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Criteria for Differential Diagnosis of Childhood Apraxia of Speech: Preliminary Results

Beril Polat[1], Özlem Ünal Logacev[2],

Summary

Purpose: The wide range of speech characteristics of childhood apraxia of speech (CAS) impedes the differential diagnosis of this disorder and causes it to be confused with different problems such as phonological disorders. In this study, it was aimed to determine the differential diagnosis features of CAS and to reveal the speech characteristics that should be included in diagnostic tests. Another aim of this study is to present a draft of a diagnostic test which will be revised in the light of the data obtained from this study. **Method:** For this purpose, frequently encountered differential diagnosis criteria in the literature was compared between 5 children with suspected CAS, 5 children with phonological disorders (PD), and 5 children with typical development (TD). Turkish Early Language Development Test (TEDİL) and the Articulation and Phonology Test (SST) was administered to all participants. A checklist prepared by the researchers by surveying various criteria for differential diagnosis in the literature was applied to those groups. This checklist includes inconsistency, voicing, isolated consonant production, vowel distortion, increased errors in increased utterance length, spontaneous and repetitive production differences, syllable stress and intonation features. **Results:** The biggest difference between children with CAS and other groups was revealed in vowel errors, syllable stress and intonation errors. These were followed by inconsistent production and voicing errors. Increased errors in increased utterance length and isolated consonant production errors were similar to each other between CAS and PD groups. No difference was observed between the spontaneous and repetitive productions of children with CAS. **Conclusion:** As a result of this research, it is concluded that vowel errors, syllable stress errors and intonation errors are more determinant in revealing the distinction between MEA and FB than other problems. It is believed that a test that claims to diagnose MPA must necessarily be capable of evaluating these problems.

Keywords: childhood apraxia of speech, phonological disorder, differential diagnosis

[1] Sorumlu Yazar, Uzm. Dkt., Günışığı Çocuk ve Aile Danışmanlık Merkezi, ORCID: 0000-0003-1851-0773, polatberil91@gmail.com
[2] Dr. Öğr. Üyesi, İstanbul Medipol Üniversitesi, Dil ve Konuşma Terapisi Bölümü, ORCID: 0000-0002-5509-5655 ologacev@medipol.edu.tr

Çocukluk Çağı Apraksisinin Ayırıcı Tanı Kriterlerinin Değerlendirilmesi: Ön sonuçlar

Özet

Amaç: Çocukluk çağı konuşma apraksisi (ÇÇA) olan bireylerde hareket dizilimlerini planlama ve/veya programlamadaki sorunlar nedeniyle hatalı konuşma sesi ve prozodi üretimi görülür (ASHA, 2007). Çocukluk çağı konuşma apraksisinin tanı kriterlerin geniş bir yelpazeye yayılmış olması, bu bozukluğun ayırıcı tanısını zorlaştırmakta ve fonolojik bozukluk gibi farklı sorunlarla karıştırılmasına sebep olmaktadır. ASHA'ya göre üç ayırıcı tanı kriteri ön plana çıkmaktadır. Bunlar; hece veya kelimenin tekrarlı üretiminde tutarsız ünlü/ünsüz hataları, ses ve hecelerin arasında uzatılmış ve bozulmuş koartikülatör geçişler ve etkilenmiş prozodidir. Ancak bu üç özellik dışında pek çok farklı dil ve konuşma özelliği bu bozukluk ile özdeşleştirilmiştir. Söz konusu bu çalışmada çocukluk çağı apraksisi tanısında kullanılabilecek ayırtedici özellikleri saptayarak tanı testlerinde yer alması gereken konuşma özelliklerini incelemek amaçlanmıştır. Ayrıca elde edilen bu ön veriler doğrultusunda ileride bir değerlendirme testi geliştirilmesi planlanmaktadır. **Yöntem:** Belirlenen amaç doğrultusunda literatürde sık rastlanan ayırıcı tanı kriterleri; 4;0 ve 6;0 yaş aralığındaki 5 ÇÇA'sı olan, 5 fonolojik bozukluğu (FB) olan ve 5 tipik gelişim gösteren (TGG) çocuklar arasında karşılaştırılmıştır. Gruplar arasındaki farklar betimsel model kullanılarak ortaya konulmuştur. Tüm katılımcılara Türkçe Erken Dil Gelişim Testi (TEDİL), Sesletim Sesbilgisi Testi (SST) uygulanmıştır. ÇÇA'lı grup dil ve konuşma terapistleri tarafından ÇÇA tanısıyla yönlendirilen çocuklardan oluşmaktadır. ÇÇA'lı grubun sesletim yaşı FB grubuyla, kronolojik yaşı TGG'li grupla eşleştirilmiştir. Bu gruplara araştırmacılar tarafından hazırlanan, çeşitli ayırıcı tanı kriterlerini değerlendiren bir kontrol listesi uygulanmıştır (EK 1). Bu kontrol listesinde tutarlılık, ötümlüleştirme, izole doğru ünsüz üretimi, ünlü hataları, spontan ve taklit yoluyla üretim, artan hece/sözcede doğru üretim, hece vurgusu ve entonasyon özellikleri yer almaktadır. Hece vurgusu ve entonasyon, abartılı ve abartısız tekrarlar olmak üzere iki farklı şekilde değerlendirilmiştir. Bu ayırıcı özellikler, alan yazında tanı kriterlerinin taranması ve ÇÇA değerlendirmesinde kullanılan çeşitli değerlendirme araçlarının incelenmesi ile belirlenmiştir. **Bulgular:** ÇÇA'lı çocuklarla diğer gruplar arasındaki en büyük farklılığın; ünlü hataları, hece vurgusu ve entonasyon hatalarında ortaya çıktığı, bunu tutarsız üretimler ve ötümlüleştirmenin izlediği tespit edilmiştir. Hece/sözce uzadıkça artan hatalar ve izole ünsüz üretimi ÇÇA ve FB gruplarında benzer şekilde seyretmektedir. ÇÇA'lı çocukların spontan ve taklit yoluyla üretimleri arasında ise fark gözlenmemiştir. **Sonuç:** Bu araştırmanın sonucunda ünlü hataları, hece vurgusu hataları ve entonasyon hatalarının ÇÇA ve FB arasındaki ayrımı ortaya koymakta diğer sorunlara göre daha belirleyici olduğu kanısına varılmıştır. İzole ünsüz üretimi, hece/sözce uzunluğu arttıkça artan hatalar ve spontan ve taklit yoluyla üretimde hataların ise ÇÇA ve FB grubunu

