An Adaptation of the Dynamic Evaluation of Motor Speech Skill for Online Delivery in Arabic for Saudi Children

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Abstract

The American Speech-Language-Hearing Association [ASHA], (2007) defines childhood apraxia of speech (CAS) as ‘a neurological childhood (pediatric) 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)’ (p. 1). There are three main features: inconsistent production of syllables or words, abnormal prosody, and lengthened or disrupted coarticulatory transitions between sounds and syllables (ASHA, 2007). Despite its prevalence, there have been very few studies looking at its characteristics in Arabic-speaking children. Furthermore, there are no assessment tools with Arabic stimuli. As a result of this, it is important to develop protocols for assessing Saudi children with suspected CAS that are culturally appropriate.

The aim of the thesis was to develop an adapted version of the Dynamic Evaluation of Motor Speech Skill [Ar-DEMSS] in the Saudi dialect of Arabic. Further to this, the tool was then administered to two groups of children: one typically developing and the other with a diagnosis of CAS.

This study involved 49 Saudi children from public schools and speech and language clinics in Jeddah, Saudi Arabia, aged 36 to 84 months (three to seven years old). A typically-developing group consisted of 43 children between the ages of 3 to 7, while the CAS group included only six children between the ages of 3 to 6.

Several tests, including the Ar-DEMSS, an articulation test, a nonverbal oral apraxia test, an oral structure and function test, and a DDK, were used to evaluate children with CAS and typically developing children.

The findings showed that typically developing children performed better than those with CAS on all sections of the Ar-DEMSS test. The results also indicated that children with CAS demonstrate vowel errors, prosody deficits, overall articulatory problems, and inconsistent productions across attempts. There were some features highlighted in the Saudi child population such as vowels and consonants being distorted/omitted, syllables being reduced, pauses, lexical stress errors, and inconsistent productions. There were difficulties with CV, CVC, disyllabic, and multisyllabic words for children with CAS.

This study represents the first adaption of DEMSS into a Semitic language. It indicates that Ar-DEMSS has the potential to be further validated for use in Saudi Arabia to assist with the identification of children with CAS.

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List of abbreviations

AMR	Alternating Motion Rate
Ar-DEMSS	Arabic Dynamic Evaluation of Motor Speech Skill
CAS	Childhood Apraxia of Speech
CV	C=Consonant and V=Vowel
DDK	Diadochokinetic
DEMSS	Dynamic Evaluation of Motor Speech Skill
SLTs	Speech and Language Therapists
SMR	Sequential Motion Rate
SSDs	Speech Sound Disorders

Declaration

I, Rawan Alamoudi, confirm that the Thesis is my own work. I am aware of the University's Guidance on the Use of Unfair Means (www.sheffield.ac.uk/ssid/unfair-means). This work has not been previously been presented for an award at this, or any other, university.

Introduction

Speech Sound Disorders (SSDs) refer to difficulties associated with perception, motor production, or the phonological representation of speech segments and sounds. The nature of SSDs can be organic or functional. Organic SSDs result from causes such as structural problems (e.g., cleft palate), motor or neurological disorders (e.g., CAS and dysarthria), and sensory or perceptual problems (e.g., hearing loss). Functional SSDs are associated with actual speech production (e.g., articulation disorders) and the linguistic aspects of speech production (e.g., phonological disorders).

SSDs are the most common form of paediatric communication difficulty, accounting for more than 70% of all speech–language therapy cases (Dodd, 2014). Additional studies have reported that the prevalence of SSDs ranges from 2.3% to 24.6% (Eadie et al., 2015; Jessup et al., 2008; Keating et al., 2001; Law et al., 2000; McKinnon et al., 2007).

Unfortunately, studies reporting epidemiological data on SSDs in Saudi Arabia are sparse. A few studies have indicated that speech and communication disorders are the second most common type of disability among children in Saudi Arabia. For example, 6.33% of Saudi Arabian children under the age of 16 years were found to have major disabilities, the most common form being motor disability, followed by learning disability (Al-Hazmy et al., 2004). According to another study on the prevalence of children with disabilities in the eastern part of Jeddah, motor disabilities, speech and language disabilities, and mental disabilities ranked highest (Milaat et al., 2001). Despite this, there is a lack of studies describing motor speech disorders—especially CAS—in terms of their prevalence, definition, assessment tools, or intervention approaches in the Saudi population.

Therefore, the aim of this thesis is to develop an adapted version of the Dynamic Evaluation of Motor Speech Skill [DEMSS] in the Saudi dialect of Arabic (i.e., the Arabic-DEMSS [Ar-DEMSS]). This tool can assist Saudi speech and language therapists (SLTs) in the differential diagnosis of SSDs in children aged 3 years and older who have speech impairment. The Ar-DEMSS was developed as a preliminary tool to provide a general overview of the characteristics of CAS in Saudi children.

This thesis is divided into seven chapters. The first two chapters will provide a literature review on the topic of CAS. Specifically, Chapter 1 will discuss its definition, prevalence, aetiology, core deficit, features, differential diagnosis, and assessment tools. Chapter 2 will provide an overview of the Arabic phonological system, including the consonants, vowels, and syllable structures used in the Arabic language. English phonology will be discussed.

Chapter 3 will present an overview of speech acquisition in English and Arabic and will describe the content of the DEMSS and Ar-DEMSS. Then, the adaption stages from the DEMSS to the Ar-DEMSS will be discussed in greater detail, including the process of transition and adaption, the Ar-DEMSS stimuli, and its content and scoring system.

Chapter 4 will outline this study's research design and methods, the participants' characteristics, the process of recruitment, and the assessment procedures. Chapters 5 and 6 will present details of the results, featuring descriptive statistics of typically developing children and of the CAS group for all the assessment procedures—and specifically those related to the Ar-DEMSS. Chapter 6 will explore the case studies of three children with CAS. The last chapter, Chapter 7, will summarize the study's aims, findings, limitations, clinical implications, and future directions, and will provide a conclusion to the study.

Chapter 1 CAS: Theories and Assessment

The first chapter will explore and give an overview of CAS, including its related definitions, prevalence, core deficits, characteristics, and related assessment tools. At the end of this chapter, the study aims and research questions will be presented.

1.1 Definition of CAS

Although 40 years of research has been conducted on the disorder of CAS, it remains poorly understood (Davis et al., 1998). However, recent decades have seen increased studies that have significantly advanced our understanding of the disorder (ASHA, 2007; RCSLT, 2024). Much of the descriptive work related to the apraxia of speech was conducted at the end of the 20th century (Crary, 1993; Morley, 1972; Stackhouse, 1992). For example, Morley (1959) represented CAS as the 'limited and defective use of the phonetic sounds of speech'. Ferry et al. (1975) stated that the speech of children with CAS is unintelligible or absent. Lohr (1978) reported on five children with apraxia who were nonverbal. Deputy (1984) used the label CAS to refer to children who have many misarticulations.

Accordingly, Guyette and Diedrich (1981, p. 39) described CAS as a disorder 'in search of a population', because of the doubt surrounding the diagnostic criteria required to make an accurate diagnosis. Although CAS is a universally accepted condition, there is still no generally agreed upon definition describing it (Royal College of Speech and Language Therapists [RCSLT], 2011). Clinicians assign this label to children with severe, irregular, and persistent speech problems (Crary, 1981; Shriberg et al., 1997a). Marquardt et al. (2002) defined CAS as a neurological-based disorder in the programming of articulatory movements. Moreover, Crary (1993) referred to CAS as a neurological disorder in motor programming and sequential speech gestures.

The committee for apraxia of speech in children noted in 2007 that in the previous 10 years, more than 50 definitions had appeared in the clinical literature (ASHA, 2007). As a result, ASHA (2007) proposed the following definition of CAS: ‘a neurological childhood (pediatric) 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). CAS may occur as a result of known neurological impairment, in association with complex neurobehavioral disorders of known and unknown origin, or as an idiopathic neurogenic speech sound disorder. The core impairment in planning and/or programming spatiotemporal parameters of movement sequences results in errors in speech sound production and prosody’. (p.1).

1.2 History of Terminology

Since Morley et al. (1954) first described CAS, it has been referred to using a variety of terms, including ‘developmental apraxia of speech’, ‘articulatory apraxia’, ‘developmental verbal dyspraxia’, ‘developmental articulatory apraxia’, and ‘developmental dyspraxia’ (Davis et al., 1998; McLeod & Baker, 2017). Even more terms were used to describe this disorder in the past, indicating there has long been a lack of consensus among researchers and clinicians.

1.2.1 Developmental Verbal Dyspraxia Versus CAS

According to the RCSLT’s (2011) policy statement, the term ‘developmental verbal dyspraxia’ is used widely in the United Kingdom, while ‘CAS’ is the accepted term in the United States, and they are used interchangeably in the research literature. However, there are differences between and nuances within these terms. For example, does ‘childhood’ refer to a congenital or an acquired condition with a specific cause, and does ‘developmental’ also indicate a congenital condition? Moreover, there is a distinction between ‘apraxia’, which involves a total absence, and ‘dyspraxia’, which indicates a lack of function or a partial absence. Last, the term ‘speech’ involves speech and prosodic characteristics; by contrast, the term ‘verbal’ relates not only to prosody and speech but also to language and other communication skills (RCSLT, 2011).

1.3 Prevalence

Shriberg et al. (2019) found that CAS occurred in 1 out of 1,000 children, similar to Shriberg et al. (1997a), who reported that it occurred in 0.1% to 0.2% of children (i.e., 1 to 2 per 1,000). However, according to Forrest (2003), the prevalence of CAS is unknown. Also, Shriberg et al. (2019) found that CAS was more prevalent in children with known neurodevelopmental conditions, such as 4.3% of children with CAS alone and 4.9% of children with CAS and dysarthria. Broomfield and Dodd (2004) examined the incidence of different subtypes of speech disorder among children but found no single case that could be diagnosed as CAS. Delaney and Kent (2004) estimated that about 4% of 15,000 cases of speech impairment were of unknown cause and could be described as CAS. From these findings, it can be concluded that there is a need for further research to identify the real prevalence of CAS. Unfortunately, no epidemiological data are available about the prevalence of CAS in Saudi Arabia. Hall et al. (1993) found that English-speaking children with CAS were more prevalent among males than among females (74% of 229 cases). Similarly, Lewis et al. (2004a) reported that, in a sample of 22 English-speaking children with CAS, there was a higher prevalence of CAS among males, at a ratio of 2:1 (males to females). Hall et al. (1993), however, concluded that although there were more males with CAS, the ratio was lower than 2:1. These studies of the gender ratio present in idiopathic CAS indicate that CAS occurs more often in males than in females.

1.4 Views on the Existence of CAS

CAS has been studied for many years; however, there are still controversies regarding its existence, terminology, definitions, diagnostic characteristics, symptomatology, assessment tools, and intervention approaches (Davis et al., 1998). McCabe et al. (1998) illustrated three different opinions about the nature of CAS resulting from these controversies, which have led to the failure to determine the valid diagnostic features for the disorder. The first view is that CAS is a separate diagnostic entity from other SSDs, such as phonological disorders or dysarthria (e.g., Milloy, 1986). The second view is that CAS is a syndrome or that it involves a symptom complex (Ozanne, 1995). A syndrome consists of several features, signs, and symptoms, not all of which are required to diagnose the condition. The third view is that there is a lack of evidence to support CAS as a distinct disorder (Guyette & Diedrich, 1981; Klein, 1996). For example, some studies have viewed CAS as an expressive language disorder or as an articulation impairment (Gierut, 1998). Hodge (1994) mentioned that children with CAS have late speech onset; thus, he believed the disorder to be an expressive language delay affecting children's spelling, writing, and reading skills.

As stated by McCabe et al. In 1998, CAS diagnosis had at least three different viewpoints. However, a decade later, clinical guidelines and scientific advances relating to the condition have also evolved. In light of this, McCabe et al. (2024), in conjunction with the positions presented by both RCSLT (2011) and ASHA (2007), are cognizant of the fact that apraxia of speech is a separate category of childhood speech sound disorders that requires research in addition to proper intervention. According to the ASHA of 2007, CAS can be described as a motor speech disorder characterized by the child's inability to plan and organize the movements needed to speak. ASHA also pointed out that CAS may include features such as disrupted coarticulatory transitions between sound and syllables, prosody disturbances, and difficulty producing accurate and consistent speech sounds. The RCSLT (2011) has expanded the definitions of CAS by stressing that diagnosis must always be differential. From their recommendation, CAS should be differentiated from dysarthria and phonological impairment. Thus, for the RCSLT to convey the nature of the disorder appropriately, a multidimensional assessment method was proposed. The use of standardized tests, and dynamic assessment procedures. The RCSLT updated its guidelines in 2024 to incorporate the latest research findings and clinical advances. Additionally, the report acknowledges the fact that CAS can co-occur with other developmental disorders and its presentation differs widely from child to child, and the need for effective treatment.

In recent guidelines from the ASHA and RCSLT, diagnostic criteria have been clarified. The importance of a comprehensive assessment and individualized treatment has been emphasized. There is remarkable growth in the evidence base for CAS. As epidemiological, diagnostic, and intervention research provides more information about CAS, SLTs can become more confident in assessment, diagnosis, and intervention. Because CAS's evidence base is constantly evolving, SLTS must stay up-to-date.

1.5 Aetiology

CAS can be congenital, or it can be acquired during speech development (ASHA, 2007). Both conditions can occur as idiopathic neurogenic SSDs, such as in children with no detectable neurobehavioural disorders or neurological abnormalities.

Furthermore, CAS can be expressed as primary or secondary symptoms in association with complex neurobehavioural disorders such as epilepsy, autism, fragile X syndrome, Prader–Willi syndrome, and Rett syndrome (Bashina et al., 2002; Scheffer et al., 1995). However, a recent study involving the evaluation of prosody and speech among 46 verbal children with autism did not support the hypothesis of the co-occurrence of the two disorders (Shriberg et al., 2011). This is consistent with Cabral and Fernades (2021), who investigated the prevalence of CAS among children with autism. In their analysis, CAS appeared to be rare among children with autism spectrum disorder. Tierney et al. (2015) found that 63.6% of autistic children also had apraxia, 36.8% of children with apraxia also had autism, and 23.3% had both. Consequently, it is essential to assess all children with apraxia for signs of autism as well as all children with autism for signs of apraxia, due to the high level of comorbidity between apraxia and autism. A study by Brown et al. (2000), CAS is caused by neonatal brachial plexus palsy, which is an acquired condition. Thus, CAS is clearly caused by neurological problems such as trauma, infection, brain cancer, or a childhood stroke.

Many studies have discussed the observation that the biological families of children with CAS show higher rates of language, speech sound, verbal learning, and reading disorders than occur in the general population. For example, Morley (1965) found that 67% of CAS cases in a sample had a family history of speech and/or language impairment. Other investigators identified that 6 out of 11 CAS cases had family members who had experienced speech and language disorders (Thoonen et al., 1996). Furthermore, Lewis et al. (2004a) demonstrated that 86% of 22 children with CAS had strong evidence of a family history of speech and language disorders.

However, there is a low incidence of CAS among the family members of children with CAS. A genetic study indicated that in a particular extended family, 50% of the individuals presented with CAS (Hurst et al., 1990). The feature they experienced most was the inability to sequence oral movement, which is a hallmark feature of CAS (Watkins et al., 2002). Another study revealed there is a gene mutation at chromosome 7q31, which is called the *FOXP2* gene (Lai Fisher et al., 2001). Approximately one third of the identified cases of CAS have been reported to be genetically aetiological, with a number of genes implicated (Hildebrand et al., 2020; Kaspi et al., 2023). These genes appear to be related to neurodevelopmental diseases (Kaspi et al., 2023). ASHA (2007) reported that the main aetiology of CAS is still undetermined, but most of the evidence is associated with a 'core impairment in planning and/or programming spatiotemporal parameters of movement sequences', which 'results in errors in speech sound production and prosody' (p. 3). However, the majority of CAS cases are reported to be idiopathic (Murray et al., 2015).

1.6 Core Deficit

The controversy surrounding CAS arises from the different theoretical perspectives on the underlying deficit of the disorder (RCSLT, 2011; Davis et al., 1998). For example, many definitions have been proposed for the term 'CAS', with many different core deficits being identified; for example, the suggestion that the main problem relates to input processing and production has been analysed, and if so, whether sensory, prosodic, or auditory aspects of perception cause the deficit (RCSLT, 2011). There is still disagreement among researchers about whether the core deficit in CAS is a linguistic deficit, a motor programming deficit, or both (Edeal & Gildersleeve-Neumann, 2011). For instance, Robin (1992) mentioned that CAS results from a motor problem, which is a separate clinical entity from dysarthria and phonological disorder. Furthermore, when SLTs diagnose CAS, they generally consider it to be a motor problem, without assessing whether the child has a language disorder (Crary, 1997). The proponents of the motor perspective do not contradict the linguistic deficit in CAS, but they view these difficulties as being associated with—or a consequence of—speech motor control. In contrast, McNeill et al. (2009) viewed CAS as a linguistic deficit and proposed phonological awareness treatment.

Despite the existence of many theoretical perspectives on CAS, there is still little evidence to refute or to support these theories (Maassen et al., 2003). Shriberg et al. (2012) investigated whether CAS is limited to motor planning and programming impairments (i.e., transcoding) or whether children with CAS have auditory perceptual (i.e., encoding) and/or memory processing difficulties. Their findings showed that participants with CAS had significantly lower syllable repetition task scores in transcoding, memory, and encoding than did the control group. It was concluded that participants with CAS experienced transcoding, memory, and auditory perceptual encoding deficits. Many other studies have also reported memory and encoding deficits (Maassen et al., 2003; Marion et al., 1993; Marquardt et al., 2002; McNeill et al., 2009). Transcoding deficits were also mentioned in several past studies (Grigos et al., 2015; Nijland et al., 2002; Robin, 1992). Due to the core impairment in planning and/or programming spatiotemporal parameters of movement sequences, the next section will discuss speech motor control.

1.7 Speech Motor Control

'Motor control' is defined as the systems and strategies required in producing speech (Kent, 2000). It involves a sequence of procedures to organise and coordinate different functional movements. Children's oral motor skills are governed by the function of the lips, cheeks, jaw, and tongue, which play a major role in development, speech, and feeding. For instance, research on typical oral motor development has revealed that jaw control is acquired by the age of about 15 months, followed by the acquisition of upper and lower lip control, and tongue control (Green et al., 2000). With maturation, upper and lower lip movement patterns began to resemble those of adults. Many studies of infants have hypothesised why they commonly produce syllables that can be produced without changing lip or tongue, including labial consonants with neutral vowels, alveolar and dental consonants with high front vowels, and velar consonants with high back vowels (Davis & MacNeilage, 1995). These syllables are believed to be common because infants can open and close their jaws at an early age, resulting in consonant–vowel alternations, with the lower lip being used for labials or the tongue for alveolars and velars.

Such findings suggest that children with CAS may continue to exhibit these immature patterns (Velleman, 1994). When a child overcomes interdependent inflexible patterns related to sucking, the child can produce different syllables with different prosody patterns (ASHA, 2007). Therefore, 'the labiomandibular movement patterns established for feeding may influence initial attempts to coordinate these structures for speech' (Green et al., 2000, p. 252). As a result, among experts, nonspeech oromotor therapy is not considered essential or adequate to improve speech production (Lee & Gibbon, 2015; McCauley et al., 2009; ASHA, 2007). This is because speech demands finer levels of coordination (Green et al., 2000) but lower levels of strength compared to other oral-motor activities (Forrest, 2002).

