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Characteristics of Childhood Apraxia of Speech Among Jordanian Children Arabic Speaking

خصائص تعذر الأداء الكلامي- الأبراكسيا للأطفال الناطقين بالعربية الأردنية

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Abstract:

Background: Childhood apraxia of speech (CAS) is a motor-based deficit primarily in the structural representation of verbal output that is estimated to occur in 1 to 2 children per 1,000.

Difficulties in diagnosing CAS emerged from the common features that it shares with other speech sound disorders. Purpose: To investigate the diagnostic features of speech errors of childhood apraxia among Jordanian Arabic-speaking children to highlight the nature of speech disorder and its relation to general phonological disorders. Methods: Twelve children with apraxia (4 -11 years old) were recruited. A list of 25 Arabic words that differ in length was created to test the participants' speech skills. Testing, recording, transcribing was conducted over three weeks by well-trained speech pathologists. Results: All the words were positive for inconsistency among all participants, a positive very strong correlation ($r=.848$, $p<0.0001$) was revealed between the length of stimuli and the word inconsistency, the word production accuracy of the participants was poor and below the average. Idiosyncratic processes were the most observed errors. Demonstrate inconsistent phonological errors, inconsistent word production, and poor accuracy of production highly correspondent with stimuli length. That contributes to guide clinicians when assessing any speech disorders. Future research is recommended to get a privileged insight into this phenomenon based on the analysis of diakinetic and motor characteristics besides the correct consonants and vowel productions.

Keywords: Arabic-Speaking, Childhood Apraxia, Diagnostic Features, Phonological Disorder, Speech Sounds Disorders.

الملخص:

برزت صعوبات تشخيص تعذّر الأداء الكلامي في مرحلة الطفولة (CAS) نتيجة للخصائص المشتركة التي يتقاسمها مع اضطرابات أصوات الكلام الأخرى. الهدف: هدفت الدراسة إلى استقصاء الخصائص التشخيصية لأخطاء الكلام لدى الأطفال الذين يعانون من تعذّر الأداء الكلامي في مرحلة الطفولة من الناطقين بالعربية الأردنية، بهدف تسليط الضوء على طبيعة اضطراب الكلام وعلاقته بالاضطرابات الفونولوجية العامة. المنهجية: شارك في الدراسة اثنا عشر طفلًا يعانون من تعذّر الأداء الكلامي، تراوحت أعمارهم بين 4 و11 سنة. وأُعدّت قائمة مكوّنة من 25 كلمة عربية تختلف في طولها لاختبار المهارات الكلامية لدى المشاركين. وقد أُجريت عملية الاختبار والتسجيل والتفريغ الصوتي على مدى ثلاثة أسابيع من قِبل اختصاصيي نطق ولغة مدرَّبين تدريبًا جيدًا. النتائج: أظهرت جميع الكلمات عدم اتساق في الإنتاج لدى جميع المشاركين، كما كُشف عن وجود ارتباط قوي جدًا وموجب ($r = .848$، $p < 0.0001$) بين طول المثيرات وعدم اتساق إنتاج الكلمات. وكانت دقة إنتاج الكلمات لدى المشاركين ضعيفة وأقل من المتوسط. وكانت العمليات الفونولوجية الفردية أو غير النمطية أكثر الأخطاء ملاحظة. وأظهرت النتائج وجود أخطاء فونولوجية غير متسقة، وإنتاج غير متسق للكلمات، وضعف في دقة الإنتاج، مع ارتباط وثيق بطول المثيرات. ويسهم ذلك في توجيه الاختصاصيين عند تقييم اضطرابات الكلام المختلفة. ويوصى بإجراء المزيد من البحوث للحصول على فهم أعمق لهذه الظاهرة، استنادًا إلى تحليل الخصائص الحركية والتتابعية الحركية للكلام، إلى جانب دراسة الإنتاج الصحيح للأصوات الساكنة والصوائت.

الكلمات المفتاحية : الناطقون بالعربية، تعذّر الأداء الكلامي في مرحلة الطفولة، الخصائص التشخيصية، الاضطراب الفونولوجي، اضطرابات أصوات الكلام.

Introduction

Expressive language and speech development is one of the major domains of development that can be affected due to Childhood Developmental Disorders (CDD) (Johnson, 2017). CDD, including speech sound disorders (SSD), are the most common and prominent reasons for pediatric referrals to speech-language pathologists, representing near 70 % of the caseloads (Dodd, 2014). Children with

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comprehension and expression disorders are most likely to be referred to speech-language pathologists by 36 months of age (Norbury et al., 2017).