birbirinden ayırmakta yetersiz kalabileceği görülmüştür. Hem hece vurgusunda hem de entonasyonda abartılı söyleme görevlerinde TGG grubunda bile zorluklar yaşanması çocukların abartılı söyleme yönergesini anlamakta zorlanmış olabileceklerini düşündürmüştür. Bu çalışma ÇÇA olan çocukların ayırıcı tanısına yardımcı olacak test maddelerini belirleyerek, ileride oluşturulacak değerlendirme araçlarına ışık tutmak üzere bir ön çalışma olarak tasarlanmıştır. Katılımcı sayısının azlığı en önemli sınırlılığıdır ve bunun nedeni de bozukluğun doğasıyla ilgilidir. Bu bozukluğun, hiç sözel çıktısı olmayan bireylerden fonolojik bozuklukla karıştırılabilecek bireylere uzanan geniş spektrumda ortaya çıkması ve tanı koymadan kaynaklanan sıkıntılar homojen bir araştırma grubu oluşturulmasını güçleştirmektedir. Karşılaştırmanın sözel çıktısı daha az olan ÇÇA'lı çocuklarla yapılması araştırılan özelliklerde daha ciddi sorunların tespit edilmesine neden olabilir.

Anahtar sözcükler: çocukluk çağı apraksisi, fonolojik bozukluk, ayırıcı tanı

Introduction

Individuals with childhood apraxia of speech (CAS) present inaccurate production of speech sounds and prosody as a result of disordered planning and/or programming of movement sequences (American Speech-Language-Hearing Association [ASHA], 2007). Although discussions about the etiology, evaluation, and differential diagnosis of CAS from other speech sound disorders continue, three main criteria for differential diagnosis stand out: Inconsistent vowel/consonant errors in repeated production of syllables or words, extended and distorted coarticulatory transitions between sounds and syllables, and affected prosody (ASHA, 2007).

A wide spectrum of symptoms has been reported in the literature. For example, Forrest (2003) asked speech and language therapists (SLTs) to write down the criteria that distinguish CAS from other disorders. A total of 50 different speech characteristics were described by the therapists regarding the diagnosis of CAS. Of these characteristics, the most frequently reported ones were inconsistent productions, general oral-motor difficulties, groping, difficulty in imitating sounds, more errors with increasing length of utterance, and difficulty in sequencing sounds. On the other hand, in a survey conducted by Teverovsky et

al. (2009), families reported that their children diagnosed with CAS might also experience difficulties in areas such as receiving and using non-verbal messages, attention, and fine motor skills.

Apart from these opinions of therapists and families, there are also certain speech characteristics reported in studies conducted directly with individuals with CAS and used in the assessment of this disorder. Examination of these characteristics reveals that the following speech errors are often claimed to distinguish CAS from phonological disorders (PD): inconsistency, voicing, isolated consonant production, vowel distortion, increasing difficulty with more complex syllable structure, differences in spontaneous and imitated production, syllable stress and intonation. These characteristics will be explained in detail in the following section.

Speech Characteristics which can Differentiate CAS from Phonological Disorders

Inconsistency in speech errors has been reported as the diagnostic criterion of CAS in many studies (Crosbie et al., 2005; Iuzzini, 2012; Stackhouse, 1992). These studies draw attention especially to inconsistencies at the segmental and lexical level. It should be noted that inconsistency is not a characteristic specific to CAS. Inconsistent errors are also frequently observed in phonological disorders, and some production diversity, which can be confused with inconsistencies, can occur in children with typical development especially between the ages of 2-3 (Holm et al., 2007). Inconsistent errors observed in children with typical development disappear at the age of 5, but inconsistent errors may persist in children with CAS and PD. These inconsistencies observed at segmental and lexical levels are more prevalent in CAS than in PD (Iuzzini, 2012). Since inconsistent productions are an important symptom of speech impairment, it is among the responsibilities of SLTs to understand the difference between production diversity, which is considered normal, and inconsistency.

