)	Median	Variance	Variation coefficient (%)	
IO	D (s)		0.20 (0.02)	0.21	0.0004	10.00	0.20 (0.02)	0.20	0.0004	10.00	0.339
	CF (Hz)		7913.32 (1028.70)	8206.16	1058240.94	12.99	7931.83 (777.69)	8048.20	1058240.94	9.80	1.000
	B (Hz)	I	5977.25 (1001.51)	5961.16	1003038.65	16.75	5613.16 (823.16)	5492.00	1003038.65	14.66	0.418
		F	13109.73 (1085.70)	13145.67	1178757.26	8.28	15653.35 (1734.59)	15952.00	1178757.26	11.08	0.001*
	FT (Hz)	F1	684.57 (105.56)	693.33	11144.84	15.41	661.13 (89.99)	654.29	11144.84	13.61	0.560
		F2	1534.07 (169.97)	1580.60	28892.63	11.07	1514.57 (188.41)	1511.68	28892.63	12.43	0.634
		F3	2843.04 (226.79)	2840.83	51436.47	7.97	2696.52 (650.09)	2509.09	51436.47	24.10	0.287
MO	D (s)		0.17 (0.01)	0.17	0.0001	5.88	0.16 (0.01)	0.17	0.0001	6.25	0.525
	CF (Hz)		7826.79 (1147.82)	8177.66	1317491.77	14.66	7898.59 (780.37)	7991.50	1317491.77	9.87	1.000
	B (Hz)	I	5800.15 (1039.86)	5739.00	1081326.98	17.92	5647.55 (1027.44)	5343.83	1081326.98	18.19	0.634
		F	13217.22 (1173.42)	12842.00	1376923.57	8.87	16159.18 (1675.66)	16546.00	1376923.57	10.36	0.000*
	FT (Hz)	F1	699.62 (107.36)	713.27	11526.84	15.34	660.61 (114.33)	642.77	11526.84	17.30	0.525
		F2	1515.49 (165.71)	1529.53	27463.10	10.93	1544.00 (155.89)	1514.27	27463.10	10.09	0.874
		F3	2808.32 (207.73)	2807.68	43154.78	7.39	2774.10 (630.62)	2985.97	43154.78	22.73	0.958

* Significant values (p<0.05) – Mann-Whitney U Test

Note: IO= initial onset; OM = medial onset; D = duration, in seconds; CF = cutoff frequency; B = frequency band of higher noise concentration; FT= formantic transition; I = initial; F = final; SD = standard deviation

Table 2. Comparison between AG and TDCG regarding the acoustic parameters obtained for the [ʃ] sound

Acoustic parameters			AG				TDCG				p-value
			Mean (SD)	Median	Variance	Variation coefficient (%)	Mean (DP)	Median	Variance	Variation coefficient (%)	
IO	D (s)		0.19 (0.02)	0.19	0.0004	10.52	0.19 (0.02)	0.19	0.0004	10.52	1.000
	CF (Hz)		3656.49 (522.73)	3693.16	273247.22	14.29	3532.94 (946.72)	3416.20	273247.22	26.79	0.702
	B (Hz)	I	2583.90 (669.77)	2504.00	448599.20	25.92	2513.74 (676.27)	2380.40	448599.20	26.90	0.702
		F	9565.02 (828.08)	9468.00	685727.44	8.65	11006.36 (1107.17)	11294.50	685727.44	10.05	0.002*
	FT (Hz)	F1	658.49 (110.50)	657.42	12212.02	16.78	648.07 (118.59)	618.58	12212.02	18.29	0.792
		F2	1716.04 (183.43)	1704.67	33648.85	10.68	1980.70 (151.05)	2008.42	33648.85	7.62	0.003*
		F3	2830.18 (209.62)	2863.80	43943.40	7.40	3057.72 (308.55)	3128.01	43943.40	10.09	0.058
MO	D (s)		0.17 (0.01)	0.17	0.0001	5.88	0.16 (0.02)	0.16	0.0004	12.50	0.396
	CF (Hz)		3848.31 (585.81)	3829.50	343177.06	15.22	3536.43 (1033.39)	3574.33	343177.06	29.22	0.312
	B (Hz)	I	2681.65 (604.00)	2479.16	364826.85	22.52	2369.38 (631.04)	2306.33	364826.85	26.63	0.186
		F	9700.32 (969.05)	9567.50	939070.92	9.98	10704.58 (1637.16)	10803.33	939070.92	15.29	0.095
	FT (Hz)	F1	645.82 (106.50)	646.24	11342.43	16.49	648.52 (132.47)	615.00	11342.43	20.42	1.000
		F2	1695.39 (180.53)	1696.66	32592.07	10.64	2021.99 (204.56)	1997.36	32592.07	10.11	0.001*
		F3	2839.41 (248.02)	2831.19	61518.35	8.73	3044.11 (382.22)	2986.81	61518.35	12.55	0.241

