Marileda Barichello Gubiani[1]
Karina Carlesso Pagliarin[1]
Marcia Keske-Soares[1]

Tools for the assessment of childhood apraxia of speech

Instrumentos para avaliação de apraxia de fala infantil

ABSTRACT

Purpose: This study systematically reviews the literature on the main tools used to evaluate childhood apraxia of speech (CAS). **Research strategy:** The search strategy includes Scopus, PubMed, and Embase databases. **Selection criteria:** Empirical studies that used tools for assessing CAS were selected. **Data analysis:** Articles were selected by two independent researchers. **Results:** The search retrieved 695 articles, out of which 12 were included in the study. Five tools were identified: Verbal Motor Production Assessment for Children, Dynamic Evaluation of Motor Speech Skill, The Orofacial Praxis Test, Kaufman Speech Praxis Test for Children, and Madison Speech Assessment Protocol. There are few instruments available for CAS assessment and most of them are intended to assess praxis and/or orofacial movements, sequences of orofacial movements, articulation of syllables and phonemes, spontaneous speech, and prosody. **Conclusion:** There are some tests for assessment and diagnosis of CAS. However, few studies on this topic have been conducted at the national level, as well as protocols to assess and assist in an accurate diagnosis.

RESUMO

Objetivo: Revisar sistematicamente na literatura os principais instrumentos utilizados para avaliação da apraxia de fala infantil. **Estratégia de pesquisa:** Realizou-se busca nas bases Scopus, PubMed e Embase. **Critérios de seleção:** Foram selecionados estudos empíricos que utilizaram instrumentos de avaliação da apraxia de fala infantil. **Análise dos dados:** A seleção dos artigos foi realizada por dois pesquisadores independentes. **Resultados:** Foram encontrados 695 resumos. Após a leitura dos resumos, foram selecionados 12 artigos completos. Foi possível identificar cinco instrumentos: *Verbal Motor Production Assessment for Children, Dynamic Evaluation of Motor Speech Skill*, *The Orofacial Praxis Test*, *Kaufman Speech Praxis Test for children* e o *Madison Speech Assessment Protocol*. São poucos os instrumentos utilizados para identificação da apraxia de fala infantil e a maioria destina-se à avaliação da realização de praxias e/ou movimentos orofaciais, sequências de movimentos orofaciais, articulação de fonemas simples, fonemas complexos e sílabas, fala espontânea, além da adequação da prosódia. **Conclusões:** Percebe-se que existem instrumentos que se propõem a avaliar e diagnosticar a apraxia de fala infantil. No entanto, ainda são escassos os estudos sobre esse tema em nível nacional, bem como protocolos padronizados e validados para a população brasileira que avaliem e ajudem em um diagnóstico preciso.

Correspondence to address:
Marileda Barichello Gubiani
Rua Senador Cassiano do Nascimento, 85, apartamento 102, Centro, Santa Maria (RS), Brazil, CEP: 97050-680.
E-mail: mari_gubiani@yahoo.com.br

INTRODUCTION

This systematic review addresses a literature overview on the tools for the assessment of childhood apraxia of speech (CAS) and differential diagnosis. CAS is one of the subtypes of childhood speech disorder of unknown origin, being defined as a motor disorder of the sounds that specifically interferes with the planning or execution of orofacial movements during the production of phonemes[1]. The characterization of CAS is widely discussed in literature, but there is much divergence regarding the criteria for its diagnosis[2,3].

The American Speech-Language-Hearing Association (ASHA)[4] defines CAS as a disorder of neurological origin in which the consistency and accuracy of speech movements are impaired in the absence of neuromuscular deficits. It was characterized by inconsistent errors of consonants and vowels in repetitive production of syllables and words; inadequate coarticulation of sounds in the transition between sounds and syllables; inappropriate prosody, especially in stressed syllables (lexical or phrasal).

According to Shriberg et al.[5], the diagnosis of apraxia of speech requires segmental and suprasegmental features. Segmental features are articulatory groping, especially in the beginning of speech utterance; substitution errors, mainly characterized by metathesis; inconsistent speech exchanges; and more errors in vowels. Suprasegmental features refer to inconsistent stress (syllables) and perception of nasopharyngeal resonance.

