Original Article
Artigo Original

Ultrasound analysis of tongue contour for the sound [j] in adults and children

Análise quantitativa das curvas de língua na avaliação ultrassonográfica da fala para o som [j] em adultos e crianças

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ABSTRACT

Purpose: Analyze and compare the mean tongue contours and articulatory gestures in the production of the sound [j] in adults and children with typical and atypical speech development. The children with atypical development presented speech sound disorders. **Methods:** The diagnosis was determined by speech assessments. The study sample was composed of 90 individuals divided into three groups: 30 adults with typical speech development aged 19-44 years (AT), 30 children with typical speech development (CT), and 30 children with speech sound disorders, named as atypical in this study, aged four years to eight years and eleven months (CA). Ultrasonography assessment of tongue movements was performed for all groups. Mean tongue contours were compared between three groups in different vocalic contexts following the sound [j]. The maximum elevation of the tongue tip was considered for delimitation of gestures using the Articulate Assistant Advanced (AAA) software and images in sagittal plane/Mode B. The points that intercepted the language curves were analyzed by the statistical tool R. The graphs of tongue contours were obtained adopting a 95% confidence interval. After that, the regions with significant statistical differences ($p<0.05$) between the CT and CA groups were obtained. **Results:** The mean tongue contours demonstrated the gesture for the sound [j] in the comparison between typical and atypical children. For the semivowel [j], there is an articulatory gesture of tongue and dorsum towards the center of the hard palate, with significant differences observed between the children. **Conclusion:** The results showed differences between the groups of children regarding the ability to refine articulatory gestures.

Descritores

Fala
Acústica da fala
Ultrassom
Adulto
Criança
Fonoaudiologia

RESUMO

Objetivo: Analisar e comparar os contornos médios de língua e os gestos articulatórios na produção do [j] em adultos e crianças com desenvolvimento típico e crianças com desenvolvimento atípico de fala. As crianças com desenvolvimento atípico de fala apresentavam desordens nos sons da fala caracterizadas como desvio fonológico. **Método:** O diagnóstico foi determinado pelas avaliações fonoaudiológicas. Desse modo, a amostra foi constituída por três grupos: 30 adultos com desenvolvimento típico de fala (idades entre 19 e 44 anos), 30 crianças com desenvolvimento típico de fala e 30 crianças com desvio fonológico, denominadas neste estudo como atípicas (idades entre quatro anos e oito anos e onze meses). Para todos os grupos, foi realizada avaliação ultrassonográfica dos movimentos da língua. A pesquisa comparou os contornos médios de língua entre os três grupos em diferentes contextos vocálicos seguintes ao som [j]. Para a delimitação dos gestos, considerou-se a elevação máxima da ponta da língua, utilizando-se *software Articulate Assistant Advanced* (*AAA*) e imagens no plano sagital/Modo B. Os pontos que interceptaram as curvas de língua foram analisados pela ferramenta estatística R. Os gráficos dos contornos de língua foram obtidos através do cálculo de intervalo com 95% de confiança. Depois dessa etapa, foram obtidas as regiões com diferenças significativas (p-valor $\leq$ 0,05) entre os grupos de CT e CA. **Resultados**: Os contornos médios de língua demonstraram o gesto para a semivogal [j] na comparação entre crianças típicas e atípicas. Para a semivogal [j], há um gesto de língua, de dorso, em direção à área central do palato duro, sendo observadas diferenças significativas entre as crianças. **Conclusão:** Os resultados permitiram concluir que existem diferenças entre os grupos de crianças quanto à capacidade de refinar os gestos articulatórios.

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INTRODUCTION

Perception and production for speech are not inseparable; both are intrinsically modulated and refined. In this context, tests, mistakes and successes are thoroughly practiced and they are influenced by intrinsic and extrinsic factors, such as: organic alterations and environmental factor consequences, respectively[1].

To produce speech, there has to be, among other factors, muscle balance among orofacial structures, so that they may organize themselves, coordinate the sequence of movements with planning and, later, may perform sound production in a clear and coherent way. In order to understand the atypical speech, with the objective of proposing advances in evaluation and in future planning of the therapeutic process, that has been a challenge and is supported by the use of new technologies[2].

In Brazil, among these new technologies, the ultrasound analysis of tongue movements has recently been used. This feature offers important advances in the area of speech, since it allows the apprehension of the articulatory gestures, from the perspective of the Gestural Phonology. Within these new directions, questions arise on the causes of phonological disorders, especially those cases with no apparently involved etiology, affecting their development and also socialization and education[3].

The ultrasound technique in speech therapy uses images with real-time representations of the movements performed by the tongue while speaking. It is a safe, non-invasive and direct technique, able to reveal details of the articulatory gestures, under the focus of the Gestural Phonology.