* Significant values (p<0.05) – Mann-Whitney U Test

Note: IO= initial onset; OM = medial onset; D = duration, in seconds; CF = cutoff frequency; B = frequency band of higher noise concentration; FT= formantic transition; I = initial; F = final; SD = standard deviation

DISCUSSION

Analyzed data tried to establish relationships between the acoustic parameters of the studied sounds: (a) in the different groups (AG and TDCG); (b) in different word positions; (c) in different points of articulation.

The analysis of the sounds in the studied groups, AG and TDCG, evidenced that, for the acoustic parameters duration and cutoff frequency, there was no significant differences between groups, both for the production of [s] and [ʃ], in IO and MO positions, which showed that the productions of adults and children were statistically similar when considering these parameters[9,17]. Children in our sample had statistically equal values to those found in the AG, in both two parameters. On the contrary, another study[18] found that children's productions were usually in regions of higher frequencies when compared to the productions of a group of adults, which, according to the authors, may be related to size and the opening of the vocal tract.

According to the same analysis, it was observed a difference between AG and TDCG when the groups were compared for the parameter end of the frequency band of higher concentration of fricative noise, for the studied sounds in all positions. It was noticed that the difference was present only in frequency values of the end of the band of concentration of fricative noise, which could be explained by the size of the vocal tract of children[18], that favored the reinforcement of higher frequencies.

Table 3. Comparison of the studied parameters for [s] and [ʃ] sounds regarding word position

Acoustic parameters		AG		TDCG	
		[s] OI *versus* [ʃ] OI	[s] OM *versus* [ʃ] OM	[s] OI *versus* [ʃ] OI	[s] OM *versus* [ʃ] OM
D (s)		0.000*	0.000*	0.008*	0.004*
CF (Hz)		0.378	0.004*	0.734	0.910
B (Hz)	I	0.086	0.239	0.910	0.055
	F	0.818	0.306	0.734	0.301
FT (Hz)	F1	0.031*	0.243	0.910	0.910
	F2	0.109	0.051	1.000	0.734
	F3	0.027*	0.854	1.000	0.820

* Significant values ($p<0.05$) – Wilcoxon Signed-Rank test
Note: IO= initial onset; OM = medial onset; D = duration, in seconds; CF = cutoff frequency; B = frequency band of higher noise concentration; FT= formantic transition; I = initial; F = final

Table 4. Comparison of the studied parameters for [s] and [ʃ] sounds regarding their points of articulation

Acoustic parameters		AG		TDCG	
		[s] OI *versus* [ʃ] OI	[s] OM *versus* [ʃ] OM	[s] OI *versus* [ʃ] OI	[s] OM *versus* [ʃ] OM
D (s)		0.000*	0.678	0.203	0.910
CF (Hz)		0.000*	0.000*	0.004*	0.004*
B (Hz)	I	0.000*	0.000*	0.004*	0.004*
	F	0.000*	0.000*	0.004*	0.004*
FT (Hz)	F1	0.045*	0.000*	0.570	0.820
	F2	0.000*	0.000*	0.004*	0.004*
	F3	0.404	0.644	0.129	0.301

