

Marcia Keske-Soares¹
Letícia Bitencourt Uberti¹
Marieli Barichello Gubiani¹
Marileida Barichello Gubiani¹
Marizete Ilha Ceron¹
Karina Carlesso Pagliarin¹

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Correspondence address:

Marileida Barichello Gubiani
Universidade Federal de Santa Maria
– UFSM
Rua Senador Cassiano do Nascimento,
85, Centro, Santa Maria (RS), Brasil,
CEP: 97050-680.
E-mail: mari_gubiani@yahoo.com.br

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Performance of children with speech sound disorders in the dynamic evaluation of motor speech skills

Desempenho de crianças com distúrbios dos sons da fala no instrumento “Avaliação dinâmica das habilidades motoras da fala”

ABSTRACT

Purpose: To compare performance between children with typical speech acquisition, phonological disorders, and childhood apraxia of speech for the variables overall articulatory accuracy and consistency of the Dynamic Evaluation of Motor Speech Skill - Brazilian Portuguese version (DEMSS-BR). **Methods:** Study participants were 18 children of both genders aged 4 years and 6 months to 5 years and 8 months. The sample was divided into three groups: six children with typical speech acquisition (TSA), six children with phonological disorder (PD), and six individuals with childhood apraxia of speech (CAS). All participants were submitted to the DEMSS-BR and had their subscores of speech accuracy and consistency measured. Performance comparison between the groups was statistically evaluated using the Mann-Whitney U Test. **Results:** Participants in the group with CAS presented poorer performance for the variables overall articulatory accuracy and consistency compared with those of participants in the other two groups. **Conclusion:** The group of children with childhood apraxia of speech presented poorer performance on the DEMSS-BR compared with those of the groups with typical speech acquisition and phonological disorders. The study demonstrated that the DEMSS-BR assists with differential diagnosis of children with speech sound disorders.

RESUMO

Objetivo: Comparar o desempenho das crianças com aquisição de fala típica, desvio fonológico e com apraxia de fala na infância nas variáveis precisão de produção e consistência do instrumento “Avaliação dinâmica das habilidades motoras da fala” (DEMSS-BR). **Método:** A amostra foi constituída por 18 crianças com idades entre 4 anos e 6 meses a 5 anos e 8 meses, de ambos os gêneros, divididas em três grupos: seis com aquisição típica de fala, seis com desvio fonológico e seis com apraxia de fala na infância. Todas foram avaliadas por meio do instrumento DEMSS-BR, e o desempenho foi observado a partir da análise das variáveis de precisão da produção e consistência da fala. Para comparação do desempenho entre grupos utilizou-se o teste U de Mann-Whitney. **Resultados:** O grupo com apraxia de fala na infância apresentou desempenho inferior nas variáveis de precisão da produção e consistência da fala quando comparado aos demais grupos. **Conclusão:** O grupo com apraxia de fala na infância apresentou pior desempenho no DEMSS-BR quando comparado aos de crianças típicas e com desvio fonológico. Desta forma, foi possível constatar que o DEMSS-BR auxilia no diagnóstico diferencial de crianças com distúrbios dos sons da fala.

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¹ Universidade Federal de Santa Maria – UFSM - Santa Maria (RS), Brasil.

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INTRODUCTION

Speech sound disorders derive from a variety of etiologies and result in impairment at different levels of speech production, such as the linguistic-phonological level, where omissions and substitutions (phonological disorder) are observed⁽¹⁾, and/or the motor level, in which difficulties in the planning and execution of motor speech are found (childhood apraxia of speech)^(2,3). One of the many challenges for speech-language pathologists in the differential diagnosis of these deficits is to determine to what degree motor impairment affects children with these disorders^(2,3).

Some characteristics are frequently found in speech sound disorders, such as slow development, reduced phonetic and phonemic inventories, multiple errors in sound utterance, decreased percentage of correct consonants, and speech unintelligibility⁽⁴⁾. These features may be present in both severe phonological disorders and childhood apraxia of speech (CAS), hindering the accurate diagnosis of these disorders.

The following characteristics can be mentioned among those described to assist with differentiation between phonological disorder (PD) and CAS: limited repertoire of consonants and vowels; frequent omissions; high incidence of vowel errors; inconsistent articulation; altered suprasegmental features (prosody, fluency, and voice); increased number of errors in larger speech units; significant difficulties in imitating words and phrases; predominant use of simple syllabic forms⁽⁵⁾. There is a need for greater quantification of diagnostic markers focusing on the specific characteristics of CAS that are not frequently observed in children with severe phonological disorders⁽⁵⁾.

