Literature Review

https://doi.org/10.1590/2317-6431-2021-2524

Audiology Communication Research
ISSN 2317-6431

Methods of assessing of childhood apraxia of speech: systematic review

Métodos de avaliação da apraxia de fala na infância: revisão sistemática

Aline Mara de Oliveira[1], *Isadora Nunes*[1], *Greicyhelen Santos da Cruz*[2], *Léia Gonçalves Gurgel*[2]

ABSTRACT

Purpose: Systematically review the protocols and/or assessments that contribute to the diagnosis of CAS and classify them according to the clinical dimension evaluated **Research strategy:** Study of systematic literature review in the databases MEDLINE (accessed via PubMed), LILACS, Scopus and SciELO with the descriptors Apraxias, Childhood apraxia of speech, Evaluation, Assessment, Validation Studies, Evaluation Studies, Language Therapy, Rehabilitation of Speech and Language Disorders, Child and Child, Preschool. **Selection criteria:** The search for scientific articles in the databases was conducted by three independent researchers. Studies that clearly assessed subjects with suspected or diagnosed PIA were included. The reviewers performed data collection with regard to methodological characteristics, interventions and study outcomes using standardized forms. The main data collected was related to the assessment procedures of CAS. **Results:** Most studies (14 of the 21 included) made an association between the assessment of motor and/or articulatory and segmental skills. Five performed an evaluation of all listed aspects: motor and/or articulatory, segmental and suprasegmental; and two underwent only motor and/or articulatory assessment. The age of the subjects in the present study ranged from 3 to 12 years. **Conclusion:** The assessment of CAS generally involves the association between the assessment of motor and/or articulatory and segmental skills. It is suggested that further studies in order to evidence validity for the assessment of CAS.

Keywords: Rehabilitation of speech and language disorders; Speech; Speech intelligibility; Apraxias; Child

RESUMO

Objetivos: Revisar sistematicamente os protocolos e/ou avaliações que contribuem para o diagnóstico de apraxia de fala na infância (AFI) e classificá-los de acordo com a dimensão clínica avaliada. **Estratégia de pesquisa:** Estudo de revisão sistemática da literatura nas bases de dados MEDLINE (acessado via PubMed), LILACS, Scopus e SciELO, com os descritores *Apraxias*, *Childhood apraxia of speech*, *Evaluation*, *Assessment*, *Validation Studies*, *Evaluation Studies*, *Language Therapy*, *Rehabilitation of Speech and Language Disorders*, *Child* e *Child, Preschool*. **Critérios de seleção:** A busca nas bases de dados foi conduzida por três pesquisadores independentes. Foram incluídos estudos que avaliavam, de forma clara, sujeitos com suspeita ou diagnóstico de AFI. Os revisores realizaram a coleta de dados no que diz respeito às características metodológicas, intervenções e desfechos dos estudos, por meio de planilhas previamente elaboradas especificamente para o presente estudo. O dado principal coletado foi referente aos procedimentos de avaliação da AFI para crianças. **Resultados:** A maior parte dos estudos (14 dos 21 incluídos) realizou a associação entre a avaliação de habilidades motoras e/ou articulatórias e segmentais. Cinco realizaram avaliação de todos os aspectos elencados: motor e/ou articulatória, segmental e suprassegmental e dois realizaram apenas avaliação motora e/ou articulatória. A idade dos sujeitos variou de 3 a 12 anos. **Conclusão:** A maioria das pesquisas considerou a associação entre habilidades motoras e/ou articulatórias e segmentais para avaliação da apraxia de fala na infância. Sugere-se a realização de mais estudos, a fim de buscar evidências de validade.

Descritores: Reabilitação dos transtornos da fala e da linguagem; Fala; Inteligibilidade da fala; Apraxias; Criança

Study carried out at Departamento de Fonoaudiologia, Centro de Ciências da Saúde, Universidade Federal de Santa Catarina – UFSC – Florianópolis (SC), Brasil.

[1]Departamento de Fonoaudiologia, Centro de Ciências da Saúde, Universidade Federal de Santa Catarina – UFSC – Florianópolis (SC), Brasil.

[2]Fonoaudióloga, Florianópolis (SC), Brasil.

Conflict of interests: No.

Authors' contribution: AMO, IN, GSC and LGG participated in the idealization of the study, collection, analysis and interpretation of data and writing of the article; AMO and LGG participated, as a supervisor, in the idealization of the study, analysis, data interpretation and writing of the paper.

Corresponding author: Aline Mara de Oliveira. E-mail: aline.mara.oliveira@ufsc.br

Received: May 21, 2021; **Accepted:** September 13, 2021

INTRODUCTION

Childhood Apraxia of Speech (henceforth CAS) is a rare disorder that affects 0.1% of the population, manifesting itself as a disturbance in the ability to produce phonemes and syllables with precision and consistency taking into consideration articulatory and suprasegmental aspects. It is believed that a deficient motor planning is responsible for that as well as the basis of such disorder compromising, thus, the formation of words and sentences. For this reason, the child has difficulties to effectively plan the sequence of motor acts fundamental for speech, since this task requires fast and precise orofacial movements[1].

As reported by the American Speech-Language-Hearing Association[2], CAS is a disorder of neurobiological basis, characterized by undermining, in the absence of neuromuscular impairment, the expression of language in its oral modality, due to the presence of deficit in the precision and articulatory movement consistency. Furthermore, it is characterized by speech unintelligibility, due to the presence of errors during repetitive production of syllables and words, which can occur with both consonants and vowels, with emphasis on inadequate coarticulation in the transition between phonemes and syllables and inappropriate prosody, especially regarding the lexical and phrasal stress, as well as error inconsistency.

Yet, CAS may arise from compromises in the central nervous system, along with genetics and/or complex neurobehavioral disorders. It is also noteworthy that some of the characteristics of CAS, mentioned above, may be manifested in conditions whose speech sounds are impaired, e.g. in severe phonological disorders. Based on what was acknowledged above, the need for a thorough and grounded assessment is reinforced in order to identify the degree of impairment presented by the patient[3].

Previous studies[4-6] involved motor and/or articulatory aspects, segmental aspects of consonants/vowels and suprasegmental aspects in the process of differential diagnosis between CAS and other alterations of speech sound disorders (SSD). With regard to CAS, mainly, it is paramount to investigate the presence of error inconsistency (different errors for the same target sound) and interruptions or lengthening in the sound transition (coarticulation) during the production of vowels and/or consonants in the syllables and/or words, as well as the production of unexpected prosodic patterns (lexical or phrasal)[2,5].

Divergences regarding the diagnostic criteria for this disorder still remain, making its characterization convoluted[7]. The assessment and accurate diagnosis of CAS have been discussed in the literature for years and, in an endeavor to develop a consistent protocol, some instruments have been produced in recent decades, with a view to improving the diagnosis[8].