Individuals express thoughts and emotions through speech, respond to their environment, and control it through unique, complex, dynamic motor activity. The production of speech involves the creation of sounds and syllables to enable communication with others. These speech sounds are produced to achieve a continuous sequence of movement. To communicate effectively, one must convert an abstract idea into a linguistic symbol (i.e., morphological, phonological planning, and syntactic), which all happens during a non-motor phase. These linguistic codes are then transmitted into codes that can be conveyed by motor systems, such as speech systems. ‘CAS’ is a label that is used to describe a subtype of SSDs that are due to inefficiencies in the neural processing involved in the planning and programming of the movement needed for speech production. ‘Praxis’ is a term used to refer to the planning and programming of a specific movement (Stedman, 2005; Strand, 2020). As mentioned earlier, producing speech requires the integration a variety of neurocognitive, neuromotor, neuromuscular, and musculoskeletal functions.

There are three stages involved in the motor speech process. The first is the cognitive–linguistic process level of verbal communication, which features the organisation of emotions, feelings, and thoughts into a code that follows the rules of language. Second, these verbal expressions must be structured for neuromuscular execution, which occurs at the motor speech planning, programming, and control level. Sensorimotor planning involves initiating spatial (i.e., the place and manner of articulation) and acoustic goals (i.e., each speech sound is specified and regulated to occur concurrently and sequentially). Sensorimotor programming involves temporal (i.e., timing) goals that are ‘instructions for the timing of muscle contraction so that specific structures move in the right direction, at the right time, with the right speed and force to reach a specific articulatory configuration’ (Strand & McCauley, 2019, p. 3). Third, the actual movement of the muscles occurs, during what is referred to as the ‘neuromuscular execution stage’ (Strand, 2020). To perform speech motor programmes, the central and peripheral nervous systems must coordinate together to control breathing, phonation, resonance, and articulation muscles in an appropriate manner, to generate an acoustic signal that corresponds to the programme's goals (Duffy, 2013).

Nijland et al. (2003) investigated whether a motor programming deficit can be found in children with CAS. The aim of their study was to find out whether children with CAS have reduced articulatory compensation in comparison with normally speaking children. A bite block was used to examine any compensation at the level of motor programming. Specifically, a bite block was used to stabilise children's jaws during speech and non-speech activities and to isolate tongue movements from mandible movements (Solomon et al., 2016). The bite block restricted the children's jaw movement and allowed their tongue to move independently. The children with CAS experienced more varied responses to the bite block manipulation as well as more compensation deficits when repeating utterances than did the typically developing children. However, the findings indicated that the children with CAS improved in terms of their vowel and coarticulation quality in response to bite block condition. These results indicated a deficiency in motor programming in CAS. Nijland et al. (2002) examined coarticulation in children with CAS compared to typical children and adults by having them repeat nonsense words. They found that the second formant (f2) values were higher and more variable in children with CAS than in other groups; they also identified an idiosyncratic coarticulation pattern and less distinctive sounds between vowels in children with CAS.

Grigos et al. (2015) examined the temporal and spatial aspects of articulatory control in children with CAS, comparing them with children with speech disorders and with typically developing children during a speech task containing increasing word lengths. The results showed that the children with CAS did not have stable motor planning and that they exhibited a spatiotemporal instability of the jaw movement that was significantly higher than that of the children with other speech disorders.

1.8 Review of Studies of CAS Features

1.8.1 Speech Motor Behaviours

There have been numerous studies attempting to identify the diagnostic characteristics of CAS compared to typical development or the development of other speech disorders. All research designs are necessarily limited by the diagnostic uncertainty of whether a child suspected to have CAS does, in fact, have it (ASHA, 2007). For instance, Forrest (2003) explored the diagnostic criteria used by 75 SLTs to identify CAS; in the study, the SLTs were asked to provide the top three hallmarks that they used to diagnose CAS. The largest number of responses involved high/groping-effort production, general oral-motor difficulties, the inability to imitate sounds, difficulties sequencing phonemes, inconsistent productions, and increased difficulty with sound production as the utterance length increases.

Several studies have demonstrated the efficacy of different measures to diagnose CAS, both clinically and for research participant selection, including the repetition of syllables (i.e., maximum repetition rate) and the production of alternating syllables (i.e., diadochokinesia [DDK] rate or alternating motion rate; ASHA, 2007). Lewis et al. (2004a) found that non-words and multisyllabic words were more difficult for preschool and school-age children with CAS to repeat than they were for children with non-CAS speech delay. They found errors in syllable reduction, the deletion of initial consonants, voicing errors, and vowel errors. In addition, the DDK scores were significantly lower in children with CAS on the oral-motor assessment (Robbins and Klee, 1987).

Another study, by McCabe et al. (1998), identified the most common features seen in CAS, as follows: inconsistent speech production, syllable omission, idiosyncratic sound substitution, vowel distortion, slow development of speech, expressive language impairment, many articulation errors at initial assessment, and delays and deficits in the acquisition of speech skills. Peter and Stoel-Gammon (2005) and Davis et al. (1998) also outlined the most commonly observed features of CAS, including reduced DDK rates, omission errors, a limited phonemic inventory, vowel distortions, abnormal prosody, increased errors with increasing speech complexity, receptive and expressive language deficits, and inconsistent articulation errors. Further, Maassen et al. (2003) showed that the speech errors are less predictable in children with CAS than in typically developing children.

A longitudinal study was carried out by Stackhouse and Snowling (1992) to examine the speech errors in two children with CAS. During phase one, these children demonstrated poorer performance in spontaneous naming, continuous speech, and imitation than did a group of typically developing children. The major issues were with vowel sounds and syllable structures, as a result of persistent articulatory incoordination. During phase two, although the two children had reached articulatory maturation, they still demonstrated syllable structure planning deficits. Both had deficits at the motor programming level for speech production. One child had difficulties with output phonology, and the other child had difficulties with input phonology and lexical representation. These children’s articulation had improved with age, but they still had difficulties in producing novel and complex words. These results indicate that children with CAS experience motor difficulties as well as difficulties with the linguistic aspects of speech.

Although there are many studies that discuss the different symptoms of CAS, ASHA's position statement (2007) concluded that while there is no agreed-upon set of diagnostic features of CAS, three segmental and suprasegmental characteristics frequently occur, resulting in deficits in the planning and programming of movements: '1- inconsistent production errors in consonants and vowels in repeated productions of syllables or words, 2- lengthened and disrupted coarticulatory transitions between sounds and syllables, 3- abnormal prosody, especially in the realisation of lexical or phrasal stress.'(p. 2). Chenausky et al. (2020) validated these three signs in a factor analysis of signs of CAS.

Iuzzini-Seigel et al. (2017) investigated whether speech inconsistency is a characteristic of CAS, to differentiate it from speech delay. They recruited 48 children, 10 with CAS, 10 with CAS and language impairment (LI), 10 with speech delay, 9 with LI, and 9 typically developing children. They measured inconsistency in production at the phonemic and token-to-token levels. The results suggested that, at the phonemic level and for the token-to-token production of multisyllabic words, the children with CAS and CAS+LI were less consistent than were the children with LI alone. In contrast, the children with LI displayed similar levels of speech consistency compared to the children with CAS or CAS+LI for repeated productions of the phrase, 'buy Bobby a puppy'. This evidence supports the hypothesis that one of the core characteristics of CAS is speech inconsistency.

1.8.2 Prosodic Disturbances

Several studies have suggested that prosodic difficulties are the most significant hallmark of CAS (Shriberg et al., 1997a, 1997b; Odell & Shriberg 2001; Shriberg et al., 2003a). Children with CAS have a reduced range of—or variable—pitch and loudness, which can be perceived as monotonous or monoloud speech by listeners (Shriberg et al., 2003b). Research groups have also explored the role of prosodic disturbances in the differential diagnosis of CAS using several perceptual and acoustic measures (Murray et al., 2015; Shriberg et al., 2011, 2012; Strand et. al., 2013).

A series of studies by Shriberg et al. (1997a, 1997b) compared the speech and prosody-voice profile of children with CAS and children with speech delay. The result demonstrated that 52% of the 53 children with suspected CAS who were evaluated displayed inappropriate stress in conversational speech samples. Their speech revealed an equal, excess, or misplaced stress pattern on one or more words within a phrase, or a misplaced stress on one or more words due to block or prolongation, which was the only feature that distinguished children with CAS from those with other speech impairments.

Velleman and Shriberg (1999), in contrast, found that the lexical variables in children with CAS were not significantly different from those in children with speech delay. The children with CAS did not exhibit any differences in stress errors from the children in the other group, suggesting that they were misdiagnosed or had a delay rather than a disorder causing the errors. It was observed that the participants with CAS who excessively stressed syllables either omitted or overstressed weak syllables; in addition, syllable omissions persisted much later in CAS subjects. However, Shriberg et al. (2003a) revealed that stress errors can change over time in individuals with CAS.

In a study conducted by Munson et al. (2003), non-word stimuli were used to examine the acoustic correlate of lexical stress production in children with CAS and children with phonological disorders. The duration, fundamental frequency, and intensity of each vowel in trochaic (strong–weak) and iambic (weak–strong) non-words were measured. Additionally, perceptual judgments by a trained listener were collected to measure how accurately the stress was produced by the subjects in the study. The findings showed that there were no significant differences in the acoustic measures between the groups; however, the trained listener perceived that the productions of those with CAS were less likely to match the target stress pattern than were those of the phonological disorders group.

These findings are consistent with those of Skinder et al. (1999), who also found no significant differences in acoustic variables between those with CAS and those without speech disorders. Shriberg et al. (2003a) used acoustic measures (i.e., intensity, frequency, and duration) to assess lexical stress as a diagnostic marker in children with CAS. The participants were asked to imitate 24 disyllabic words in isolation. Three groups of eight words had to be produced in one of the three disyllabic stress patterns (i.e., iambic, trochaic, or spondaic). The results revealed differences in the children's lexical stress; of the 11 children, 5 had an atypical lexical stress pattern. These results are consistent with a praxis deficit in speech motor control.

In contrast, Kopera and Grigos (2020) measured the production of lexical stress among two groups, using acoustic and kinematic variables: children with and without CAS. For the acoustic measure, they found no significant differences between the groups. However, for the kinematic measure, it was revealed that the children with CAS produced smaller durational differences between stressed and unstressed syllables. This evidence indicates that children with CAS have reduced temporal control for lexical stress production, according to kinematic results.

Shriberg et al. (2003b) examined the coefficient of variation marker ratio among 15 children with suspected CAS. Their results showed that the children with CAS had less temporal variation in speech events but increased temporal variation in pause events. It should be noted, however, a number of methodological differences prevent direct comparisons between the above studies. For instance, there were differences in the stimuli, participant groups, and types of lexical stress analysed.

1.8.3 Non-Speech Motor Skills

As there is some overlap between the two motor speech disorders CAS and dysarthria, non-speech motor behaviours are mostly used to distinguish between these children. It has been proposed in some studies (Shriberg et al., 1997a; Davis et al., 1998) that the following non-speech motor behaviours are the most frequent signs of CAS (although some are also associated with dysarthria): general awkwardness, impaired volitional oral movements, mild motor development delays, mildly low muscle tone, abnormal orosensory perception, hypersensitivity or hyposensitivity in the oral area, and oral apraxia.

Limb apraxia and oral apraxia have been investigated in children with CAS, and some features of oral apraxia—such as problems with oral volitional movement—have been reported in those with CAS (McCabe et al., 1998). Stackhouse (1992) mentioned that children with CAS have a history of feeding difficulties and low muscle tone. In addition, CAS is likely to co-occur with limb apraxia, and the children affected may present with gross and/or fine motor control problems (Dewey et al., 1998, Iuzzini-Seigel et al., 2019). Davis and Velleman (2000) highlighted the importance of observing speech output rather than being limited to noticing the 'red flags', such as feeding difficulties, oromotor dyspraxia, drooling, limited babbling and vocalisation, and developmental coordination disorder. Many of these problems may also be representative of other conditions, such as speech delay, dysarthria, and expressive language delay.

1.8.4 Literacy and Metalinguistic Skills

Marquardt et al. (2002) assessed the metalinguistic awareness of syllables relative to age. Their findings suggested that children with moderate to severe CAS exhibit deficits in accessing, detecting, and comparing syllabic representations in both structure and position. These children were shown to suffer from linguistic problems, as demonstrated by their poor phonological representation systems, such as in relation to syllables and phonemes (Marion et al., 1993).

McNeill et al. (2009) compared the reading development and phonological awareness of children with CAS relative to children with other speech disorders. Their results showed that children with CAS have a greater phonological awareness deficit (i.e., rhyme awareness, alliteration awareness, phoneme identification, and letter knowledge) than do children with inconsistent speech disorders. This result is consistent with the findings of Lewis et al. (2004b), who also showed that children with CAS experience more phonological awareness deficits than do children with other speech disorders.

Similar results were presented in prior studies, which claimed that children with CAS experience severe reading and phonological awareness impairments (Lewis et al., 2004b; Marion et al., 1993; Marquardt et al., 2002; Stackhouse & Snowling, 1992). This evidence indicates that children with CAS experience a linguistic deficit in addition to other motor deficits. However, Miller et al. (2019) compared the reading outcomes of 40 preschoolers with a history of suspected CAS to 119 children with

SSDs. They found that children with CAS are similar to their peers with SSDs in terms of literacy development, including language, decoding, and phonological awareness.

1.9 Aspects to Consider in CAS Diagnosis

Although a standardised assessment tool to distinguish CAS from other speech disorders is not available, many children are still labelled as having CAS. A model involving speech output planning and programming, explained by Ozanne (2005), proposed three levels of deficit, as follows: 1) deficits in the phonological plan or template, 2) deficits in the assembly of a phonetic plan or programme, and 3) deficits in the implementation of a motor speech programme. The first level considers linguistic and phonological impairment, while the other two reflect motor impairment. Children with CAS can present with problems at all three levels. However, often, children with CAS will demonstrate deficits at the motor level, while children with phonological disorders will experience deficits at the linguistic level.

In contrast, Stackhouse (1992) suggested that four aspects must all be considered in diagnosing CAS: linguistic, cognitive, phonetic, and motor deficits. She listed 47 symptoms of CAS. Not all of the symptoms are related to speech behaviours, as some will be presented in case history only, while others are only revealed during assessment and treatment. It is therefore important to look at a child's linguistic and motoric abilities, and to build therapy goals based on these.

1.10 Differential Diagnosis

CAS is a condition that results from a planning and programming deficit; it is not related to phonological disorders or muscular weakness, as is dysarthria. However, when reviewing the research literature, it becomes clear that there is no validated diagnostic feature that distinguishes CAS from other childhood SSDs. For example, children with CAS and phonological disorders share common features; in both groups, speech sound production are not developmentally appropriate, and as a result, their speech is highly unintelligible. Often, children suffering from phonological disorders have difficulty forming and accessing abstract representations of the sound structure of words. The underlying cause of this disorder is linguistic impairment (Munson et al., 2003). CAS is different from phonological disorders, but the two have common surface symptoms, with the same characteristics exhibited in both conditions. These include difficulties with vowels, consonants, phonotactic inventory constraints, the use of simple word shapes and syllables, vowel errors, the omission of segments and structures, increased errors with utterance length and/or complexity, and altered suprasegmentals (Bowen, 2014).

Strand and McCauley (2008) reported that children with CAS and SSDs both demonstrate reductions in their phonetic and phonemic inventories. However, children with CAS show a lesser use of vowels, produce several non-developmental errors, and have an inconsistent production of sounds. Diepeveen et al. (2020) examined the clinical judgement of SLTs in diagnosing and treating children with SSDs in the Netherlands. They interviewed 33 SLTs and asked 137 other SLTs to fill out a questionnaire on the same topic. The findings indicated that the SLTs used observation and case history to diagnose SSDs, in conjunction with a variety of assessment tools. The SLTs further mentioned the unique features they used to diagnose CAS, such as being a late talker; having problems coordinating the tongue, lips, and jaw; groping for sounds; having difficulties with multisyllabic words; and demonstrating inconsistent production. They also used different tests to diagnose CAS, including the Nuffield Dyspraxia Programme, language assessment, speech samples, and prompts.

In addition to linguistic difficulties, CAS is represented by motor planning and/or programming difficulties in the absence of muscular paralysis and weakness. Dysarthria, in contrast, is a motor speech disorder resulting from weakness, paralysis, or abnormality in the muscular control of the speech mechanism, originating from impairments in the central or peripheral nervous system (Iuzzini-Seigel et al., 2022). There is a need to develop standardised tests and a full battery of assessment tools to distinguish between speech sounds problems, such as an oral structural–functional evaluation, motor speech examination, and sound systems assessment test.

An oral structural–functional evaluation is currently used to confirm the presence of nonverbal oral apraxia and dysarthria. While children with CAS and phonological disorders demonstrate normal function in terms of strength, speed, coordination, ability to vary muscular tension, and range of motion, children with dysarthria show impairments in all these aspects. Motor speech examination is thus a vital tool that helps determine a differential diagnosis in the context of severe speech disorders. It investigates the child's ability to imitate words with increased levels of phonetic complexity and length. It can help SLTs to observe characteristics associated with speech praxis deficits. For example, behaviours such as lexical stress errors, groping, the segmentation of multisyllabic words, inconsistent production, and vowel errors can be noted (Strand & McCauley, 2008).

Williams et al. (1980) conducted a study that seemed to confirm the belief of SLTs that CAS is a discrete disorder with several specific common features that are not associated with functional articulatory impairment or dysarthria. For instance, they mentioned that the usual hallmarks of CAS are groping when trying to produce a sound, problems in producing individual sounds or a sequence of sounds volitionally, inconsistent phoneme error production, and deviant rather than immature articulatory behaviour.

1.11 Speech Sound Development in CAS

There is a need for Arabic studies that examine the development of speech sounds in children with CAS—including consonants, vowels, syllable structures, and prosody—and to compare them with those of typically developing children and children with other speech difficulties. However, in a study by Overby and Caspari (2015), they investigated early vocalization, consonant acquisition, and syllable structure among English-speaking infants and toddlers, later diagnosed with CAS.

1.11.1 Early Speech Skills

'Volubility' refers to 'the amount of vocalisation produced regardless of the type of vocalisation' (Overby & Caspari, 2015). Overby and Caspari (2015) carried out a study to explore volubility, consonant singleton acquisition, and syllable structure development in English-speaking infants and toddlers with typical speech sound production and those later diagnosed with CAS. At the time the study was conducted, no other study had examined the volubility of infants and toddlers who were later diagnosed with CAS. The first hypothesis of the study was that infants and toddlers who were later diagnosed with CAS would experience lower overall volubility than other children. This hypothesis was rejected, as no significant difference in the number of vocalisations was noted.

However, in other studies, the parents of children who were later diagnosed with CAS reported that their children were silent and babbled very little (Aziz et al., 2010; Velleman & Strand, 1994). Davis and Velleman (2000) mentioned that limited vocal output is one of the characteristics associated with CAS. Another study was conducted that explored the speech history of children with CAS; of the 192 parents interviewed, 71% mentioned that their children had minimal speech at the time of diagnosis, 52% of them had poor intelligibility, and 42% had difficulties in speaking (Teverovsky et al., 2009). Aziz et al. (2010) investigated the speech, language, and non-speech oral skills among Arabic-speaking children. Participants included 30 children—10 children with suspected CAS, 10 with multiple phonological disorders, and 10 with typical speech and language development. The study found that 80% of the parents of children with CAS said that their children babbled very little and had reduced phonetic diversity. However, Highman et al. (2013) confirmed that low volubility in infancy and toddlerhood is not a diagnostic feature for CAS.