Although the diagnosis of PD is frequently addressed⁽¹⁾ and this impairment presents better defined features, the characterization of CAS, as well as its diagnosis, are divergent in the literature^(3,6,7). In this sense, segmental and suprasegmental characteristics may contribute to the composition of a diagnosis⁽⁸⁾. The following segmental characteristics are worth highlighting: articulatory groping, especially at the beginning of speech production; substitution errors; inconsistent speech exchanges; larger number of errors on vowels⁽⁸⁻¹²⁾. Regarding the suprasegmental characteristics, the following should be emphasized: inadequate prosody, mainly in inconsistent utterance of the accent (stressed syllable), and perception of nasopharyngeal resonance⁽⁸⁾.

Experts show no consensus on which and how many characteristics are needed to obtain the diagnosis of CAS⁽¹³⁾; whereas some studies report a need for more than five^(13,14), others point to a necessity of at least eight⁽¹⁵⁾. The crucial difference is that, in CAS, the features tend to remain in later stages of the child's life compared with other speech sound disorders such as severe phonological disorder⁽⁷⁾.

In order to diagnose CAS, a combined evaluation should be performed through interpretation of the observations made by a professional with knowledge and experience in the area

(subjective assessment) and the use of valid and reliable protocols (objective assessment)⁽¹⁶⁾.

The *Dynamic Evaluation of Motor Speech Skills* (DEMSS)⁽²⁾ was designed to assist with the differential diagnosis of speech sound disorders. This test aims to dynamically assess the motor skills of young children's speech. The DEMSS was adapted to Brazilian Portuguese, and it is known as DEMSS-BR⁽¹⁷⁾. This instrument has been validated, is being standardized⁽¹⁸⁾, and is able to present a differential diagnosis of children with these disorders⁽¹⁸⁾.

Speech accuracy (or overall articulatory accuracy) and consistency are among the DEMSS variables. Speech accuracy refers to the response of the child being examined; this variable is fundamental for the diagnosis of CAS because apraxic children present difficulties in performing/producing words correctly. Speech consistency refers to the child's response to stimulus as the number of attempts increase (whether the child can always imitate the same form or present different utterances as the number of attempts increase)⁽²⁾.

In this context, the objective of this study is to compare the performance of children with typical speech acquisition, phonological disorders, and childhood apraxia of speech for the variables overall articulatory accuracy and consistency of the DEMSS-BR instrument.

METHODS

This study is part of a research project duly registered and approved by the Research Ethics Committee of the aforementioned Institution under protocol no. 16239413.0.0000.5346. According to the norms of the National Health Council (CNS), Resolution 466/12, specific authorization of the participants was requested to their parents/legal guardians, who have read and signed an Informed Consent Form (ICF) prior to study commencement. The children also orally agreed to participate in the activity.

This is a cross-sectional, descriptive, quantitative study conducted with children from public and private schools in a municipality in the south of Brazil.

Study participants

Study participants were 18 children of both genders aged 4 years and 6 months to 5 years and 8 months. The sample was divided into three groups: six children with typical speech acquisition, six children with phonological disorders, and six children with childhood apraxia of speech.

From the group of children with childhood apraxia of speech (CAS), the other two groups were matched for age. Table 1 shows the characterization of study participants according to group.

Table 1. Characterization of study participants according to groups: typical speech acquisition, phonological disorder, and childhood apraxia of speech

	TSA	PD	CAS
	n (%)	n (%)	n (%)
Gender			
Male	4 (66.6)	4 (66.6)	5 (83.3)
Female	2 (33.3)	2 (33.3)	1 (17.7)
Age (mean)	4:11	5:0	4:11
Type of school			
Public	66.66%	0 (0)	5 (83.3)
Private	33.33%	6 (100)	1 (17.7)

Caption: n = number of participants; TSA = typical speech acquisition; PD = phonological disorder; CAS = childhood apraxia of speech

Instruments and procedures

Participants were included in the study after undergoing a series of assessments in order to discard and/or classify possible organic impairments and language delays. These evaluations were conducted by three speech-language pathology (SLP) researchers with experience in the area of speech sound disorders and three SLP students previously trained in the application of these assessments.