Increasing difficulty with increasing utterance length has been identified as another differential diagnostic criterion. In the study conducted by Forrest (2003), SLTs reported that children who were thought to have CAS often made more errors as the utterance length increased. According to Dodd et al. (2006), both inconsistent production and more errors with increasing utterance length can be observed in CAS and inconsistent phonological disorder. Therefore, although they are not evidence for CAS alone, occurrence patterns and rates of increase in errors and inconsistencies with increasing utterance length can help in differential diagnosis.

Voicing errors and errors producing consonants and vowels in isolation have been reported in the literature as symptoms of CAS (Aziz et al., 2010; Crary et al., 1984; Davis et al., 2005; Forrest, 2003; Lewis, 2018). Crary et al. (1984) found that children with symptoms of CAS performed phonological processes such as final consonant deletion, initial consonant deletion, medial consonant deletion, syllable deletion, consonant cluster reduction, voicing, fronting, stopping, substitution of liquids and vowel errors. Maassen et al. (2003), on the other hand, reported that children diagnosed with CAS had more difficulty perceiving vowel sounds than children with typical development. In their study on three children with suspected CAS, Davis et al. (2005) reported errors in consistent production of vowels.

Among the prosodic features, syllable stress and intonation have been considered as other criteria for differential diagnosis (Munson et al., 2003; Wells & Peppe, 2003; Wells et al., 2004). Disruptions in prosody may be accompanied by difficulty in initiating an expression and transitioning between syllables, and inappropriate syllable boundaries in utterances. These characteristics have been argued to be diagnostic criteria for differential diagnosis for apraxia of speech, childhood apraxia of speech, and ataxic dysarthria (Boutsen & Christman, 2002). In a study on children with suspected CAS and those with PD, Munson et al. (2003) found that the children with CAS performed syllable stress less accurately. Wells

and Peppe (2003) examined the intonation skills of children with speech disorders and indicated that children with speech and language disorders constituted a highly heterogeneous group and that, as a result, the researchers had difficulty reaching a conclusion about the relationship between speech and language disorders and intonation difficulties. In another study, 260 SLTs were asked about the most common characteristics in childhood apraxia, and suprasegmental problems were found to be among the nine most common characteristics (Shakibayi et al., 2019).

A controversial question is whether children with suspected CAS experience impairments in auditory-perceptual encoding and/or short-term memory in addition to difficulties they experience in planning and programming (Shriberg, 2012). Furthermore, it has been shown that abnormal praxis observed in children with speech sound disorders may also affect visual-motor integration skills.

The diagnostic criteria of CAS are not limited to the speech characteristics mentioned above. There are many other diagnostic criteria, especially including groping, delayed development of expressive language, or slow diadochokinetic rate. However, the present study is limited to speech characteristics such as inconsistency, voicing, isolated consonant production, vowel distortion, increasing difficulty with more complex syllable structures, differences between spontaneous and imitated production, syllable stress and intonation. As a matter of fact, it is not possible to find all of this wide range of diagnostic criteria in a single case of CAS. Besides, there is no consensus on a minimum number or characteristic for diagnosis. This difficulty to clearly diagnose CAS has recently led researchers to substitute the term CAS with ‘suspected CAS’ (Lewis et al., 2004, Murray et al., 2015).

Given that there is much confusion in differential diagnosis of CAS and PD, investigation of the particular problems which can differentiate CAS from PD should be prioritized. In order to be able to identify potential differentiating characteristics, the present

study examines both these diagnostic criteria and the items in various tools used in CAS assessment (Dynamic Evaluation of Motor Speech Skills – DEMSS, Strand et al., 2013; Kaufman Speech Praxis Test – KSPT, Kaufman, 1995). A checklist was created based on the identified speech characteristics. This study aims to determine which of these speech characteristics are more informative for differential diagnosis and to conduct preliminary research to pave the way for a test that can be used in the diagnosis of CAS.

Method

A descriptive model was used to evaluate the diagnostic criteria that distinguish between CAS, PD and typical phonological development (TD) in children and to reveal the differences between the groups. Ethical approval was obtained from the Institutional Review Board of Istanbul Medipol University (decree no:507, number: 10840098-604.01.01-E.3144). The families of the participants in the study signed an informed consent form.

Participants

Fifteen children between the ages of 4-6, of whom 5 diagnosed with CAS, 5 with PD and 5 with TD, participated in the study. Children with any auditory, cognitive, social or psychological problems were not included in the study.

General information about the participants is given in Table 1. First of all, individuals diagnosed with CAS by speech and language therapists were evaluated in terms of participation criteria and those who met the conditions were included in the study. Later PD group whose articulatory age was approximately equivalent with CAS group (highlighted in light gray in Table 1) were recruited. Next, the TD group was formed with children whose chronological age (highlighted in dark gray in Table 1) was similar to that of the CAS group. All the participants were male.