* Significant values ($p<0.05$) – Wilcoxon Signed-Rank test
Note: IO= initial onset; OM = medial onset; D = duration, in seconds; CF = cutoff frequency; B = frequency band of higher noise concentration; FT= formantic transition; I = initial; F = final

Furthermore, in relation to the transition formant, no other significant differences were observed between groups for the [s] sound. For the [ʃ] sound, there was a difference for F2 values, in IO and MO positions. The F1 and F2 of the vowel are the main definers of these sounds. The F1 of the vowel (also the most intense) varies with the height of the tongue; the higher the position of the tongue, the lower the frequency of F1(19). The F2 is related to horizontal movements and to the advancement of the tongue in the oral cavity(19). The F3 is related to the resonance of the posterior cavity of the oral cavity, however it is a difficult measure to be observed, especially in the absence of dynamic data of speech production(20).

The difference in the values of formant transition in relation to the groups (as well as the differences found only in AG and not in both groups) may be related to neuromaturation of orofacial structures, such as the tongue, which can be positioned differently in each group for the production of the studied sounds. This difference might be related to alterations of the orofacial structures present in children; as they are still in development, placement of the tongue, mouth opening, among other characteristics, can be changed(18,21,22). Moreover, it is possible to infer that the size of the vocal tract of children, in this case, could also explain the statistical differences found, since the frequencies reinforced are directly related to the size of the vocal tract(18).

The values of vowel formants found in this study for TDCG were decreased when compared to those found for a similar group of speakers of the same language(10). For French speakers, the values of cutoff frequency of the [ʃ] sound correspond to the values of F3 and F4 of the vowel, and these values for the [s] sound, to those of the fifth formant (F5) or higher(20). For the [s] sound, this comparison was not possible because the values of F5 or higher were not measured.

Analyses regarding the [s] and [ʃ] sounds and the different word positions in which they were studied showed that they had different, significant, duration values in both groups, being longer in initial position. These findings relate to the idea that the initial position of the word and the tonic position are always more prominent(11,23).

For the parameter cutoff frequency, this difference appeared only for the AG, when analyzing the [ʃ] sound, which could be explained by neuromaturation of orofacial structures and by craniofacial growth, important for speech production, that is still developing in the TDCG. This may alter their production, making it, sometimes, unstable(18,22).

Regarding the parameter formant transition, a difference was found for the values of F1 and F3, in AG, in the differentiation of the word position (IO and MO) of the [s] sound. This result was not expected, because it was imagined that the fricative would equally influence the formants of the [a] vowel, regardless the word position. The F1 values in IO were higher than the values found in MO. For F3, the values were lower in IO than in MO.

The parameter frequency band of higher concentration of fricative noise was not different for any of the analyzed sounds. Therefore, the finding suggests that this parameter does not differentiate the [s] and [ʃ] sounds in terms of the position occupied by them.

When the relationship between alveolar and alveolar-palate points of articulation of the sounds was analyzed, differences were found for the parameters cutoff frequency and frequency band, for both groups (AG and TDCG). The cutoff frequency of the fricative noise and the frequency band of higher concentration of fricative noise were, thus, considered good acoustic parameters to differentiate the point of articulation of voiceless fricatives (alveolar and alveolar-palate), i.e., these parameters provide primary cues for such differentiation. Cutoff frequency values were also investigated in other languages, such as European Portuguese and English, and the findings were similar to those found in this study, both for [s] and [ʃ] sounds(12,24), differentiating these sounds based on this parameter(11).