In the late 1990s and early 2000s, the number of specific protocols for CAS increased considerably, with emphasis on the 1995 Kaufman Speech Praxis Test for Children (KSPT)[9] and the 1999 Verbal Motor Production Assessment for Children (VMPAC)[10]. The KSPT analyzes the oral structures and motor function of speech in children aged 2 to 6[9], while the VMPAC assesses aspects of oromotor control and speech characteristics within the age range of 3 to 12[10]. Both point out evidence of content and criterion validity.

In 2013, a protocol – commonly used in the present-day – was published: the Dynamic Evaluation Motor of Speech Skills (DEMSS)[11], which assesses motor function, prosody and production consistency, diagnosing SSD, such as CAS. The test has been widely used in research and in clinical practice, due to the evidence of validity and reliability it presents[11]. In 2016, the DEMSS was translated and adapted to Brazilian Portuguese (DEMSS-BR) and presented evidence of reliability and accuracy; however, its validation is still imperative, in addition to the definition of normative data[7].

Recently, Oliveira et al.[6] have proposed specific assessments of speech production, aiming to make the differential diagnosis between children with severe phonological disorders and children with suspected CAS. The authors culturally and linguistically adapted the following tests to Brazilian Portuguese: Multisyllabic Word Repetition Assessment[12]; Assessment of Phrasal Stress[13]; Speech Inconsistency Task[14,15] and Maximum Performance Task[16]. All tests were sensitive to differentiating groups of children with SSD.

Nevertheless, despite the fact that there has been some growth in relation to the number of protocols and their psychometric properties over the years, the evaluation parameters of CAS are still, in a way, subjective and the diagnosis sometimes occurs through exclusion of other impairments[1]. Hence, nationwide, instruments for the assessment of CAS – validated and standardized for the sociocultural reality of the country – are still scarce, which makes it difficult to accurately diagnose the disorder[7].

OBJECTIVES

Considering all the literature presented in the previous section, this study aimed to systematically review the protocols and/or assessments for CAS and classify them according to the evaluated clinical dimension.

Research strategies

The following electronic databases (up to May 2019) were explored: MEDLINE (accessed via PubMed), LILACS, Scopus and SciELO. The systematic review was conducted in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) recommendations. The descriptors were selected from DECs (Descriptors in Health Sciences), along with the Boolean operators.The following search terms used were: Apraxias, Childhood apraxia of speech, Evaluation, Assessment, Validation Studies, Evaluation Studies, Language Therapy, Rehabilitation of Speech and Language Disorders, Child and Children, Preschool and terms in between. Words related to outcomes were not included in order to increase the sensitivity of this research. There was no restriction on the type of assessment researched, language, or design of the researched study.

Selection criteria

All studies whose definition of CAS was complete and scientifically based were included, as well as those that consistently evaluated subjects with suspected or confirmed diagnosis of CAS. Researches whose samples were not within the age group of zero - 12 were excluded.

Data analysis

The investigators evaluated titles and abstracts of all articles identified by the search strategy. All abstracts that did not present enough information regarding the inclusion and exclusion criteria were selected for evaluation of the full text. At the full-text stage, three reviewers independently assessed the full articles and made their selections according to the previously stipulated eligibility criteria. Two independent evaluators performed data collection as to the methodological characteristics, study interventions and outcomes.

Previously formatted spreadsheets were used for data collection. At all stages of the study, disagreements were resolved by consensus. The main data collected was related to CAS assessment procedures for children. For the present study, three dimensions of speech assessment were listed considering: 1) motor and/or articulatory aspects, 2) segmental aspects, 3) suprasegmental aspects[5].

RESULTS

As a result from the initial search, 230 abstracts were identified, from which 49 studies met the inclusion criteria and were considered as potentially relevant for further detailed analysis. After reading the full texts, in total, 20 studies were chosen to compose the sample for this review. Figure 1 shows the selection diagram of the studies in all their stages.

The age of the subjects included in the articles included in this study ranged from 3 to 12. The main characteristics of the included studies are shown in Chart 1, namely the authors and year of publication, the journal published and impact factor, study design, sample number and type, and instruments used.

In all, 19 instruments were used by the studies included in this research to assess CAS. Among them, 4 were the most frequent: Goldman-Fristoe Test of Articulation – Second Edition[41] and Diagnostic Evaluation of Articulation and Phonology – DEAP[42], both used in 55% of the selected studies; Test of Polysyllables[43], cited in 30% of the included studies, and also the Oral and Speech Motor Control Protocol[44], used by 25% of the selected studies.

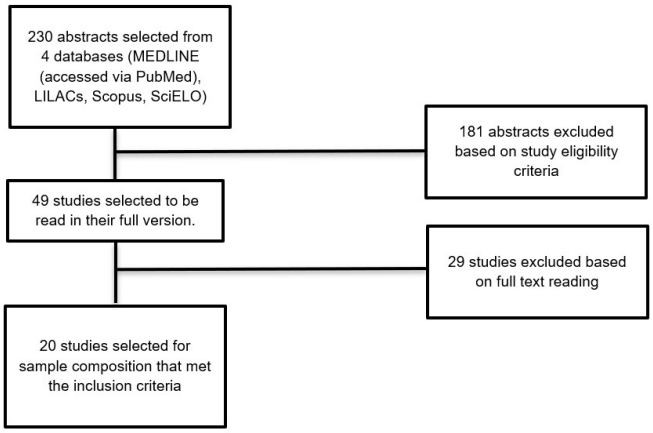

Figure 1. Study selection diagram

As for the assessment dimensions, it was detected that, from the 20 studies included, 14[5,19-24,27,28,30,33,34,36,39] (70%) performed the association between the assessment of motor and/or articulatory and segmental skills. Thus, it was found that CAS is most commonly assessed based on the association of articulatory and/or motor analysis and segmental aspects of children's speech.

From the remaining 6 studies, 5[11,17,25,37,38] (25%) evaluated all aspects listed in this review (motor and/or articulatory, segmental and suprasegmental) and 1[18] (5%) performed only the motor and/or articulatory assessment.

The instruments used to assess motor and/or articulatory aspects were: Oral and Speech Motor Control Protocol[44]; Goldman-Fristoe Test of Articulation–Second Edition[41]; Verbal Motor Production Assessment for Children - VMPAC[10] and Arabic Articulation Test[29], as shown in Chart 2.

Eight protocols were used to assess segmental aspects of speech: Test of Polysyllables[43]; Children's Test of Nonword Repetition - CNRep[46]; Syllable Repetition Task[47]; The Arabic Syllable Accuracy Word Task[40]; Beginner's Intelligibility Test–BIT[32]; Intelligibility Test of Children's Speech–TOCS[35]; Children's Speech Intelligibility Measure–CSIM[31] in addition to Maximum Performance Task[48], as shown in Chart 3.

Two instruments were used to exclusively assess suprasegmental aspects of speech: Emphatic Stress Task[13] and Profiling Elements of Prosody in Speech-Communication-PEPS-C[49]. Additionally, it was observed that spontaneous speech can also be used as a sample for investigation of suprasegmental aspects of speech, as shown in Chart 4.