Gestural Phonology directs and expands the knowledge about the acquisition and development of language, in the analysis of articulatory gestures. In this theory, articulatory gestures are a minimal unit of speech/language perception and production[1,2], where tasks involved by speech articulators, defined by the actions coordinated by the subject, are dynamically specified. The structures involved in speech organize themselves and overlap; they are co-dependent factors to represent the speech chain.

Ultrasonography allows analyzing, how articulatory gestures overlap and are modulated by the linguistic context, regarding their magnitude and the influence of different vocalic contexts following the same sound, in minimal word pairs[4]. The coronal glide [j] is of high occurrence in the natural languages, being phonetically a sound produced continuously and without friction. In the typical phonological acquisition of Brazilian Portuguese, the production of [j] is linked to the environment of diphthongs or triphthongs. The production of this glide needs to be characterized, because in the atypical acquisition, the glide replaces the liquid consonants.

Among the alterations normally found in children with speech sound disorders, the replacement of the liquids for [j] stands out. This substitution is traditionally characterized as a repair strategy[5], in which the child makes a less complex sound, in this case the [j], since it is an easily reproduced sound by these children.

The facility of production of the [j] and its precocious acquisition is because this sound presents a single articulatory gesture of tongue, with less complexity. This sound is produced and acquired in early ages, both in the development of typical speech as atypical. This is the fact that justifies the analysis of the production of the glide [j]. The aim of this research was to analyze and to compare the mean contours of tongue and articulatory gestures in the production of [j] in adults and children with typical development and atypical speech development (speech sound disorders).

METHODS

The research involved the assessment of speech and ultrasonography of tongue movements in adults and children. The participants to this research were adults with proper acquisition and development of the speech/language, denominated typical adults (AT), children with proper acquisition and development of the speech/language, denominated typical children (CT) and children with alterations in the speech sound system, denominated and characterized in this study as atypical children (speech sound disorders) (CA).

It is an experimental research, quantitative, qualitative and descriptive. All participants were selected by convenience and signed the Informed Consent Term, according to regulations by the Research Ethics Committee of the Institution where the work was conducted, approved by protocol n. 442,786.

Evaluations on language/speech, hearing and ultrasound images were conducted in a speech therapy support center of a higher education institution.

In order to create groups, for all individuals, the following evaluations were conducted: articulatory examination, orofacial motricity and neurovegetative functions[6], evaluation of comprehensive and expressive language for adults (reading and text interpretation) and for children - fact sequencing and narration[7], hearing screening in a quiet environment for frequencies from 500 Hz to 600 Hz, to 20 dB (*Interacoustic Screening Audiometer*, AS208 portable audiometer), and the Computerized Phonological Assessment Tool (INFONO) for all children[8].

After the initial evaluations, the following criteria were considered for the inclusion in this research: normal hearing in both ears and absence of otitis media of repetition; adequate structures and functions of the stomatognathic system; development of language adequate with the age, except for the sound systems of the CA and also absence of complaints related to learning; high school education for AT, and school attendance for all children; absence of socio-emotional factors relevant to adequate language development; and absence of speech therapy before the research.

The CTs should present a sound system suitable for chronological age and the CAs should present speech sound disorders. All participants should be members of monolingual PB families from a central city in the southern region of Brazil.

Participants who did not meet the inclusion criteria were excluded from the study, as well as children who did not attend school and members of bilingual or non-local dialect families.

After all evaluations that included the eligibility criteria, out of a total of approximately 120 individuals, 90 participants were selected for the ultrasonographic assessment of tongue movements, constituted into three groups:

- group 1 (AT): 30 adults, 15 males and 15 females, aged between 19 and 44;
- group 2 (CA): 30 atypical children (speech sound disorders), aged between 4 and 9, 18 males and 12 females. The CAs presented different severity degrees characterized by the Percentage of Consonants Correct - Revised (PCC-R)

(Shriberg et al., 1997); in the CA group, all children properly produced the sound [j];

- group 3 (CT): composed by 30 children with typical speech development, aged between 4 and 9, also 18 males and 12 females, the age was-matched in relation to Group 2.

In order to confirm the parity hypothesis of the groups of children in relation to the ages, the F test was initially performed to verify the equality of variances between the groups, resulting in a non-significant value for the variance difference (p-value = 0.452). The standard deviation of the group of typical children was 0.86 months and the atypical, 0.88 months. Then, the T-test was performed to compare the mean of two independent samples under the hypothesis of homoscedasticity (equality of variances), also resulting in a non-significant value (p-value = 0.660).

The average age of the typical children was six years and six months and the atypical age, five years and 11.4 months. Thus, it can be concluded that the samples of typical and atypical children were perfectly matched as to their distribution, both in relation to the mean value and the dispersion of the ages.

The ultrasound evaluations (USG) of the tongue were performed were performed individually, during approximately 30 to 40 minutes in a single session. Every participant should be sitting inside an acoustic enclosure, with mouth height positioned microphone (Shure – SM48), feet on the ground, erect backbone, ultrasound probe (65C10EA endocavitary transducer) externally fixed below the jaw, on the floor of the mouth, held by a head stabilizer (*Articulate Instruments Ltd*.). On the probe, a transducer gel was used, allowing the capture and visualization of the images from the tongue contour, using the frequency of 5.0 MHz[9].