Table 1

Participants' Chronological Ages, Articulatory Age Equivalents and Language (Receptive and Expressive) Age Equivalents

CAS			PD			TD		
	Age Equivalent			Age Equivalent			Age Equivalent	
Age	Articulation	Language Receptive-Expressive	Age	Articulation	Language Receptive-Expressive	Age	Articulation	Language Receptive-Expressive
5;8	2.4	7.2-6.2	5;11	<2.0	4.1-4.3	5;7	5.4	7.1-6.1
5;8	2.6	7.2-7.1	4;3	<2.0	3.3-4.2	5;9	>8.0	7.2-7.2
5;3	2.9	4.1-4.2	6;2	<2.0	8.1-7.1	5;0	>8.0	6.2-6.2
5;6	<2.0	5.2-4.1	4;7	<2.0	5.4-4.1	5;4	4.6	>8.1->8.1
5;6	2.0	7.1-5.3	4;11	<2.0	6.1-5.3	5;3	6.6	4.3-5.2

The participants with CAS and PD were selected from among the children who applied to MEDKOM (İstanbul Medipol University Language, Speech and Swallowing Therapy and Innovative Technologies Research and Application Center) or Günışığı Child and Family Counseling Center. The TD participants, on the other hand, were selected from various kindergartens in Istanbul.

Data Collection Tools and Procedure

Turkish Early Language Development Test (TEDİL) was administered to all the participants to assess their receptive and expressive language development (Topbaş & Güven, 2013). For the assessment of articulation, two subtests (Articulation Screening Subtest - SET, and Auditory Discrimination Subtest - İAT) of the Turkish Articulation and Phonology Test (SST; Topbaş, 2005) were employed.

Another data collection tool used in the study is the checklist developed by the authors of the present study (Appendix 1). The sections of the checklist, the tasks expected from children in each section and the diagnostic criteria tested are shown in Table 2. Please note that in some sections more than one criterion for differential diagnosis are assessed.

Table 2

Checklist Subtests, Tasks and Assessed Criteria

Speech Stimulus	Task Expected from the Child	Differential Diagnostic Criteria
Repeating syllables	The child repeats the spoken structure.	Inconsistency, voicing
Isolated consonant production	The child repeats the spoken consonant.	Isolated consonant production
Words from repeating syllables	The child repeats the spoken word.	Vowel distortion, voicing
Naming words with simple syllable structures	The child names the picture shown.	Production of sounds in simple syllable structures, voicing, vowel distortion
Imitation of words with simple syllable structures	The child repeats the spoken word.	Production of sounds in simple syllable structures, voicing, vowel distortion
Naming words with a complex syllable structure	The child names the picture shown.	Production of sounds in complex syllable structures, voicing, vowel distortion
Sentences with increasing word count	The child repeats the spoken sentences.	Inconsistency due to increasing syllable/word length, consistency
Words with an increasingly complex syllable structure	The child repeats the spoken words.	Syllable stress, increasing syllable length
Syllable stress in phrases	The researcher first produces phrases and compound nouns with normal syllable stress and then with exaggerated stress. The child is asked to imitate both instances.	Syllable stress
Intonation in sentence repetition	The researcher first produces sentences with normal syllable stress and intonation, and then with exaggerated stress and intonation. The child is asked to imitate both instances.	Intonation
Syllable stress in sentence completion	The child completes unfinished sentences.	Syllable stress

Data Analysis

Instructions for the implementation of the checklist and how to score each subsection are detailed in Appendix 1. The areas highlighted in dark gray in the tables were not assessed.

Table 3 shows how the calculations regarding speech characteristics were made based on the scores obtained from each part of the checklist. More than one speech characteristic was tested in the same item in order to obtain as much data as possible and to evaluate a particular speech characteristic in structures of different complexity.

Table 3

Description of How Frequencies or Percentages of Speech Characteristics Were Calculated as Part of The Checklist

Speech Characteristic	**Calculation of frequency/percentage**	**Levels**
Consistency	Percentage of correct articulations, compatible with the instructions, in the sections of repeating syllables and sentences with increasing number of words.	Two levels (phonemes and words)
Vowel distortion	Percentage of words with vowel errors in all the columns by the name of vowels errors.	Single level
Voicing	Percentage of the number of words with voicing errors in all the columns by the name of voicing.	Single level
Isolated consonant production	Percentage of correctly imitated sounds in the isolated consonant production section.	Single level
Spontaneous and imitated production	Percentage of correctly produced words during naming of pictured words with simple syllable structures and during imitation of simple words after the therapist.	Two levels (picture naming and imitation)
Correct production in increasing syllable/word length	Percentage of the items correctly produced in the following sections: naming words with complex syllable structure, sentences with increasing number of words, repetition of words (simple to complex syllables).	Single level
Syllable stress	Frequency of producing target syllables with correct syllable stress during production of repeating words (simple to complex), phrases and sentence completion.	Single level for words with increasingly complex syllable structure and sentence completion; two levels for phrases (exaggerated and non-exaggerated)
Intonation	Number of repeated sentences with correct intonation in the sentence repetition section.	Two levels (exaggerated and non-exaggerated)

All phonetic transcriptions were performed based on the consensus of the researcher and a speech and language therapist. These transcriptions were used to calculate the percentage of following parameters: consistency, voicing, vowels distortion, isolated consonant production, spontaneous and imitated production, correct production in increasing syllable/word length.

The syllable stress and intonation items in the checklist were evaluated perceptually by the researcher and two other speech and language therapists. Prior to this assessment, the researcher provided a short training to the speech and language therapists on syllable stress and intonation patterns in the Turkish language. Following the training, the therapists, who

were blind to the participants, did the scoring. The average scores given by the researcher and the therapists were obtained.