Childhood apraxia of speech (CAS) is a CDD that affects speech intelligibility and causes a communicative disability. CAS is recognized as a pediatric neurological speech sound disorder in which the precision and consistency of movements underlying speech are impaired in the absence of neuromuscular deficits (e.g. abnormal reflexes, abnormal tone) or referred to idiopathic presentations (American Speech-Language-Hearing Association [ASHA], n.d.a; Zehnhoff-Dinnesen, Wiskirska-Woźnica Bożena, Neumann, & Nawka, 2020). CAS is defined as a motor-based deficit primarily in the structural representation of verbal output (Björelius & Tükel, 2017). CAS was estimated to occur in 1 to 2 children per 1,000 (0.1%–0.2%) (ASHA, n.d.a). The prevalence estimate for CAS in children recruited in 2019 for idiopathic SD was 2.4% (Shriberg, Kwiatkowski, & Mabie, 2019), 73.3% mild, 20.0 % mild-moderate, 6.7% moderate-severe (Shriberg, Strand, Jakielski, & Mabie, 2019). Malmenholt et al. (2016) reported a prevalence rate that ranges from 0.125% based on clinical referral data, to 4.3% estimates of children with suspected CAS. This size of the range demonstrates the difficulty of the diagnosing of CAS. CAS diagnosis has been difficult because it shares many features with other speech sound disorders SSD and expressive communication disorders (Murray, McCabe, Heard, & Ballard, 2015).

A variety of terms have been used to identify children exhibiting characteristics of CAS,including articulatory apraxia, developmental articulatory dyspraxia, childhood verbal apraxia, developmental apraxia of speech, and developmental verbal dyspraxia (ASHA, n.d.a; Malmenholt, Lohmander, & McAllister, 2016)

Many of the speech errors and other behavioral features thought to be associated with CAS were even found in children with more broadly defined speech sound disorders. Errors in speech sound production and prosody that appear in CAS cases primarily occur due to the impairment in planning and/or programming of the spatial and temporal parameters of sequenced movements (e.g. praxis of the lips, jaw, tongue, and vocal folds) (ASHA, n.d.a; Björelius & Tükel, 2017). The ASHA identify six major behavioral domains in association with CAS: non-speech motor, speech production, prosody, speech perception, language, and metalinguistic literacy (ASHA, n.d.a). Lists of proposed speech behaviors, including slow development of speech, reduced phonemic inventories, multiple speech sound errors, and unintelligibility, were used to characterize CAS (ASHA, 2007). On the other hand, Malmenholt et al. (2016) reported seven speech characteristics for CAS; inconsistent speech production, sequencing difficulties, oro-motor deficits, vowel errors, voicing errors, consonant clusters deletion, and prosodic disturbance in descending order.

The commonly proposed characteristics that are unfamiliar in children with speech sound disorders other than apraxia include vowel errors, inconsistency of errors, increased errors in complex syllable and word shapes (especially omissions, particularly in word-initial position), groping, unusual errors, frequent regression, or loss of words, differences in performance of automatic (overlearned) versus volitional (spontaneous or elicited) activities that don’t fit the overall pattern of CAS (Iuzzini & Forrest’s, 2010; Malmenholt et al., 2016; van der Merwe & Steyn, 2018). Concurrent deficits in articulation, receptive and expressive language, suprasegmental, verbal/non-verbal oral-motor functioning, neurological development, and motor skills have been included in descriptions of the CAS disorder (Björelius & Tükel, 2017).

The diagnostic process of developmental SSD sits as a clinical problem due to some challenges such as the size of the category, contrastive symptomatology, limited relevant investigation, and weak long-

term outcomes (Dodd, 2014). ASHA (n.d.a) stated that the diagnostic challenge is to differentiate CAS from speech delay, dysarthria, and other speech sound disorders. Moreover, evaluating CAS, especially at early stages between two to five years old, is confusing for speech-language pathologists (SLPs) due to the common symptoms, shared characteristics among CAS, and other speech impairments including autism spectrum disorder (Chenausky et al., 2020).

Over the past two decades, there has been a significant increase in research that identifies potential diagnostic markers of CAS to differentiate it from the other articulation disorders (Allison, Cordella, Iuzzini-Seigel, & Green, 2020; Iuzzini-Seigel, Murray, 2017b). Despite the efforts, the criteria, that have been found in previous studies, were employed frequently and appear insufficient to differentiate CAS from other SSDs (Dodd, 2014; Murray, Iuzzini-Seigel, Maas, Terband, & Ballard, 2021).