Studies[6-8] have used the features pointed by Davis et al.[9] as diagnostic criteria for apraxia of speech. These characteristics are divided into specific features of speech production and general characteristics of speech and orofacial movements. Among specific characteristics of speech production are limited repertoire of consonants and vowels; frequent omissions; high incidence of errors in vowels; inconsistent articulation; changed suprasegmental features (prosody, voice quality, and fluency); increase in errors in larger speech units; significant difficulties in repeating words and phrases; and predominant use of simple syllabic forms. Among the general characteristics of language and orofacial movements, the authors point out impaired voluntary oral movements reduced language expression compared to language understanding, and reduced diadochokinetic abilities.

However, there are no criteria as to how many features are required for the diagnosis of speech apraxia[8]. Some studies reported more than five[8,10], others, at least eight[11].

These characteristics tend to remain in the later child's life with CAS compared with other speech, sound, or language disorders. Therefore, it is important to create evaluation protocols that lead to early diagnosis[3]. In addition, it is noteworthy that some CAS features may also be present in the clinical picture of other speech sound disorders, such as severe phonological order disturbances (phonological disorder), where children may get unsystematic exchanges of speech, sounds, and articulation groping, which may lead to confusion and misdiagnosis[3]. Thus, the process of CAS evaluation should be quite detailed and requires accurate and valid measures.

A survey conducted in the USA with 75 speech therapists showed more than 40 features currently being used to diagnose apraxia of speech. These results were considered consistent with the literature on the subject; that is, there is a well-defined standard for the diagnosis and interpretation of the subject[2].

From the foregoing, it is clear that the criteria for diagnosis of CAS are often subjective (patient observation) and directed by exclusion of other diseases. Thus, evaluation of CAS is not always made through protocols, since not all of them present norms and psychometric properties for the child population.

In view of the difficulties seen in the literature to establish the diagnosis of CAS, this study sought to identify which instruments have been used to assess children presenting this impairment. With this review, we aimed to answer the following questions: Which tools have psychometric criteria for the children population? What are the aspects evaluated by assessment tools aimed at CAS?

RESEARCH STRATEGY

For this review, we carried out searches in PubMed, Scopus, and Embase databases in the months of October 2013 and February 2014. Abstracts of articles published in the last 11 years (2003–2014), whether or not in open access journals, were included.

Two constructs were used in the searches: evaluation AND apraxia of speech. The evaluation construct was composed of the following combinations of keywords: "Evaluation" OR "Instrument" OR "Test" OR "Battery" OR "Assessment" OR "Task" OR "Screening." Speech apraxia construct consisted of the associations "Orofacial praxis" OR "Motor speech disorders" OR "Speech praxis" OR "Apraxia of speech" OR "Developmental motor speech disorders" OR "Developmental dyspraxia" OR "Verbal developmental apraxia."

The research was carried out in steps. First, the constructs were searched separately, with their due keywords. From the result of each construct, a new search with the combination of both constructs was performed. The keywords were selected from specific articles of the area. However, the language (English, Spanish, and Portuguese) and the age of the study population (15 years) were the limitations of this study.

SELECTION CRITERIA

The searches retrieved 695 abstracts, being 42 from Embase, 69 from Pubmed, and 584 from Scopus. Of these, 23 were selected based on the following criteria: being an empirical study and addressing CAS assessment through a tool. Articles that used no formal assessment tool for the diagnosis of apraxia and articles not available online were excluded from the sample.

DATA ANALYSIS

All abstracts were reviewed independently by two researchers of the area. After the selection, the ones approved by both evaluators were included in the study. But those presenting

disagreement were submitted to a third evaluator. The flow of articles selection is shown in Figure 1.

RESULTS

Based on the number of selected articles, it is clear that there are few studies using formal assessment protocols for CAS diagnosis. The tools found in the studies were *Verbal Motor Production Assessment for Children* (VMPAC)[12]; *Dynamic Evaluation of Motor Speech Skill* (DEMSS)[13], *The Orofacial Praxis Test*[1], *Kaufman Speech Praxis Test for children* (KSPT)[14], and *Madison Speech Assessment Protocol* (MSAP)[5]. These tools are used in research to specifically assess apraxia of speech, but other tests are also applied to examine other language functions in children with apraxia, including phonology, expressive, and receptive vocabulary.

Tools mostly evaluate the following characteristics: conduction of voiced praxis, praxis and/or orofacial movements, sequences of movements, simple phonemes, complex phonemes and syllables, spontaneous speech, articulation accuracy, prosody, and error consistency. Following, we will briefly describe the tools that have been used in the articles selected for this review.