This series of assessments included a questionnaire to parents (especially prepared for the study) aiming to analyze pre-, peri-, or post-natal factors that could interfere in the child's cognitive, linguistic and motor development, and another questionnaire to the teachers (based on the Conners' scale - adapted)⁽¹⁹⁾ with the objective of investigating behaviors in the classroom. In order to discard hearing loss, airway hearing screening was performed at 500 to 4KHz frequencies, monaural in both ears, using an INTERACOUSTICS-AD 229 portable audiometer, in descending-ascending order. Screening was performed in a silent room in the schools where the children were enrolled. A normality criterion of up to 15 dBHL auditory threshold was used according to the three-tone mean of the 500, 1000 and 2000 Hz frequencies.

The aspects of orofacial motricity were assessed through the Orofacial Myofunctional Evaluation with Scores (OMES)⁽²⁰⁾ to verify the characteristics of the phonoarticulatory organs and functions of the stomatognathic system. The Auditory Vocabulary Test⁽²¹⁾ was used to verify comprehensive language and the Child Naming Test⁽²²⁾ was applied to examine expressive language. Finally, the Assessment of Phonological Awareness (APA)⁽²³⁾ was applied to observe the child's phonological system.

After these evaluations were conducted, the participants were classified into three groups: typical speech acquisition (TSA), phonological disorder (PD), and childhood apraxia of speech (CAS), in which the clinical judgment of speech-language therapists was also considered. From this, all children included in this study were evaluated using the Dynamic Evaluation of Motor Speech Skill - Brazilian Portuguese version (DEMSS-BR).

The DEMSS-BR^(17,18) is composed of seven verbal tasks with different levels of complexity (monosyllables, disyllables, and trisyllables). Initially, a stimulus is presented to the individual by imitation. If the child cannot imitate it, visual, tactile and/or synesthetic cues are provided to assist with the best articulation of the word. A differentiated score is assigned to each articulatory track offered. The total score of the instrument considers the child's subscores for overall articulatory, vowel and prosodic accuracy, and consistency (of correct or incorrect responses).

The variable overall articulatory accuracy is related to the child's response. It can be correct on the first attempt with no cues (4 points), correct on the first attempt with a cue (2 points), correct on two to four attempts (1 point), or incorrect after all cued attempts (0 points). In addition, if the individual presents consistent substitutions or distortions, they are considered incorrect, but receive a score of 3 points. This score is assigned to distinguish consistent from inconsistent errors. Consistency refers to how the response is presented as the number of attempts increase. For instance, a child may present a consistent response when it is always produced in the same way - correct or incorrect response (score = 1), or inconsistent response when there are different forms of utterance for the same stimulus (score = 0).

The DEMSS-BR also includes the variables vowel and prosodic accuracy, but they were not analyzed in this study.

Data analysis

Descriptive analysis was conducted on the subscores of the DEMSS-BR for each child, as well as for the variables overall articulatory accuracy and consistency for the groups. In addition, performance comparison between the groups was statistically evaluated with application of the Mann-Whitney U Test using the SPSS 20.0 software for *Windows* at 5% significance level.

RESULTS

Tables 2 and 3 show the performance of each of the 18 participating children in each task of the DEMSS-BR regarding the variables overall articulatory accuracy and consistency, respectively. Children with childhood apraxia of speech (CAS) presented the lowest scores compared with those of children in the other groups for both variables. Children with CAS presented greater difficulty in the tasks of monosyllabic words with consonant-vowel-consonant structure, disyllabic words with duplicate syllables, with the same consonant and, mainly, in polysyllabic words.

The results obtained indicate that the group of children with CAS presented poorer performance compared with those of children with typical speech acquisition (TSA) and with phonological disorder (PD), in both speech accuracy (overall articulatory accuracy) and speech consistency (Tables 4 and 5). Moreover, no significant differences for the analyzed variables were observed between children with TSA and PD (Table 5).