The relations between phonological awareness, phonological representation, and speech skills prompted scholars to hypothesize that speech and language characteristics in CAS result from an impairment to selection and retrieval in the phonological representation system (Galluzzi, Bureca, Guariglia, & Romani, 2015; Terband et al., 2019). In contrast to speech delay, the characteristics of CAS are likely to continue beyond the developmental span (ASHA, n.d.a). Diagnosis of CAS was conducted in clinical studies either by observation for behavioral markers or by using standardized diagnostic tests (Sayahi & Jalaie, 2016; Strand, Duffy, Clark, & Josephs, 2014). The differential diagnosis relies on perceptually based feature lists that lack the functional definitions of each feature and context of these features, as well as a lack of assessment tool (Murray et al., 2021; Sayahi & Jalaie, 2016). There are six published standardized tests of CAS (i.e. Screening Test for Developmental Apraxia of Speech (STDAS), Kaufman Speech Praxis Test for Children (KSPT), Verbal Motor Production Assessment for Children (VMPAC), the Apraxia Profile (AP), the Oral Speech Mechanism Screening Examination (OSMSE), and the Verbal Dyspraxia Profile (VDP) which were used more than behavioral markers (Sayahi & Jalaie, 2016).

According to Murray et al. (2021), the diagnostic characteristics, subject selection criteria, theoretical constructs, and diagnostic protocols for differential diagnosis vary across previous studies related to CAS. However, none of the tools described in the literature met the criteria to be recommended for clinical use (Malmenholt et al., 2016). For an instance, VMPAC failed to meet six of the eight criteria. The most recent tool was Dynamic Evaluation of Motor Speech Skill (DEMSS; Strand & McCauley, 2019), which was recommended by Gubiani et al. (2015) for adaptation as it has a defined protocol and known reliability and validity. Strand et al. (2014) suggested a way to reduce errors in perceptual judgments that is to identify the consistent characteristics with the diagnostic label and quantify the presence and severity of it. Malmenholt et al. (2016) recommended applying a cluster of diagnostic markers to identify CAS as well as Duchow et al. (2019) who define four clusters to assess CAS and developmental coordination disorder (DCD).

One of the important studies for CAS, Iuzzini-Seigel et al. (2017a) who investigated the core feature of CAS and the differential diagnostic marker between CAS and speech delay. The study recruited 48 children (4;7 - 17;8 years) with CAS, CAS + language impairment, speech delay, language impairment, and typically-developed children (TD). The result was that speech inconsistency was the core feature of CAS and the effective diagnostic marker with speech delay. Overby et al. (2019) examined the speech-language skills of 17 children (3;5–8;8 years) with CAS, SSD, TD using home videos from birth to 2 years of age to analyze the consonant emergence and syllabic structure. The study revealed that children with CAS were the lowest group regarding the observed speech skills, such as fewer resonant consonants and diverse phonetic repertoire.

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Shakibayi et al. (2019) conducted a survey study to underline the speech characteristics and co-occurring problems of CAS based on the Iranian SLPs' knowledge and experience. The most indicated markers were inconsistency, consonant sequencing problems, low intelligibility, groping, and slow diadochokinetic (DDK). While in French, Meloni et al. (2020) studied the differential markers between CAS and phonological disorder (PD) among French-speaking children (5;10–9;2 years) and concluded that French-speaking children with CAS exhibited the same speech errors similar to English-speaking children with CAS except producing intrusive schwas or vowels.

On the other hand, several Arabic studies targeted CAS in different aspects (Abdou, Afsah, Baz, & Abou-Elsaad, 2020; Alkheraiji and Rutter, 2017; Shaalan, 2017; Shahin et al., 2015; Yagoub, 2020) that were considered quite limited. Few Arabic studies have focused on CAS in Arabic regarding its core features, however, only one example was found in the literature, Aziz et al. (2010) explored the language, speech, and oro-motor differences in order to investigate the possible diagnostic markers between CAS and multiple PDs among 30 pre-school Egyptian Arabic-speaking children (4-6 years). The study revealed a number of distinguishing diagnostic markers between CAS and multiple PDs, such as difficulty in prosodic features, consonant cluster productions, and difficulty in processing syllabic information. Therefore, highlighting the study of CAS characteristics in Arabic and the ability to use these features as a diagnostic criterion can avoid the overlap between severe phonological disorder and apraxia of speech which might be presented through the current study.

Purpose of the study

The current study attempts to explore CAS among Jordanian Arabic-speaking children in order to investigate the core characteristics of the speech production and speech errors associated with CAS in this population. Furthermore, the study attempts to find the pattern of speech errors in Jordanian Arabic-speaking children with CAS.

Method

This study uses a longitudinal design that incorporates quantitative research methodologies. This study was approved by the ethics committee for scientific research (ECSR) at Zarqa University (ECSR #2/3/2021), and was conducted at Amman center for speech, language and swallowing.