VMPAC assesses motor functions of speech and oral structures (including tasks related to feeding) and aims to assess children aged 3–12 years. It brings contributions to the diagnosis, treatment planning, and drilling during the therapy of children with CAS. The test presents some evidence of validity (content) and well-defined standards. Furthermore, it uses a 3-point scale (0=incorrect; 1=partially incorrect; 2=correct) to check accuracy and quality of motor movements and allows the identification of motor speech interruption level(s)[12].

The VMPAC test includes:
1. total motor control (neurophysiological support for speech: control of the head, neck, posture, etc.);
2. oromotor control;
3. sequencing and two complementary areas;
4. connected speech and language; and
5. speech characteristics.

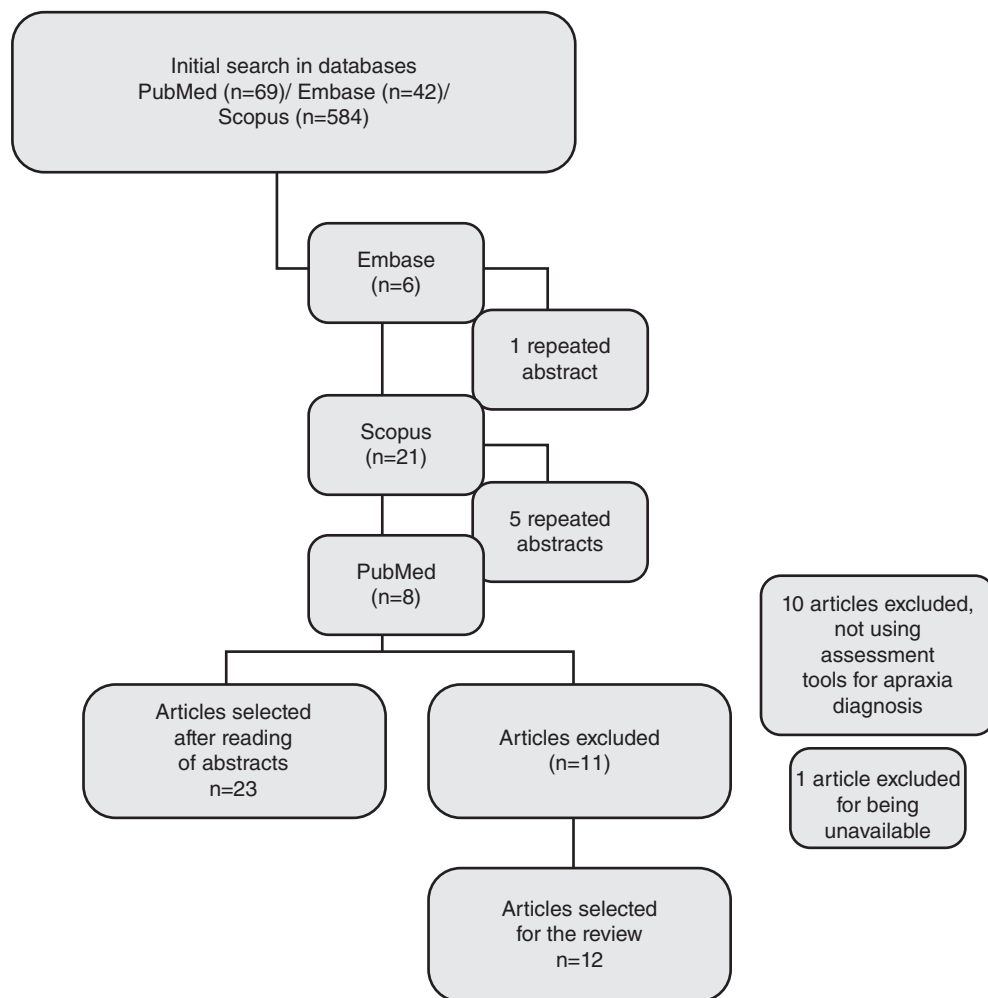Each subsection can be interpreted independently.

Figure 1. Flow of analysis of abstracts and full papers selected from PubMed, Embase, and Scopus databases.

The battery is composed of 82 items (20 total motor control, 46 oromotor control, and 16 sequencing skills). The items related to total motor control assess postural tone and stability in breathing, phonation, and articulation system, as well as oromotor reflexes and vegetative functions. The items related to oromotor control assess the integrity of verbal and nonverbal movements of the jaw, lips, and tongue. The sequencing items assess nonverbal skills sequencing, sequence of doubled and tripled phonemes.