1.11.2 Emergence of Consonants

There is still no available research discussing the emergence of Arabic consonant sounds in children who are later diagnosed with CAS. Davis and Velleman (2000) indicated that English-speaking children with CAS experience a limited variety of vowels and consonants. When these children are three years and older, they experience many consonant errors, such as substitutions, stopping errors, and/or omissions (Lewis et al., 2004b; Marquardt et al., 2001). However, consonant errors are also associated with children who have other speech problems. Jacks et al. (2006) suggested that a key difference between English-speaking children with CAS and those with other speech problems is that their consonant errors are qualitative (i.e., type of error) rather than quantitative (i.e., number of errors).

Lewis et al. (2004b) examined the phonological skills of English-speaking children with CAS and those with other speech disorders. They found that children with CAS experience atypical errors such as vowel errors, initial consonant deletion, and voicing errors more often than do children with other speech disorders. The most frequent error (100%) among the CAS group was final consonant deletion; syllable reduction was the second most common error (90%), followed by liquid reduction (80%) and cluster simplification (60%). Shriberg et al. (1997c) reported that English-speaking children with CAS experience consonant errors—specifically, an omission rate of 42%, compared to a rate of 25% in the group with other forms of speech delay. This result is consistent with that of Jacks et al. (2006), who found that English-speaking children with CAS have a 42% omission rate and 34% substitution rate, along with a higher rate of final consonant deletion compared to initial or medial consonant deletion.

1.11.3 Limited Syllable Structure

Few studies have discussed the syllable structure of infants with CAS. Davis and Velleman (2000) reported that children with CAS use incomplete syllables for consonants or vowel structures, and few word shapes with a consistent meaning. It has also been reported that children with CAS use a small number of different syllable structures (Highman et al., 2013).

1.12 Assessment Tools

Researchers commonly use checklists that consist of different diagnostic features, despite the lack of reliable and valid assessment tools. Researchers often use the three previously discussed consensus features outlined by ASHA to confirm CAS diagnosis in participants, either as a single requirement or along with additional tools. For instance, Grigos and Case (2018) expected participants to exhibit each of the three consensus characteristics more than three times in different speaking contexts, such as in single words, connected speech, and syllable sequencing.

Another study, by Thomas et al. (2016), specified a set of specific features to identify the presence CAS. They selected participants whose inconsistency level was greater than 40% on the Diagnostic Evaluation of Articulation and Phonology test, who presented syllable segregation within at least 10 words, and who demonstrated stress pattern mismatches of at least 15% on the Test of Polysyllables (Gozzard et al., 2006). Moreover, some researchers have used Strand's 10-point checklist (Shriberg et al., 2011) as a diagnostic tool in their studies (e.g., Shriberg et al., 2017; Zuk et al., 2018). It is evident that in diagnosing CAS, researchers rely on their perceptual judgments or subjective opinions. As of now, Saudi Arabia does not have an assessment tool for diagnosing CAS. The following section presents several assessment tools available for diagnosing CAS in English-speaking children and only one study has been conducted for diagnosing CAS in Arabic-speaking children in the Egyptian dialect, most of which are not reliable or have not yet been validated.

1.12.1 Verbal Motor Production Assessment for Children-Revised (VMPAC-R)

The Verbal Motor Production Assessment for Children- Revised (VMPAC-R; Hayden & Namasivayam, 2021) was developed to examine oral structures in tasks related to feeding and the motor functions of speech among children aged 3 to 12 years. This tool was evaluated and shown to have partial evidence of validity (Gubiani et al., 2015). The VMPAC-R instrument assesses the following: oromotor control, which relates to verbal production and nonverbal movements of the jaw, lips, and tongue; total motor control (such as postural tone, breathing, and phonation); connected speech and language; speech characteristics; and speech and oral sequencing. As an example, Shriberg et al. (2003a) used the VMPAC to screen children aged 3 to 12 years, assessing their lexical stress as a diagnostic feature for CAS. They found that children with CAS had prosodic difficulties resulting from deficits in speech praxis and motor control.

1.12.2 Madison Speech Assessment Protocol (MSAP)

The Madison Speech Assessment Protocol (MSAP) is a test that measures cognitive, linguistic, behavioural, and developmental risk factors, as well as measures of speech, prosody, and voice (Shriberg et al., 2010). This tool assists in differentiating CAS from other SSDs. This test consists of 25 tasks, including the following: the Goldman Fristoe Test of Articulation, which is 'a test is used to evaluate the articulation of consonants sounds in words and sounds in sentences' (Goldman & Fristoe, 2000); a hearing screening test; a conversational speech sample; a lexical stress task; a task involving the use of simple and complex words and sentences; a non-word repetition task; an emphatic lexical task; a multisyllabic task; a task related to rhotic and sibilant consonants; a DDK task; a sustained vowel and consonant test; an orofacial examination; oral and written language scales; and the Kaufman Brief Intelligence Test (Shriberg et al., 2010).

1.12.3 Single-Word Test of Polysyllables, and Oral and Speech Motor Control Protocol (OMA)

Murray et al. (2015) carried out a study to provide a clinically feasible and reliable assessment test to identify the characteristics of CAS rather than relying solely on expert opinions. The participants were children aged 4 to 12 years who had been identified by a clinician as being suspected of having CAS. The diagnosis of CAS relied on the 3 consensus-based features in the ASHA (2007) position statement and any 4 of the 10 characteristics in Strand's 10-point checklist (Shriberg et al., 2011). This checklist includes lexical stress; a slow rate of speech; syllable segregation; the transition into vowels, consonants, or vowel distortions; groping; voicing errors; intrusive schwa; slow DDK rate; difficulty achieving initial articulatory configuration; and gradually increasing difficulty with longer or more phonetically complex words.

The Single-Word Test of Polysyllables (Gozzard et al., 2008) has been utilised to examine sound, syllable sequencing, articulation, and lexical stress accuracy (prosody). Additionally, the Oral and Speech Motor Control Protocol (OMA), which includes the rate of DDK, has been used to examine anatomical and physiological abnormalities within oral mechanisms (Robbins & Klee, 1987). Other studies have supported the reliability of these tests in differentiating CAS from other speech disorders. Clinicians were able to elicit challenging motor behaviours that demonstrated deficits in motor planning and programming in CAS through a real-word polysyllabic test and the OMA, specifically in the DDK task concerning the non-word /pətəkə/ (Murray et al., 2015a).

1.12.4 Kaufman Speech Praxis Test (KSPT)

The Kaufman Speech Praxis Test (KSPT; Kaufman, 1995) is a norm-referenced diagnostic assessment tool used to assist in identifying and treating CAS. This protocol assesses children aged 2 years to aged 5 years and 11 months. The test relies on measuring the child’s imitation of the clinician and making it possible to find where the child’s speech system is breaking down. The test includes four aspects to be evaluated (Gubiani et al., 2015):

1. Extensive oral movements
2. Simple oral movement (isolated vowel, e, a), vowel movement + vowel /ou, ai/, simple consonants /p,b,m,d,t/ CVCV /mama, papa/ (VCV, CV, CVC)
3. The complex phonemic and syllabic level, such as complex consonant production /k,f,v,g/, front to back (t→k) / back to front (g→d), complex disyllabic, and complex words
4. Spontaneous speech

1.12.5 Nuffield Dyspraxia Programme Assessment (NDP3)

In the Nuffield Dyspraxia Programme Assessment (NDP3; Williams & Stephens, 2004), it measures the production of consonants and vowels in isolation, single words with different phononotactic structures, phrases, and sentences, as well as oromotor skills and DDK skills. In addition, the assessment aims to identify the segmental and suprasegmental features of CAS, allowing it to be differentiated from other conditions. It is possible to plan interventions based on the profile of skills demonstrated at different levels of the phonotactic structure (Williams & Stephens, 2004, 2010; RCSLT, 2024). In addition, the NDP3 recommended intervention has a more robust evidence base, making it suitable for younger children and those with more severe difficulties (Murray et al., 2015; McCabe et al., 2024).

1.12.6 Egyptian Study for Developing an Assessment Tool in Arabic

A recent study by Abdou et al. (2020) sought to develop an Arabic screening tool in the Egyptian dialect for children with CAS aged between 4 and 16 years. The study recruited 10 children with suspected CAS, 20 children with phonological disorders, and

40 typically developing children. Four items were included in the Arabic test battery for CAS: the receptive–expressive discrepancy, using the Preschool Language Scale, Fourth Edition (Arabic version); the consistency of speech productions, using the Mansoura Arabic Articulation Test (Abou-Elsaad et al., 2009); the assessment of the speech and non-speech motor tasks of the articulators; and the assessment of prosody. The children with CAS were examined using a variety of tools. For example, the Mansoura Arabic Articulation Test was used to assess the consistency of speech production among 25 words; the participants were shown pictures and asked to name what they saw 3 times, with a 10-minute interval between each target (or separated by another activity). A speech motor assessment task included three isolated vowels, three isolated consonants, three CV syllables, four CVC syllables, two clusters of CVCC, two disyllabic words, two trisyllabic words, two phrases, two sentences, and counting (automatic). The prosody assessment involved commenting on five pictures with correct prosody.

They found an apparent discrepancy in receptive–expressive language in the group of children with apraxia, caused by their speech involvement. Moreover, their results supported the hypothesis that children with CAS experience inconsistent production, using a consistency subtest. In contrast, they did not find any significant evidence of a relationship between oral apraxia and CAS. There were significant differences between the CAS group and other groups on the speech motor items. In addition, the CAS group had the lowest score on the DDK test. Last, there were differences between the two groups in the results of the prosodic test part.

The Arabic screening tool thus showed reliability and validity. Additionally, the sensitivity and specificity were 100%, demonstrating its usefulness in identifying normally developing children versus those with CAS or phonological disorders (Abdou et al., 2020). However, the criteria for choosing words in the consistency, prosody, and speech motor tasks were not clearly defined. When choosing words for an articulation test to measure consistency, the familiarity of the words, syllable shapes, and early phoneme development must be taken into consideration. In addition, certain vowels and consonant sounds were used without identifying them or explaining why they were used. As part of the speech motor task scoring, three points were given: correct response, correct response with cueing, and incorrect response (Strand et al., 2013; Gubiani et al., 2015). As the researchers incorporated vowels and consonants into one scoring system, they did not specify whether each child's speech production would be considered accurate if the child experienced developmental errors. There was also no mention of the amount of cueing that would be provided for each child.

1.12.7 Dynamic Evaluation of Motor Speech Skill (DEMSS)

The Dynamic Evaluation of Motor Speech Skill (DEMSS) is a criterion-referenced assessment tool that was developed to help in the differential diagnosis of severe SSDs in children, including CAS (Strand & McCauley, 2019). It is the only test for diagnosing CAS for which the reliability and validity have been demonstrated (Gubiani et al., 2015). The DEMSS was designed for use among children aged three years and older who have severe speech impairment with limited speech production, reduced vowel differentiation, and reduced phonemic or phonetic inventories but who are able to imitate sounds. The DEMSS can be used by clinicians to determine whether a child has difficulties in the planning and programming of specific speech movements. It was designed to examine a child's speech movements even if the child does not produce many words, syllables, or sounds. However, it does not address the entire speech and language system.

The test consists of simple words that vary in their vowel content, prosodic content, phonetic complexity, and length. Therefore, this test will not serve as a phonological or articulation test since both of them sample all segments of a language. The DEMSS provides stimuli and scoring procedures intended to allow the observation of features and characteristics associated with CAS (ASHA, 2007; Strand, 2003). This includes prosodic inaccuracy (e.g., incorrect lexical stress), inconsistency in vowels and consonants across repeated trials, and lengthened and disrupted coarticulatory transitions between syllables and sounds (i.e., articulatory inaccuracy). Strand and McCauley (2019) cited their rationale for developing the DEMSS as being the need for a criterion-referenced tool for use among children who are young and/or severely speech impaired, to facilitate a differential diagnosis of SSDs; they also sought to create a dynamic tool to facilitate judgments of severity and prognosis, and a tool that would better facilitate treatment planning and stimulus selection.

1.12.7.1 DEMSS reliability and validity

A measurement instrument's integrity and quality can only be assured by evidence of its validity and reliability (Kimberlin & Winterstein, 2008). Reliability evidence is required to develop a test because it determines whether the test is susceptible to a variety of sources of error (e.g., variations caused by re-administrations, testers, and within-tester inconsistencies). This is particularly true for motor speech examinations of children, as the nature of young children and their response to artificialities in speech testing present a high degree of error possibility (Kent et al., 1987, as cited in Strand et al., 2013). ‘Validity’ refers to the degree to which a test measures what it is supposed to measure.

In a study published by Strand et al. (2013), the authors examined the DEMSS’s intra-rater stability, inter-rater stability, and test–retest stability, as well as its construct validity for identifying children with CAS and with SSDs. The reliability was assessed using two methods: percent agreement and intraclass correlation coefficients (ICCs); specifically, the degree of agreement between raters on the same test was measured using percent agreement, while the degree of correlation between repeated measurements of the same participant was measured using an ICC.

It was found that the DEMSS has acceptable intra-rater, inter-rater, and test–retest reliability levels. There was an 89% test–retest mean agreement for the DEMSS, as the children’s performance across two test administrations was quite consistent, indicating a high level of reliability (or low level of error). With an intra-rater agreement of 89%, the clinicians rated the children’s performance on the DEMSS consistently, with little significant difference between them. The inter-rater reliability was 91%, indicating an acceptable level of reliability between clinicians. A validity cluster analysis identified three major groups of children: those with clinically significant CAS, those with mild CAS, and those with other SSDs. The probability of correct classification (i.e., the discrimination of children with or without CAS) was greater than 90%.

1.12.7.2 DEMSS content

The DEMSS incorporates 8 subtests containing 60 utterances, focussing on using early developing consonants with a range of vowels in different early developing syllable shapes. Items are judged according to four sub-scores: vowel accuracy, overall articulatory accuracy, prosodic accuracy, and consistency. The DEMSS is a reliable and valid dynamic assessment that allows clinicians to offer cues or help, such as simultaneous production, a slowed rate of speech when prompting, and repeated attempts to produce utterances (Strand et al., 2013). The time required for the administration and scoring of the DEMSS ranges from 10 to 30 minutes. In some cases, children who need extra cues or attention may require up to 40 minutes. The following table (Table 1.1) demonstrates the utterance types (i.e., subtests) and judgments associated with the DEMSS.

Table 1.1. *Description of the content of the DEMSS.*

Utterance type	**Number of items**	**Examples**	**Number of judgments for each variable (yielding a total of 186 judgments for the 60 items)**			
			Overall articulatory accuracy	**Vowel accuracy**	**Prosodic accuracy**	**Consistency**
Consonant–vowel (CV)	10	Me, hi, toy	10	10		10
Vowel–consonant (VC)	10	Up, eat, out	10	10		10
Reduplicated syllables	4	Papa, boo-boo	4	4	4	
Consonant–vowel–consonant (CVC1; same first and last consonant)	6	Mom, peep, dad	6	6		6
CVC2 (different first and last consonant)	10	Mad, bed, hop	10	10		10
Disyllabic 1 (one consonant, two vowels)	6	Baby, puppy	6	6	6	
Disyllabic 2 (more varied phonemes)	8	Bunny, happy	8	8	8	
Multisyllabic	6	Banana, potato	6	6	6	6
Total	60		60	60	24	42
Range of possible scores			(0-240)	(0-120)	(0-24)	(0-42)
Total possible score			426			

1.12.7.3 Basic rules for scoring

Vowel accuracy. Scoring begins after the child's first attempt at imitation. It is essential that the vowel is scored on the first attempt for the stressed syllable in a disyllabic and multisyllabic word. A clinician gives a score of (2) if the vowel in the stressed syllable is produced accurately, (1) indicates uncertainty (i.e., when the tester is unsure if the imitation was correct), (0) if vowel distortion occurs, and (X) for a refusal or no attempt.

Prosodic accuracy. Scoring begins after the child's first attempt at imitation. A clinician gives a score of (1) for a correct response, (0) for an incorrect response, and (X) for a refusal or no attempt.

Overall articulatory accuracy. A clinician gives a score of (4) for an accurate production at the first attempt, (3) for a consistent developmental substitution error at the first attempt, (2) for a correct response after one cued trial or after immediate self-correction, (1) for a correct indirect imitation after additional cued trials, (0) for an incorrect indirect non-cued trial after all cued attempts, and (X) for a refusal or no attempt.

Consistency. A clinician gives a score of (1) when production is consistent across all trials, (0) when production is inconsistent across more than two trials, and (X) when production is refused or no attempt is made.

1.12.7.4 Uses of dynamic assessment in the DEMSS

The dynamic nature of the DEMSS allows for the provision of systematic cueing and the use of strategies such as simultaneous production or a slowed rate. Repeated attempts to produce a word can be made, which is accounted for in the scoring. When a clinician uses a dynamic assessment method, it may show evidence of inconsistent production for vowels and consonants in repeated productions of words. The scoring allows for subsequent non-cued imitations, which show a child's change in performance; for example, after a clinician implements supports, such as temporal, tactile, and visual cues, the child's accuracy in producing words may improve, revealing their emerging skill. Further, as the child tries to imitate specific speech movements with cueing help, they may increase their effort and/or attention towards acquiring a specific temporal or spatial target. In this way, it is possible to observe timing errors, segmentation, groping, and other features related to CAS that are frequently not observable in non-cued repetitions or spontaneous speech (Strand & McCauley, 2019); in spontaneous speech, a child will always produce words they can say accurately in favour of those for which they make persistent errors, which limits the observer from noticing features that may occur when the child tries to produce novel words.

The use of cueing also makes it possible to judge the severity of the disorder and determine the prognosis, which in turn inform an effective treatment plan. For instance, when a child has difficulty producing a target even with cueing assistance or needs significant cueing to produce the target correctly, this shows that the problem is severe, and careful consideration is needed regarding how to achieve optimum progress. Moreover, as different types of cues are used in the assessment, this provides evidence of the most beneficial help to include in treatment. Errors observed in vowels and across syllable structures during the assessment will also help the clinician to choose the content and complexity of the early target list (Strand & McCauley, 2019).

1.12.7.5 Suggested hierarchy of cues

When the initial attempt is incorrect, the clinician provides the first cued trial. First, the examiner tells the child to pay attention to the clinician's face while producing a slightly slower auditory model. At this time, you may also use a gesture to emphasize the clinician's articulation configuration. For instance,

- Pointing with thumb and forefinger to rounded or closed lips
- Making a hand gesture (e.g., fingers slowly closing downward toward the thumb to signify closing the mouth a bit)
- Pointing to retracted lips.

When the child's response is incorrect, the clinician shows the model and asks the child to repeat it simultaneously with the clinician.

1.12.7.6 Types of cueing not allowed during the DEMSS

- Separating phonemes within a syllable
- Using a mirror for cueing during testing can cause distractions and increase test administration time.

1.12.8 Adaptation of the DEMSS in Other Languages

Two studies have been conducted on adapting or translating the DEMSS in different languages: Brazilian Portuguese and Swedish. Chinese researchers have also inquired whether it could be adapted for Chinese, which has a different language structure than does English (Wong et al., 2022). The content and scoring system of this tool, however, are highly centred around features that are commonly used for diagnosing CAS in English, so it is unclear if it could be used for syllable-timed languages (such as Chinese). The following sub-sections will discuss the adaptation of the DEMSS into two different languages.