Participants

Twelve children with suspected CAS participated in the study (8 males, 4 females) with the age range of (4-11) years old, with a mean age of (6.33±1.875) years. Six participants were previously diagnosed with CAS, and six were suspected of having CAS. Further, six of the participants had a history of treatment for CAS, the mean of the previous therapy period was (9.58±9.501) months, while the other six participants had no or beginning therapy. The participants were selected based on referrals from speech therapists, parents' complaints, and clinical screening. The exclusion criteria were any speech deficits due to organic causes (i.e. hypernasality, oral-motor disorder, and hearing impairment) and/or neural developmental disorders, such as autism, mental retardation, or dysarthria. All participants completed a usual comprehensive assessment including history, oral-motor examination, judgment of intelligibility, observation, and documentation of speech sample, communication, and cognition. Sixteen of the participants were considered to have CAS based on the following criteria: (a) unintelligibility of speech with an inability to imitate pure vowels:/a:/, /u:/, /i:/, vowel to vowel movement in diphthong production, (b) limited or impaired phonemic repertoire and inability to

produce simple isolated consonants, (c) inability to produce reduplicated syllables with normal coordination, and (d) prosodic disturbances. Four of the participants who showed development with the phonemic inventory and progress in imitating a list of words with consistent speech errors were excluded. The demographic information of the participants is summarized in Table 1.

The medical history of the participants was confirmed by the parents and the consent forms were collected from the parents before the beginning of the study.

Materials and Procedures

Since there are no reliable tests of CAS, examination of CAS features with a single-word picture elicitation was conducted by the use of a customized list of 25 words that contain 495 syllables. The list was carefully designed to contain stimuli of familiar Arabic sounds that vary in length in syllabic complexity (e.g. CVC, CVCVC). In Arabic, only three shapes of syllables were detected: consonant-vowel (CV), CVC, and CVCC that frequently altered to easier production; CVCVC (i.e. /bint/→ [bi.nit]), another shape often produced by reduction of short vowels is CCV(C) (i.e. /ħiba: l/→ [hba: l]) (Amayreh & Dyson, 2000). The list included 5 monosyllabic items, 11 disyllabic items, and 9 bolysyllabic items and a form was created for each child to record the responses. The included Arabic vowels and consonants were shown with their frequency of occurrence in figure 1.

Ten TD Arabic children with an age range of (4-7 years) and who acquired the consonants with 100% articulation accuracy were exposed to the words with pictures in order to test TD children's responses to the selected words and pictures. In which, the least frequent errors were fronting, final consonant deletion, consonant sequence reduction, initial voicing, final devoicing, and stopping (Amayreh & Dyson, 2000).

Procedures

Testing was conducted over three weeks; each word in the list was tested nine times along three weeks through different sessions (3 sessions/week); sessions were 20 min each. Sessions were led by speech pathologists who were trained as research assistants.

First, stimuli were presented three times by SLP followed by a real object picture presentation and using syllabification or exaggerated intonation. Second, children were asked explicitly to produce the word or name the picture. Third, the trained therapist recorded the speech production. Each child's utterance was audio-recorded, and transcribed by three independent, well-trained, and licensed speech pathologists. The responses were analyzed using international phonetic transcription and based on phonological processing disorders that were extracted from Peña-Brooks and Hegde's (2015). Table 2 shows the assessment list of words.

*Accuracy of productions*3 The children's accuracy of productions was measured regarding the accuracy of speech sound production within the whole word based on the adult-like realization of consonants. Each correct or adult-like production was assigned a score of 1 and incorrect productions, e.g. typical phonological processes, substitutions, omissions, etc., were assigned a score of 0. The percentage of the accuracy of syllable number production was measured for each word and each participant using the following calculation: (Σ (number of produced syllables across all sessions)/Σ (total number of targeted syllables production across sessions)) *100.

Word inconsistency

Inconsistency was measured at the word level and was determined using the following calculation: (Σ (number of different productions for each word across all trials)/Σ (total number of target trials)) *100. Inconsistency percentages of 11.1% or higher were considered positive for inconsistency. The production should vary with at least one phoneme level (consonant or vowel) to consider an inconsistent production.

For example, a child produced a list of 25 words 3 times per week with a total of 225 trials. When a child produced 102 different production of 225 targeted production, (e.g. for /ka:sih/ that mean "glass", the child said /ta:tih/, /ta:/, and /ta:tis/). This child's Word inconsistency percent would be 45.3%, calculated as (102/225) × 100.

Complexity level of the length of stimuli

The complexity level of the length of stimuli was explored regarding the participant's ability to produce the correct number of syllables and comparing multisyllabic with monosyllabic words that range from one to four syllables for example; /ba:b/= door is one syllable, /ka:sih/= glass is two syllables, /saj.ja:rɑ/= car is three syllables, and /bur.tu.qɑ:li:/=orange is four syllables.