The sagittal plane/B Mode was chosen to analyze images, since it allows visualizing the tongue, from root to tip. Images were captured, recorded and analyzed with the use of the *Articulate Assistant Advanced* (AAA) software. Finally, participants were oriented to say the same sentence with words containing the sound [j]. All words were represented in figures appearing in the computer screen. Each figure was isolated presented and inserted in the sentence "say__**word**__again", in the order presented on Chart 1. Finally, six repetitions of the same word in the same vehicle-sentence were recorded for each participant.

After recording images, the tongue contour of each participant was drawn in the AAA software, in each repetition, in the image referring to the maximum elevation of the tongue inner area during the sound [j] (frame). The sound [j] was identified by speech spectrography, by the simultaneous analysis of audio and video, properly synchronized by the software.

After image (frame) selection, the same fan angle was chosen for all participants (120°, available in the software for DP6600 ultrasonography). The fan has 42 rays that project over the image. Rays reaching the image of the tongue contour are constituted by values (intersection points) that correspond to distances (in mm), since the beginning of each ray, at the basis of the fan, until the tongue curve (Figure 1). Distance values were extracted from the software and were equivalent to the 100% reliability criterion.

Chart 1. List of words and their representations in figures in the vowel contexts / a / and /u/, in minimum pairs

Next Vocal Context	Target	Word
/a/	[j]	[ˈkajɐ] (CAIA)
------	[j]	[ˈkaj] (CAI)
/u/	[j]	[ˈkaju] (CAIO)

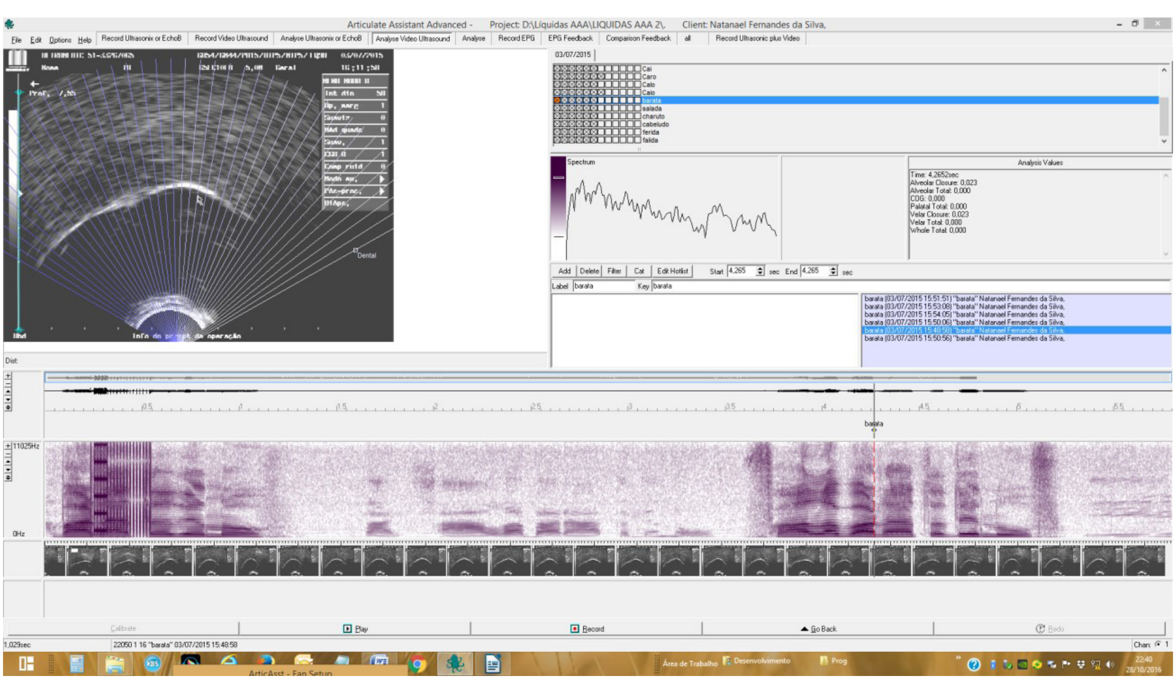


Figure 1. Previous selection of the angle for analysis of the images - 120 degree angle - selection of the anterior area of the tongue (dental) to the right of the video

Thus, the points that intercepted each tongue curve in each repetition (0 to 41) were copied from the AAA software, as shown in Figure 2, to the Word program, and then to the Excel program. It should be noted, however, that only the points that intercepted each tongue curve (100% confidence) were filled in the Excel worksheet.

The worksheets, were exported to the R statistical tool (*R Core Team*). In the R environment, the average values of tongue contours were calculated in word repetitions from each group and so were the respective confidence intervals around average values. Intervals were obtained with 95% confidence around each average point of tongue curves (splines). Thus, the mean lines and confidence intervals of the tongue surface contours of the three groups analyzed (AT, CT and CA) were obtained.