1.12.8.1 Brazilian Portuguese

The diagnosis of CAS in Brazil was difficult due to the lack of standardised assessment tools. Therefore, DEMSS was adapted into Brazilian Portuguese (DEMSS-BP; Gubiani et al., 2021). The adaptation process occurred over six stages. First, the administration and scoring systems were translated and back translated. Second, new stimuli were developed for Brazilian Portuguese. Third, expert judges determined the most appropriate words to indicate their presence in young children's vocabulary in terms of the words' representativeness and the children's stage of phoneme development. Fourth, the judgement of typical children's speech and language ability were reviewed to ensure word familiarity. Fifth, in a pilot study, the DEMSS-BP was administered to one child with CAS. Sixth, based on the analysis of this, the adapted DEMSS-BP was deemed to have an adequate level of content validity. The authors are now working on adding new tasks, testing a larger sample, and further examining the reliability and validity of the test, as the DEMSS-BP requires additional research to ensure its robustness. However, their findings up to now have contributed to overcoming the lack of evidence in clinical practice and research in Brazil related to CAS diagnosis (Gubiani et al., 2021)

Following the creation of the DEMSS-BP, a study by Keske-Soares et al., (2018) was undertaken to compare the performance of different groups of children utilising the DEMSS-BP. Six children with CAS, six children with typical speech language development, and six children with phonological disorders—with ages ranging four years and six months to five years and eight months—were examined in two components of the DEMSS-BP: overall articulatory accuracy and consistency. The children with CAS achieved the lowest scores among the groups. However, no significant differences were found between typical children and the phonological disorders group. The main difficulties faced by the children with CAS were monosyllabic words, duplicated syllables, and polysyllabic words. Also, while there is no doubt that the phonological disorders groups exhibited systematic substitutions, they did benefit from visual, auditory, tactile, and articulatory cues. In contrast, the children with CAS experienced speech production inconsistencies when repeating words at different times, and they still struggled with longer words even after being provided with cues. The main limitation of this study is the small number of participants. However, it is clear that overall articulatory accuracy and consistency are crucial variables for the differential diagnosis of SSDs.

1.12.8.2 Swedish

In response to the DEMSS, a Swedish tool was created to evaluate motor speech planning and programming deficits. As the first motor speech examination in Swedish, the Dynamisk motorisk talbedomning (DYMTA) is slightly different from the DEMSS, as it includes the DYMTA-A and DYMTA-B. As a whole, the DYMTA was developed for use among a wide range of ages and different levels of severity; thus, it contains both simple and complex words. The DYMTA-A focusses on early developing sounds and syllable structures for young children and/or children with severe SSD. The DYMTA-B contains more difficult words that require more complex transitional movements for children with less severe SSD (Rex et al., 2021a)

Rex et al. (2021a) evaluated the reliability and validity of DYMTA. In their study, preliminary evidence suggested good reliability and validity. It was found that this instrument has an acceptable level of intra- and inter-rater reliability. The DYMTA was shown to be a good tool for distinguishing between children with CAS and those without CAS. The study's main limitation is its small sample size. Rex et al. (2021b) examined the performance of typically developing Swedish-speaking children aged three to eight years on the DYMTA-A and DYMTA-B tests. Overall, all age groups scored over 90% in both tests, indicating that young children at the age of three demonstrate good motor speech abilities.

1.13 Telehealth During COVID-19 for Speech and Language Services

The COVID-19 outbreak forced a practice change from face-to-face care to telehealth around mid-March 2020. Pandemic restrictions such as lockdowns and social distancing measures lead to the shutdown of commercial and institutional facilities, affecting several healthcare services. Specifically, SLTs managed these changes by shifting service delivery to telehealth (Lincoln et al., 2015; Werfel et al., 2021). It helped sustain the support per the safety measures established to protect everyone's health. Telehealth facilitated the delivery of assessment and therapy, hence continuing to support the patients during the pandemic (Campbell & Goldstein, 2022). This also emphasized the role of telehealth in delivering vital services in emergencies to avoid disrupting speech and language therapy.

COVID-19 has greatly impacted the healthcare delivery system, with the telehealth system being enhanced significantly. Telehealth, which means delivering care services or information using telecommunications technologies, has emerged as a significant resource during the pandemic. ASHA embraces telehealth to provide speech and language services while stating that telehealth should involve as much patient confidentiality, safety, and service quality as face-to-face services (ASHA, 2020b, 2020c).

The application of telehealth, especially in speech sound, has been an area of research interest. Therefore, ASHA pointed out that telehealth therapy may not be perfect, encouraging the SLTs to adhere to the principles of the practice and the Code of Ethics for remote services (ASHA, 2020a). Most paediatric assessments are not tested for validity and reliability when administered remotely (ASHA, 2020c). According to Werfel et al. (2021) also mentioned that parents were worried about undertaking teleassessments while unsure of a child's capacity to engage in meaningful remote assessments. These parents were concerned with issues such as the child's ability to stay focused, how distractible or difficult the child was, and even issues with technology that, in turn, could impact and bias the results (Werfel et al., 2021). Deviations from standardized evaluations, such as prompting or changing delivery, may negatively affect the interpretation of scores or result in future in-person reassessments for valid results (ASHA, 2020c). The Campbell and Goldstein study agreed that telehealth is practically similar to conventional face-to-face communication. For instance, Campbell and Goldstein (2022) conducted a study that determined that the application of video conferencing technologies produced similar results to face-to-face ratings on issues of dependability and efficacy for assessments and therapeutic approaches. These findings prove that telehealth is a practical approach to delivering interventions and can be considered a comparable replacement for face-to-face contact (Freckmann et al., 2017). However, people prefer face-to-face communication as they believe it is more effective and direct communication is possible, thus increasing the chances of accurate diagnosis and treatment (Campbell & Goldstein, 2022).

The validity or reliability of the scoring system that happens through telehealth is also an essential factor to look at (Campbell & Goldstein, 2022). The practicality of scoring systems that quantify speech sound outcomes through other means is critical in achieving the desired level of accuracy within the process. Interrater reliability is also considered in the study by Campbell and Goldstein (2022), concluding that tests conducted through a telehealth model have the same reliability as those performed face-to-face. Although SLTs rely on picture-based assessments in articulation testing, there is a lack of sufficient substantiation of the validity and reliability of standardized speech tests conducted remotely (ASHA, 2020a). Waite et al. (2006) provided acceptable reliability for using the video-conferencing method in scoring the Single Word Articulation Test compared to face-to-face communication. Additional challenges exist for SLTs during videoconferencing sessions, especially in the synchronous mode, compared to direct communication; this is particularly true in cases involving picture stimuli (Hall-Mills et al., 2021). With both limited time and other potentially related variables, SLTs need to be cautious about monitoring the quality of audio and video in order to record children's responses accurately. Furthermore, challenges such as poor broadband and technology breakdowns are other factors that reduce the validity of speech sound assessment through the Internet (Freckmann et al., 2017).

For telehealth to be effective, there are several tools as well as infrastructures that must be in place. Accessibility through a reliable and sufficient internet connection and devices is critical in facilitating assessment and therapy sessions through telehealth (Campbell & Goldstein, 2022). In addition, Campbell and Goldstein (2022) emphasize that telehealth can reliably score speech-sound assessments during the COVID-19 pandemic, highlighting its importance for the continuous provision of speech-language services. This Study confirms that telehealth assessments are as accurate as face-to-face assessments, provided that assessors have received sufficient training and telecommunication facilities (Lincoln et al., 2015). This validation strengthens the argument that telehealth can bring accurate diagnosis and therapy outcomes from a distance, eradicating disruptions attributed to pandemic limitations. However, as the telehealth system progresses as an essential healthcare intervention, the significance of having a stable technological background and compliance with guidelines for SLTs and speech and language therapy remains vital for the efficiency of the telehealth solution in speech and language therapy (ASHA, 2020a).

1.14 Purpose of the Current Study

1.14.1 General Aim

The aim of this study was to develop an adapted version of the DEMSS in the Saudi dialect of Arabic (the Ar-DEMSS). This tool can assist Saudi SLTs in the differential diagnosis of SSDs in children aged three years and older who have speech impairment. This test was designed for children who have limited speech output or no functional verbal communication but who can at least attempt imitation. The DEMSS provides evidence of difficulties in praxis or motor planning and programming for speech.

1.14.2 Rationale for Developing the Ar-DEMSS

Following is the rationale for the development of the Ar-DEMSS:

1. There was previously no assessment tool for severe speech disorders in Saudi Arabic-speaking children. The Ar-DEMSS was developed as a preliminary tool to provide a general overview of CAS characteristics in Saudi children.

2. Dynamic assessment is an important and valuable aspect of differentially diagnosing children with SSDs (Strand & McCauley, 2019).
3. Support is needed to help plan an effective intervention for severe speech disorders in Arabic.
4. The DEMSS has been successfully translated to other languages, including Brazilian Portuguese (Gubiani et al., 2021) and Swedish (Rex et al., 2021a, 2021b).

1.14.3 Specific Aims

The specific aims of this study were as follows:

1. To develop an adapted version of the DEMSS for use in Arabic
2. To administer the adapted test among 49 Arabic-speaking children aged between 3 and 7 years
3. To interpret the test results in line with the DEMSS and look specifically at those children with a suspected CAS profile
4. To present a more detailed profile of two to three children with suspected CAS profiles using a case series

1.14.4 Research Questions

To achieve the above stated aims, the following research questions were posed:

Research Question 1: How do typically developing Arabic-speaking children aged 3 to 7 perform on the Ar-DEMSS in terms of (a) their total score and (b) their subscores related to vowel accuracy, prosody, overall articulatory accuracy, and consistency?

Research Question 2: How do Arabic-speaking children with CAS perform on the Ar-DEMSS in terms of (a) their total score and (b) their subscores related to vowel accuracy, prosody, overall articulatory accuracy, and consistency?

Research Question 3: What are the speech characteristics of Arabic-speaking children with CAS aged 3 to 5?

Chapter 2 - Arabic Phonology

2.1 Background to the Arabic Language

Arabic is one of the most widely spoken languages in the world. It is used by roughly 422 million native and non-native speakers. Arabic is an official language in 20 countries extending from Western Asia to North Africa, including Morocco, Algeria, Mauritania, Tunisia, Libya, Egypt, Sudan, Djibouti, Somalia, Saudi Arabia, Kuwait, Bahrain, Qatar, the United Arab Emirates, Oman, Yemen, Jordan, Syria, Iraq, and Lebanon (Watson, 2002, p. 8). Arabic was officially made the sixth language of the United Nations in 1973, alongside Spanish, English, French, Russian, and Chinese (United Nations, 2020).

Arabic is a Semitic language, a branch of the Afro-Asiatic languages that also includes Ethiopian and Hebrew. As Islam spread, Arabic became the dominant language of North Africa and the Middle East, extending far beyond the Arabian Peninsula (Comrie, 2008). As Arabic is the predominant language spoken in the Middle East (Alhuri, 2015), it is spoken by most Muslims as well as by many millions of Jews and Christians (Alhuri, 2015). Many non-native speakers use Arabic for religious purposes, such as reading the Quran and prayer books (Abdelhadi, 2017). Before the appearance of the Prophet Mohammed and Islam, Arabic was unrecognised and unknown (Farghaly, 2010); however, in the seventh century, when Islam began to spread, Arabic became an international language.

According to Alshamrani (2012), there are several forms of Arabic. Classical Arabic is the language of the Quran; Modern Standard Arabic is the language used in education, official speeches, religious ceremonies, and the media; and colloquial Arabic is the informal form of the language for everyday use. Ferguson (1956) defined ‘diglossia’ as the presence of two or more forms of a language, such as a prestigious high form (e.g., Modern Standard Arabic) and a low form with no official status (e.g., colloquial Arabic dialects).

Arabic can be distinguished from other languages in terms of morphology, phonology, syntax, and semantics. For example, its sentence structure differs from that of English; in classical Arabic, sentences follow a verb–subject–object pattern, which would be grammatically inappropriate in English. However, some Arabic dialects use the subject–verb–object pattern (Comrie, 2008). Jabbari (2012, 2013) compared Modern Standard Arabic and the colloquial Egyptian and Iraqi dialects and found significant differences between these forms of Arabic in terms of syntax, phonology, morphology, and lexicon. The various dialects of colloquial Arabic—which include Egyptian, Tunisian, Algerian, Levantine, Iraqi, Gulf, and Maghrebi Arabic (Zaidan & Callison-Burch, 2013)—mean that different speech communities may either struggle to or be unable to understand one another. For example, Levantine Arabic speakers may have trouble understanding the Moroccan dialect due to its French and Berber influences.

2.2 Saudi Arabia

As this study focussed on developing an adapted version of the DEMSS in the Saudi dialect of Arabic, it is important to explore and understand this region’s language system. Saudi Arabia is home to the holy cities of Mecca and Medina; it is the birthplace of the Prophet Mohammed, the Quran, and Islam. Saudi Arabia occupies 80% of the Arabian Peninsula and is divided into four main parts: Al Hijaz, Najd, Asir, and Al Hasa. For administrative purposes, it is divided into five provinces: the eastern province (Al Ahssa), the central province (Najd), the western province (Al Hijaz), the southern province (Asir), and the northern province (Tabouk; AlMunajjed, 1997, p. 1). As is the case in many countries, various dialects are spoken within Saudi Arabia. Najdi is spoken in and around Riyadh (Ingham, 1994, p. 1), Shargi is spoken in the eastern province, and Hijazi is spoken in the western province, including in Jeddah, Taif, and the holy cities of Mecca and Medina. The Hijazi dialect is not considered pure Saudi Arabic due to its degree of borrowing from the Jordanian, Egyptian, and Palestinian dialects (Margaret, 1975).

2.3 Arabic Phonological System

Arabic is a Semitic language, which can be distinguished from other languages because of the inclusion of a large number of consonant sounds and a restricted vocalic system. Its phonological system differs from that of other languages due to the inclusion of pharyngeal and laryngeal sounds. Modern Standard Arabic contains 28 consonants and 6 vowels, including 3 short vowels and 3 long vowels. Consonants are produced with the complete or partial closure of the vocal cavity, while vowels are articulated without any obstruction in the vocal tract. Short vowels are not expressed in written graphemes but may be demonstrated with diacritics (Sabir & Alsaeed, 2014).

2.3.1 Phonological Features of Arabic

As Watson (2002, p. 1) noted, the Arabic sound system has a number of distinctive features, including uvular fricative, pharyngeal (the middle of the throat), pharyngealized ‘emphatic’, and laryngeal sounds (at the larynx). McCarthy (1989) described Arabic as having guttural properties (all larynx sounds), as some Arabic sounds are produced in the posterior region of the vocal tract, such as the pharyngeal sounds /ħ/ and /ʕ/, the laryngeal sounds /h/ and /ʔ/, and the uvula sounds /χ/ and /ʁ/. Further, Arabic contains unique ‘emphatic’ consonants that require the retraction of the root of the tongue towards the wall of the pharynx, including the following: /t̲/, /d̲/, /ð̲/, /s̲/, and /q/ (the plain counterparts of which are /t/, /d/, /ð/, and /s/; Amayreh & Dyson, 1998).

2.3.2 Consonants

Compared to English, the Arabic sound inventory includes additional sounds and excludes others (Amayreh & Dyson, 1998). Gadoua (2000) classified the Arabic consonants according to their place of articulation, manner of articulation, and vibration of the vocal folds (i.e., whether voiced or voiceless; see Table 2.1). These sounds are thus divided into eight plosives, thirteen fricatives, one affricate, one flap, one lateral, two nasals, and two semi-vowels.

2.3.3 Place of Articulation

'Place of articulation' refers to the point at which the flow of air is obstructed in the vocal tract to produce a sound. There are many different places of articulation, as shown below in Table 2.2. Bilabial sounds (e.g., /b/, /m/, and /w/) are produced between the upper and lower lips. Labiodental sounds (e.g., /f/) are produced through constriction between the upper teeth and lower lip. Dental sounds (e.g., /ð̲/, /θ/, and /ð/) are made by placing the tip of the tongue between the upper and lower teeth. Alveolar sounds (e.g., /d/, /t/, /d̲/, /t̲/, /z/, /s/, /l/, /n/, and /r/) are produced by touching the tip of the tongue to the alveolar ridge, which is the hard ridge behind the upper teeth. Postalveolar sounds (e.g., /ʤ/) are articulated by placing the tongue behind the alveolar ridge. Palatal sounds (e.g., /ʃ/ and /j/) are made by placing the tongue body against the hard palate. Velar sounds (e.g., /k/) are produced by touching the back of the tongue to the soft palate (i.e., the velum). Uvular sounds (e.g., /q/, /x/, and /ʁ/) are produced when the back of the tongue touches the uvula. Pharyngeal sounds (e.g., /ħ/ and /ʕ/) are produced at the pharynx. Glottal sounds (e.g., /h/ and /ʔ/) are produced at the glottis (Al-Ani, 1970).

Table 2.1. *The Arabic voiced versus voiceless sounds.*

Voiced	/b/, /m/, /ð/, /ð̲/, /n/, /d/, /z/, /l/, /r/, /j/, /w/, /ʁ/, /ʕ/, /ʤ/, /d̲/
Voiceless	/f/, /θ/, /t/, /s/, /q/, /k/, /χ/, /ħ/, /ʔ/, /s̲/, /t̲/, /ʃ/, /h/

Table 2.2. *Place and manner of articulation of sounds in Arabic (Amayreh & Dyson, 1998).*

	Bilabial	**Labiodental**	**Dental**	**Alveolar**	**Post-alveolar**	**Palatal**	**Velar**	**Uvular**	**Pharyngeal**	**Glottal**
Plosive	/b/			/t/ /d/ /t̲/ /d̲/			/k/	/q/		/ʔ/
Fricative		/f/	/θ/ /ð/ /ð̲/	/s/ /z/ /s̲/		/ʃ/		/χ/ /ʁ/	/ħ/ /ʕ/	/h/
Affricate					/ʤ/					
Trill				/r/						
Lateral				/l/						
Nasal	/m/			/n/						
Approximate glide	/w/					/j/				

2.3.4 Vowels

Modern Standard Arabic contains three short and three long vowel phonemes: /a/, /aː/, /i/, /iː/, /u/, and /uː/ (see Table 2.4 and Table 2.5). In addition, two diphthongs (/aj/ and /aw/) are maintained in some dialects (e.g., San'ani in Yemen and parts of the Arabian Peninsula), while other dialects (e.g., Cairene, some Levantine dialects, central Sudanese, and Hijazi) use /e:/ and /o:/ (see Table 2.3). Arabic vowels are almost all allophonic across the dialects. This means that the vowel sounds are affected by adjacent consonant sounds, especially when these are pharyngeal and emphatic. Vowels do not occur in the initial position in Arabic words. Further, all vowel sounds are voiced, and their production is based on the height of the tongue, advancement (front or back), and rounding of the lips (Watson, 2002; see Fig. 1).

Table 2.3. *Example of /o:/ and /e:/ vowels.*

N***aw***m	/n**o:**m/	(sleep)
B***aj***t	/ **be:**t/	(house)

Table 2.4. *Short vowels in Arabic*

	Front	**Central**	**Back**
Close	/i/		/u/
Open	/a/		

Table 2.5. *Long vowels in Arabic.*

	Front	Central	Back
Close	/i:/		/u:/
Open	/a:/		
Diphthongs	/aj/, /aw/		

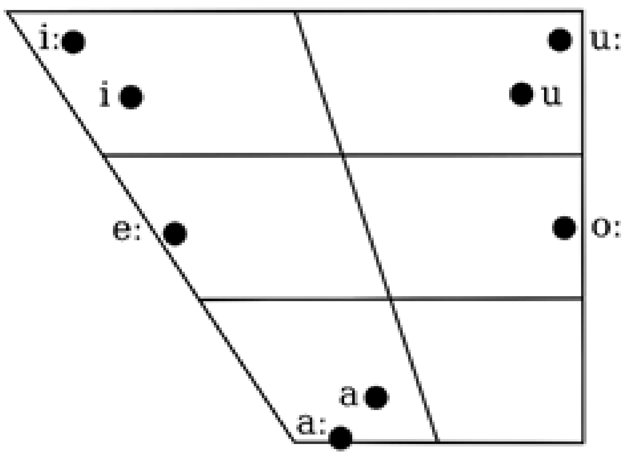

Figure 2.1. *The Arabic vowel chart.*

2.4 Syllable Structure in Arabic

Many studies have analysed the syllable types and structures of Arabic (e.g., Al-Ani & May, 1973; Broselow, 1979, 1980; McCarthy, 1979; Selkirk, 1981). According to Jarrah (1993), syllable weight can take three forms: light syllables, which have a consonant followed by a short vowel (e.g., CV); heavy syllables, which have a consonant followed by a long vowel (e.g., CVV) or a vowel and a consonant (e.g., CVC); and superheavy syllables, which have a consonant followed by one or two vowels, followed by one or two consonants (e.g., CVVC, CVCC, or CVVCC). Watson (2011) described light syllables as open, heavy syllables as closed or open, and superheavy syllables as closed or double-closed.