Data analysis

Statistical analysis was performed using SPSS Version 26.0 (2019, IBM Corporation New York). Descriptive statistical analysis was employed to report on the occurrence of variables. The ANOVA test was conducted to detect group differences for age, therapy period, word and syllable accuracy of production, inconsistency of production, length of stimuli, and phonological processes. Tukey Post hoc test was utilized to identify subgroup comparisons that caused significant differences. The significance level was set to be less than 0.05 ($p < 0.05$).

The Pearson r coefficient test was conducted to explore the relationship between the percentage of word and syllable accuracy of production, word inconsistency, and the percentage of phonological processes among all participants. A value of 0.1–0.19 was considered a very weak correlation, a value of 0.2-0.39 weak, a value of 0.4–0.59 a moderate one, a value of 0.6–0.79 strong, and a value of 0.8-1.0 very strong (Mukaka, 2012).

Results

The participants produced a total of 218 phonological processes, which include 47.7% idiosyncratic processes, 33.9% syllable structure (final consonant deletion, reduplication, unstressed syllable deletion, initial consonant deletion, and epenthesis), 13.3% substitution (stopping, fronting, and baking), and 5.1% assimilation in descending order which illustrated in figure 2.

Accuracy of productions

The results showed that the word production accuracy of the participants was poor and below the average (mean=18.74% ±68.05). However, it was found that the percentage of adult-like production measured by words was the highest in the first five words (43%, /ba:b/=door;

55%, /beɪt/=home; 45%, /bo:t/=shoes; 47%, /lo:z/=almond; and 52%, /mo:z/=banana). The syllable number accuracy percentage was considered high (mean=85.15%±14.05). The percentages of syllable number accuracy of the first five words were 100%, while the word (/mu.kaʔ.ʕa.ba:t/= blocks) was the

lowest percentage (51.85%). The percentage of the adult-like production and syllables number measured by participants is summarized in table 3.

Word inconsistency

According to the number of different productions of the word (mean=50.52±17.8), it was found that all the words were positive for inconsistency among all participants (min=36%, max=58.2%; >11.1%). Where the five highest percentages were (85.9%) /xud.rɑ.wa:.t/= vegetables, (72.2%) /qi.tɑ:r/=train, (68.5%) /ʁas.sa:.le/= washing machine, (64.9%) /xa.za:.ne/= closet, and (64.9%) /bur.tu.qɑ:.li:/=orange. While the lowest five percentages were (16.7%) /beɪt/=home, (18.5%) /ba:b/=door, (18.5%) /bo:t/=shoes, (27.8%) /mo:z/=banana, and (29.7%) /lo:z/=almond.

length of stimuli

Our word list included words 5 monosyllabic, 11 bisyllabic, and 9 multisyllabic words. The mean percentages of word length subgroups based on the correct number of syllables production were (100%) monosyllabic, (91.6%) bisyllabic, and (68.9%) multisyllabic, whereas the mean percentages of word length subgroups based on the different number of word production were (64.8%) multisyllabic, (51.7%) bisyllabic, and (22.22%) monosyllabic. The findings represented a significant difference between the monosyllabic and bisyllabic words and the correct number of syllables produced (0.045*, p<0.05*), and a significant difference between the multisyllabic and bisyllabic words and the number of different productions of the word (0.009, *p<0.05).

Correlation Results

The Pearson r test revealed a significant positive moderate correlation (r =0.468, *p<0.0001*) between the percentage of syllable production and the percent of adult-like production, a significant positive moderate correlation (r = 0.478, *p<0.0001*) between the previous therapy period and the percentage of adult-like production, a significant positive weak correlation (r = 0.232, *p<0.0001*) between the age and the percentage of adult-like production, a significant negative moderate correlation (r = -0.494, *p<0.0001*) between the percentage of different word production and the percentage of adult-like production, a significant negative very weak correlation (r = -0.160, *p<.0001*) between word inconsistency and previous therapy period, and a significant positive very weak correlation (r = 0.179, *p<0.0001*) between word inconsistency and age. A positive very strong correlation (r=0.848, *p<0.0001*) was found between the length of stimuli and the word inconsistency, and a negative very strong correlation (r=-0.875*, p<0.0001*) between the length of stimuli and the correct number of syllables. The correlation between the word inconsistency and the correct number of syllables was negative strong (r=-0.759, *p<0.0001*). There was a significant difference between idiosyncratic processes and the adult-like production (0.027*, p<0.05*) with a negative very strong correlation (r=-0.864, *p<0.0001*).