It is also noteworthy that some tests evaluated more than one dimension, such as the Diagnostic Evaluation of Articulation and Phonology–DEAP[42] and the Kaufman Speech Praxis Test for Children[9], which took into account both motor and/or articulatory aspects, as well as segmental aspects. Other 3 protocols analyzed all three dimensions listed in this study: Dynamic Evaluation of Motor Speech Skills (DEMSS)[11] and its adaptation to Brazilian Portuguese[50]; Multisyllabic Word[12] and Strand's 10-point Checklist[51].

DISCUSSION

The present study indicated the main methodologies for assessing CAS considering studies involving children with age ranging from zero to 12. It was recognized in the included studies that the assessment occurs more frequently involving the association between the assessment of motor and/or articulatory and segmental skills. Still, some studies performed only motor assessment. Others, the combination of the three dimensions. It was found that the associated assessment, that is, including more than one dimension, favors a better understanding of the child's speech performance, providing more detailed and in-depth information about speech and enabling better conditions for the organization of effective interventions. These findings are in agreement with other studies, such as the Brazilian research[7] which stated that, for a better diagnosis, a combined assessment should be carried out based on the application of different validated and reliable protocols.

From the 20 studies included, 14[5,19-24,27,28,30,33,34,36,39] considered the association between these abilities to assess CAS. It became apparent that the main factors evaluated by the studies included in this research are linked to motor and/or articulatory and

Chart 1. Characteristics of the included studies

Authors and year of publication	Periodical and IF	Título	Objective	Delimitation	Number and Sample Type	Valuation Dimension	Used instrument(s)
Keske-Soares et al., 2018[17]	CODAS (N.A.)	Performance of children with speech sound disorders in the instrument "Dynamic evaluation of motor speech skills"	Compare the performance of children with typical speech acquisition, phonological disorder and CAS in the variables production accuracy and consistency of the instrument "Dynamic evaluation of motor speech skills" (DEMSS-BR).	Cross-sectional, descriptive, quantitative.	18 children; both male and female; 4 years and 6 months to 5 years and 8 months of age.	Motor/or articulatory, segmental and suprasegmental aspects.	*Dynamic Evaluation of Motor Speech Skills* DEMSS-BR[18]
Gomez et al., 2018[19]	Lang Speech Hear Serv Sch. (N.A.)	*Treating Childhood Apraxia of Speech With the Kaufman Speech to Language Protocol: A Phase I Pilot Study*	Expand the evidence base for the treatment of Childhood Apraxia of Speech by completing a feasibility study on the Kaufman Speech to Language Protocol approach (Kaufman, 2014).	Experimental study before and after intervention.	2 children; one male with 5 years and 8 months of age and another female with 4 years and 4 months of age.	Motor/or articulatory and segmental aspects.	*Goldman-Fristoe Test of Articulation–Second Edition*[20]; *Test of Polysyllables*[21]; *Diagnostic Evaluation of Articulation and Phonology–*DEAP[22]; *Oral and Speech Motor Control Protocol*[23].
Thomas et al., 2018[24]	Speech Lang Pathol. (1,280)	*Combined clinician parent delivery of Rapid Syllable Transition (ReST) treatment for childhood apraxia of speech*	Report treatment and fidelity results on the combination of treatment with rapid syllable transition (ReST) linked with home practice.	Case series study	5 children; both male and female; from 5 years and 1 month to 11 years and 7 months of age.	Motor/or articulatory and segmental aspects.	*Goldman-Fristoe: Test of Articulation–Second Edition*[20]; *Test of Polysyllables*[21]; *Diagnostic Evaluation of Articulation and Phonology–*DEAP[22]; *Oral and Speech Motor Control Protocol*[23].
Preston et al., 2017[25]	Am J Speech Lang Pathol (1,713)	*Variable Practice to Enhance Speech Learning in Ultrasound Biofeedback Treatment for Childhood Apraxia of Speech: A Single Case Experimental Study*	Evaluate the role of variability of practice through prosodic variation during speech training, in the treatment of biofeedback for children with CAS.	Experimental case study	6 children; school age.	Motor/or articulatory, segmental and suprasegmental aspects.	*Goldman-Fristoe: Test of Articulation–Second Edition*[20]; *Emphatic stress task*[13]; *Multisyllabic Word Repetition Task*[12]; *Maximum performance task*[16,26]; *Syllable Repetition Task*[17], *percentages of correct consonants and the percentage of items with additionals*[25].
Thomas et al., 2016[27]	Lang Commun Disord (1,504)	*Telehealth delivery of Rapid Syllable Transitions (ReST) treatment for childhood apraxia of speech*	Conduct a Phase 1 efficacy study of CAS treatment through teleconsultation and in person, in addition to discussing the efficacy of ReST treatment.	Case series study	5 children; both male and female; from 5 years and 5 months to 11 years and 2 months of age.	Motor/or articulatory and segmental aspects.	*Goldman-Fristoe Test of Articulation–Second Edition*[20]; *Test of Polysyllables*[21]; *Diagnostic Evaluation of Articulation and Phonology–*DEAP[22]; *Oral and Speech Motor Control Protocol*[23].

Subtitle: IF = impact factor; N.A. = not available; PROMPT = Prompts for Restructuring Oral Muscular Phonetic Targets

Chart 1. Continued...

Authors and year of publication	Periodical and IF	Título	Objective	Delimitation	Number and Sample Type	Valuation Dimension	Used instrument(s)
Murray et al., 2015[28]	J Speech Lang Hear (1,906)	*A Randomized Controlled Trial for Children With Childhood Apraxia of Speech Comparing Rapid Syllable Transition Treatment and the Nuffield Dyspraxia Programme-Third Edition*	Compare the experimental treatment of Rapid Syllable Transition Treatment (ReST) and the Nuffield Dyspraxia Program - Third Edition.	Case series study	26 children; 18 boys and 8 girls; 4 to 12 years old.	Motor/or articulatory and segmental aspects.	*Goldman-Fristoe Test of Articulation–Second Edition*[20]; *Test of Polysyllables*[21]; *Diagnostic Evaluation of Articulation and Phonology*–DEAP[22]; *Oral and Speech Motor Control Protocol*[23]; *Strand's 10-point checklist*[29].
Murray et al., 2015[5]	J Speech Lang Hear (1,906)	*Differential Diagnosis of Children with Suspected Childhood Apraxia of Speech*	Identify a set of objective measures that differentiate CAS from other speech alterations.	Cross-sectional, descriptive, quantitative.	72 children; both male and female; 4 to 12 years old.	Motor/or articulatory and segmental aspects.	*Test of Polysyllables*[21]; *Diagnostic Evaluation of Articulation and Phonology*–DEAP[22]; *Oral and Speech Motor Control Protocol*[23]; *Strand's 10-point checklist*[29].
Tükel et al., 2015[18]	Speech Lang Pathol -0.8	*Motor functions and adaptive behavior in children with childhood apraxia of speech*	Understand the extent of undiagnosed motor and behavioral problems in children with CAS, determining the profile and relationships between motor functions of non-oral, manual and global body speech/production and adaptive behaviors in CAS.	Cross-sectional, descriptive, quantitative.	18 children; 5 girls and 13 boys; 4 years and 4 months old to 10 years and 6 months old.	Motor/or articulatory aspects.	*Verbal Motor Production Assessment for Children*–VMPAC[10]
Namasivayam et al., 2015[30]	Lang Commun Disord. (1,504)	*Treatment intensity and childhood apraxia of speech*	Investigate the effects of treatment intensity on outcome measures related to articulation, communication and speech intelligibility for children with CAS submitted to individual motor speech intervention.	Experimental study before and after intervention.	37 children; 9 girls and 28 boys; between 32-54 months of age.	Motor/or articulatory and segmental aspects.	*Kaufman Speech Praxis Test for Children*[9]; *Goldman-Fristoe Test of Articulation–Second Edition*[20]; *Children's Speech Intelligibility Measure*—CSIM[31]; *Beginner's Intelligibility Test*—BIT[32].
McCabe et al., 2014[33]	Dev Neurorehabil. (1,578)	*Orthographically sensitive treatment for dysprosody in children with childhood apraxia of speech using ReST intervention*	Report the efficacy of the ReST intervention used in conjunction with pseudoword stimuli, containing orthographic cues that are strongly associated with strong-weak or weak-strong patterns of lexical stress.	Case study with follow-up.	4 children; 4 boys; 5 years and 5 months old to 8 years and 6 months of age.	Motor/or articulatory and segmental aspects.	*Diagnostic Evaluation of Articulation and Phonology*–DEAP[22]