Since there were only five participants in each group in the study, no inferential statistical analysis was conducted. The data obtained were visualized with boxplots using the "OpenSource Statistics Software R" program (R Development Core Team, 2008). In the boxplots, the straight line inside the boxes represents the median, the upper edge of the boxes represents the 75th percentile, while the lower edge represents the 25th percentile, the tip of the vertical line represents the maximum value while the bottom of the vertical line represents the minimum value.

Results

The present study examined consistency, voicing, correct production of isolated consonants, vowel errors, spontaneous and imitated production, correct production in increasing syllable/utterance length, syllable stress and intonation characteristics. A single feature was sometimes tested multiple times within different manipulations. This section presents the findings concerning the aforementioned parameters.

Frequency of consistent production was compared at two different levels based on words and phonemes (Figure 1). The analyses of consistent production percentages based on both phonemes and words revealed that the CAS group made less consistent productions; however, inconsistent productions were also observed in the PD group. Word-level inconsistencies were more common than phoneme-level errors.

Figure 1

Phoneme-and Word-Level Consistent Correct Production Percentages of CAS, PD and TD Groups

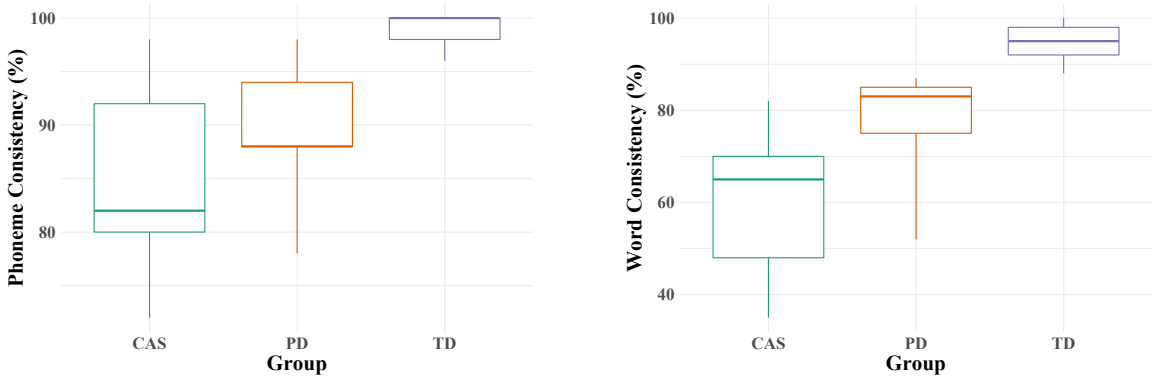


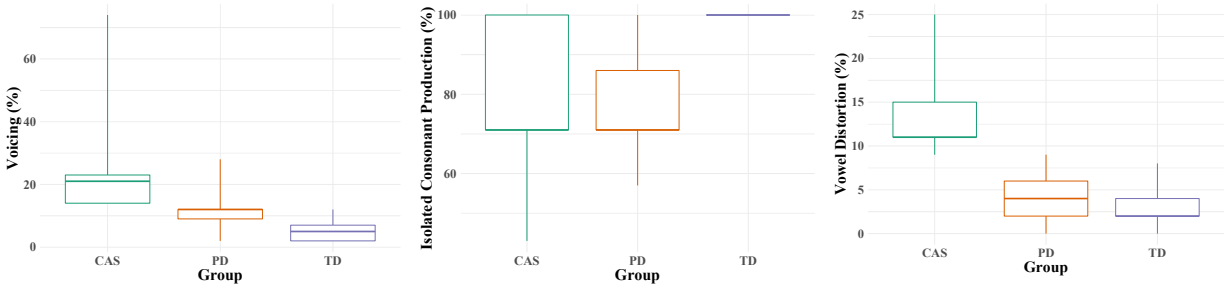
Figure 2 presents the percentages of voicing errors, correct isolated consonant production and vowel distortion. Voicing errors occurred at the rate of approximately 21% in the CAS group, 11% in the PD group and 5% in the TD group.

Isolated consonant production skills were tested by targeting the sounds /t, s, k, j, n, dʒ, p/. Accordingly, all the participants in the TD group articulated the target consonants correctly (Figure 3). On the other hand, the participants in the CAS and PD groups showed similar performance and were able to articulate approximately 70% of the target sounds correctly.

The CAS group made the highest percentage of vowel errors (11%). These errors were rarely observed in the PD (4%) and TD (2%) groups. The PD and TD groups showed a similar pattern of performance.

Figure 2

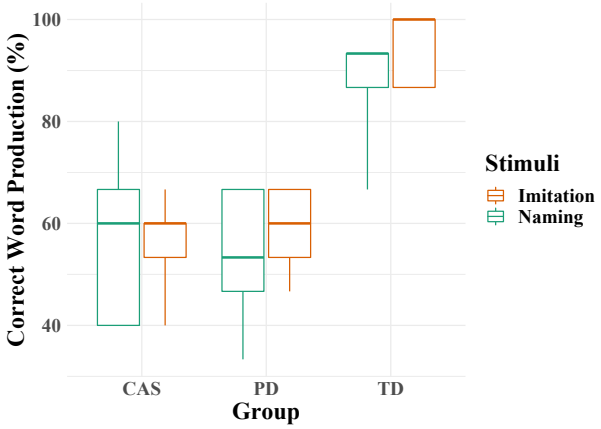
Percentages of Voicing Errors, Correct Production of Isolated Consonants and Vowel Distortion in the CAS, PD and TD Groups



It was found that the CAS group performed better in naming pictures, i.e., spontaneous production, compared to the PD group (Figure 3). However, the CAS and PD groups made errors at the same rate during the imitated production task. The CAS group exhibited a similar performance in the spontaneous and imitated production tasks. Both disorder groups performed lower than the TD group.