Arabic syllables must begin with a consonant; an initial vowel is not permitted (Gadoua, 2000). Most researchers have also found that Arabic words cannot start with an initial consonant cluster (i.e., a complex onset, e.g., Aljumah, 2008; Edzard, 2000; Gadoua, 2000; McCarthy, 2005). However, complex onsets are allowed in some dialects, such as Casablanca Moroccan Arabic (Boudlal, 2001), the Hadrami dialect (Al-Saqqaf, 1999), and some Saudi dialects (e.g., Najdi; Prochazka, 1988, p. 22). Table 2.6 outlines the Arabic syllable types and structures.

Table 2.6. *Arabic syllable types and structures.*

CV	**ka**tab	he wrote	light/open
CVV	**saa**kin	Resident	heavy/open
CVC	**jam**al	Camel	heavy/closed
CVVC	sakaa**keen**	Knives	superheavy/closed
CVCC	da**rabt**	I hit	superheavy/closed

2.4.1 Arabic and English Lexical Stress

'Stress' is the more prominent production of one syllable in a word compared to others, making it clearer, higher, longer, and louder than other syllables (Betti & Ulaiwi, 2018; Halpern, 2009; Hussein & Alkumet, 2013). Arabic and English have different lexical stress patterns. In Arabic, stress does not change the meaning of words; however, in English, the position of the stress can differentiate two meanings, such as seen in the noun '**per**mit' and verb 'per**mit**'. In English, stress is considered a word property, with rules that do not need to be explicitly taught; that is, the stress is memorised when the word is learned (Carr, 1999).

Betti and Ulaiwi (2018) identified a number of similarities between Arabic and English lexical stress. Both languages require emphasis on a certain syllable within a word. Stress is attached to each strong syllable, and each word has only one primary stress. Both languages also have different types of stress in words, phrases, and sentences. Articles are not usually stressed, although stress can be applied in English in some cases. Other similarities include that word stress is used for contrast and emphasis, that the most common degrees of stress are primary and secondary, and that stress assignment is associated with phonological and morphological structure.

Betti and Ulaiwi (2018) also found several key differences between Arabic and English lexical stress. First, while the stress rules are fixed and clear in Arabic, giving rules to follow for stress placement, the stress rules vary in English because stress placement is used in a limited number of noun–verb pairs. Second, English pronouns do not receive stress, but Arabic pronouns do. Third, in English, articles, prepositions, pronouns, conjunctions, adverbs, and auxiliaries are stressed for specific purposes. Fourth, in English, stress assignment is determined by phonological, morphological, and syntactic factors, while in Arabic, stress placement is determined by the type and number of syllables within the word. Last, in Arabic, stress is used to discriminate between vowels and consonants; in English, it is used to distinguish between word classes.

According to Himadri and Sharma (2018), English stress follows some rules. For instance, stress is always on a vowel rather than a consonant, and words have only one stressed syllable, although in some long words, it is possible to have a secondary (i.e., smaller) stress. Indeed, English stress is so complex that there are often exceptions to rules. Moreover, as Carr (1999) stated, stress placement is sensitive to syntax. For example, content words (e.g., verbs, nouns, adverbs, and adjectives) receive stress, while function words (e.g., pronouns, articles, and conjunctions) do not.

According to Betti and Ulaiwi (2018), several factors need to be considered in English lexical stress, including whether the word originates from Latin or Greek; whether it is morphologically complex, simple, or compound; and the number of syllables in the word. Regarding this latter consideration, if the word has only one syllable, the primary stress will be on that syllable (e.g., **heart**). If the word is a noun with two syllables, the stress usually will be on the first syllable (e.g., **wa**ter); but there is an exception where the second syllable is stressed (e.g., gui**tar**). If the word is a verb with two syllables, the stress will be on the second syllable (e.g., re**lax**). If it is a verb with three syllables and the final syllable is strong, the stress will be placed on this last syllable (e.g., enter**tain**); if the final syllable is weak, the stress has to be penultimate (e.g., de**ter**mine); and if both the second and final syllables are weak, the stress will be applied to the initial syllable (e.g., **pa**rody). Nouns and adjectives have the same rules. If the word contains five or six syllables, the stress will be antepenultimate and occur on the fourth syllable (e.g., organi**sa**tion).

By contrast, the Arabic stress rules are as follows: the stress always falls on the ultimate syllable if that syllable is superheavy (e.g., ri-**jaal** [men], CV**CVVC**); in monosyllabic words, the stress falls on the ultimate syllable (e.g., **qad** [already], **CVC**); the stress is applied to the penultimate syllable in disyllabic words (e.g., **hi-**ya [she],

CVCV); and in polysyllabic words, the stress falls on the penultimate syllable if it is heavy (e.g., ja-**dii**-dun [new], CV**CVV**CVC) and on the antepenultimate syllable if the penultimate syllable is light (e.g., **ka**-ta-ba [he wrote], **CV**CVCV; ka-**li**-ma-ti [my word], CV**CV**CVCV).

2.5 Phonology of English

English has been adopted globally as an international language. As part of the Germanic branch of the Indo-European language family, English differs from Arabic in terms of semantics, syntax, phonology, and morphology. English has 24 consonant phonemes and 20 vowel phonemes. As in Arabic, sounds are classified based on place of articulation, manner of articulation, and voicing (see tables 2.7, 2.8, and 2.9).

Table 2.7. *The English voiced versus voiceless sounds.*

Voiced	/b/, /d/, /g/, /v/, /m/, /n/, /ŋ/, /l/, /r/, /ʒ/, /ð/, /z/, /j/, /w/, /dʒ/
Voiceless	/f/, /θ/, /s/, /ʃ/, /h/, /p/, /t/, /k/, /tʃ/

Table 2.8. *English phonological system (Bowen, 2015).*

	Bilabial	**Labiodental**	**Dental**	**Alveolar**	**Postalveolar**	**Palatal**	**Velar**	**Glottal**
Plosive	/p/ /b/			/t/ /d/			/k/ /g/	
Nasal	/m/			/n/			/ŋ/	
Trill								
Tap or flap								
Fricative		/f/ /v/	/θ/ /ð/	/s/ /z/		/ʃ/ /ʒ/		/h/
Affricate					/tʃ/ /ʤ/			
Glides (approximant)	/w/			/r/		/j/		
Liquid (lateral approximant)				/l/				

Table 2.9. *Manner of articulation in English (Bowen, 2015).*

Plosive	/p/, /b/, /t/, /d/, /k/, /g/, /h/
Fricative	/f/, /v/, /s/, /z/, /θ/, /ð/, /ʃ/, /ʒ/
Nasal	/m/, /n/, /ŋ/
Lateral liquid	/l/
Gliding semi-vowels	/w/, /j/
Rhotic liquid	/r/
Affricate	/tʃ/, /dʒ/

The differences between Arabic and English phonemes are made clear by comparing tables 2.2 and 2.8 above. English has the bilabial sound /p/ and labiodental /v/, which do not exist in Arabic. In English, the sounds /θ/ and /ð/ are interdental, while /θ/, /ð/, and /ð̲/ are dental in Arabic. Arabic has additional alveolar sounds, including the stops /t̲/ and /d̲/, the trill /r/, and the fricative /s̲/. Meanwhile, English has the additional palatal sounds /ʒ/ and /tʃ/ and a rhotic /r/ that do not exist in Arabic. In English, there are also additional velar sounds (/g/, /ŋ/, and /w/), while Arabic has additional places or points of articulation, including the uvular stop /q/, fricatives /x/ and /ʁ/, pharyngeal fricatives /ħ/ and /ʕ/, and postalveolar /ʤ/. Finally, Arabic has the glottal fricative /ʔ/. The sounds common to both languages are as follows: /b/, /m/, /w/, /f/, /θ/, /ð/, /t/, /d/, /s/, /z/, /n/, /l/, /r/, /j/, /ʃ/, /k/, and /h/.

2.5.1 English Vowels

English vowels differ significantly from Arabic vowels in their quantity (see Fig. 2). English has a large number of vowel phonemes, which also change from one dialect to another. English vowels can be either diphthongs or monophthongs, and they are characterised based on how they are produced (see Table 2.10). Specifically, vowels are differentiated based on the position of the tongue (i.e., front, centre, or back of the oral cavity), the height of the body of the tongue (i.e., high towards the palate or low in the mouth), the degree of lip rounding (i.e., the presence versus absence of lip rounding), and the amount of muscle tension (i.e., more or less tense or lax).

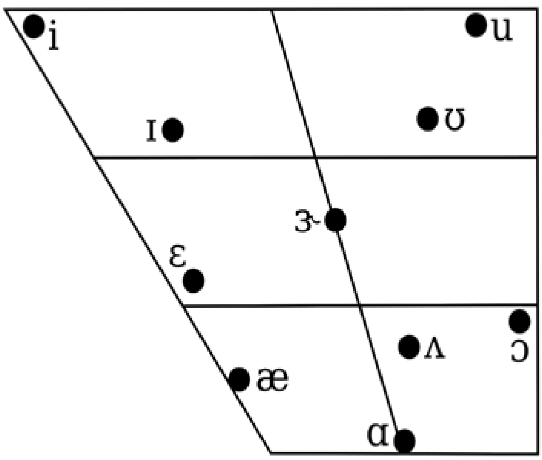

Figure 2.2. *The English vowel chart (Wells, 1982).*

Table 2.10. *Diphthongs and their corresponding sounds in words (Stein & Fabus, 2011).*

Diphthongs	Examples
aɪ	five, eye
aʊ	owl, cow
eɪ	say, eight
əʊ	coat, comb
ɔɪ	coin, boy
ɛə	where, hair
ɪə	here, near
ʊə	poor, boar

2.6 English Syllable Structure

An English syllable can be presented with a small Greek sigma: σ (Carr, 1999). It can be viewed in terms of the onset and the rime. The 'onset' is the initial consonant of a syllable, while the 'rime' comprises a nucleus (a vowel) and a coda (the consonants that follow the nucleus; see example in Fig. 3). English has open syllables that end with a vowel and closed syllables that end with a consonant. In English, a syllable can begin with a vowel or a bi- or triconsonantal sequence. This is not permitted in Arabic. The syllable structures CV, CVC, and CVCC are common in both languages; however, the

VC and V structures are exclusive to English. See examples of open and closed syllable structure in English in Table 2.11.

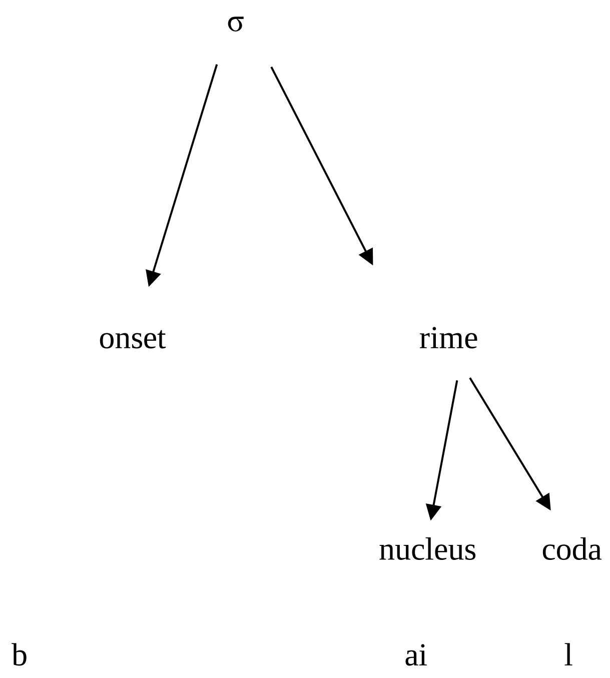

Figure 2.3. *Example of onset and rime using the word 'bile'.*

Table 2.11. *English syllable structure types (Jehjooh, 2009).*

Open syllables	**Word**	**Transcription**
V	eye	/aɪ/
CV	tea	/ti:/
CCV	sky	/skaɪ/
CCCV	spray	/spreɪ/

Closed syllables		
VC	it	/ɪt/
VCC	else	/els/
VCCC	asks	/a:sks/
CVC	fit	/fɪt/
CVCC	silk	/sɪlk/
CVCCC	text	/tekst/
CVCCCC	texts	/teksts/
CCVC	flies	/flaɪz/
CCCVC	straight	/streɪt/
CCVCCCC	prompts	/prompts/
CCVCCC	plants	/plænts/
CCCVCC	springs	/sprɪŋz/
CCCVCCC	splints	/splɪnts/

Note. Consider accent variation such as in the British accent, the word ask would be transcribed as /ɑːsks/ and plants would be /plɑːnts/.

Chapter 3 - Developing the Ar-DEMSS Test

Introduction

Speech and language therapy provision is a newly developing field in Saudi Arabia (Alanzi, 2017). While several studies have discussed phonology and articulation in the Arab region (Dyson & Amayreh, 2000; Hariri, 2016), there is still a lack of research into CAS among children in Saudi Arabia, especially in the Arabic language. As a result, the development of standardised assessment tools has been lacking in the field. Instead, work has focussed on translating or adapting English-language assessment tools into Arabic (Abou-Elsaad et al., 2009). No studies have yet discussed CAS in Saudi Arabia in terms of prevalence, features, assessment tools, or interventions. In Saudi Arabia, CAS is not well known as a distinct disorder, and it tends to be confused in differential diagnosis with other SSDs, specifically phonological disorders. Therefore, the aim of this study was to develop a tool to assist in distinguishing Arabic-speaking children with CAS from those with other SSDs, to allow them to receive effective treatment.

3.1 Description of the DEMSS

The DEMSS was designed for use among children aged three years and older who have severe speech impairment with limited speech production, reduced vowel differentiation, and reduced phonemic or phonetic inventories but who are able to imitate sounds. The DEMSS can be used by clinicians to determine whether a child has difficulties in the planning and programming of specific speech movements. It was designed to examine a child’s speech movements, even if the child does not produce many words, syllables, or sounds; however, it does not address the entire speech and language system.

The test consists of simple words that vary in their vowel content, prosodic content, phonetic complexity, and length. The DEMSS provides stimuli and scoring procedures intended to allow the observation of features and characteristics associated with CAS. This includes prosodic accuracy such as lexical stress, inconsistency in vowels and consonants across repeated trials, and lengthened and disrupted coarticulatory transitions between syllables and sounds (i.e., articulatory accuracy; ASHA, 2007; Strand, 2003).

3.2 Overview of Speech Acquisition in English

3.2.1 Consonant Acquisition

A recent study by Crowe and McLeod (2020) presented the typical age of acquisition of English consonants by children. They worked to evaluate the literature across different studies which described the acquisition of English consonants in children. They found that most of the consonants were acquired by 5 years.

- Consonants acquired at age 2 years to 2 years and 11 months /b, m, n, h, p, d, w/
- Consonants acquired at age 3 years to 3 years and 11 months /g, f, k, t, j, ŋ/
- Consonants acquired at age 4 years to 4 years and 11 months /v, z, ʤ, s, ʧ, l, ʃ/
- Consonants acquired at age 5 years to 5 years and 11 months /ɹ,ð,ʒ/
- Consonants acquired at age 6 years to 6 years and 11 months /θ/

3.2.2 Vowel Acquisition

According to a study by Kent and Rountrey (2020), typically developing children acquire the vowel inventory by 24 months. There is also evidence that the vowel inventory can be completed by the age of 14 months or even earlier (Buhr, 1980; Oller and Eilers, 1982; Kent & Bauer, 1985; Davis & MacNeilage, 1990). In a study conducted by Selby et al. (2000), the production of vowels in children aged 15 to 36 months was found to be normal. By the time a child reaches 18 months, only some English vowels have been acquired—/a, i, u, ʌ, æ, ʊ, ɔ/—whereas at 24 months, /a, i, u, æ, ʊ, ɔ, ɪ, e, ɛ, o/ have been acquired, and at 36 months, all the English vowels have been acquired.

3.2.3 Syllable Structure

Stoel-Gammon (1987) studied the syllable shape used by children between the ages of three and six. The results indicated that children use monosyllabic words (CV and CVC) and disyllabic words (CVCV and CVCVC). Dodd (1995) described 5 syllable shapes used by children between 20 and 36 months of age. At 20 months, she found that all children utilised these structures in monosyllabic words: V, CV, VC, and CVC. In addition, some children were able to use these structures in words that were disyllabic and multisyllabic.

3.3 DEMSS' Content

The English version of the DEMSS consists of 60 utterances subdivided into 8 groups based on their syllable structure (i.e., CV, VC, reduplicated syllables, CVC1, CVC2, disyllabic 1, disyllabic 2, and multi-syllabic). Simple words (nouns, verbs, and prepositions) are used that were functional and familiar to children, such as 'bye', 'ape', the letter 'm', 'boo-boo', 'peep', 'bed', 'uh-oh', 'open', and 'peekaboo' (Strand & McCauley, 2019).

3.4 Adaptation Stages

During the development of an instrument, it is necessary to take into account factors such as the language and culture of the country in which it will be applied. It is essential to maintain similarity between the original and the adapted version throughout the adaptation process, to ensure that the objectives and methods of the original instrument are maintained (Pernambuco et al., 2017). As part of its original form, the DEMSS measured motor speech skills by repeating words. Upon repeating each word correctly twice, the examiner proceeds to the next stimulus, without giving additional cues. When errors are observed, the examiner can repeat the word and elicit additional repetition attempts using visual, temporal, tactile, and kinaesthetic cues. A child is allowed to repeat each word four to six times to help improve their performance (Gubiani et.al., 2021). To develop the Arabic version of the DEMSS, corresponding stimuli were selected based on the structure of the original version (Strand et al., 2013).

3.4.1 Process of Translation and Adaptation

The researcher examined the process through which the original test was developed, to understand how it was designed, administered, and scored (as the scoring instructions differ between stimuli). It was important that the administration and scoring instructions of the original DEMSS were maintained in the Ar-DEMSS.

3.4.2 Development of Ar-DEMSS Stimuli

Due to the significant differences between Arabic and English in terms of word structure and phoneme acquisition, it was necessary to develop new stimuli for the Ar-DEMSS. The following factors were considered when selecting potential stimuli: syllable structure based on the DEMSS structure, order of phoneme acquisition in

Arabic, simplicity, representativeness (i.e., real words), and presence in children's vocabulary. In the DEMSS, the stimuli included words with early developing sounds in English; however, some later developing sounds were also included (Gubiani et al., 2021).