Subtitle: IF = impact factor; N.A. = not available; PROMPT = Prompts for Restructuring Oral Muscular Phonetic Targets

Chart 1. Continued...

Authors and year of publication	Periodical and IF	Título	Objective	Delimitation	Number and Sample Type	Valuation Dimension	Used instrument(s)
Dale and Hayden, 2013[34]	Speech Lang Pathol (0.80)	*Treating speech subsystems in childhood apraxia of speech with tactual input: the PROMPT approach*	Examinar sistematicamente a eficácia do PROMPT para crianças com apraxia da fala na infância (AFI). Systematically examine the efficacy of PROMPT for children with Childhood Apraxia of Speech (CAS).	Case series study	4 children; 3 boys and one girl; between 3 years and 6 months and 6 years old.	Motor/or articulatory and segmental aspects.	*Verbal Motor Production Assessment for Children–VMPAC*[10]; *Diagnostic Evaluation of Articulation and Phonology–DEAP*[22]; *Intelligibility Test of Children's Speech*–TOCS+[35]
Strand et al., 2013[11]	Speech Lang Hear	*A motor speech assessment for children with severe speech disorders: reliability and validity evidence*	Report evidence of reliability and validity for the Dynamic Evaluation of Motor Speech Skills (DEMSS).	Validation study	81 children; 63 boys and 18 girls; 36 to 79 months of age.	Motor/or articulatory, segmental and suprasegmental aspects.	*Dynamic Evaluation Motor of Speech Skills*–DEMSS[11]
Preston et al., 2013[36]	Speech Lang Pathol (0.80)	*Ultrasound biofeedback treatment for persisting childhood apraxia of speech*	Evaluate the effectiveness of a treatment program for children with persistence of speech sound errors - includes ultrasound biofeedback - associated with CAS.	Case series study	6 children; all male; Nine to ten years old.	Motor/or articulatory and segmental aspects.	*Verbal Motor Production Assessment for Children–VMPAC*[10]; *Goldman-Fristoe Test of Articulation–Second Edition*[20]; *Diagnostic Evaluation of Articulation and Phonology–DEAP*[22]; *Emphatic Stress Task*[13].
Maas et al., 2012[37]	Speech Lang Pathol (1,906)	*Feedback frequency in treatment for childhood apraxia of speech*	Examine the role of feedback frequency in the treatment of CAS.	Case series study	4 children; 2 boys and 2 girls; 5 to 8 years old.	Motor/or articulatory, segmental and suprasegmental aspects.	*Dynamic Evaluation Motor of Speech Skills–DEMSS*[11]; *Goldman-Fristoe Test of Articulation–Second Edition*[20];
Murray et al., 2012[38]	BMC Pediatr. (1,983)	*A comparison of two treatments for childhood apraxia of speech: methods and treatment protocol for a parallel group randomised control trial*	Conduct a larger-scale clinical trial of rapid syllable transition treatment (ReST) compared to the Nuffield Dyspraxia Programme – Third Edition (NDP3).	Randomized controlled trial.	20 children; N.A.; between 4 and 12 years old.	Motor/or articulatory, segmental and suprasegmental aspects.	*Diagnostic Evaluation of Articulation and Phonology–DEAP*[22]; *Test of Polysyllables*[21]; *Profiling Elements of Prosody in Speech Communication–PEPS-C*[37]; *Goldman-Fristoe Test of Articulation–Second Edition*[20].
Ballard et al., 2010[23]	Speech Lang Hear (1,906)	*A treatment for dysprosody in childhood apraxia of speech*	Phase II study with 3 children. Investigate the effectiveness of a treatment that aims to improve the control of the relative durations of non-word syllables, composed of 3 syllables representing strong-weak and weak-strong emphasis patterns.	Case series study	3 children; 2 boys and 1 girl; between 7 and 10 years old.	Motor/or articulatory and segmental aspects.	*Goldman-Fristoe Test of Articulation–Second Edition*[20]; *Children's Test of Nonword Repetition–CNRep*[39]; *Diagnostic Evaluation of Articulation and Phonology–DEAP*[22].

Subtitle: IF = impact factor; N.A. = not available; PROMPT = Prompts for Restructuring Oral Muscular Phonetic Targets

Chart 1. Continued...