Figure 3

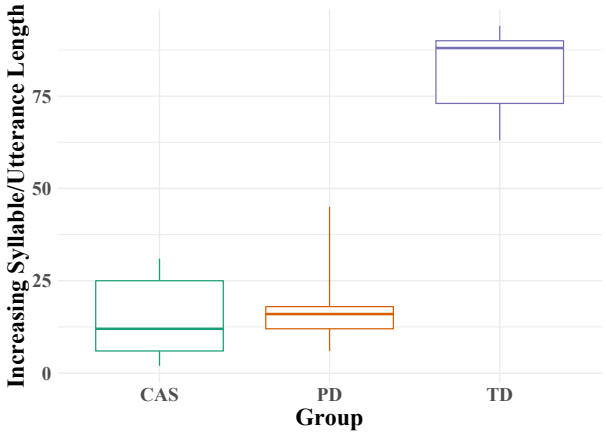
Percentages of Correct Spontaneous and Imitated Production in the CAS, PD and TD Groups



It was observed that the longer the syllable/utterance in speech stimuli, the more production errors made by the CAS and PD groups than the TD group (Figure 4). The two disorder groups had highly similar percentages of production errors.

Figure 4

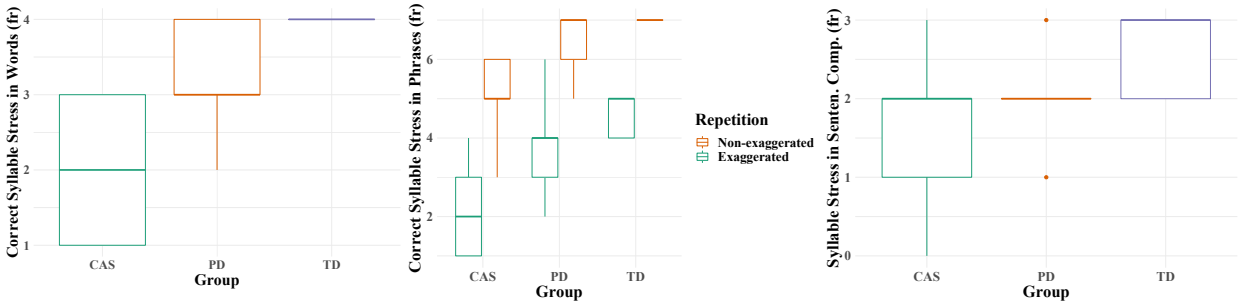
Percentages of Correct Production with Increasing Syllable/Utterance Length ın the CAS, PD and TD Groups



Syllable stress was assessed in three different ways: in single words, in phrases, and during sentence completion (Figure 5). In addition, speech stimuli in phrases and sentences were tested twice in exaggerated and non-exaggerated contexts. In the checklist, there were four items on syllable stress within words, seven items on syllable stress in phrases, and three items on sentence completion. It was observed that the CAS group had the highest percentage of syllable stress errors in all these sections. As for syllable stress in exaggerated and non-exaggerated contexts, the PD and TD groups obtained similar scores in the non-exaggerated repetition task, while the CAS group received the lowest score. In general, all the groups showed lower performance on exaggerated repetitions.

Figure 5

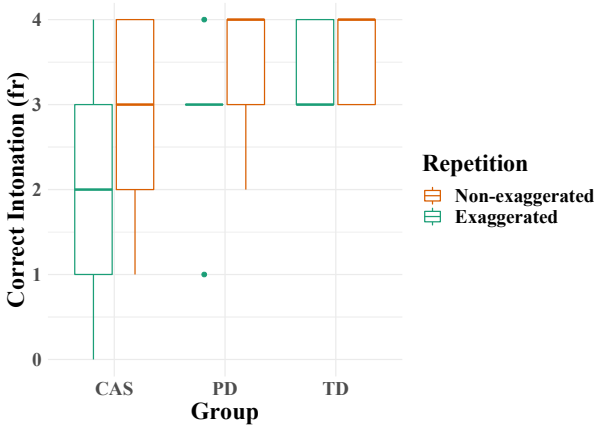
Frequencies of Correct Syllable Stress in Single Words, Phrases and Sentence Completion in the CAS, PD and TD groups



Speech stimuli were repeated twice in exaggerated and non-exaggerated contexts also in tasks where correct intonation was assessed. The intonation errors of the CAS group were more than the other groups in both repetition contexts.

Figure 6

Frequencies of Correct Intonation in the CAS, PD and TD Group



The PD and TD groups showed similar findings in the non-exaggerated repetition condition, while the CAS group showed poor performance. In addition, intonation errors were also identified in the PD and TD groups during exaggerated repetitions.