Done this step, regions with significant differences were also obtained (p-value <0.05) between the CT and CA groups. Regions presenting significant differences are the ones that did not contain the horizontal line referring to zero (representing the hypothesis of null difference) contained within the lower and upper limits of the respective intervals with 95% confidence for the difference between median lines.

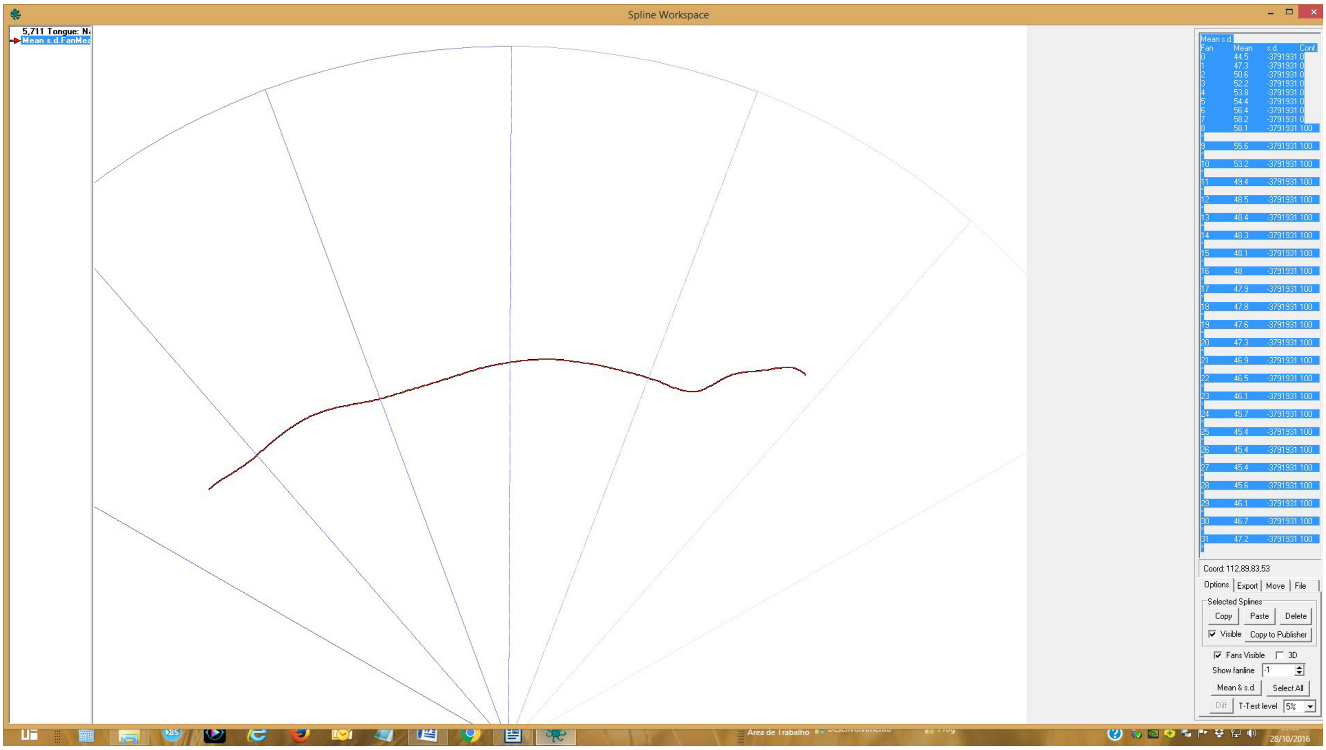


Figure 2. Select the values corresponding to the radii (mm) and the confidence at each point (0-41) through the resource Ctrl + c and later Ctrl + v for Word