Authors and year of publication	Periodical and IF	Título	Objective	Delimitation	Number and Sample Type	Valuation Dimension	Used instrument(s)
Iuzzini and Forrest, 2010[20]	Clin Linguist Phon (N.A.)	*Evaluation of a combined treatment approach for childhood apraxia of speech*	Investigate the impact of a dual treatment approach that includes a stimulability training protocol paired with a modified basic vocabulary treatment focused on speech sounds produced by children with CAS.	Case study	4 children; 2 boys and 2 girls; between 3 and 6 years old.	Motor/or articulatory and segmental aspects.	*Goldman-Fristoe Test of Articulation–Second Edition*[20]; *Diagnostic Evaluation of Articulation and Phonology*–DEAP[22].
Aziz et al., 2010[22]	J Pediatr Otorhinolaryngol. (1,125)	*Childhood apraxia of speech and multiple phonological disorders in Cairo-Egyptian Arabic speaking children: Language, speech, and oro-motor differences*	Question a possible significant difference in oral speech, speech and non-speech performance among children with childhood apraxia of speech, with multiple phonological disorder and typical children that can be used for differential diagnostic purposes.	Case-control study	30 children; 16 boys and 14 girls; between 4 and 6 years old.	Motor/or articulatory and segmental aspects.	*Arabic Articulation Test*[29]; *The Arabic Syllable Accuracy Word Task* (ASAWT)[40]
Sealey and Giddens, 2010[21]	Clin Linguist Phon (N.A.)	*Aerodynamic indices of velopharyngeal function in childhood apraxia of speech*	Document differences in velopharyngeal function in children diagnosed with CAS and children with typical speech development.	Case-control study.	6 children; N.A.; between 5 and 9 years old.	Motor/or articulatory and segmental aspects.	*Kaufman Speech Praxis Test for Children*[9]
Newmeyer et al., 2009[39]	Phys Occup Ther Pediatr. (0.75)	*Results of the Sensory Profile in children with suspected childhood apraxia of speech*	Review and compare the results of the sensory profile in children with a specific type of phonological disorder, childhood apraxia of speech and explore the relationship between sensory processing deficit and sound production.	Cross-sectional study	38 children; 33 boys and 5 girls; Three to 10 years old.	Motor/or articulatory and segmental aspects.	*Kaufman Speech Praxis Test for Children*[9]

Subtitle: IF = impact factor; N.A. = not available; PROMPT = Prompts for Restructuring Oral Muscular Phonetic Targets

segmental skills. Ergo, the most frequent way to assess CAS hinges on the association of such skills.

Only 24%[11,17,25,37,38] of the papers selected in this review analyzed suprasegmental speech abilities, a fact that can compromise the diagnosis of CAS. Research[13,17,52] has stated that suprasegmental characteristics contribute to the composition of the assessment, favoring the differential diagnosis, as individuals with CAS often present inadequate prosody, due to the inconsistency of the lexical stress.

According to the American Speech-Language-Hearing Association (ASHA)[2], the diagnosis of CAS requires that a child meet, at least, all three characteristics, namely: (1) inconsistency between words and syllables; (2) lengthened and interrupted coarticulation transitions and (3) inadequate prosody. In such a way, it was found that most studies did not include the prosodic aspects (suprasegmental skills of speech), both from the perspective of lexical and phrasal level.

The Dynamic Evaluation Motor of Speech Skills (DEMSS)[11] instrument, as well as its Brazilian version (DEMSS-BR)[50], stands out among the other protocols, as it is quite complete, considering that it evaluates all three skills: motor and/or articulatory, segmental and suprasegmental. The study[17], carried out with 18 children,

Chart 2. Protocols for motor and/or articulatory evaluation

Author and Year	Name and Authors	Target Audience	What it assesses	Objectives	Peculiarities	Psychometric properties
Gomez et al., 2018[19]; Thomas et al., 2018[24]; Murray et al., 2015[28]; Murray et al., 2015[5]	*Oral and Speech Motor Control Protocol* (Robbins and Klee, 1987)[44]	American children from 2 years and 6 months to 6 years and 11 months of age.	It evaluates orofacial structures and functions.	Determine whether deficits in oral structures or functions might justify speech difficulties.	It contains three parts: 1. Evaluation of structures, made from visual inspections; 2. Functional evaluation, made from verbal commands; 3. Evaluation of the syllable repetition rate and the duration of vowel extension.	It presents measures of reliability and internal consistency (Robbins and Klee, 1987)[44].
Gomez et al., 2018[19]; Thomas et al., 2018[24]; Preston et al., 2017[25]; Thomas et al., 2016[27]; Murray et al., 2015[28]; Ballard et al., 2010[23]; Iuzzini and Forrest, 2010[20]	*Goldman-Fristoe Test of Articulation* GFTA-2 (Goldman and Fristoe, 2000)[41]	It can be used in a wide age group: 2 years and 0 months old to 21 years and 11 months of age.	It evaluates the production of consonants in initial, medial and final position, as well as the production of consonant clusters.	Measure the articulation of consonant sounds and determine the types of speech production errors.	It consists of 34 images that allow you to obtain up to 53 target words.	Validated for the English language and standardized by gender (male and female) for the American population.
Tükel et al., 2015[18]; Dale and Hayden, 2013[34]; Preston et al., 2013[36]	*Verbal Motor Production Assessment* *for Children*- VMPAC (Hayden and Square, 1999)[10]	Children aged 3 years to 12 years and 11 months old.	It evaluates the motor functions of speech as well as the oral structures.	Analyze the accuracy and quality of motor movements, identifying the levels of motor speech interruption.	It consists of 82 items, subdivided into 5 areas: 1. Global motor control; 2. Oromotor control; 3. Sequencing; 4. Connected speech and oral language; 5. Speech characteristics.	Study and reliability test-retest and among examiners; content and construct validity; standardized (McCauley and Strand, 2008)[45]
Aziz et al., 2010[22]	*Arabic Articulation Test* (Kotby et al., 1986)[29]	N.A.	It evaluates the production of consonants and vowels alone besides in different positions of the words (initial, intermediate and final).	Analyze the production of the word at the articulatory level.	It consists of 23 images that should be named, allowing the evaluation of 23 Arab consonants along with 6 vowels.	N.A.

Subtitle: N.A. = Not Available. Source: Elaborated by the authors

concluded that the protocol is sensitive for diagnosing CAS, fulfilling its purpose of assisting in the differential diagnosis of SSD. The research[17] also pointed out that the variables "production accuracy" and "speech consistency", contained in the test, are significantly meaningful in the evaluation process.

Consequently, the DEMSS[11] protocol must be considered by the evaluator when choosing the evaluation instrument. It must be stressed that the DEMSS-BR is still in the adaptation process and has not yet been validated; however, it has been showing accuracy, stability and reliability evidence[50]. It is appropriate to point out that the protocol translation is only the first step in the process, and cross-cultural adaptations are indispensable.

It is also noteworthy the significant shortage of instruments with psychometric evidence to assess CAS in Brazil. Among the protocols cited in the studies included in this research, very few of them have been translated into Brazilian Portuguese and none of them is cross-culturally adapted. Only the aforementioned DEMSS-BR[50] and the recent translation of the Multisyllabic Word[12] (Assessment of Repetition of Multisyllabic Words) by Oliveira et al. (2020)[6], which proves the great gap with regard to the assessment of CAS nationwide.

Another study[53] also reiterates that apraxia affects all linguistic levels of the child - syntactic, semantic, pragmatic, phonetic and phonological. For that reason, it reinforces the importance of a comprehensive language assessment for an accurate and adequate diagnosis and not only of motor and/or articulatory aspects, even if these are shown to be significantly compromised in CAS.