Discussion

This study aimed to determine the diagnostic criteria that distinguish CAS from phonological disorders and to conduct a preliminary investigation of an assessment tool that is in the process of development. For this purpose, a checklist was developed based on the speech characteristics reported in tests used for assessment of CAS and in other studies, including inconsistency, voicing, isolated consonant production, vowel errors, errors in spontaneous and imitated production, increasing difficulty with increasing syllable/word length, syllable stress and intonation errors. This checklist was administered to the participants in the CAS, PD and TD groups. To make a valid comparison, the CAS group was

matched with the PD group in terms of articulatory age, and with the TD group in terms of chronological age.

The CAS and PD groups made more errors than the TD group on the items where inconsistent productions were assessed. Since inconsistency was observed in both the CAS and PD groups, it does not seem to act as a differential diagnostic criterion alone. In their study on delayed speech and CAS, Iuzzini-Seigel et al. (2017) also found that in certain speech stimuli, inconsistency was ineffective in distinguishing between the groups. Evaluating the severity of inconsistency rather than determining its presence may be more useful in distinguishing between CAS and PD.

In parallel with inconsistent productions, voicing errors were also observed in PD and CAS. It is noteworthy that the frequency of voicing errors, despite not being very meaningful on its own, was higher in the CAS group, as well. Lewis (2018) listed voicing as one of the 18 most common CAS characteristics in her study. Chenausky (2020), in a study conducted with 57 participants with CAS, found voicing errors statistically insignificant.

In the production of isolated consonants, the CAS and PD groups made errors at the same rate. Aziz et al. (2010) found that children with CAS produced fewer isolated consonants than children with PD. The reason for the lack of difference between the groups in this respect in our study may be that the SET age equivalents of the CAS and PD groups were kept close to each other. However, based on the previous literature, it was predicted that children with CAS would have more difficulty when they were asked to produce these sounds by imitation; therefore, this characteristic was added to the checklist. Nevertheless, the results did not come out as expected since the children with CAS showed similar performance to those with PD in imitated production of isolated sounds. In this respect, our findings did not attribute a differential value to isolated speech sound production.

Another differential diagnostic criterion assessed in the present study was vowel errors. It was observed that the CAS group made more vowel errors compared to the other groups and that the error rates of the other groups were very low. Vowel errors can play a very deterministic role in differential diagnosis. Previous research on CAS reported that children with this disorder made distorted vowel productions and had difficulties in perceiving vowels (Davis et al., 2005; Maassen et al., 2003; Pollock & Hall, 1991).

When spontaneous and imitated productions were compared, it was observed that the CAS and PD groups performed more poorly than the TD group during both production tasks, and the error rates of both disorder groups were close to each other in the imitated production task. However, a striking finding is that the CAS group performed better than the PD group in spontaneous picture naming. Among all the speech characteristics evaluated, the only one in which the CAS group performed better than the PD group was this task. This result may stem from the fact that the speech stimuli did not contain complex syllable structures or from the limited number of participants. Whether this task would produce similar results in complex words as well should be tested with a larger number of participants.

It is stated in the literature that increasing difficulty with increasing length of utterance can be considered as a differential diagnostic criterion (Crary, 1984; Forrest, 2003). In our study, however, the error rate associated with increasing syllable/utterance length was similar in the CAS and PD groups. The fact that the CAS and PD groups consisted of children with the same SET (articulation test) age equivalent and the small number of participants may underlie this result.

Prosodic problems are considered by some researchers among the main characteristics that distinguish CAS from PD and are generally accepted by ASHA as one of the three main differential characteristics. Unfortunately, it is not easy to test this very important component, to quantify it or to include it in the assessment process. In their study with children who have

difficulties in any area of speech and language, Wells and Peppe (2003) assessed intonation in context. Although such an assessment would yield the most accurate result, it would be necessary to take hours of recordings to obtain a comprehensive result. Therefore, prosodic features do not appear to be economical to use in assessment tests. Testing prosodic features in the most economical way could be accomplished through repetition of certain words and sentences bearing the syllable stress and intonation patterns specific to that language. In this study, prosodic features were examined in terms of syllable stress and intonation. Words and phrases with stress placed on different syllables were prepared and the participants' verbal output was assessed perceptually. In parallel with Munson et al. (2003), the present study found the highest rate of syllable stress errors in the CAS group. In syllable stress and intonation tasks, the CAS group performed worse than the other groups in both exaggerated and non-exaggerated repetitions. While the PD and TD groups received similar scores in the non-exaggerated production task, the CAS group performed very poorly. Based on these findings, it was concluded that syllable stress and intonation might be a differential characteristic. The fact that even the TD group had difficulties in both syllable stress and intonation in the exaggerated production tasks suggests that the participants may have had difficulties in understanding the instructions for exaggerated production.

Designed as a preliminary investigation, this study aimed to determine the test items that will aid differential diagnosis of children with CAS, thereby laying the groundwork for assessment tools that will be created in the future. The major limitation of the study is the small number of participants included, which is related to the nature of the disorder. It is challenging to form a homogeneous research sample due to the appearance of this disorder across a wide spectrum ranging from individuals with no verbal output to individuals whose symptoms can be confused with phonological disorders and due to the present difficulties in making a diagnosis. Other limitations include the fact that all the participants were boys and

that acoustic analyses could not be performed on the items in which syllable stress and intonation were measured. In addition, only children with a certain level of verbal output were included in the CAS group in order to complete the items in the checklist. Inclusion of children with CAS having lower verbal output may have led to identification of more serious problems in the characteristics investigated.