Table 2. Performance of the participating children regarding the overall articulatory accuracy variable of the DEMSS-BR

Accuracy											
Group	Code	Gender	Age	VV	CV	Duplicate syllables	CVC	Same consonant	Varied form	Polysyllables	Total (Maximum score = 176)
TSA	Child 1	F	5.08	20	40	16	16	20	32	32	176
	Child 2	F	4.11	20	40	16	16	20	32	32	176
	Child 3	M	5.03	20	40	16	12	20	32	30	170
	Child 4	M	4.08	18	40	16	16	20	32	30	172
	Child 5	M	5.03	20	40	16	16	20	32	32	176
	Child 6	M	4.06	20	38	16	16	20	32	30	172
PD	Child 7	M	5.02	20	40	16	16	20	32	32	176
	Child 8	M	5.08	20	40	16	16	20	32	32	176
	Child 9	M	4.07	20	40	16	16	20	32	32	176
	Child 10	F	5.00	20	40	16	16	20	30	32	174
	Child 11	M	5.02	20	39	16	15	20	32	32	174
	Child 12	F	4.05	20	36	16	16	17	29	28	162
CAS	Child 13	F	4.11	20	40	16	14	20	30	30	170
	Child 14	M	5.08	20	33	16	12	20	32	26	159
	Child 15	M	5.03	20	31	12	12	16	23	12	126
	Child 16	M	4.06	18	28	13	13	16	29	22	139
	Child 17	M	4.08	20	28	12	12	11	8	7	98
	Child 18	M	5.03	16	26	16	3	6	18	5	90

Caption: VV = vowel-vowel; CV = consonant-vowel; CVC = consonant-vowel-consonant; TSA = typical speech acquisition; PD = phonological disorder; CAS = childhood apraxia of speech

Table 3. Performance of the participating children regarding the speech consistency variable of the DEMSS-BR

Consistency											
Group	Code	Gender	Age	VV	CV	Duplicate syllables	CVC	Same consonant	Varied form	Polysyllables	Total (Maximum score = 44)
TSA	Child 1	F	5.08	5	10	4	4	5	8	8	44
	Child 2	F	4.11	5	10	4	4	5	8	8	44
	Child 3	M	5.03	5	10	4	4	5	8	8	44
	Child 4	M	4.08	5	10	4	4	5	8	8	44
	Child 5	M	5.03	5	10	4	4	5	8	8	44
	Child 6	M	4.06	5	10	4	4	5	8	8	44
PD	Child 7	M	5.02	5	10	4	4	5	8	8	44
	Child 8	M	5.08	5	10	4	4	5	8	8	44
	Child 9	M	4.07	5	10	4	4	5	8	8	44
	Child 10	F	5	5	10	4	4	5	8	8	44
	Child 11	M	5.02	5	10	4	4	5	8	8	44
	Child 12	F	4.05	5	10	4	4	5	8	8	44
CAS	Child 13	F	4.11	5	10	4	4	5	8	7	43
	Child 14	M	5.08	5	10	4	4	5	8	7	43
	Child 15	M	5.03	5	8	4	4	4	6	7	38
	Child 16	M	4.06	5	6	3	4	4	7	6	35
	Child 17	M	4.08	5	8	3	4	3	3	2	28
	Child 18	M	5.03	5	10	4	1	3	7	3	33

Caption: VV = vowel-vowel; CV = consonant-vowel; CVC = consonant-vowel-consonant; TSA = typical speech acquisition; PD = phonological disorder; CAS = childhood apraxia of speech

Table 4. Descriptive data on the speech accuracy and consistency variables of the DEMSS-BR)

	TSA			PD			CAS		
	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median
Accuracy	173.67	2.66	174.00	173.00	5.78	175.00	130.33	32.13	132.50
Consistency	44.00	0.00	44.00	44.00	0.00	44.00	36.67	5.88	36.50

Caption: TSA = typical speech acquisition; PD = phonological disorder; CAS = childhood apraxia of speech; SD = standard deviation

Table 5. Performance comparison between the study groups regarding the speech accuracy and consistency variables of the DEMSS-BR

	Apraxia x Typical	Apraxia x Phonological disorder	Typical x Phonological disorder
	<i>p</i>	<i>P</i>	<i>p</i>
Accuracy	0.004	0.006	0.80
Consistency	0.002	0.002	1.00

Values statistically significant at 5% level ($p < 0.05$) according to the Mann-Whitney U test

DISCUSSION

The findings of this study show that children with childhood apraxia of speech (CAS) presented worse results than those in the other groups regarding the variables analyzed (overall articulatory accuracy and consistency), as shown in Table 4. In this survey, these variables were fundamental for the differential diagnosis between these pathologies (phonological disorder and CAS).