In addition to the clinical markers proposed by ASHA[2] for an accurate diagnosis of CAS, children need communicative intent, regardless of age or severity. For these reasons, some studies included in this review refer to methods/instruments that are not specific for CAS, but that assess language and speech more comprehensively, e.g. Peabody Picture Vocabulary Test–Fourth Edition[26] and Clinical Evaluation of Language Fundamentals Preschool–Second Edition[54], included in the

Chart 3. Protocols for segmental speech evaluation

Author and Year	Name and Authors	Target Audience	What it assesses	Objectives	Peculiarities	Psychometric properties
Gomez et al., 2018[19]; Thomas et al., 2018[24]; Thomas et al., 2016[27]; Murray et al., 2015[28]); Murray et al., 2015[5]; Murray et al., 2012[38]	*Single Word Test of Polysyllables* (Gozzard et al., 2004)[43]	Children within the age range of 4-12 years old.	It assesses syllable segregation, coarticulatory transitions and errors of lexical stress.	Evaluate speech production from polysyllabic words.	It presents 25 polysyllabic words.	N.A.
Ballard et al., 2010[23]	*Children's Test of Nonword Repetition - CNRep* (Gathercole and Baddeley, 1996) [46]	Children within the age range of 4-8 years old.	It evaluates, by means of a task of repetition, short-term memory.	To analyze the transient storage of unknown phonological forms, observing working memory, fundamental for the development of reading and writing.	It consists of 40 pseudowords of different lengths (ranging from 2 to 5 syllables). These are presented to the child, who should repeat them immediately.	It presents high test-retest reliability. It has standardization measures. (Gathercole and Baddeley, 1996) [46].
Preston et al., 2017[25]	*Syllable Repetition Task* (Shriberg et al., 2009)[47]	It evaluates a wide age group.	It evaluates, by means of an imitation task, the speaker's ability to repeat pseudowords composed of 2 to 4 syllables.	Analyze the transient storage of unknown phonological forms.	It consists of 18 items, which merge combinations between sound consonants /b/, /d/, /m/ and /n/, in addition to the vowel /e/. For example: /bede/, /debeme/ and / menebede/.	It presents internal reliability, simultaneous validity, transcription validity and reliability (Shriberg et al., 2009)[47]
Aziz et al., 2010[22]	*The Arabic Syllable Accuracy Word Task* - ASAWT (Velleman, 2002)[40]	N.A.	Evaluates the syllabic accuracy from repetition tasks.	Analyze the individual's ability to produce accurately a number, shape or sequence of syllables.	It consists of 32 items of different syllabic structures, such as CV and CVC. The levels of tasks were organized into 8 categories with increasing task difficulty.	N.A.
Namasivayam et al., 2015[30]	*Beginner's Intelligibility Test* - BIT (Osberger et. al, 1994)[32]	Children within the age range of 4-8 years old.	It evaluates, by means of sentence repetition tasks, the intelligibility of the individual's speech.	Analyze the therapy effectiveness, as well as the impact of the disorder on the understanding of the individual's speech.	It has 4 lists, each consisting of 10 sentences. The evaluator reads them and the patient should repeat them in sequence. The therapist records in audio the individual's speech, which is analyzed by independent listeners later on.	N.A.
Dale and Hayden, 2013[34]	*Intelligibility Test of Children's Speech* - TOCS (Hodge et al., 2009)[35]	Children within the age range of 3-7 years old.	It evaluates the intelligibility of words and phrases from the patient's speech.	N.A.	It consists of a software that presents, on a computer, a spoken model (words and/ or phrases) and its image, for the patient to imitate.	N.A.
Wilcox and Morris, 1999[31]	*Children's Speech Intelligibility Measure* - CSIM (Wilcox and Morris, 1999)[31]	N.A.	It evaluates, by means of word repetition tasks, the intelligibility of the individual's speech.	Analyze the therapy efficacy, as well as the impact of the disorder on the understanding of the patient's speech.	It is composed of lists of 50 words, which differ in pre- and post-treatment evaluation. The patient should imitate the therapist's model and his/her speech should be recorded in audio. It is analyzed by independent listeners later on.	N.A.
Rvachew et al., (2005)[48]	*Maximum Performance Task* (Rvachew et al., 2005[48]	N.A.	It evaluates the motor functioning of speech.	Analyze the duration of phonation, how quickly syllables can be repeated, etc.	It is composed of tasks with sustentation of fricatives and vowels, as well as repeated production of monosyllables and trisyllable /pataka/.	Standardization; Predictive validity: sensitivity and specificity[16].

Subtitle: N.A. = Not Available. Source: elaborated by the authors

Chart 4. Protocols for suprasegmental speech evaluation

Author and Year	Name and Authors	Target Audience	What it assesses	Objectives	Peculiarities	Psychometric properties
Shriberg et al., 2010[13]	*Emphatic*	N.A.	It evaluates the ability to imitate the phrasal stress correctly.	Verify if the child perceives the contrast between the words, differentiating the stressed words from the unstressed ones.	It consists of phrases like "João LOVES to play soccer".	It was recently translated into Portuguese (Oliveira, et al. 2020)[6]
	Stress Task				The evaluator utters the sentence and the child must repeat it.	
	(Shriberg et al., 2010)[13]					
Peppé and McCann, (2003)[49]	*Profiling Elements of Prosody in Speech-Communication*- PEPS-C	Wide age group, which covers both adults and children.	It evaluates receptive and expressive prosodic skills on two levels, formal and functional	Evaluate prosodic impairment in individuals with speech and language disorders.	A spoken expression is played, while two image options appear on a computer screen. The patient should choose the one that corresponds with the statement heard (when the task is receptive); or talk about the images, when the task is expressive.	PEPS-C is not standardized and there are only some normative data. However, it has already been adapted to several languages[49].
	(Peppé and McCann, 2003)[49]					

Subtitle: N.A. = Not Available. Source: Elaborated by the authors

study[19]. The Clinical Evaluation of Language Fundamentals–Fourth Edition[54] was used in several studies[5,20,23,24,37].

Further studies should be carried out with the aim of seeking psychometric evidence specifically focused on assessing CAS, including articulatory, motor and suprasegmental aspects of speech. Additionally, it is important that more reviews, like this one, be implemented, including studies with other age groups. Similarly, it is vital to expand studies that cover the evaluation process of CAS, including the translation process and cross-cultural adaptation, which incorporate psychometric measures in the different parameters of speech production (assessments that address the motor and/or articulatory, segmental and suprasegmental aspects, separately and combined), as these aspects make up the diagnostic criteria for CAS.

As limitations of this review, there is a dearth of uniformity in the design of the included studies and the small number of Brazilian studies involving assessments covering all skills (motor and/or articulatory, segmental and suprasegmental) to reach the diagnosis of CAS.

Another crucial limitation was the obstacle in accessing some original assessment protocols, in particular the Kaufman Speech Praxis Test for Children (KSPT)[9,19,30], Dynamic Evaluation of Motor Speech Skill[11,18] and Verbal Motor Production Assessment for Children–VMPAC[10,18,34,36]. Nonetheless, due to their importance for the scope of this research, we chose to reference them in a secondary way. That is, from the descriptions of research projects that made their use, making possible, in this way, their description and this study characterization.