RESULTS

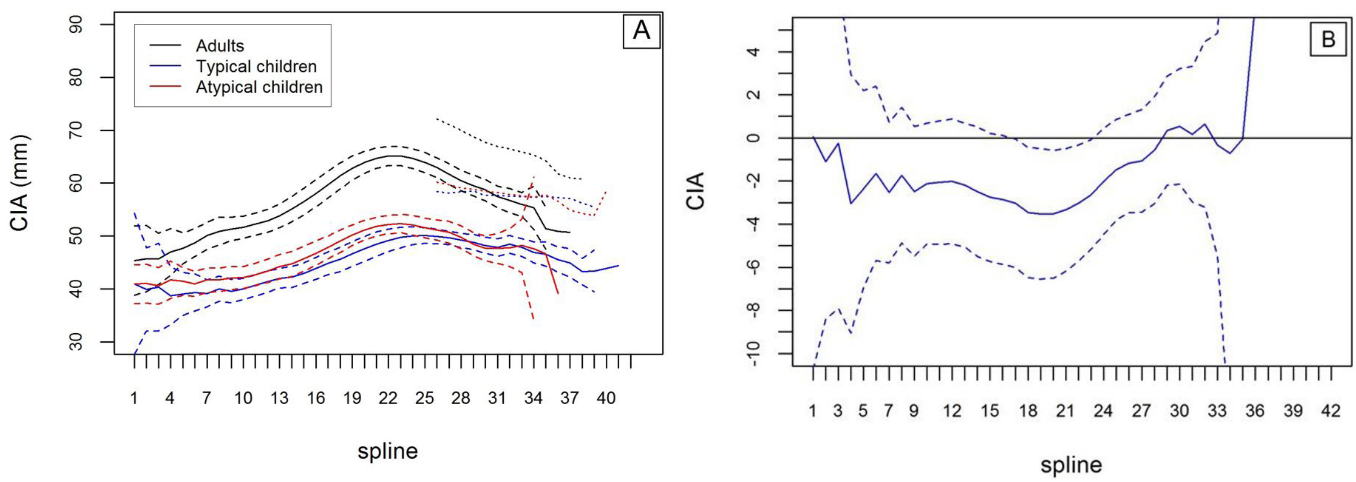
Three Figures 3, 4 and 5 will be presented, which show, on the right, the frontal area of the tongue (blade and tip), central (dorsum) and left (root of the tongue). Over the frontal part of the tongue, there is a dotted line (in black), corresponding to the frontal part of the hard palate.

The acronyms used were: CIA, which corresponds to the word "caia" [ʻkajɐ]; CAI, which corresponds to the word "cai" [ʻ kaj]; and CAO, which corresponds to the word "caio" [ʻkaju]– a boy's name. These acronyms were adopted in the study for tabulation and statistical analysis of the data and identification of the words in the corresponding charts and tables. Therefore the groups have:

A) Medium lines and confidence intervals of the surface contours of the tongue for sound [j] in each word in the three groups: "fall" [ʻkajɐ] ([j] preceding the vowel / a /); "Falls" [ʻkaj] ([j] in the final vowel context of the word); "Caio" [ʻkaju] ([j] preceding the vowel /u/);

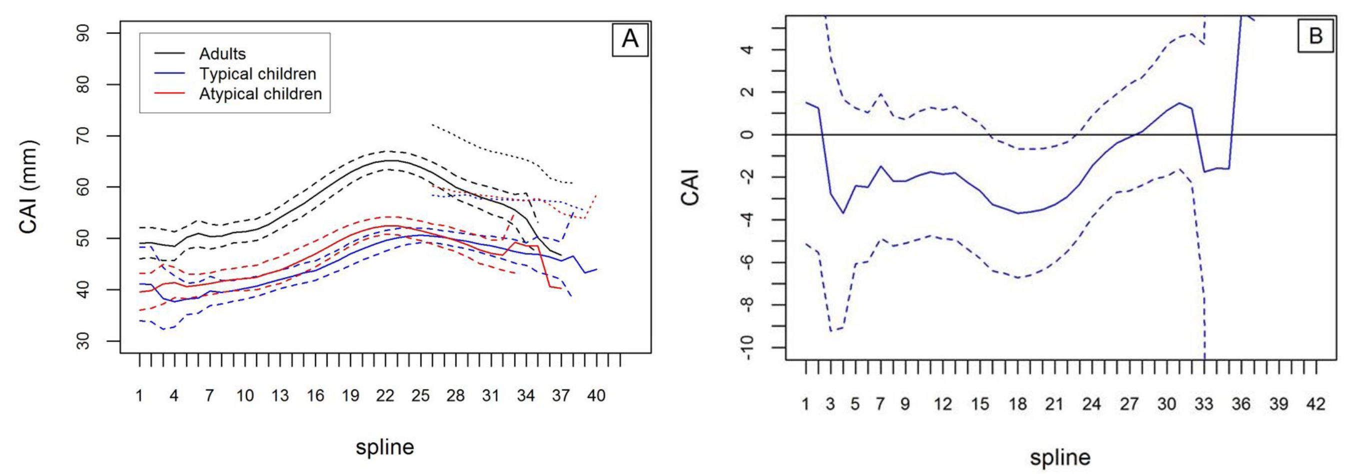
B) Differences of the tongue curves between CT and AC for each word.

For all figures, there were significant differences in the mean tongue contours in the dorsum region between CT and CA. In the splines, points 14 to 22 presented these differences (Table 1), and for all the vowel contexts studied, the differences occurred in this region. It was observed that, for all words, in all groups, there is a tongue gesture in the production of sound [j], but the tongue contours differ depending on the word produced, and the greater magnitude of tongue was observed in the following vowel context of / u / in the word "caio" [kaju], in relation to other contexts such as the following from / to / in "fall" [ʻkajɐ], and final in' fall ʻ[ʻ kaj].