As part of the development of the Arabic version of the test, the researcher followed Strand and McCauley's (2019) plan; it was required to follow the syllable structure used in the DEMSS. The Ar-DEMSS thus follows the instructions of the original DEMSS, using the syllable shapes CV, CVCV, etc. The words chosen for the Ar-DEMSS were simple, functional, and familiar to children (e.g., nouns, verbs, alphabet letters, and prepositions). Due to the fact that this is an imitation test and not a vocabulary test, it must be appropriate for children with limited speech output. Despite this, it was not possible to find real Arabic words adhering to a CV syllable rule; as a result, some common prepositions were used in addition to a few words alphabet letters, such as 't', which will produce the sound /ta:/. Moreover, Arabic does not have VC word structures; therefore, they could not be included. The included words were taken from the JISH Arabic Communicative Development Inventory: Saudi, which includes common words used by young children (Dashash & Safi, 2014). The following sections will discuss the translation of stimuli (i.e., content), the administration procedures, and the scoring systems.

3.5 Description of the Ar-DEMSS

3.5.1 Content

The Ar-DEMSS was created with a list of words that adapt to the Arabic language structure. The content of the Ar-DEMSS includes a hierarchy of simple words that differ in vowel content, prosodic content, length, and phonetic complexity. These utterances contain early developing consonant sounds paired with several different vowels across a range of early developing syllable shapes.

The Ar-DEMSS comprises 54 utterances subdivided into 7 groups (i.e., CV, reduplicated syllables, CVC1, CVC2, disyllabic 1, disyllabic 2, and multi-syllabic). The VC syllable structure was removed from the Ar-DEMSS because Arabic syllables must begin with a consonant; they cannot start with an initial vowel (Gadoua, 2000). The list of the words used in the Ar-DEMSS is included in Appendix D.

Looking at the Ar-DEMSS in more detail (see table 3.1), the number of words in the CV group is ten, while the reduplicated syllable group contains four words, the CVC1 group has seven words, the disyllabic 1 group contains seven words, the CVC2 group consists of twelve words, the disyllabic 2 group has eight words, and the multisyllabic group has six words. There is a difference between the original DEMSS and the Ar-DEMSS in terms of the number of stimuli. However, it was attempted to match the number of stimuli in the original DEMSS.

Table 3.1. *Number of words in the DEMSS and Ar-DEMSS.*

Subtest	**Number of words in the DEMSS**	**Number of words in the Ar-DEMSS**
CV	10	10
VC	10	**Excluded**
Reduplicated syllables	4	4
CVC1	6	7
CVC2	10	12
Disyllabic 1	6	7
Disyllabic 2	8	8
Multisyllabic	6	6
Total words	**60**	**54**

3.6 Development of Arabic Phonological System

When creating the Ar-DEMSS, it was essential to explore Arabic phonological development, as it was necessary to include stimuli based on early phoneme development; also, phonological processes may affect scores related to overall articulatory accuracy. After examining the DEMSS's syllable structure, the researcher reviewed studies discussing the early development of speech sounds. It was important to understand phonotactic rules as well as age of acquisition before selecting items for the Ar-DEMSS. The Ar-DEMSS had to include some important points related to the phonological development in the Arabic language, including vowels, syllable structure, and some phonological processes that occur in Arabic-speaking children. While normative studies concerning Arabic phonological development have been conducted, studies related to the Saudi dialect have been lacking; as such, the present review sought to facilitate the development of Arabic stimuli for the Ar-DEMSS. Furthermore, it was crucial to understand the phonological process present in the Arabic language because, in relation to the overall articulatory accuracy variable, a child may score 3, indicating a consistent consonant error, such as substitution, in which a child substitutes a single sound for several others. However, consonant omissions such as deletion of the final consonant will not result in a score of 3, and the child will receive cueing instead.

The purpose of this section is, thus, to describe the early developing syllable shapes, vowels, and speech sounds present in Arabic-speaking children with different dialects (i.e., Jordanian, Egyptian, Kuwaiti, and Qatari). During the development of the assessment tool, no study had been published about the early acquisition of speech sounds in the Saudi dialect. Due to this, the selection of stimuli was based on collecting all relevant studies and identifying the early sounds that were common across all of them. (A summary of early sound acquisition in Arabic is presented in table 3.2).

3.6.1 Jordanian and Palestinian Dialect Studies

One of the most comprehensive studies of Arabic child phonology was done by Amayreh and Dyson (1998). They recruited 180 Jordanian children aged between 2 years and 6 years and 4 months. The researchers designed a picture-naming test, in which 58 words were used to elicit spontaneous responses that represented all possible initial, medial, and final consonants in Modern Standard Arabic. Furthermore, they identified three levels of consonant acquisition: the customary level, at which 50% of children produced correct consonants in at least 2 different positions; the acquisition level, in which 75% of children produced correct consonants in all different positions; and the mastery level, in which 90% of children produced correct consonants in all different positions. Their findings showed that children aged between 2 years and 3 years and 10 months acquire the consonants /b/, /t/, /d/, /k/, /ʔ/, /f/, /ħ/, /m/, /n/, /l/, and /w/, whereas children aged between 4 years and 6 years and 4 months acquire /s/, /ʃ/, /x/, /ɣ/, /h/, /r/, and /j/. However, some sounds are not acquired by the age of 6 years and 4 months, such as /q/, /t̲/, /d̲/, /θ/, /ð/, /ð̲/, /z/, /s̲/, and /ʕ/.

In another study, conducted by Amayreh and Dyson (2000), the spontaneous speech samples of 13 children aged 14 to 24 months were analysed. The speech samples were investigated in terms of consonant inventory in different word positions: syllable initial, word initial; syllable initial within word; syllable final within word; and syllable final, word final. In addition, they examined the frequencies of occurrence, the rank order of consonants, and the consonants preferred by some of the children. The study showed that three consonants were used by all the children: /b/, /d/, and /j/. Moreover, 4 consonants were found in 10 out of 13 children: /t/, /ʔ/, /m/, and /w/. Additionally, six consonants, /ʃ/, /ʕ/, /ħ/, /h/, /n/, and /l/, were found in at least five children. In each manner of articulation, 50% of the consonants were stops, 16.9% were fricatives, 12.5% were glides, 11.6% were nasals, 7.6% were liquids, and 1.8% were affricates.

Furthermore, Dyson and Amayreh (2000) examined the phonological/articulation errors made by 50 children aged between 2 years and 4 years and 4 months. The children were divided into groups, with 5 girls and 5 boys in each age group, and speech samples were elicited using a 58-word picture-naming articulation test in order to determine the percentage of consonants produced that were different from the adults' targets (in Educated Spoken Arabic). The researchers also looked at the phonological patterns or processes at play. The findings from this study showed that the most difficult consonants were the emphatic stops /q/, /d̲/, and /t/, the emphatic fricatives /ð̲/ and /s̲/, the dental non-emphatic fricatives /θ/ and /ð/, and the /r/. The smallest number of consonant errors occurred in pronouncing /b/, /t/, /m/, /n/, /l/, /x/, /ʔ/, and /ħ/. Moreover, the children experienced phonological patterns or processes such as de-emphasis 50% or more of the time, the stridency deletion and lateralization of /r/ between 25% and 50% of the time, sequence reduction 17% of the time, and final devoicing 23% of the time. Other lesser phonological processes such as initial voicing, fronting, syllable deletion, final consonant deletion, and de-nasalisation occurred 5% to 10% of the time.

3.6.2 Egyptian Dialect Studies

Ammar and Morsi (2006) examined the acquisition of Egyptian Arabic phonology. The purpose of this study was to describe the typical phonological development of 36 typically developing Egyptian children aged between 3 and 5 years old. The children were divided into two groups based on their age; the first group included five boys and five girls (aged three to four years old), and the second group included 13 boys and 13 girls (aged four to five years old). Ammar and Morsi outlined the criteria for speech sound acquisition: if sound occurs correctly in at least 90% of the responses, it is considered mastered, and if it occurs correctly in 50% to 89% of the responses, it is considered customary.

According to the study's results, the first group acquired and mastered 13 phonemes /ʃ/ /m/, /t/, /ʔ/ /n/, /l/, /j/, /k/, /χ/, /ħ/, /f/, /w/, and /h/, while the remaining phonemes were in customary production. The second group mastered the above-listed phonemes in addition to /ʕ/, and the remaining phonemes were in customary production. The first group also showed phonological processes that occurred in more than 50% of participants, such as devoicing, de-emphasis, cluster simplification, /r/ deviation, and sibilant deviation. Also, 20% of the participants presented with velar fronting and final consonant deletion. According to the study's findings, devoicing is the most significant process continuing after the age of four. The second group most commonly exhibited the processes of sibilant deviation, /r/ deviation, devoicing, and de-emphasis; a few participants—accounting for 5% or less—also showed cluster simplification, di- and polysyllabic simplification, velar fronting, and a zero score of final consonant deletion.

A study was carried out by Saleh et al. (2007) to present the phonemic inventory and phonological processes of 30 Egyptian children aged between 12 and 30 months. The results showed that children acquire the following sounds before 2 years and 6 months: /b/, /t/, /d/, /g/, /k/, /ʔ/, /v/, /f/, /θ/, /z/, /s/, /ʃ/, /x/, /ɣ/, /h/, /ħ/, /ʕ/, /r/, /l/, /w/, /m/, /n/, and /j/. Moreover, the study reported the following phonological processes: weak syllable deletion, glottal replacement, and regressive assimilation. A most recent study by Abou-Elsaad et al. (2019) explored the developmental phonological processes of 120 native Egyptian Arabic-speaking children aged between 2 and 5 years old. The authors developed the Mansoura Arabic Test for Phonological Processes to elicit a single word using a picture-naming task. Based on the findings, the phonological processes present were assimilation (75.8%), followed by syllable structure processes (55.8%), substitution processes (55.8%), and unusual processes (43.3%). The total assimilation rate was 46.6%, while that of postvocalic devoicing (51.7%). The most common syllable processes were syllable deletion (39.2%) and cluster reduction (30%). Also, the substitution processes were major in-palatal fronting (25%), velar fronting (19.2%), and lateralization (29.2%). Finally, glottal replacements occurred at a rate of 27.5%, while the backing of fricatives occurred at a rate of 15%.

3.6.3 Kuwaiti Dialect Studies

Ayyad (2011) studied the phonological development of 80 typically developing children between the age of 3 years and 10 months, and 5 years and 2 months. The findings reported that 90% of all children acquired the following consonant inventory: /b/, /bː/, /t/, /d/, /tʕ/, /tːʕh/, /k/, /g/, /qː/, /ʔ/, /m/, /n/, /w/, /j/(ː)/, /rː/, /f/, /ðʕ/, /ʃ/, /ħ/, /h/, and /tʃ/. The younger age group had acquired /sˤ/ and /χː/, while the older age group also included /χ/ and /ʁ/.

Alqattan (2015) also explored the typical phonological development of Kuwaiti children by eliciting spontaneous speech samples. The study included 70 children, with ages ranging from 1 year and 4 months to 3 years and 7 months. Alqattan referred to three levels of consonants acquisition: customary production (50–74%), acquisition (75–89%), and mastery (90%). By the age of 3 years and 7 months, it was reported that these consonants were mastered: /p/, /b/, /t/, /d/, /k/, /ɡ/, /ʔ/, /m/, /n/, /f/, /s/, /w/, /l/, and

/ɫ/. The acquired consonants, meanwhile, were /r/, /z/, /ʃ/, /x/, /ħ/, /ʕ/, /h/, /j/, /ʤ/, /ʧ/, /tˤ/, and /sˤ/, and the customary produced were /q/, /ɾ/, /ɣ/, and /ðˤ/. The sounds that were not yet acquired were /ŋ/, /v/, /θ/, /ð/, /ʒ/, /dˤ/, and /zˤ/. Moreover, the most frequently occurring phonological processes were stopping, cluster reduction, de-emphasis, gliding, coda deletion, and lateralization.

3.6.4 Qatari Dialect Study

Albuainain (2012) examined children's phonological processes and some errors that were observed in spontaneous speech samples. The study included 140 native Qatari children whose age ranged between 1 year and 4 months, and 3 years and 7 months. Based on the results, substitution, assimilation, and syllable structure processes were the main types of phonological processes observed. The following are some examples of the substitution processes observed:

- /r/ deviation, in which the consonant /r/ is replaced by /l/, a vowel, or a glide, or it might be assimilated or deleted
- Sibilant deviation, in which the sibilants can be substituted by interdentals or a dental/alveolar stop (e.g., /d/ [t] and /s/ [ɵ])
- Glottal replacement, in which the glottal stop sound is replaced by fricatives or plosives (e.g., /ʕ/ [ʔ])
- Fronting, in which a velar or palatal is replaced with a fronting sound (e.g., /k/ [t], /ʃ/ [s])
- Backing, in which the bilabial, dental, labio-dental, palatal, alveolar, or postalveolar consonant is replaced with a velar (e.g., /f/ [g])
- Stopping, in which the affricates and fricatives are replaced with stop consonants (e.g., /s/ [t], /ʤ/ [d])

The following are some examples of the assimilation processes observed:

- Final consonant devoicing, in which the voiced consonants became voiceless (e.g., /d/ [t]).
- Consonant harmony (e.g., /ʤawaal/ [wawaal] ‘mobile’)
- Vowel harmony (e.g., /dabdaob/ [dobdob] ‘bear’)

The following are some examples of the structural simplification processes observed:

- Consonant cluster simplification (e.g., /kalb/ [kab] ‘dog’)
- Consonant deletion (e.g., /xa:lid/ [a:lid] ‘boy’s name’)
- Weak syllable deletion (e.g., /ma:ma:l [ma:] ‘mother’)
- Metathesis (e.g., /t̲ma:t̲/ [mt̲a:t̲] ‘tomato’)

3.6.5 Syrian Dialect Study

Owaida (2015) studied speech sound acquisition and phonological processes in Syrian children. Owaida developed a picture-naming test to examine 160 children between the ages of 2 years and 6 months, and 6 years and 6 months. The results showed that all Syrian Arabic consonants were acquired by age of 6 years and 5 months except for the affricate /dʒ/. Among the early consonants, acquired between 2 years and 6 months and 4 years were / b/, /f/, /ʕ/, /j/, /n/, /m/, /d/, / t/, /l/, /w/, /ʔ/, and /h/; meanwhile, the intermediate consonants acquired between 4 and 5 years were /x/, /s/, /z/, /ʕ/, /t̲/, /d̲/, and /k/, and the late acquired consonants, between 5 years and 6 years and 5 months, were /ʃ/, /r/, /s̲/, and /ɣ/. Furthermore, the phonological errors observed were de-emphasis, /r/ deviation, devoicing, backing, assimilation, glottalisation, stopping, fronting, weak syllable deletion, and stridency deletion. According to this study, Syrian children do not produce phonological marker errors by the age of 5 years and 5 months.

Table 3.2. *Studies discussing early sound acquisition in Arabic.*

Study	Dialect	Number of participants	Age	Age of early sound acquisition	Criteria	Speech sounds acquired	Common early sounds in all studies
Amayreh & Dyson (1998)	Jordanian	180	2.0–6.4	2.0–3.10	Customary: 50% Acquired: 75% Mastery: 90%	/b, t, d, k, f, m, n, l, w, ʔ, ħ/	/b, t, d, k, f, m, n, l, w, j, f, h, ħ, s, ʔ, ʃ/
Ammar & Morsi (2006)	Egyptian	36	3.0–5.0	3.0–4.0	Customary: 50–89% Master: 90%	/ħ, m, t, n, l, j, k, x, f, w, h, ʔ, ʃ/	
Saleh et al. (2007)	Egyptian	30	1.0–2.5	By 2.6	High frequency of occurrence (when it is produced by 50% or more of the group)	/b, t, d, g, k, ʔ, f, v, θ, z, s, ʃ, x, ɣ, h, ħ,ʕ, r, l, w, m, n, j/	
Alqattan (2015)	Kuwaiti	70	1.4–3.7	By 3.7	Customary: 50–74% Mastery: 90% Acquired: 75–89%	/p, b, t, d, k, g, ʔ, m, n, f, s, w, l, ɫ/	
Owaida (2015)	Syrian	160	2.6–6.6	2.6–4	Acquired: 90% in initial and final position or medial and final position	/b, f, j, n, m, d, t, l, w, h, ʔ, ʕ/	

3.7 Syllable Structure

As described in a previous section (2.4), the Arabic syllable structure and types are CV, CVV, CVC, CVVC, CVCC, and CVVCC (Jarrah, 1993). A recent study by Mashaqbaa et al. (2019) examined early word syllable structure and phonological processes among 20 Jordanian Arabic–speaking children aged 1 to 3 years. Speech samples were elicited using a picture-naming task, in addition to spontaneous speech productions. The findings showed that children produced syllable shapes such as CV, CVV, CVC, and CVVC. CVC was the most common syllable shape, followed by CVV and CVVC, among all age groups.

3.8 The Arabic Vowels

Omar (1991) explained that Modern Standard Arabic contains six monophthong vowels, including three short and three long vowel phonemes: /a/, /aː/, /i/, /iː/, /u/, and /uː/. In addition, two diphthongs (/aj/ and /aw/) are maintained in some dialects (e.g., San'ani in Yemen and parts of the Arabian Peninsula), while other dialects (e.g., Cairene, some Levantine dialects, central Sudanese, and Hijazi) use /e:/ and /o:/ (Watson, 2002). A study by Amayreh and Dyson (2000) that found that children acquired the Modern Standard Arabic vowels by the age of 2 (/a/, /a:/, /i/, /i:/, /u/, and /u:/), in addition to /e:/ and /o:/. Moreover, Owaida (2015) found that Syrian children acquire all vowels, with 90% accuracy, by the age of 2 years and 6 months to 2 years and 11 months.

3.9 Overview of Phonological Processes in Children

The development of speech sounds can be analysed in two different ways. 'Phonemic acquisition' refers to the speech-sound use, functions, behaviour, and organisation of speech-sound system, while ‘phonetic acquisition’ refers to the motor production of speech sound (Dodd, 2003). The error patterns of a child’s phonological system can be categorised into two groups. The first involves substitution error patterns, in which one sound is substituted for another—for instance, velar fronting, stopping, backing, voicing, affrication, vocalisation, the gliding of liquids, and deaffrication (Dodd, 1995). The second involves syllable error patterns, in which errors occur in the syllable structure of a word—for example, final consonant deletion, reduplication, consonant cluster reduction, weak syllable deletion, metathesis, coalescence, and epenthesis (Dodd, 1995). When children develop syllables by imitating an adult’s speech production, they are likely to use phonological processes to reshape the syllable to the adult’s production. Due to the fact that phonological errors can affect children’s DEMSS scores, the Arabic phonological process has to be explained. A summary of the phonological processes studied in Arabic is presented in Table 3.3.

Table 3.3. *Studies discussing Arabic phonological patterns and processes.*

Study	**Dialect**	**Age**	**Phonological processes**	**Common phonological processes in all studies**
Dyson and Amayreh (2000)	Jordanian	2.0–4.4	De-emphasis, stridency, deletion and lateralization of /r/, sequence reduction, and final devoicing Other less common phonological processes such as initial voicing, fronting, syllable deletion, final consonant deletion, and de-nasalisation	De-emphasis, /r/ deviation, devoicing, fronting, weak syllable deletion, final consonant deletion, glottal replacement, assimilation, stopping, backing, cluster reduction, and lateralization.
Ammar and Morsi (2006)	Egyptian	3.0–5.0	Devoicing, de-emphasis, cluster simplification, /r/ deviation, and sibilant deviation Other less common phonological processes such as velar fronting and final consonant deletion	
Saleh et al. (2007)	Egyptian	1.0–2.5	Weak syllable deletion, glottal replacement, and regressive assimilation	
Albuainain, (2012)	Qatari	1.4–3.7	Sibilant deviation, /r/ deviation, glottal replacement, fronting, backing, stopping, final consonant devoicing, consonant cluster simplification, consonant deletion, weak syllable deletion, and metathesis	
Alqattan (2015)	Kuwaiti	1.4–3.7	Stopping, cluster reduction, de-emphasis, gliding, coda deletion, and lateralisation	
Owaida (2015)	Syrian	2.2–6.6	De-emphasis, /r/ deviation, devoicing, backing, assimilation, glottalization, stopping, fronting, weak syllable deletion, and stridency deletion	

Abou-Elsaad et al. (2019)	Egyptian	2.0–5.0	Assimilation, postvocalic devoicing, syllable deletion, cluster reduction, palatal fronting, velar fronting and lateralization, glottal replacements, and the backing of fricatives	

3.10 Scoring System in the Ar-DEMSS

Categorical and binary scoring methods were adapted from the DEMSS. In Strand and McCauley's view, categorical and dynamic scoring methods are used for different reasons. The scoring methods were thus chosen according to the purpose of each measure. Because the goal of the DEMSS is to determine a child's ability to respond to cues, the scoring system had to go beyond the binary method of 'right' and 'wrong'. Using a categorical scoring system, SLTs will be able to note the type and severity of errors as well as how the child responds to cues.