As a result of this research, it was found that vowel errors, syllable stress and intonation errors could play a central role in differential diagnosis, and that the rate of inconsistency and voicing errors could be instrumental in distinguishing between CAS and PD. Production of isolated consonants, increasing difficulty with increasing syllable/utterance length, and errors in spontaneous and imitated production were found to be inadequate to distinguish between CAS and PD.

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Appendix

Appendix-1: Checklist for the Assessment of Chilhood Apraxia of Speech

CHECKLIST FOR THE ASSESSMENT OF CHILDHOOD APRAXIA OF SPEECH

Beril POLAT & Özlem ÜNAL LOGACEV

Personal Information

Name Surname:
Gender:
Diagnosis:

Date of Test:
Date of Birth:
Chronological Age:

Repeating Syllables (Non-words)

Please take a deep breath and keep repeating the following syllables until you run out of breath.

	CONSISTENCY	VOICING
papapa		
tatata		
kakaka		
patapata		
takataka		
TOTAL		

Isolated Consonant Production

Please repeat the sounds I will say after me.

/t/	
/s/	
/k/	
/j/	
/n/	
/d͡ʒ/	
/p/	
TOTAL	

Words from Repeating Syllables

Please repeat the words I say after me.

	VOICING	VOWEL ERRORS
mama		
cici		
dede		
baba		
pepe		
TOPLAM		

Naming Simple Words

Please look at the pictures and tell me what they are.

TARGET WORD	IPA	VOICING	VOWEL ERRORS
su			
dağ			
at			
ev			
üç			
ok			
kek			
mum			
kel			
fil			
sus			
muz			
şişe			
lale			
nine			
TOTAL			

Imitating Simple Words

Please repeat the words I say after me.

TARGET WORD	IPA	VOICING	VOWEL ERRORS
bu			
çiğ			
ye			
al			
iç			
öp			
ot			
tut			
sos			
baş			
tır			
çek			
nane			
koku			
şaşı			
TOTAL			

Naming Complex Words

Please look at the pictures and tell me what they are.

HEDEF SÖZCÜK	IPA	INCREASING SYLLABLE LENGTH	VOICING	VOWEL ERRORS
fare				
tabak				
atkı				
ilaç				
dolap				
köprü				
üçgen				
balık				
çiçek				
şapka				
kestane				
kelebek				
telefon				
patates				
gergedan				
otobüs				
ayakkabı				
bilgisayar				
TOTAL				

Sentences with Increasing Number of Words

Please repeat after me …

	INCREASING WORD LENGTH	CONSISTENCY
/s/ sil selim sil selim silgiyle sil selim sayfayı silgiyle sil		
/m/ maymun maymun yedi maymun muz yedi maymun masada muz yedi		
/p/ patladı top patladı pis top patladı pis top pat diye patladı		
/d/ yedi dede yedi dede domates yedi dede bir dilim domates yedi		
/t͡ʃ/ çaktı çivi çaktı çekiçle çivi çaktı çekiçle üç çivi çaktı		
TOTAL		

Repeating Words (Simple Syllables Through Complex Syllables)

Please repeat after me …

	SYLLABLE STRESS	INCREASING SYLLABLE LENGTH
kitap kitaplar kitaplarım kitaplarımda		
kal kale kalem kalemtıraş		
al alt altı altın altında		
TOTAL		

Phrases

Instruction for non-exaggerated repetitions: Please repeat after me …
Instruction for exaggerated repetitions: Now say it like this …

		SYLLABLE STRESS
çay bardağı	NON-EXAG.	
	EXAG.	
buzdolabı	NON-EXAG.	
	EXAG.	
boya kalemi	NON-EXAG.	
	EXAG.	
sulu boya	NON-EXAG.	
	EXAG.	
okul çantası	NON-EXAG.	
	EXAG.	
benim şekerim	NON-EXAG.	
	EXAG.	
öğretmenin kalemi	NON-EXAG.	
	EXAG.	
TOTAL NON-EXAGGERATED		
TOTAL EXAGGERATED		

Repetition of Sentences

Instruction for non-exaggerated repetitions: Please repeat after me …
Instruction for exaggerated repetitions: Now say it like this …

		INTONATION
Annen geldi mi?	NON-EXAG.	
	EXAG.	
İstanbul'da oturuyorlar.	NON-EXAG.	
	EXAG.	
Odamı hep toplarım.	NON-EXAG.	
	EXAG.	
Hayvanların en vahşisi aslandır.	NON-EXAG.	
	EXAG.	
TOTAL NON-EXAGGERATED		
TOTAL EXAGGERATED		

Sentence Completion

Please complete the sentences that I say.

	SYLLABLE STRESS
Kız şeker seviyor. Ama kız ıspanak…	
Bu çocuk okula gidiyor. Ama bu çocuk hasta okula…	
Kız oyun oynamak istiyor. Ama ders çalışmak…	
TOTAL	