Discussion

Throughout the study of CAS, there were limited observations that enabled the researchers to draw a clear picture about rare speech disorders in Arabic and to have the diagnostic tool related to the speech features in the Arabic population. In general, this study aimed to explore CAS features among Arabic children and the results demonstrated a number ofresults that contrast with previous findings in the literature. One finding revealed that there was no clear differentiation between CAS and other SSD. However, inconsistent phonological processes were observed. The idiosyncratic processes were the most observed followed by the syllable structure processes, while the substitution and assimilation were the least frequent. This

result conflicts with Aziz et al. (2010) who found that the most frequent error types were omissions (50.4%) and substitutions (32.1%). However, both results agreed that final consonant deletion occurred more often and that initial consonant deletion was infrequent. On the contrary with PD participants who exhibited substitutions (37.2%) more than omissions (18.6%) and were more obvious. However, our findings match those of Duchow et al. (2019) who investigate the co-occurrence of CAS and DCD. They found that the common characteristics regarding phonological planning were higher (mean=63.96%) than other signs of motor programming, planning, and prosodic impairment (35.5%, 53.3%, and 13.7% respectively). That may reflect the hypothesis that there is no steady production of phonological processes combined with common idiosyncratic processes, as a common speech characteristic for CAS, and that can support the difference between PD and CAS in both English and Arabic languages (Malmenholt et al., 2016; Murray et al., 2021; Terband et al., 2019).

Accuracy of productions

The results of the accuracy of word production and the accuracy of production of syllables number were high with monosyllabic words but lower for multisyllabic words. This is consistent with studies that highlighted low intelligibility as a differential diagnostic for CAS on English and on Iranian (Shakibayi, Zarifian, & Zanjari, 2019; Meloni, Schott-Brua, Vilain, Lœvenbruck, Consortium, & MacLeod, 2020). In Shalan's (2010) study that included 22 children with the age range of 5-9 years, the accuracy production decreased as the number of syllables increased. Alkheraiji and Rutter (2017) agreed with lowest accuracy occurring in multisyllabic words but not disyllabic words which were found to be the most accurate. Azizi et al. (2010) found that the accuracy of producing Arabic consonants and vowels was significantly lower in children suspected with CAS than children with PD within all contexts (isolation, word, and connected speech): the syllable number accuracy scores for CAS subjects were 92.2% for monosyllabic words, 68.3% for disyllabic words, and 45.8% for multisyllabic words; for PD subjects the syllable number accuracy rates were 100% for monosyllabic words, 93.3% for disyllabic words, and 77% for multisyllabic words.

Word inconsistency

The present results exhibited a high percentage of word inconsistency production significantly at the level of multisyllabic words while the most consistent production was at the level of monosyllabic words among all participants. Most of the utterances were unpredictable productions and were pronounced differently each time. For example, the child's utterances for the word /xud.rɑ.wa:.t/ "vegetables", were [ta:ti],[ʔal], [ba:t], [ʔa.ki:ka], [ʕudu.wa], [Xa.da:t].

Despite the difference between the target production and the children's repetitions, it is sometimes possible to expect the pattern of the target word to understand the intended meaning such as [Xa.da:t] which may be near to some extent from the target word.

That supports the proposal that the core feature of CAS is inconsistency which is sensitive to the stimuli, presented by Meloni et al. (2020) and Iuzzini-Seigel et al. (2017a, 2019) who found a mean rate of 60 % inconsistency for children with CAS in multisyllabic words. The result is also in line with that of Shakibayi et al. (2019) found that inconsistent production was the most detected feature for CAS (86.9%) among Iranian SLPs. On the other hand, Murray et al. (2015) estimates that inconsistency is 30% accurate as a predictor of CAS, a lower figure than other predictors.

Furthermore, age and word inconsistency correlations were noted to be weak in contrast with Alkheraiji and Rutter (2017) who reported the positive correlation due to the developmental effect, as the word consistency decreased in the youngest Arabic children and increased in older children. It might be related to the small number of participants, type of speech tasks, and targeted stimuli which may demonstrate dialect and culture differences. Speech inconsistency was evidenced across all ranges of stimuli tested; thus, it can contribute to the differential diagnosis of CAS from other SSD.