The tasks of the DEMSS-BR are organized hierarchically, from simple to complex words, which vary in extent and point of articulation (anterior, middle, and posterior)^(17,18). Children with apraxia of speech present deficits as variability in the point of articulation increases, as well as word extension, showing difficulties even when cues are provided⁽²⁴⁾, as it can be verified in Table 2. This was observed in the tasks involving different syllabic structures and consonant substitutions, but mainly in polysyllabic words, in which five of the six children with CAS presented difficulties in articulation and, consequently, in speech accuracy. Moreover, as shown in Table 3, the poorest performance of children with CAS is more evident with respect to speech consistency, considering that no child reached the maximum subscore for this variable of the DEMSS-BR.

In contrast, children with phonological disorder (PD) had better performance than those with CAS, because the substitutions were systematic. Still, these children benefited from visual, tactile, auditory and articulatory cues, which improved their speech production. Nevertheless, even when they did not reach the target correctly, the substitutions remained consistent.

The speech of individuals with CAS, unlike that of those with PD, presents many inconsistencies with several different utterances of the same target at different times^(3,25). The results of this survey indicate that assessing the variable consistency seems to be fundamental for a differential diagnosis of these disorders, because individuals with CAS present difficulty in this variable.

Speech patterns in children with PD include omission, substitution of vowels and consonants, additions, and distortions associated with articulatory impairment, as well as the systematic use of phonological processes⁽²⁴⁻²⁷⁾. Children with PD presented poorer performance in overall articulatory accuracy compared

with those of children with typical speech acquisition (TSA), considering that the latter did not present substitutions in their utterances, as it can be verified in Table 5.

Children with TSA presented better performance in instruments that evaluate speech and the articulation praxis^(26,28). This result^(26,28) was also found in this study, because the individuals with CAS had poorer performance in the DEMSS-BR.

It is worth noting that the words that compose the DEMSS-BR were selected considering phonemes that belong to the phonological system of young children. Thus the consonants that compose the instrument can be perfectly articulated/uttered by 3-year-old children with typical speech development⁽¹⁶⁾. Therefore, in general, no significant performance deficits were observed in this group with regard to speech accuracy, because when the cue was again provided, the children were able to correctly utter the target.

The DEMSS-BR is a new tool that intends to fill a clinical and scientific gap in the Brazilian reality, considering that instruments that intend to assess severe speech sound disorders and aid in the differential diagnosis of CAS are still scarce. The variables overall articulatory accuracy and consistency should be observed in children with speech sound disorders, because they may be one of the diagnostic markers for CAS^(2,8-12,16). In the present research, this finding was confirmed because statistical significance was observed when these variables were compared between the different groups.

It is important to have a test that is able to correctly identify speech disorders in children, that is, provide a differential diagnosis between these disorders, and it should be considered by examiners when choosing the assessment tool to be used in clinical practice. When the correct choice of instrument is not considered, an inadequate diagnosis may be performed⁽²⁷⁾, which will often only be noticed with the non-therapeutic evolution of the case.

Furthermore, there is a lack of objective and validated assessments for speech sound disorders in Brazil⁽¹⁶⁾. This is proposed by the DEMSS-BR, which proved to be capable of discriminating speech sound disorders, especially CAS, in the present study.

This survey conducted a combined evaluation⁽¹⁶⁾, considering that an observational assessment was performed for the diagnosis of speech sound disorders (PD and CAS) and an objective assessment was achieved using the DEMSS-BR instrument. The results showed that the DEMSS-BR is sensitive to diagnose CAS through the variables overall articulatory accuracy and consistency, presenting significant results in the different study groups.

This study presents a significant limitation, the inclusion of a small group of children with CAS, which made the TSA and PD groups also small because the groups were paired. Therefore, further application of the DEMSS-BR to a larger sample of children with this impairment comparing it with cases of speech sound disorders is suggested.

CONCLUSION

Results show that the variables overall articulatory accuracy and consistency, analyzed in the DEMSS-BR, are important diagnostic markers in speech sound disorders, demonstrating that this instrument assists with differential diagnosis between phonological disorder (PD) and childhood apraxia of speech (CAS).

In this study, children clinically diagnosed with CAS presented poorer performance in the analyzed variables (overall articulatory accuracy and consistency) compared with those of children with PD and typical speech acquisition, evidencing that the aforementioned variables are essential for the assessment and differential diagnosis of speech sounds disorders.

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Author contributions

LBU and MBG were responsible for the study design, collection and classification of data, and writing of the manuscript; MBG and MIC participated in the collection and classification of data and writing of the manuscript; KCP and MKS collaborated with the statistical analysis of data and writing and revision of the manuscript.