CONCLUSION

The evaluation of CAS occurs, more frequently, involving the association between the analysis of motor and/or articulatory and segmental skills. On this account, it was found that the associated assessment, that is, including more than one dimension, favors a better understanding of the child's speech performance, providing more specific information about speech development, which enables the organization of more effective interventions.

Many studies do not include the assessment of suprasegmental aspects of speech, thereupon demonstrating a far-reaching gap in the assessment of CAS in children. It was also observed that, in Brazil, there are few specific instruments for CAS, evidencing the need for more efforts to cross-culturally adapt the protocols that already exist and are widely used in other countries.

REFERENCES

1. Morgan AT, Murray E, Liégeois FJ. Interventions for childhood apraxia of speech. Cochrane Database Syst Rev. 2018;5(5):CD006278. PMid:29845607.
2. ASHA: American-Speech-Language-Hearing Association. Childhood apraxia of speech [Internet]. Rockville: ASHA; 2007 [citado em 2019 Ago 27]. Disponível em: http://www.asha.org/policy/PS2007-00277.htm
3. Shriberg LD, Wren YE. A frequent acoustic sign of speech motor delay (SMD). Clin Linguist Phon. 2019;33(8):757-71. http://dx.doi.org/10.1080/02699206.2019.1595734. PMid:30945568.
4. Fish M. Here's how to treat childhood apraxia of speech. San Diego, CA: Plural Publishing; 2016.
5. Murray E, McCabe P, Heard R, Ballard K. Differential diagnosis of children with suspected childhood apraxia of speech. J Speech Lang Hear Res. 2015;58(1):43-60. http://dx.doi.org/10.1044/2014_JSLHR-S-12-0358. PMid:25480674.
6. Oliveira AM, Veschi GV, Polii L, Silva CEE, Berti LC. Speech production measures in Brazilian Portuguese children with and without Speech Sound Disorder. In: Babatsouli E, editor. On under-reported monolingual child phonology. 1st ed. Bristol: Multilingual Matters; 2020. p. 380-400.
7. Gubiani MB, Pagliarin KC, Keske-Soares M. Instrumentos para avaliação de apraxia de fala infantil. CoDAS. 2015;27(6):610-5. http://dx.doi.org/10.1590/2317-1782/20152014152. PMid:26691627.

8. Marini C. Habilidades práxicas orofaciais em crianças com desvio fonológico evolutivo e com desenvolvimento fonológico típico [tese]. Santa Maria: Curso de Distúrbios da Comunicação Humana, Universidade Federal de Santa Maria; 2010.

9. Kaufman N. Kaufman speech praxis test for children. Detroit: Wayne State University Press; 1995.

10. Hayden D, Square P. Verbal motor production assessment for children. San Antonio: The Psychological Corporation; 1997.

11. Strand EA, McCauley RJ, Weigand SD, Stoeckel RE, Baas BS. A motor speech assessment for children with severe speech disorders: reliability and validity evidence. J Speech Lang Hear Res. 2013;56(2):505-20. http://dx.doi.org/10.1044/1092-4388(2012/12-0094). PMid:23275421.

12. Preston JL, Edwards ML. Phonological processing skills of adolescents with residual speech sound errors. Lang Speech Hear Serv Sch. 2007;38(4):297-308. http://dx.doi.org/10.1044/0161-1461(2007/032). PMid:17890510.

13. Shriberg LD, Fourakis M, Hall S, Karlsson H, Lohmeier HL, McSweeny JL, et al. Extensions to the Speech Disorders Classification System (SDCS). Clin Linguist Phon. 2010;24(10):795-824. http://dx.doi.org/10.3109/02699206.2010.503006. PMid:20831378.

14. Marquardt TP, Jacks A, Davis BL. Token-to-token variability in developmental apraxia of speech: three longitudinal case studies. Clin Linguist Phon. 2004;18(2):127-44. http://dx.doi.org/10.1080/02699200310001615050. PMid:15086134.

15. Preston JL, Koenig LL. Phonetic variability in residual speech sound disorders: exploration of subtypes. Top Lang Disord. 2011;31(2):168-84. http://dx.doi.org/10.1097/TLD.0b013e318217b875. PMid:23087533.

16. Thoonen G, Maassen B, Gabreëls F, Schreuder R. Validity of maximum performance tasks to diagnose motor speech disorders in children. Clin Linguist Phon. 1999;13(1):1-23. http://dx.doi.org/10.1080/026992099299211.

17. Keske-Soares M, Uberti LB, Gubiani MB, Gubiani MB, Ceron MI, Pagliarin KC. Performance of children with speech sound disorders in the dynamic evaluation of motor speech skills. CoDAS. 2018;30(2):e20170037. http://dx.doi.org/10.1590/2317-1782/20182017037. PMid:29791618.

18. Tükel Ş, Björelius H, Henningsson G, McAllister A, Eliasson AC. Motor functions and adaptive behaviour in children with childhood apraxia of speech. Int J Speech Lang Pathol. 2015;17(5):470-80. http://dx.doi.org/10.3109/17549507.2015.1010578. PMid:25740430.

19. Gomez M, McCabe P, Jakielski K, Purcell A. Treating childhood apraxia of speech with the kaufman speech to language protocol: a phase i pilot study. Lang Speech Hear Serv Sch. 2018;49(3):524-36. http://dx.doi.org/10.1044/2018_LSHSS-17-0100. PMid:29625432.

20. Iuzzini J, Forrest K. Evaluation of a combined treatment approach for childhood apraxia of speech. Clin Linguist Phon. 2010;24(4-5):335-45. http://dx.doi.org/10.3109/02699200903581083. PMid:20345262.

21. Sealey LR, Giddens CL. Aerodynamic indices of velopharyngeal function in childhood apraxia of speech. Clin Linguist Phon. 2010;24(6):417-30. http://dx.doi.org/10.3109/02699200903447947. PMid:20136498.

22. Aziz AA, Shohdi S, Osman DM, Habib EI. Childhood apraxia of speech and multiple phonological disorders in Cairo-Egyptian Arabic speaking children: Language, speech, and oro-motor differences. Int J Pediatr Otorhinolaryngol. 2010;74(6):578-85. http://dx.doi.org/10.1016/j.ijporl.2010.02.003. PMid:20202694.

23. Ballard KJ, Robin DA, McCabe P, McDonald J. A treatment for dysprosody in childhood apraxia of speech. J Speech Lang Hear Res. 2010;53(5):1227-45. http://dx.doi.org/10.1044/1092-4388(2010/09-0130). PMid:20798323.

24. Thomas DC, McCabe P, Ballard KJ. Combined clinician parent delivery of Rapid Syllable Transition (ReST) treatment for childhood apraxia of speech. Int J Speech Lang Pathol. 2018;20(7):683-98. http://dx.doi.org/10.1080/17549507.2017.1316423. PMid:28443686.

25. Preston JL, Leece MC, McNamara K, Maas E. Variable practice to enhance speech learning in ultrasound biofeedback treatment for childhood apraxia of speech: a single case experimental study. Am J Speech Lang Pathol. 2017;26(3):840-52. http://dx.doi.org/10.1044/2017_AJSLP-16-0155. PMid:28715554.