Length of stimuli

The simplest type of a syllable is CV, and we assume that any addition of segments amounts to increase in complexity. It was observed that at the level of monosyllabic words there were no vowel substitutions or common idiosyncratic processes. Moreover, at the level of bisyllabic words, each participant showed many different phonological errors such as syllable reduplication (i.e. [ka:ka],[ta:ta] for /ka:sih/ which means glass), assimilation (i.e. [ka:ke] for /ka:se/), velar assimilation (i.e. [ʔu.nun] for /ʔu.ðun/), and devoicing. The most variation of phonological errors was observed at the level of multisyllabic words, (i.e. / mu.kaʔ.ʔa.ba:.t/ "cubes", became [mo:ba], [mu:ti],[baka:ta:t],[ʔa:je] and[ka:t]). This result is represented by the positive very strong correlation found between the length of stimuli and the inconsistency, which might be explained by the effect of complexity as increasing the number of syllables that usually contain more and different phonological elements than shorter words. On the other hand, the negative very strong correlation was found with the correct number of syllables decreased when the word length increased. An agreement was found with Shakibayi et al.'s (2019) study that reported errors in polysyllabic words as a feature for CAS (62.7%) which is also consistent with Meloni et al. (2020) and Iuzzini-Seigel (2019) results regarding the increase of difficulty with multisyllabic words. Further, Shalan (2010) suggested the similarity between Arabic-speaking children and English-speaking children regarding the effect of word length on repetition tasks, in accordance with ASHA (2007) report that speech errors are more frequent when speech demands increased. Alkheraiji and Rutter's (2017) findings represented a different point of view, the study supports the ease, accuracy, and consistency of bisyllabic words more than other lengths of words, neither longer nor shorter. However, it agreed with the variation of consistency at the level of multisyllabic words.

Surprisingly, age had no effect either on word inconsistency or the percentage of adult-like production, and the length of therapy period had no effect on word inconsistency but it did on the adult-like production. This is contrary to the result of Alkheraiji and Rutter (2017) who found that age had a significant effect on children's performance. In addition, Iuzzini & Forrest's (2010) study that reported decrease in word inconsistency for children with CAS following speech therapy and the features of CAS to become more like to a PD. Although correlations with age and period of therapy were generally weak, it is interesting that part of it was negative, and may reach significance on further study or when increasing the sample. Other findings were that the more different productions of a word, the less adult-like production and number of correct syllables, while the more correct syllable production, the more adult-like production. That might be logical in the case of CAS which was supported by current analysis and may need further investigation with a wider sample range.

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Limitations

The current study cannot be generalized beyond the selected sample. The generalization of results is restricted to the stimuli list composed of limited 25 Arabic familiar words that did not include other levels of motor programming for non-word repetition, and the utterances were taken by imitation. Focusing on the speech characteristics rather than the other behaviors of CAS is recommended. **Conclusion**

This study is one of the rare Arabic studies relating to CAS and the first to be done among Jordanian Arabic-speaking children. The study summarizes the common speech skills produced, therefore, contribute to improving diagnosis and early detection of CAS in Arabic children, in addition, to assist in differential diagnosis with other SSD. The need to address CAS in research in languages other than English is important; therefore, this study adds to what previous scholars of other languages found.

The major findings demonstrate inconsistent phonological errors, inconsistent word production, and poor accuracy of production highly correspondent with stimuli length. This can guide SLPs when assessing speech disorders to benefit from using speech assessment tools that contain different stimulus lengths.

Future research is recommended to get better insight into this phenomenon based on the analysis of diakinetic and motor characteristics besides the correct consonants and vowel productions which were not included in this study. Thus, researchers and SLPs can use the results to differentiate between children with CAS and SSD and may develop an assessment tool for Arabic population based on these results.

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Table 1. Participants' demographic information.

Subject	Gender	Age at the time of evaluations (years)	Referring diagnosis	therapy period (months)
S1	Male	6	CAS	24
S2	Male	7	Suspected	6
S3	Male	6	CAS	12
S4	Male	8	CAS	12
S5	Male	7	Suspected	24
S6	Male	11	CAS	24
S7	Female	4	Suspected	3
S8	Female	4	CAS	3
S9	Male	6	Suspected	0
S10	Female	6	Suspected	6
S11	Male	6	Suspected	3
S12	Female	5	CAS	0

Table 2. The list of words used for testing suspected children with CAS

n Words of	Words and Syllable Structure	n Words of	Words and Syllable Structure
2.	/berɪt/ - (cvc)	15.	/duf.dɑʕ/ -(cvccvc)
3.	/bo:t/ - (cvc)	16.	/bja: no:/ - (cvvcv)
4.	/lo:z/ - (cvc)	17.	/tɪf fa:ħa/ - (cvccvcv)
5.	/mo:z/ - (cvc)	18.	/mad.ra.se/ - (cvccvcv)
6.	/ka:se/ - (cvcv)	19.	/θa.la:θe/ - (cvcvcv)
7.	/ʔuð un/ - (cvcvc)	20.	/saj.ja:ra/ - (cvccvcv)
8.	/ʃa ʕɑr/ - (cvcvc)	21.	/ʁas sa:le/ - (cvccvcv)
9.	/hi la:l/ - (cvcvc)	22.	/xa.za:ne/ - (cvcvcv)
10.	/ba:lo:n/ - (cvcvc)	23.	/bur.tu qɑ:li:/ - (cvccvcvcv)
11.	/qi.tɑ:r/ - (cvcvc)	24.	/mu.kaʕ.ʕa.ba:t/ - (cvcvccvcvc)
12.	/kur.si:/ - (cvccv)	25.	/xud.rɑ.wa:t/ - (cvccvcvc)
13.	/ʤib.ne/ - (cvccv)		