3.10.1 Types of Scoring

There are two types of scoring in the Ar-DEMSS: categorical and binary. Categorical scoring is used to score the two variables of overall articulatory accuracy and vowel accuracy. Binary scoring (i.e., correct = 1; incorrect = 0) is utilised to score prosodic accuracy and consistency.

3.10.2 Specific Rules in Scoring

3.10.2.1 Vowel accuracy

It is essential that the vowel is scored on the first attempt for the stressed syllable in a disyllabic and multisyllabic word. Vowels must be scored on the child's first attempt, even if their vowel production improved after cueing:

- A score of 2 indicates correct, immediate imitation.
- A score of 1 indicates uncertainty (i.e., when the tester is unsure if the imitation was correct). It is also applied when the child self-corrects but with a delay, or

the child shows groping or trial-and-error behaviour during the self-corrected production.

- A score of 0 indicates distortion or substitution.
- A score of X indicates a refusal or no attempt at all.

3.10.2.2 Prosodic accuracy

Prosodic accuracy is scored on the first attempt. It can be noted whether one or more of the prosodic errors occurs, such as segmentation plus equal stress, segmentation plus incorrect stress, or added syllable plus equal stress.

- A score of 1 indicates correct prosody.
- A score of 0 indicates incorrect prosody (e.g., equal stress, segmentation, or incorrect lexical stress).
- A score of X indicates a refusal or no attempt at all.

3.10.2.3 Overall articulatory accuracy

The overall articulatory accuracy refers to the accuracy of the movement for the word as a whole. It is scored on the first attempt, or after cued practice and a final, non-cued, direct imitation.

- A score of 4 indicates the immediate, correct imitation of the word. The child shows accurate movement for correct sound production across the entire word. (If the second imitation is incorrect, score 4 for overall articulatory accuracy and 0 for consistency).
- A score of 3 indicates immediate imitation containing a consistent consonant substitution and accurate vowel, without any sign of groping or trial-and-error behaviour. For example, when the child presents with developmental,

consistent, and predictable errors such as fronting, w/r, w/l, or frontal lisp, keep the score of 3. However, if the child presents with consonant omissions (e.g., final consonant deletion), the child will not score 3 and will need cueing. See the previous discussion about the phonological processes in Arabic.

- A score of 2 indicates that the child needs a single additional model as a first cued trial or that the child is able to produce the correct response on the first try but after a delay.
- A score of 1 indicates a correct response after cueing. After all cueing (6), a non-cued trial in direct imitation must be elicited.
- A score of 0 indicates an incorrect response.
- A score of X indicates a refusal or no attempt at all.

3.10.2.4 Consistency scoring

Consistency scoring is completed after all trials on an item have concluded.

- A score of 1 indicates that production is consistent across all trials.
- A score of 0 indicates that production is inconsistent across more than two trials.
- A score of X indicates a refusal or no attempt at all.

Example

In the following table (3.4), a child's speech error and score explanation is presented for the word /fi:/.

Table 3.4. *Example of a child's error and scores.*

Target	Trial 1: direct imitation	Cued trails	Final non-cued elicited production	Score		
				Vowel accuracy (2,1,0)	**Overall articulatory accuracy (4, 3, 2, 1, 0)**	**Consistency (1,0)**
Fi: (in)	Distorted vowel	Exact distortion repeated each trail	Produced same distorted vowel	0	0	1

In the example shown in Table 3.4, a score of 0 for the vowel accuracy because it was clear that the child distorted the vowel at the first trial. A score of 0 was given for the overall articulatory accuracy because the child did not produce the item correctly in the final non-cued trial. Last, a score of 1 was given for consistency because the child continued to distort the vowel each time, they imitated the word.

According to the following table, Table 3.5, articulatory accuracy and vowel accuracy are both scored in the all-subtests test, whereas prosodic accuracy and consistency are only scored for specific subtests.

Table 3.5. *Ar-DEMSS structure.*

		Initial attempt			After cueing	
Section	**Word number**	**Vowel accuracy (2, 1, or 0)**	**Prosodic accuracy (1 or 0)**	**Articulatory accuracy (4, 3, or 2,)**	**Articulatory accuracy (2, 1, or 0)**	**Consistency (1 or 0)**
1. CV	10	☑	☐	☑	☑	☑
2. CVCV	4	☑	☑	☑	☑	☐
3. CVC1	7	☑	☐	☑	☑	☑
4. CVC2	12	☑	☐	☑	☑	☑
5. Disyllabic 1	7	☑	☑	☑	☑	☐
6. Disyllabic 2	8	☑	☑	☑	☑	☐
7. Multisyllabic	6	☑	☑	☑	☑	☑
Total score	54	108	25	216		35
Total possible score	384					

In each section of the test, the tester can add notes regarding their observations (Strand, 2017). Table 3.7 explains each note.

Table 3.6. *Description of each observation note.*

Note	**Definition**	**Note**	**Definition**
Inconsistent voicing errors	Voiceless sound production (t/d)	**Vowel or consonant distortion**	A vowel or consonant is replaced with a sound that may not exist in Arabic; the vocal tract is not in the right shape or length
Groping	Struggling or many attempts to place lips, jaw, or tongue in the right position to produce a sound	**Segmentation**	Difficulties transitioning between syllables in a word
Intrusive schwa	Adding schwa between consonants or at the end of the word	**Lexical stress errors**	Putting a stress pattern on the wrong syllable, or equal stress
Slow rate	Slower than the typical rate	**Trial-and-error behaviour**	Many attempts are needed to achieve correct production (can be seen during cueing)
Difficulty with multisyllabic words	Increased difficulties with more complex syllable and word shapes	**Awkward movement transitions**	Inaccurate movement from one syllable to another

3.11 Additional Information

3.11.1 Optional Transcription

The speech productions of some children reveal useful information about their speech sound system. These productions can indicate the child's most common consonant and vowel errors, such as whether they are substituted, omitted, deleted, or added. An SLT who works with children with SSDs must be able to record their speech, so transcription is an essential skill. Identifying appropriate interventions, tracking intervention progress, and assessing, analysing, and differentially diagnosing SSDs requires accurate transcription (McLeod & Baker, 2017).

3.11.2 Prosodic Error Types

For some subsections of the Ar-DEMSS, it is important to note any prosodic error types such as segmentation, equal stress, incorrect stress, weak syllable deletion, and added syllables. In addition, the tester can describe any aspect of the child's medical and developmental history, note any additional observations (e.g., DDK or nonverbal oral apraxia), and include the diagnostic statement.

Chapter 4 Methods and Procedure

This chapter discusses the methods used to conduct the project, the characteristics of the participants, the recruitment procedure, the assessment procedures, and the scoring system.

As the researcher had to work remotely during the Covid-19 lockdown, due to social distancing regulations, the absence of face-to-face interaction, the need for reliable internet access, and difficulties in coordinating meetings were some of the challenges encountered. To communicate and work remotely, the researcher relied heavily on digital platforms. A cost-effective and efficient recruitment strategy was utilised to ensure that all participants had access to the study. In addition to designing a scoring system and adapting an assessment process to the online environment, the researcher also ensured that the collected data were accurate.

4.1 Main Aims of the Study

The main aims of the study were as follows:

1. To develop an adapted version of the DEMSS for use in Arabic
2. To administer the adapted test among 49 Arabic-speaking children aged between 3 and 7 years
3. To interpret the test results in line with the DEMSS and look specifically at those children with a suspected CAS profile
4. To present a more detailed profile of two to three children with suspected CAS profiles using a case series

4.1.1 Research Questions

To achieve the above stated aims, the following research questions were posed:

Research Question 1: How do typically developing Arabic-speaking children aged 3 to 7 perform on the Ar-DEMSS in terms of (a) their total score and (b) their subscores related to vowel accuracy, prosody, overall articulatory accuracy, and consistency?

Research Question 2: How do Arabic-speaking children with CAS perform on the Ar-DEMSS in terms of (a) their total score and (b) their subscores related to vowel accuracy, prosody, overall articulatory accuracy, and consistency?

Research Question 3: What are the speech characteristics of Arabic-speaking children with CAS aged 3 to 5?

4.2 Study Design and Method

Data collection was conducted from January 2022 to March 2022. Since the study was carried out during the Covid-19 period, many modifications were made to complete the research. All participants in the study were informed that the project was to be conducted online using the video conferencing software programme Zoom (Zoom Video Communications Inc., 2016). Caregivers also received an information sheet describing the format for the meeting; a 60-min session would be held with each child, including a 5- to 10-min break, if necessary, and assessment and testing would be performed. All participants with their caregivers were informed that the study would be conducted in a secure Zoom meeting and that the data collected during the session would remain confidential. Additionally, all participants were given an opportunity to ask questions prior to the start of the meeting to ensure that they were comfortable with the process.

General Instructions

To conduct the study, the following instructions and requirements were explained to the participants in the information sheet.

- They should use a laptop with a microphone.
- The child should be seated so that the researcher can see him or her through the camera.
- The child should be placed in a quiet place free of any distractions.
- The room should be well lit. The camera should be positioned so that the child's face is clearly visible, and the background behind the child should be plain.
- The child should look directly at the camera while speaking.
- Caregivers are permitted to accompany their children.

4.3 Recording Method

Video recordings were made of the sessions to capture the verbal and nonverbal features associated with CAS, such as groping. The researcher used a microphone and headphones, and the children were also asked to use microphones and wear headphones, if possible. Using the Zoom meeting recording function, recordings of the sessions were saved as MP4 files.

4.4 Participants' Characteristics

There were four age groups for children: 3;0 to 3;11, 4;0 to 4;11, 5;0 to 5;11, and 6;0 to 7;0 years old. Children with CAS and typically developing children were evaluated using several tests, including the Ar-DEMSS, the articulation test, the nonverbal oral apraxia test, the oral structure and function test, and the DDK.

The study involved a small group of 49 Saudi children (23 boys and 26 girls) between the ages of 36 and 84 months (3 to 7 years) recruited from speech and language clinics as well as public schools in Jeddah, Saudi Arabia. The age ranges used in the study are based on Strand and McCauley's (2019) criteria. The children were divided into four age groups of 12-month intervals. There were five children in the 3-year-old group, 15 in the 4-year-old group, 18 in the 5-year-old group, and 11 in the 6-year-old group. All the children spoke Arabic as their first language at home and school.

Table 4.1. *Number of Boys and Girls in Each Age Group*

Group	Age group	Gender	N	%
CAS	3;0-3;11	B	2	100.00%
	4;0-4;11	G	1	33.30%
		B	2	66.70%
	5;0-6;0	B	1	100.00%

Typical developing children	3;0-3;11	G	2	66.70%
		B	1	33.30%
	4;0-4;11	G	6	50.00%
		B	6	50.00%
	5;0-5;11	G	8	47.10%
		B	9	52.90%
	6;0-7;0	G	9	81.80%
		B	2	18.20%

Note. B= boys, G= girls, N= number of participants, %= percentage

Exclusion Criteria

Children were excluded from the study if their histories, clinical examinations, or medical records showed any of the following:

1. Structural deficits (e.g., cleft palate)
2. Hearing loss
3. Arabic as a second language
4. Autism spectrum disorder
5. Dysarthria
6. Learning disability

A total of 80 caregivers were initially accepted to enrol their children. Many of them, however, were excluded because they declined to participate in the study, spoke Arabic as a second language, had structural problems (no upper or lower front teeth), were too young (2 years and 11 months), and were unable to concentrate. The total number of participants was finally reduced to 49, six of whom had a diagnosis of CAS carried out by a licenced SLT.

4.5 Process of Recruitment

The children were recruited from kindergartens, schools, and speech therapy clinics. This section provides an overview of the process of recruitment from kindergartens and schools, followed by an overview of recruitment from clinics.

4.5.1 Kindergartens and Schools

Public kindergartens and schools were contacted by the researcher via telephone. The researcher discussed the project topic and plan with the heads of the schools. The head of each school was then responsible for meeting with the teachers to select eligible children. The researcher instructed the school heads to recruit children who did not have hearing, speech, or language impairments.

A number of schools agreed to provide caregivers with online information sheets and informed consent documents. These documents were then distributed by teachers to families with children aged 3 to 7. When parents confirmed that their children would participate, informed consent was obtained online through a Google form, and a Zoom meeting was scheduled. Before the assessment began, the tasks were introduced and explained to the children using a visual schedule. After that, they were asked if they were willing to participate by giving their oral consent.

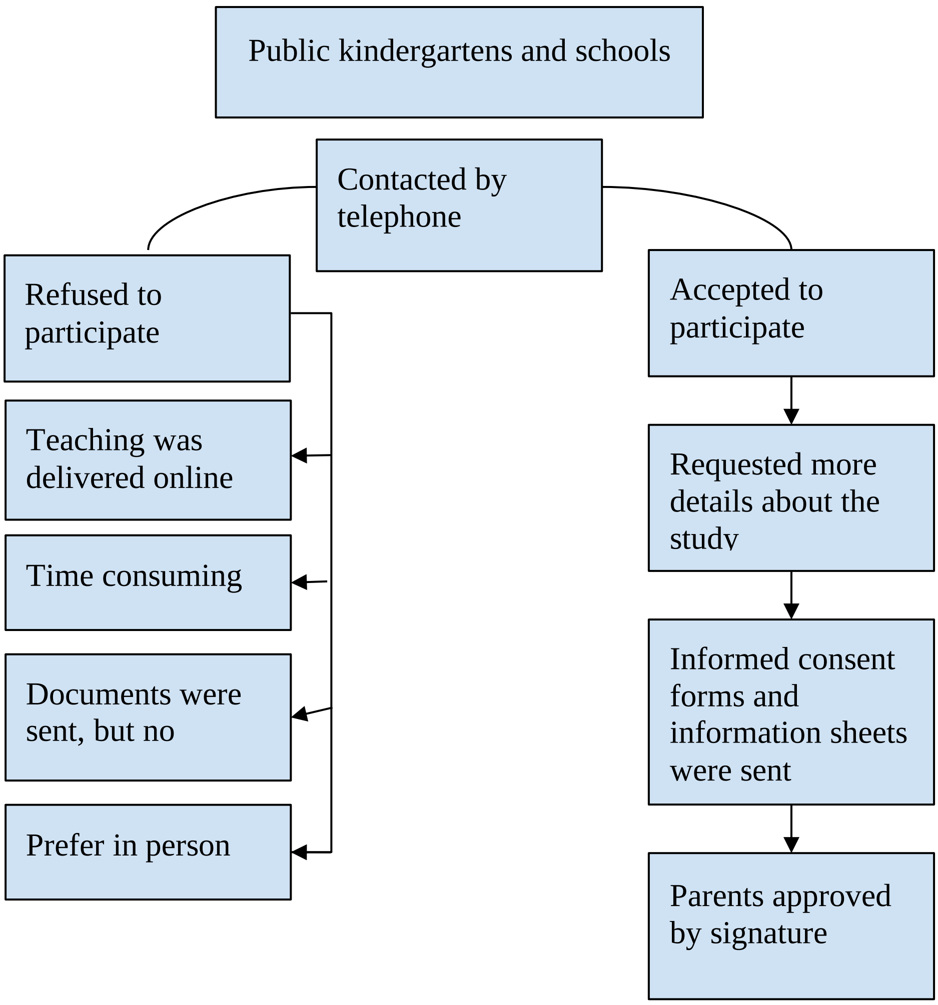

Figure 4.1. *Participant Recruitment Process in Public Kindergartens and Schools*

4.5.2 Speech Therapy Clinics

Children with severe SSDs and whose speech was unintelligible were recruited by a licenced SLT from clinics in two cities: Jeddah and Riyadh, Saudi Arabia. A letter outlining the purpose of the study and the kind of participants required was sent to the heads of clinics and hospitals that provide speech and language therapy to children, asking them for permission to recruit children from their services who had speech difficulties, specifically children with CAS. The letter also requested access to the children's files, if necessary, to examine any medical histories or red flags associated with CAS cases. Clinics accepted participation and sent all the necessary documents, including the information sheet and informed consent forms, to participants' parents. After parents confirmed their children's participation, informed consent was obtained online through a Google form, and the researcher contacted them to schedule a Zoom meeting. Before the assessment began, the children gave their oral consent to participate in the study.

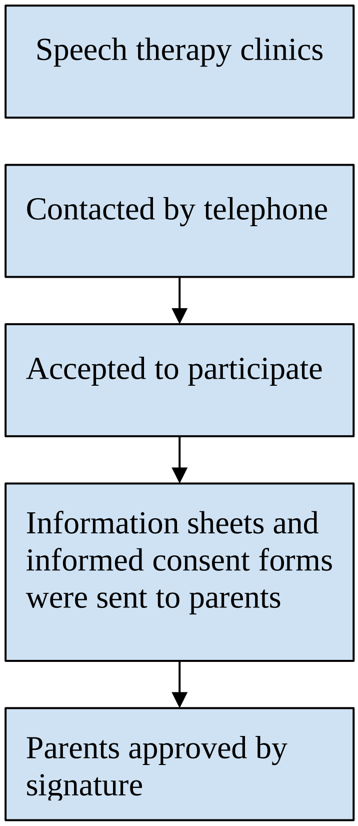

Figure 4.2. *Participant Recruitment Process in Speech Therapy Clinics*

4.6 Ethics

The ethics committee from the Health Sciences School at the University of Sheffield approved the ethics of my study on 17 August 2021, after receiving all the necessary documents, including consent forms and information sheets, that explained the details of my research. The researcher then emailed these documents to schools and clinics to obtain permission to conduct the study. Information sheets were available in two versions: one for children from schools and one for children from clinics. These documents were translated into Arabic.

4.7 Procedure

Following approval from the children's caregivers, the dates and times for the sessions were scheduled. A variety of tests were administered to children with CAS and typically developing children. These tests included the oral-facial examination, DDK task, nonverbal oral apraxia, articulation test, and Ar-DEMSS. A total of 60 minutes of testing was conducted with a 5- to 10-min break, if necessary, for all tests. In order to keep the children's interest, toys, and games were used throughout the sessions. A visual schedule was used to describe what the children would do when they met the researcher. For instance:

- First, you will move your lips, face, and tongue around in a funny manner.
- You will then make some silly sounds and say these sounds as fast as you can.
- You will then see pictures and tell me what they depict.
- Finally, you will imitate what I say, like a parrot.