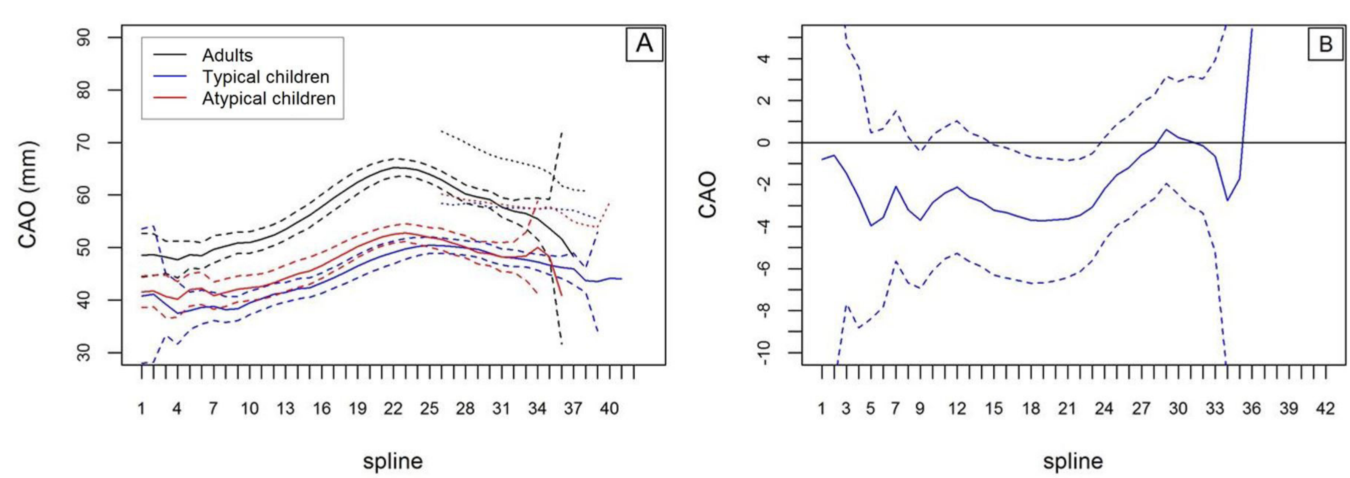
Caption: (A) Mean tongue contours for [j] in the vowel context / in the word "caia" (CIA) in AT, CT and CA; (B) Significant differences in the language curves between CT and CA (intervals that do not intersect the zero line)

Figure 3. Mean tongue contours for [j] in the following vowel context of / a / in the word ['kajɐ] (CIA)



Caption: (A) Average tongue contours for [j] in final position in the word "falls" [kaj] (CAI) in AT, CT and CA; (B) Significant differences in the language curves between CT and CA (intervals that do not intersect the zero line)

Figure 4. Mean tongue contours in the final context of the glottal [j] in the word ['kaj] (CAI)



Caption: (A) Mean tongue contours) for [j] in the vowel context / u / in the word "caio" [CAB] in AT, CT and CA; (B) Significant differences in the language curves between CT and CA (intervals that do not intersect the zero line)

Figure 5. Mean tongue contours for [j] in the following vowel context of [u] in the word ['kaju] (CAO)

Table 1. Confidence intervals, T-test statistic and associated p-value for the words CIA, CAI and CAO