Table3. Speech tasks accuracy and consistency analysis by participants

participant	% of word accuracy	% of syllable accuracy	% of inconsistency	participa nt	% of word accuracy	% of syllable accuracy	% of inconsistency
S1	12.9%	60.8%	45.33%	S7	4%	74.54%	49.32%
S2	6.67%	74.54%	56.44%	S8	0%	80%	48.24%
S3	5.78%	88.28%	56%	S9	4%	72.72%	41.76%
S4	22.2%	95.35%	58.22%	S10	24%	78.18%	42.84%
S5	44.4%	96.36%	36%	S11	4%	67.27%	50.4%
S6	6.67%	74.54%	51.11%	S12	12%	87.27%	50%

Figure 1. The frequency of occurrence of the Arabic vowels and consonants in the word list.

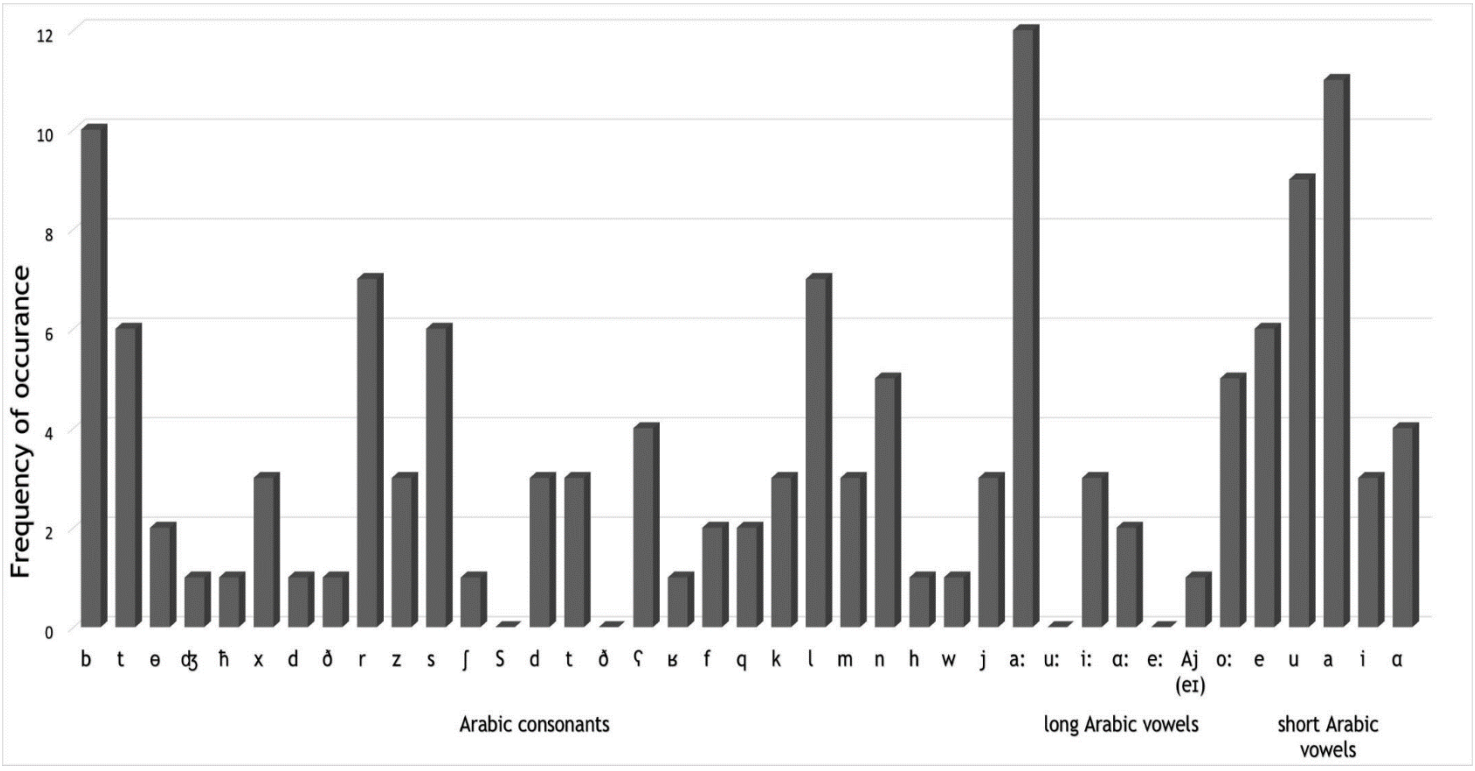

Figure 2. Occurrence of the phonological processes among participants.