26. Dunn L, Dunn L. Peabody Picture vocabulary test—III. Circle Pines, MN: AGS; 1997.

27. Thomas DC, McCabe P, Ballard KJ, Lincoln M. Telehealth delivery of Rapid Syllable Transitions (ReST) treatment for childhood apraxia of speech. Int J Lang Commun Disord. 2016;51(6):654-71. http://dx.doi.org/10.1111/1460-6984.12238. PMid:27161038.

28. Murray E, McCabe P, Ballard KJ. A randomized controlled trial for children with childhood apraxia of speech comparing rapid syllable transition treatment and the nuffield dyspraxia Programme-third edition. J Speech Lang Hear Res. 2015;58(3):669-86. http://dx.doi.org/10.1044/2015_JSLHR-S-13-0179. PMid:25807891.

29. Kotby MN, Bassiouny S, El Zomor EM. Standardization of an articulation test. In: Proceedings of the 9th Annual Ain Shams Medical Congress; 1986; Egypt. Egypt: Ain Shams University; 1986.

30. Namasivayam AK, Pukonen M, Goshulak D, Hard J, Rudzicz F, Rietveld T, et al. Treatment intensity and childhood apraxia of speech. Int J Lang Commun Disord. 2015;50(4):529-46. http://dx.doi.org/10.1111/1460-6984.12154. PMid:25581372.

31. Wilcox K, Morris S. Children's Speech Intelligibility Measure (CSIM). San Antonio: Psychological Corporation; 1999.

32. Osberger MJ, Robbins AM, Todd SL, Riley AI. Speech intelligibility of children with cochlear implants. Volta Review. 1994;96:169-80.

33. McCabe P, Macdonald-D'Silva AG, Van Rees LJ, Ballard KJ, Arciuli J. Orthographically sensitive treatment for dysprosody in children with childhood apraxia of speech using ReST intervention. Dev Neurorehabil. 2014;17(2):137-45. http://dx.doi.org/10.3109/17518423.2014.906002. PMid:24694312.

34. Dale PS, Hayden DA. Treating speech subsystems in childhood apraxia of speech with tactual input: the PROMPT approach. Am J Speech Lang Pathol. 2013;22(4):644-61. http://dx.doi.org/10.1044/1058-0360(2013/12-0055). PMid:23813194.

35. Hodge MM, Daniels J, Gotzke CL. TOCS+ intelligibility measures (Version 5.3) [Computer software]. Edmonton, Canada: University of Alberta; 2009.

36. Preston JL, Brick N, Landi N. Ultrasound biofeedback treatment for persisting childhood apraxia of speech. Am J Speech Lang Pathol. 2013;22(4):627-43. http://dx.doi.org/10.1044/1058-0360(2013/12-0139). PMid:23813207.

37. Maas E, Butalla CE, Farinella KA. Feedback frequency in treatment for childhood apraxia of speech. Am J Speech Lang Pathol. 2012;21(3):239-57. http://dx.doi.org/10.1044/1058-0360(2012/11-0119). PMid:22442284.

38. Murray E, McCabe P, Ballard KJ. A comparison of two treatments for childhood apraxia of speech: methods and treatment protocol for a parallel group randomised control trial. BMC Pediatr. 2012;12(1):112. http://dx.doi.org/10.1186/1471-2431-12-112. PMid:22863021.

39. Newmeyer AJ, Aylward C, Akers R, Ishikawa K, Grether S, deGrauw T, et al. Results of the Sensory Profile in children with suspected childhood apraxia of speech. Phys Occup Ther Pediatr. 2009;29(2):203-18. http://dx.doi.org/10.1080/01942630902805202. PMid:19401932.

40. Velleman SL. Phonotactic therapy. Semin Speech Lang. 2002;23(1):43-56. http://dx.doi.org/10.1055/s-2002-23510. PMid:11938490.

41. Goldman R, Fristoe M. Goldman fristoe test of articulation. 2nd ed. Circle Pines, MN: AGS; 2000.

42. Dodd B, Crosbie S, Zhu H, Holm A, Ozanne A. The diagnostic evaluation of articulation and phonology. London: Psych-Corp; 2002.

43. Gozzard H, Baker E, McCabe P. Children's productions of polysyllabic words. ACQuiring Knowledge in Speech. Language and Hearing. 2006;8(3):113-6.

44. Robbins J, Klee T. Clinical assessment of oropharyngeal motor development in young children. J Speech Hear Disord. 1987;52(3):271-7. http://dx.doi.org/10.1044/jshd.5203.271. PMid:3455449.

45. McCauley RJ, Strand EA. A review of standardized tests of nonverbal oral and speech motor performance in children. Am J Speech Lang Pathol. 2008 Feb;17(1):81-91. http://dx.doi.org/10.1044/1058-0360(2008/007). PMid:18230815.

46. Gathercole SE, Baddeley AD. The children's test of nonword repetition. London: Psychological Corporation; 1996.

47. Shriberg LD, Lohmeier HL, Campbell TF, Dollaghan CA, Green JR, Moore CA. A nonword repetition task for speakers with misarticulations: the Syllable Repetition Task (SRT). J Speech Lang Hear Res. 2009;52(5):1189-212. http://dx.doi.org/10.1044/1092-4388(2009/08-0047). PMid:19635944.

48. Rvachew S, Hodge M, Ohberg A. Obtaining and interpreting maximum performance tasks from children: A tutorial. J Speech Lang Pathol Audiol. 2005;29(4):146-57.

49. Peppé S, McCann J. Assessing intonation and prosody in children with atypical language development: the PEPS-C test and the revised version. Clin Linguist Phon. 2003;17(4-5):345-54. http://dx.doi.org/10.1080/0269920031000079994. PMid:12945610.

50. Gubiani MB, McCauley RJ, Pagliarin KC, Keske-Soares M. Adaptation of the dynamic evaluation of motor speech skill from English to Brazilian Portuguese. Folia Phoniatr Logop. 2018. No prelo.

51. Shriberg LD, Potter NL, Strand EA. Childhood apraxia of speech in children and adolescents with galactosemia. In: American Speech-Language-Hearing Association National Convention; 2009; New Orleans, LA. Rockville: ASHA; 2009.

52. Coêlho JF. Apraxia de fala × desvio fonológico: aspectos linguísticos e análise acústica da fala na síndrome de down [tese]. João Pessoa: Curso de Linguística, Universidade Federal da Paraíba; 2018.

53. Navarro PR, Silva PMVA, Bordin SMS. Apraxia de fala na infância: para além das questões fonéticas e fonológicas. Distúrb Comun. 2018;30(3):475-524. http://dx.doi.org/10.23925/2176-2724.2018v30i3p-475-489.

54. Wiig E, Secord WA, Semel E. The clinical evaluation of language fundamentals: preschool. 2nd ed. San Antonio: Harcourt Assessment; 2004.