By analyzing these five areas, it is possible to identify the following abilities: basic posture, breathing, phonation support for speech production; voluntary control or the jaw, tongue, and lips; ability to perform a nonverbal sequence of verbal speech and verbal movements; changes in the accuracy with increasing length and complexity of utterances; breaks in speech; and types of support that help the child.

In a North-American research aimed to identify diagnostic markers in children whose speech disorders result from a deficit in speech praxis, Shriberg et al.[15] used VMPAC. In this study[15], 35 children aged between 3 and 12 years were evaluated, and only one had suspected apraxia of speech. VMPAC was used to screen these children and to assess lexical accent (considered one of the diagnostic markers of CAS). The authors pointed out that the prosodic changes found in children with apraxia (difficulty in lexical accent) were due to the deficit in motor control and speech praxis.

No studies using this tool to assess subjects speaking Brazilian Portuguese were found.

DEM is a new tool that assesses, from imitation, the word and vowel articulation accuracy, prosody and consistency of utterance with 9 subtests, totaling 66 items. The protocol is intended for the evaluation of speech movements of young children (3–6 years and 7 months) or with severe speech disorders. During the implementation of this protocol, the child performs the stimuli in two ways: as an initial attempt and after the examiner's demonstration (articulation hint)[13].

The test assesses words with the following structures: consonant-vowel (8 items, e.g., me, hi), vowel-consonant (8 items, e.g., up, eat), duplicate syllables (4 items, e.g., mama, booboo), consonant-vowel-consonant 1 (CVC1) (6 items, e.g., mom, peep, pop), CVC2 (8 items, e.g., mad, bed, hop), dissyllabic 1 (5 items, e.g., baby, puppy), dissyllabic 2 (6 items, e.g., bunny, happy), multisyllabic (6 items, e.g., banana, kangaroo), and productions with extension increased (15 items, e.g., dad, hi dad, hi daddy).

It presents evidence of construct validity and reliability (intra-judges 89%, inter-judges 91%, and test–retest 89%)[13]. In addition, this tool was sensitive for the diagnosis of apraxia of speech in the US population.

DEMSS is not yet available in full (ongoing publishing), but we do know it is currently being adapted for other languages, including Brazilian Portuguese.

The Orofacial Praxis Test allows evaluation of the difficulties in execution of movements (e.g., throw a kiss) and sequencing of movements (e.g., opening and closing the mouth) using orofacial muscles, thus making a distinction between the type of gesture (oroverbal praxis movement, orofacial praxis movement, sequence of movements, and parallel movements) and application types (verbal and imitation requests). It is not restricted to the detection of apraxia of speech; it also helps to identify disorders affecting motor coordination at various levels.

The test consists of 36 tasks, 12 related to voiced praxis, 12 to orofacial praxis, 6 to sequence of movements, and 6 to parallel movements. It was first used in 108 Italian-speaking children aged 4–8 years[1], but does not show evidence of reliability and validity, bringing only normative data based on the evaluation.

The Orofacial Praxis Test was translated and used in Brazilian studies[16,17] to compare the performance of children with typical and atypical speech development. The results of a study[16] aimed to compare orofacial praxis of children with typical phonological development and phonological disorders showed similar performances in both groups. In another study[17], the same protocol was applied to verify the orofacial praxis of children with typical phonological development, phonological disorders, and phonetic-phonological disorders. The results showed that children with phonetic-phonological disorders had greater difficulty in carrying out the test's tasks.

KSPT helps to identify and treat CAS. It measures a child's responses through imitation of the examiner. The test has four parts with levels of increasing difficulty, and the performance of each part depends on the child's level of functioning. Part 1 has tasks involving extensive oral movements; Part 2 involves simple movements (isolated vowels /a, e/; vowel movement + vowel /ai, ou/, simple consonants /m, p, b, t, d/; CVCV /mama, papa/; VCV /opa/, CV, CVC); Part 3 comprises consonants /k, g, f, s/, complex dissyllabic, complex words; and Part 4 assesses spontaneous speech.

The protocol evaluates children aged 2–5 years and 11 months. KSPT shows evidence of criterion and content validity for the North-American population, being one of the mostly applied tools in international surveys with children[18,19].

This tool was used in a research[18] intended to determine whether abnormalities in fine motor function could be detected in children with speech sound disorders, and whether there was correlation between imitation of oral motor skills and fine motor function. KSPT was sensitive to evaluate these children.