spline	CIA				CAI				CAO			
	LI	LS	T	p-valor	LI	LS	T	p-valor	LI	LS	T	p-valor
0	-10.73	10.87	0.02	0.985	-5.15	8.17	0.55	0.600	-11.59	9.97	-0.25	0.820
1	-8.41	6.20	-0.37	0.722	-5.55	8.04	0.45	0.666	-11.60	10.37	-0.19	0.864
2	-7.91	7.43	-0.08	0.940	-9.23	3.63	-0.97	0.356	-7.67	4.74	-0.53	0.608
3	-9.05	2.94	-1.11	0.289	-9.07	1.65	-1.52	0.157	-8.82	3.59	-0.95	0.367
4	-6.93	2.20	-1.10	0.288	-6.07	1.24	-1.38	0.184	-8.39	0.46	-1.87	0.076
5	-5.68	2.40	-0.85	0.406	-5.96	1.02	-1.47	0.156	-7.82	0.67	-1.74	0.095
6	-5.79	0.74	-1.58	0.125	-4.87	1.91	-0.90	0.377	-5.65	1.50	-1.18	0.245
7	-4.87	1.42	-1.11	0.273	-5.24	0.88	-1.45	0.157	-6.68	0.27	-1.87	0.070
8	-5.49	0.53	-1.66	0.103	-5.10	0.71	-1.53	0.135	-6.93	-0.47	-2.31	0.026
9	-4.92	0.69	-1.51	0.137	-4.92	1.08	-1.29	0.204	-6.09	0.36	-1.79	0.080
10	-4.92	0.79	-1.45	0.152	-4.75	1.26	-1.17	0.249	-5.54	0.75	-1.53	0.132
11	-4.91	0.88	-1.40	0.167	-4.90	1.17	-1.23	0.223	-5.28	1.02	-1.36	0.181
12	-5.07	0.69	-1.52	0.133	-4.92	1.32	-1.16	0.251	-5.67	0.46	-1.71	0.094
13	-5.50	0.51	-1.66	0.102	-5.39	0.86	-1.45	0.152	-5.91	0.28	-1.82	0.074
14	-5.74	0.22	-1.86	0.069	-5.81	0.54	-1.67	0.102	-6.31	-0.12	-2.08	**0.042**
15	-5.86	0.13	-1.91	0.061	-6.40	-0.19	-2.12	**0.038**	-6.44	-0.25	-2.16	**0.035**
16	-6.01	-0.04	-2.03	**0.047**	-6.54	-0.42	-2.28	**0.026**	-6.58	-0.48	-2.32	**0.024**
17	-6.49	-0.43	-2.28	**0.026**	-6.72	-0.67	-2.45	**0.017**	-6.70	-0.68	-2.45	**0.017**
18	-6.55	-0.51	-2.34	**0.023**	-6.61	-0.67	-2.45	**0.017**	-6.68	-0.76	-2.52	**0.015**
19	-6.50	-0.57	-2.39	**0.020**	-6.39	-0.65	-2.45	**0.017**	-6.56	-0.79	-2.55	**0.014**
20	-6.18	-0.50	-2.36	**0.022**	-6.02	-0.56	-2.41	**0.019**	-6.43	-0.84	-2.61	**0.012**
21	-5.73	-0.34	-2.25	**0.028**	-5.48	-0.36	-2.28	**0.026**	-6.15	-0.78	-2.59	**0.012**
22	-5.18	-0.10	-2.08	**0.042**	-4.77	0.12	-1.90	0.062	-5.61	-0.53	-2.42	**0.019**
23	-4.47	0.44	-1.64	0.106	-3.87	0.91	-1.24	0.220	-4.68	0.24	-1.81	0.076
24	-3.81	0.85	-1.27	0.209	-3.21	1.45	-0.76	0.453	-3.94	0.87	-1.28	0.206
25	-3.46	1.10	-1.04	0.302	-2.70	1.92	-0.34	0.736	-3.63	1.27	-0.97	0.336
26	-3.44	1.31	-0.91	0.369	-2.64	2.39	-0.10	0.922	-3.07	1.91	-0.47	0.641
27	-3.06	1.91	-0.47	0.644	-2.39	2.69	0.12	0.903	-2.68	2.24	-0.18	0.858
28	-2.19	2.87	0.27	0.785	-2.09	3.38	0.48	0.633	-1.95	3.18	0.48	0.631
29	-2.15	3.21	0.40	0.690	-1.95	4.23	0.76	0.456	-2.46	2.91	0.17	0.865
30	-2.97	3.32	0.11	0.910	-1.61	4.59	0.98	0.334	-3.04	3.14	0.03	0.973
31	-3.19	4.47	0.35	0.728	-2.26	4.73	0.73	0.472	-3.35	3.03	-0.11	0.918
32	-5.52	4.85	-0.15	0.887	-7.75	4.25	-0.68	0.515	-5.23	3.92	-0.33	0.748
33	-13.94	12.52	-0.16	0.880	-73.72	70.57	-0.25	0.844	-11.32	5.77	-0.97	0.396
34	-80.30	80.21	-0.01	0.996	-76.13	72.90	-0.23	0.856	-88.02	84.60	-0.24	0.851
35	-	-	-	-	-	-	-	-	-	-	-	-
36	-	-	-	-	-	-	-	-	-	-	-	-
37	-	-	-	-	-	-	-	-	-	-	-	-
38	-	-	-	-	-	-	-	-	-	-	-	-
39	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-
41	-	-	-	-	-	-	-	-	-	-	-	-

Caption: CIA (caia) ['kajɐ]; CAI (cai) ['kaj]; CAO (caio) ['kaju]; LI: Lower limit; LS: Upper Limit; T: T-test; p-value ≤0.05

Table 1 shows the inferential statistics of the comparisons between the groups, that is, the confidence intervals, t-test statistic and associated p-value for the words CIA, CAI and CAO.

DISCUSSION

The average tongue contours, for all words, demonstrated the gesture of the tongue blade for the semi-vowel [j]. Thus, for the semi-vowel [j], there is a tongue gesture.

Differences in the tongue curves between adults and both children groups is evident, considering the discrepancies regarding tongue height and oral cavity size; they are determining neuro-anatomical factors for these differences. However, even if there are anatomical discrepancies and about the neuro-motor maturity, the average tongue contours in children are similar to the ones in adults. Thus, it is possible to notice that all children CTs and CAs developed their sound systems, trying to perform the task to produce these segments, towards the adult standard[10].