The parameter formant transition showed, for F1 values, significant difference when the sounds were in IO and MO positions, but only for the AG; F2 values were different in both positions and for both groups. The findings of this study corroborate the research data for North American English(12), confirming the formant transition parameter as a good differentiator of the points of articulation of [s] and [ʃ]. Regarding the BP[10], only F2 was a differentiator of the articulation points of the studied sounds. For other languages, such as Mandarin and English[13,25], the formant transition was not a good differentiator of fricatives. However, sometimes, values that can indeed contribute to the detection of the point of articulation of fricative sounds can appear[26]. It is also possible to think about the relationship between formant transition and points of articulation of fricatives; for this purpose, there seems to be an increase in the F2 value as the constriction in the oral cavity is more posterior[27]. The other parameters were not favorable to differentiate the studied sounds regarding their points of articulation.

For the duration parameter, data from this study agreed with other findings in the area, which claim that this parameter would be more appropriate to differentiate voiced and voiceless fricatives, and not as much for the points of articulation of this class of sounds[11].

The literature in the area, by studying acoustic parameters that are responsible for the differentiation of points of articulation of fricatives, have pointed out that the normalized maximum spectral slope, the most dominant slope location, the most dominant peak location, the dominace regarding the high filter and the spectral gravity center are accurate parameters for differentiation of this aspect[26].

It is important to control the context and the effect of the vowel on the sounds studied[25,28], such as with pseudowords and/or carrier phrases, used in the present study and in many other studies in the area[9-16].

CONCLUSION

For most of the studied acoustic parameters, the productions of AG and TDCG were similar. The parameter end of the frequency band of higher concentration of fricative noise was primary, or more robust, in the differentiation of the [s] sound between groups, and the parameter formant transition of F2 in IO and MO positions can be considered a more robust parameter for the differentiation of the groups regarding the [ʃ] sound. However, for some parameters, significant differences were observed between groups, word positions and points of articulation of the sounds studied. With regards to word position, the duration parameter was a primary differentiation and, on the differentiation of the articulation points of [s] and [ʃ], the cutoff frequency and the frequency band of higher concentration of fricative noise were the most robust parameters.

For speech-language pathology practice, understanding in what age child neuromotor development approaches the adult pattern can help in the decision-making process and treatment choices.

The use of acoustic analysis in clinical practice allows the use of these acoustic parameters for mapping the productions of subjects with phonological disorders, as well as for monitoring the treatment progress of these individuals.

RESUMO

Objetivo: Comparar as produções de [s] e [ʃ] de adultos e crianças com desenvolvimento fonológico típico, considerando os parâmetros acústicos: duração do ruído fricativo, banda de frequências de concentração do ruído, frequência de corte de ruído de fricção e transição formântica da vogal seguinte. **Métodos:** Participaram do estudo 26 sujeitos, divididos em dois grupos: Grupo de adultos (GA) – composto por 17 adultos jovens (média de idade: 23,61±3,44 anos), sem alterações em aspectos fonológicos da língua e; Grupo de crianças com desenvolvimento fonológico típico (GDFT) – composto por nove crianças (média de idade: 7,12±0,74 anos), com desenvolvimento fonológico típico. Foi realizada uma triagem fonoaudiológica e, após, coleta de dados para análise acústica e, para isso, foram utilizadas pseudopalavras inseridas em frases-veículo. Foram analisadas 624 produções dos sujeitos e os achados foram submetidos à análise estatística. **Resultados:** Os parâmetros de banda de frequências e transição formântica apresentaram diferenças entre os grupos GA e GDFT. Na comparação entre as posições na palavra, os parâmetros de duração, frequência de corte e transição formântica apresentaram diferença. Os parâmetros de frequência de corte, banda de frequências e transição formântica apresentaram diferença na comparação entre os pontos de articulação de [s] e [ʃ]. **Conclusão:** Para a maioria dos parâmetros acústicos estudados, as produções de GA e GDFT mostraram-se semelhantes. Para alguns parâmetros, porém, puderam-se observar diferenças entre os grupos, entre as posições na palavra e entre os pontos de articulação dos fones estudados.

Descritores: Acústica da fala; Adulto; Criança; Fala; Fonética; Comportamento verbal

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