No studies using this tool on Brazilian Portuguese-speaking subjects were found.

MSAP was developed with the purpose to identify diagnostic markers for eight subtypes of speech sound disorders of unknown origin[5]. The protocol includes 25 tasks and tests, such as: Goldman Fristoe Test of Articulation, hearing screening, spontaneous speech sample, lexical stress task, task with simple and complex words and sentences, repetition of syllables and pseudowords, tasks with rotic and hissing, diadochokinesia task, sustained vowel and consonant (/a/ and /f/), orofacial examination, oral and written language scales, and Kaufman Brief Intelligence Test. The application lasts about 1 h and can be done in one or two sessions. It is a battery with several tests/tools to aid in the differential diagnosis of apraxia of speech. Unlike other protocols presented, this is not intended only for the identification of apraxia of speech, but also for speech sound disorders.

Chart 1. Characteristics of apraxia tests found in this review

Test	Author (year)	Age group assessed	Evidence of validity	Evidence of liability	Abilities assessed
VMPAC	Hayden and Square (1999)[12]	3–12 years	Partial	No	Oral structures, motor function of speech
DEMSS	Strand et al. (2013)[13]	3–6 years and 7 months	Yes	Yes	Motor function of speech, prosody
The Orofacial Praxis Test	Bearzotti, Tavanno and Fabbro (2007)[1]	4–8 years	No	No	Oral movements, voiced and orofacial praxias
KSPT	Kaufman (1998)[14]	2–5 years and 11 months	Partial	No	Oral structures, motor function of speech
MSAP	Shriberg et al. (2010)[5]	Preschool, school children, teenagers, and adults	No	No	Oral structure, motor function of speech, prosody

Caption: VMPAC = Verbal Motor Protocol Assessment; DEMSS = Dynamic Evaluation Motor Speech Skills; KSPT = Kaufman Speech Test for Children; MSAP = Madison Speech Assessment Protocol

This protocol was applied to study different age groups[5], and intended to include, in addition to presenting the protocol, the description of a classification system for motor speech disorders. Another study[20] conducted with MSAP was aimed to determine the prevalence and phenotype of CAS in individuals with lactose intolerance, due to the high incidence of speech sound disorders in this population, even though the literature lacks this topic. The results showed high prevalence of the disorder in the sample investigated.

We found no studies using this tool on Brazilian Portuguese-speakers.

All instruments (VMPAC, KSPT, DRESS, The Orofacial Praxis Test, and MSAP) present tasks that assess the oral structures and/or motor function of speech, which is the most investigated ability, which suggests that this is one of the most impaired abilities in apraxia of speech.

It is also believed that prosody is one of the diagnostic markers for children with CAS[9]. Among the assessment tools found in this review, only two (DEMSS and MSAP) evaluate prosody in specific tasks. VMPAC evaluates connected speech, but does not mention prosody as a specific task. The characteristics of each tool described herein are shown in Chart 1.

The tools found in this review are able to assist in health professionals in CAS diagnosis, but not all of them show evidence of validity and reliability. DEMSS was the only tool with a study for validity and reliability[13]; two other tools[12,14] had partial evidence of validity (content and criteria). Empirical studies found tools used only as inclusion criteria (and diagnosis of speech apraxia), without the proposal of an evaluation protocol, except DEMSS[13] and MSAP[5].

There are other tools such as Apraxia Profile (AP) Preschool and School-Age Versions[21]; Oral Speech Mechanism Screening Examination, Third Edition (OSMSE-3)[22]; Screening Test for Developmental Apraxia of Speech – Second Edition (STDAS-2)[23]; the Verbal Dyspraxia Profile (VDP)[24]. However, these were not found in this review, perhaps because the period of research was limited to the 11 years prior to study, or because of the keywords selected, or for not being used in clinical practice and/or research anymore.

Among tools found so far, none has been adapted and standardized for the Brazilian sociocultural reality. In addition, as far as we know, there are no tools with psychometric properties for the Brazilian Portuguese language intended to assess CAS.

CONCLUSION

After identifying which tools are currently being used to assess children with apraxia of speech, we verified that there are protocols intended to assess this disorder, but not all of them show psychometric evidence.

The best diagnosis method is combined, that is, clinical assessment (observation of the child's speech) and formal evaluation (with valid and reliable protocols). In this way, CAS diagnosis can be done more judiciously.

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