Between CT an CA, significant differences in the average tongue contours would not be expected, observing that both children groups were gender- and age-matched; they also presented the sound [j] detected by the perceptual-auditory analysis. However, for all words, there were significant differences in tongue gestures between CT and CA, in the dorsum region, which are comprised between points 14 and 22 of the splines shown in Table 1.

Table 1 shows all the confidence intervals (LI: lower limit, LS: upper limit), statistic of the test p-value associated with the test statistic for the difference of the language curves by spline for the words CIA, CAI and CAO. It is noted from the initial observation of the first four columns of Table 1 concerning the word CIA that splines with p-values highlighted in red indicate significant tests for the difference between the two groups. Alternatively, to report the same inference, Figure 3 illustrates the confidence intervals sequentially for all splines. Note that the sequence of intervals with 95% confidence that does not contain the value zero is equivalent to the p-values significant at the level of 5%. In Table 1, it is possible to visualize the numerical results.

As for the vocalic contexts of the words, the posterior and high vowel /u/ following the semivowel [j] provided greater magnitude to the tongue gestures when compared to the other linguistic contexts surveyed. The greater magnitude of the [j] in the word [‘kaju] demonstrates the influence of the vowel /u/ in the next vowel context because the vowel /u/ is higher, and has a greater magnitude when compared to the vowel /a/, which is low and central, as well as the final glottal [j], in which there is no influence of a next vowel. Thus, it is possible to affirm that the language gestures are influenced by the vowel context, considering the analysis of the vowel preceding the sound searched for this research.

The articulatory gestures are not simple movements of tongue, because it is considered that there is a relation between the same ones when carrying out a task, being indispensable its analysis considering the context. The trait variables that describe the movement associated with the gesture among the articulators involved, in a context sensitive manner[1].

Context requirements influence the performance of a particular task, for example: bilabial occlusion can be achieved by lifting the chin, lifting the lower lip or lowering the upper lip, to varying degrees if the jaw movement is interrupted, the lips will automatically move to complete the occlusion and success will be instantaneous[10,11]. The goal is constant, but it may be reached in various ways, according to the context requirements. Only the adoption of the articulatory gesture as primitive of analysis allows the understanding that language emerges from phonetic to abstract[12].

The analysis of the articulatory gestures from the medium tongue contours allowed to verify significant differences between the two groups of children studied. These differences between the groups were identified especially on the dorsum of the tongue, for all words analyzed. It is important to note that the perceptual-auditory analysis detected the adequate production of this sound for all children.

Thus, the ability to refine the articulatory gestures is shown to be lower in the CA group. It is possible to understand that children develop their sound systems to achieve (in the case of typical ones) or to approach (in the atypical) to the adult standard. The difficulty of refining articulatory gestures in initial acquisition sounds and having only a tongue gesture, such as [j] in this study, may not influence the acoustic results, obtained by the perceptual-auditory analysis, but probably justifies the errors in the acquisition of more complex sounds, acquired late, contributing to perceptual-auditory analyzes that reveal an atypical speech pattern.

Ultrasonography of the tongue movements, in this environment, together with the perceptual-auditory analysis of speech, provides a thorough evaluation of the sound system, allowing the analysis of the gestural pattern among different groups of participants, especially to the ability to refine the articulatory gestures. Differences in tongue contours, evidencing less articulation refinement for atypical children, when compared to typical ones, may be associated to praxis abilities.

The movements of lips, tongue and jaw are inaccurate in early childhood, being progressively refined and dissociated as development. These transformations are essential for the effectiveness of oral communication.

Studies found tongue praxis difficulties, difficulties in moving articulators during praxis tests and in the quick repetition of syllables, as well as a lower speech speed in atypical children compared to the ones with no deficit in the sound system[13-16].

International studies[17-20] have investigated speech through instrumental analyzes, such as the USG of tongue movements, comparing children and adults, evidencing differences between the groups. The quantitative evaluation of the mean tongue contours obtained in the USG allows the analysis of articulatory gestures in children and adults, and this relatively fast, noninvasive and also a safety evaluation being able to detect the production of the sounds in the tongue images in real time.

CONCLUSION

Ultrasonographic analysis of tongue movements were able to observe that CT and CA construct a sound system closer to the AT, but there are differences among the groups of children regarding the improvement of articulatory gestures. Such differences for sound [j] are identified on the dorsum of the tongue between typical and atypical children.

The tasks for the articulatory gestures of both groups of children are similar to those of adults, and less articulatory refinement is observed in the CA group when compared to the CT.

The vocalic context following the sound [j] influences the gestural magnitude and the conformation of the articulatory gesture, both for AT and for CT and CA, that is, the formation of speech patterns is intrinsically related to the linguistic context.

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Author contributions

LSB was responsible for the collection, analysis and writing of the data, the researcher responsible for the study; SNS was responsible for collecting, analyzing and writing the data; RCSS was responsible for writing and formatting data; DAOM was responsible for the statistical analyzes and calculations, drawing charts and tables; LCB and MKS were co-orienting and guiding the study, responsible for writing and reviewing content.