4.8 Assessment Procedure

4.8.1 Oral-Facial Examination

Oral-facial examinations assess the physiology and anatomy of the structures supporting speech and swallowing (Gironda et al., 2011). To determine whether a client has efficient sensory and motor functions, these structures must be examined for structural and functional anomalies that may interfere with speech and swallowing. Additionally, information obtained may reveal that the child has weakness, decreased respiratory support, or dysphonia, indicating dysarthria (Strand & McCauley, 2019). To decide between the oral-facial examination and the Oral Motor Assessment form by

Robbins and Klee (1987), the context and assessment specifics must be considered. The oral-facial examinations often include not only motor skills but sensory and structural components as well, assessing both structural and functional aspects of the oral-facial complex. Typically, the evaluation covers a broad range of parameters, including symmetry, strength, coordination, and range of motion of oral structures. These parameters can be crucial to diagnosing many different conditions such as dysarthria (Gironda et al., 2011).

As a result of Covid-19 social distancing requirements, the oral-facial examination form was slightly modified and adapted (see Appendix B) to allow the researcher to view oral structures via an online platform, including the face, jaw, teeth, lips, and tongue. For example:

- Observation of the symmetry of the face.
- Observation of opening and closure of the mouth to determine jaw symmetry, range of motion, and movement.
- Observation of dentition, particularly the arrangement of teeth, and occlusion (molar/incisor relationship).
- Evaluation of the symmetry and range of motion of the lips.
- Evaluation of the tongue's size, colour, and abnormal movements.
- Observation of protrusion and retractions of the tongue to assess excursion, range, and speed of motion.
- Examination of tongue tip movements (up, down, right, and left) to assess normal movement and range of motion.
- Observation of the rapid side-to-side movement of the tongue.

***Scoring*.** After the researcher described the activity to the child, the researcher gave an instruction, and the child responded. Each item was then checked and recorded, and additional observations and comments were written. Table 4.3 provides an example of scoring a test item where the analysis was descriptive, such as typical or atypical. If the child completed all tasks without any problems, he scored typically. However, when the child encountered some difficulties with some tasks, he scored atypically, and the researcher provided a description of the problem.

Table 4.2. *Example of the Scoring System*

Check and circle each item noted and describe any comments.

	Evaluation of face		Comments
Symmetry	☑	Normal, droops on right, droops on left	
Abnormal movements	☑	None, grimaces, spasms	

4.8.2 *Nonverbal Oral Apraxia*

The term nonverbal oral apraxia refers to impaired voluntary oromotor movements resulting from motor planning or sequencing difficulties rather than weakness, language dysfunction, or cognitive impairments (Tognola & Vignolo, 1980). In the case of nonverbal oral apraxia, further cuing and more time may be required during Ar-DEMSS. The performance of the following seven movements was used to measure nonverbal oral apraxia:

- Opening and closing the mouth
- Showing the teeth
- Smiling
- Puffing out the cheeks
- Puckering the lips
- Protruding and retracting the tongue
- Moving the tongue from side to side

The tasks were performed based on verbal commands, and articulatory cues were used when verbal commands alone were insufficient.

Scoring

Typical

- A score of 0 refers to an accurate, immediate, and effortless response.

Atypical

- A score of 1 indicates accuracy after slower production or trial-and-error searching movements in at least 1-2 tasks.
- A score of 2 indicates accuracy after slower production or trial-and-error searching movements in at least 3-4 tasks.
- A score of 3 indicates accuracy after slower production or trial-and-error searching movements in more than 4 tasks.

4.8.3 DDK

According to Fletcher (1972), DDK is the ability to repeat syllables at a maximum rate. For instance, a speech DDK task requires participants to imitate monosyllables /pa/, /ta/, and /ka/ as quickly as possible, as well as nonsense sequences of 2 or 3 syllables made with different articulatory placements /pata/ and /pataka/ (See Appendix C).

Instructions. The tester explained to the participant that they would hear some silly words, and they had to copy exactly what was said. The tester used a small light ball, which she moved quickly by hand and then stopped. Once the tester moved the ball, the child had to repeat the monosyllables or multisyllables accurately and consistently, as much as possible, for 10 s. For example, when the tester said /pa/, the child would repeat it until she said, “stop.” The consistency of a target was measured during an interval of 10 s by counting how many versions of the same target were produced during this time. The accuracy of the target was determined when consonant deviations (p, t, k) occurred, such as insertions of sounds, deletions of sounds, changes in voicing, placement changes, exchanges between sounds, and perseveration of sounds (Yaruss & Logan, 2002).

Scoring the DDK Task

Alternating Motion Rate (AMR). The child repeated each monosyllable /pa/, /ta/, and /ka/ for 10 s.

- The child scored 0 if he showed no errors, which was considered typical; for example, if the child repeated the target many times for 10 s with no difficulty in accuracy and consistency.
- If the child had difficulty producing a single phoneme accurately and consistently more than once, he would score 1, which was considered atypical. For instance, the child would score 1 if he produced two monosyllable /pa/ and /ta/ accurately and consistently but had difficulty with one monosyllable /ka/.

Sequential Motion Rate (SMR). The child repeated the multisyllabic word /pataka/ for 10 s.

- A typical score was achieved if accurate and consistent performance was shown on the DDK task.
- An atypical score was achieved if the child struggled with accuracy and consistency on the DDK task; for instance, if the child omitted syllables, substituted incorrectly, or had an incorrect DDK sequence.

Example of Scoring Monosyllabic and Multisyllabic Syllables. The child was asked to repeat the following words as fast and as steadily as possible for 10 s:

- /p^p^p^p^…/ If accurate and consistent during the 10 s, the child scored typical.

- /pataka/ If not accurate and consistent during the 10 s, for example, /papapa/, /pata/, and /kaka/, /patata/, and /pakata/, the child scored atypical.

4.8.4 Articulation Test

The JISH articulation test was used to examine the speech sound production in the initial, medial, and final positions of a word. The test measured all sounds in Arabic. The articulation test was performed to determine a child's consistent error patterns (fronting or substitutions) (Al-Sabi & Naqawah, 2013).

Procedures. The tester asked the child, "What do you see in this picture?" and the child would name the picture. If the child did not know the word, cueing was provided to achieve the target word. An uncued trial would also elicit in direct imitation.

Scoring. The total number of errors each child made in the articulation test was recorded.

4.8.5 Ar-DEMSS

The Ar-DEMSS was performed with a list of several words adapted to the Arabic language structure. The content of the Ar-DEMSS is a hierarchy of simple words that differ in vowel content, prosodic content, length, and phonetic complexity. These utterances contain early-developing consonant sounds paired with several different vowels across a range of early-developing syllable shapes. See Chapter 3 for more information.

The Ar-DEMSS comprises 54 utterances subdivided into seven groups (i.e., CV, reduplicated syllables, CVC1, CVC2, disyllabic 1, disyllabic 2, and multisyllabic). The list of Ar-DEMSS words is included in Appendix D. Vowel accuracy and overall articulatory accuracy were assessed for all items. However, prosodic accuracy was evaluated for duplicated syllables, disyllabic words one and two, and multisyllabic words. Additionally, consistency was judged in words with consonant-vowel, consonant-vowel-consonant 1 and 2, and multisyllabic words. As these are the most accepted features of CAS, it was important to know how often these errors were produced by children with and without cues.

Table 4.3. *Utterance Types and Judgments Associated with Ar-DEMSS*

Utterance type	Number of items	Examples	Number of judgements for each variable			
			Overall articulatory accuracy	Vowel accuracy	Prosodic accuracy	Consistency
Consonant-vowel	10	/fi:/, /la:/	40	20		10
Reduplicated syllables	4	/ba:ba:/, /ma:ma:/	16	8	4	
Consonant-vowel-consonant CVC1	7	/ba:b/, /du:d/	28	14		7
CVC2	12	/fam/, /mi:n/	48	24		12
Bisyllabic 1	7	/du:da:/, /ku:ki:/	28	14	7	
Bisyllabic 2	8	/kita:b/, /tu:na/	32	16	8	
Multisyllabic	6	/kataba/, /samaka/	24	12	6	6
Total scores	54		216	108	25	35
Totals			384			

Materials. Administering the Ar-DEMSS requires only a response form, the DEMSS manual, some toys, and other types of reinforcers to maintain the child's focus on the task. Prior to administration, it is necessary to:

1. Build rapport with the child.
2. Ensure access to a quiet environment to reduce any distractions while completing the test.
3. Ensure that the clinician can face the child. This helps maintain the child's focus and allows them to access auditory and visual cues. It also allows the clinician to observe the child's efforts.

Administration Time. For typically developing children, the researcher conducts the evaluation over 10-15 minutes. Children with CAS, however, may require 25-40 minutes, depending on their severity.

Instructions.

- Introduce the child to the task. "Watch my face, and then try to say what I say. I will help you if it's a hard one."
- In the event of an incorrect response, you (the tester) can provide cues.
- Keep the child's focus on your face by using reinforcers. Holding a block near your face while instructing or cueing, for example.

Cueing Hierarchy. A number of cues were included in the test; for example, while ensuring that the child was watching her face, the tester used slower simultaneous production of the word. Gesture cues that emphasise the articulatory configuration of the tester were also used; for instance:

- Using thumbs and forefingers to point to closed or rounded lips.
- A hand gesture (fingers slowly closing, pointing downward towards the thumb to indicate a slight closing of the mouth).

- Demonstrating a retracted lip.

Specific Scoring Rules

The researcher had to read the manual and watch the tutorial videos several times until she became confident about administering the scoring system.

Vowel Accuracy. Vowels must be scored on the first attempt, even if the child improves vowel production after cueing.

Score 2 indicates correct immediate imitation.

Score 1 indicates uncertainty when the researcher is unsure (imitation was correct), when the child self-corrects but with a delay, or the child shows groping or trial and error behaviour during the self-corrected production.

Score 0 indicates distortion, or substitution.

Score x indicates refusal or no attempt at all.

Prosodic Accuracy. Prosodic accuracy is scored on the first attempt. It notes one or more of the prosodic errors, such as segmentation plus equal stress, segmentation plus incorrect stress, or added syllable plus equal stress.

Score 1 indicates correct prosody.

Score 0 indicates incorrect prosody (equal stress, segmentation, or incorrect lexical stress).

Score x, indicates refusal or no attempt at all.

Overall Articulatory Accuracy. Overall articulatory accuracy refers to the accuracy of the movement for the word as a whole. It is scored on the first attempt or after cued practice and a final, noncued, direct imitation.

Score 4 indicates immediate correct imitation of the word; the child shows accurate movement for correct sound production across the entire word. If the second imitation is incorrect, a score of 4 is provided for overall articulatory accuracy and 0 for inconsistency.

Score 3 indicates immediate imitation containing a consistent consonant substitution and accurate vowel without any sign of groping or trial-and-error behaviour. For example, when a child presents with developmental, consistent, and predictable consistent errors such as fronting, w/r, w/l, frontal lisp, keep the score of 3. However, if the child presents with consonant omissions (e.g., final consonant deletion), the child will not score 3 and will need cueing. See the previous discussion about phonological processes in Arabic.

Score 2 indicates that the child needs a single additional model as a first cued trial, or the child produces the correct response on the first try but after a delay.

Score 1 indicates a correct response after cueing. After all cueing (6), it must elicit an uncued trial in direct imitation.

Score 0 indicates an incorrect response.

Score x indicates refusal or no attempt at all.

Consistency Scoring. Consistency scoring is completed after all trials on the item.

Score 1 indicates that production is consistent across all trials.

Score 0 indicates that production is inconsistent across more than two trials.

Score x indicates refusal or no attempt at all.

If the child has significant difficulty:

The child may not be able to complete all items in all subtests due to speech severity. In this case, complete all items the child can attempt to imitate.

After two trials, the tester can stop if it is almost certain that the child will not succeed. The tester must consider two trials when determining a score of 0 if the child is unable to produce the word because it was tried with similar stimuli.

In cases where a child needs maximum cueing and shows poor performance on the easy subtest, the tester may discontinue the test.

Table 4.4. *Timing and Description of Scoring on the DEMSS (Strand & McCauley, 2019)*

		Score		
Description and timing		**Overall accuracy**	**Vowel accuracy**	**Prosodic accuracy**
An initial attempt at direct imitation	To determine consistency, elicit another uncued trial	4= correct on the first attempt 3 = consistent developmental error without distorted movement or slowed production 2 = correct response on first try, but after a delay or when the child self-corrects without additional modelling	2 = vowels were accurate 1 = uncertain 0 = vowel distortion X = refusal, or no attempt	1 = correct 0=incorrect X = refusal, or no attempt
The first practice trial (first attempt with a cue)	After an initial incorrect attempt, the tester ensures the child is paying attention to her face and provides another slightly slower auditory model and possibly a gestural cue.	2 = correct production after practice trial 1, in direct imitation		
2-6 practice trials with cueing	Tester provided cues	No scores were given		
Child's attempt at direct imitation after cueing	Tester elicited uncued direct imitation	Overall accuracy 1 = correct on this final noncued attempt after 2 or more (up to 6) cued practice trials 0 = incorrect on the final noncued elicitation after all cued attempts X = refusal or no attempt	Consistency (based on selected subtests) 1 = consistent production across all trials 0 = two trials differed X = refusal or no attempt	

Chapter 5 - Study Results

This chapter will present a comprehensive analysis of the scores of all the children who participated in the study. In Arabic, no assessment tools are available to diagnose CAS. An Arabic version of the DEMSS was developed and used to evaluate CAS features for Arabic-speaking children.

During the study, 49 participants underwent a variety of speech tests, such as an oral-facial examination and an articulation test, before the Ar-DEMSS was administered. As part of the Ar-DEMSS, a single-word sample was elicited by asking the participants to repeat and imitate the clinician's speech. The accuracy of vowels, prosody, overall articulation accuracy, and consistency were evaluated.

The results of this project will be presented in Chapters 5 and 6. Chapter 5 includes three sections:

Section 5.1 will discuss how typically developing children and children with CAS scored on the oral-facial examination, Nonverbal Oral Apraxia test, monosyllables DDK, multisyllabic sequence DDK, and an articulation test.

Section 5.2 examines the performance of typically developing children on the Ar-DEMSS total score and subscores in each variable: vowel accuracy, prosody, overall articulatory accuracy, and consistency.

Section 5.3 examines the performance of children with CAS on the Ar-DEMSS total score and subscores in each variable: vowel accuracy, prosody, overall articulatory accuracy, and consistency.

Section 5.4 provides figures representing boxplots, commonly used in statistics to visually display data distribution. These charts aim to present the performance of typically developing children and children with CAS on the Ar-DEMSS test in terms of (a) their total score, (b) their subscores related to vowel accuracy, prosody, overall articulatory accuracy, and consistency.

Chapter 6 discusses the case studies of three children diagnosed with CAS (aged 3;9, 4;5, and 5;10) and describes their performance in the Ar-DEMSS, specifically on vowels, prosody, overall articulatory accuracy, and consistency.

5.1 Typically Developing and CAS Groups

In this section, I will provide the score results from each assessment procedure for the typically developing children and the children with CAS, including an oral-facial examination, Nonverbal Oral Apraxia, DDK monosyllabic and multisyllabic alternation movement rates, and an articulation test.

5.1.1 *How Did the Typically Developing and CAS Groups Perform in the Oral-Facial Examination?*

Table 5.1 summarises the results of the oral-facial examination performed on the two groups—the CAS group and the typical developing children group—to determine whether there were any structural problems affecting their speech production. In the CAS group, there were six cases, with a typical oral-facial examination in 100% of the participants. All 43 (100%) children in the typical developing children group also had typical oral-facial examinations. Based on these results, both groups of children demonstrated adequate oral structure and function of their speech mechanisms.

Table 5.1. Frequency and Percentage of All Children with CAS and Typical developing children in the Oral-Facial Examination

Group	T/A	Frequency	Percent
CAS	T	6	100.0

Typically developing children	T	43	100.0

Note. T = typical.

5.1.2 *How Did the Typically Developing Children and CAS Groups Perform in the Nonverbal Oral Apraxia Test?*

Table 5.2 shows the results of nonverbal oral apraxia examinations among both groups. According to the criteria, a typical result reflects zero errors, while an atypical result includes one point that refers to one or two symptom errors, such as initiation difficulties or articulatory groping, which are considered mild. In the CAS group, there were only two children at age 4 who performed typically in the test (33.10% of the total CAS group). However, four children across all age groups demonstrated difficulties in their ability to sequence the voluntary nonverbal movements of their articulators as a result of visible groping and initiating difficulties. Some difficulties were noted in children with CAS, such as the inability to pucker, puff cheeks, or move their tongues in different directions. Hypothetically, if the assessment had included more tasks involving sequenced movements, such as first rounding the lips and then spreading them or smile-kiss, it is likely that children with CAS would have exhibited more pronounced difficulties. As a result of their core motor planning and coordination challenges, children with CAS have significant difficulties sequencing nonverbal oral movements. The impairment is evident when they are asked to perform tasks that require both imitating or eliciting isolated posture and sequential oral gestures, such as "smile-kiss". Based on studies by ASHA (2007), Davis et al. (1998), McCabe et al. (1998), and Shriberg et al. (1997a), it is clear that these children face significant challenges in planning and coordinating sequential movements, often exhibiting groping behaviors as they attempt to find the right positions for their articulations. The findings demonstrate the importance of including tasks that evaluate motor sequencing abilities in assessments of CAS. On the other hand, no signs of nonverbal oral apraxia were observed among any of the children in the typical developing children's groups.

Table 5.2. *Number and Frequency of Participants With CAS and Typical Developing Children in Each Age Group With Nonverbal Oral Apraxia*

Group	Age group	T/A	Score	N	%
CAS	3;0-3;11	A	1	2	100.00%
	4;0-4;11	A	1	1	33.30%
		T	0	2	66.70%
	5;0-6;0	A	1	1	100.00%
Typically developing children	3;0-3;11	T	0	3	100.00%
	4;0-4;11	T	0	12	100.00%
	5;0-5;11	T	0	17	100.00%
	6;0-7;0	T	0	11	100.00%

Note. A = atypical; T = typical; 0 = no difficulties or typical; 1 = mild difficulties (one or two symptoms of difficulties).

5.1.3 *How Did the Typically Developing Children and CAS Groups Perform in the DDK Task?*

Table 5.3 shows the frequency and percentage of participants who had difficulty with the AMR DDK task, according to age and clinical diagnosis of CAS or typical developing children.

Table 5.3. *Performance of Both Groups in the DDK Monosyllable Task*

Group	Age group	T/A	Score	Frequency	Percent
CAS	3;0-3;11	A	1	1	50
		T	0	1	50
	4;0-4;11	A	1	1	33.3
		T	0	2	66.7
	5;0-6;0	T	0	1	100
Typically developing children	3;0-3;11	T	0	3	100
	4;0-4;11	T	0	12	100
	5;0-5;11	T	0	17	100
	6;0-7;0	T	0	11	100

Note. A = atypical; T = typical; 0 = no errors; 1 = errors on the /ka/ monosyllable.

CAS Group. As shown by the results in Table 5.3, there were two 3-year-old children in the CAS group. One produced the DDK monosyllable accurately, while the other had an error only in /ka'ka/ monosyllable production. In the 4-year-old age group, there were three children, and only one (33.3%) had difficulties producing the /ka'ka/ syllable. Lastly, in the 5-

year-old age group, there was only one child, and he was able to produce the DDK monosyllable accurately.

Typical Developing Children Group. In the typical developing children group, all 43 children from different age groups were able to produce the DDK monosyllable accurately with no errors.

Table 5.4 presents the performance of both groups in multisyllabic DDK. For the CAS group, out of six, only one child (16.6%), aged 4 years, did not show any difficulties in the DDK task. The other five children of various ages demonstrated difficulties in the DDK task; they were not able to sequence the required syllables together.

On the other hand, for the typical developing children group, in the 3-year-old group, out of three children, one (33.3%) was not able to accurately produce it. Altogether, 16.7% of the 4-year-olds, 11.8% of the 5-year-olds, and 18.2% of the six-year-olds had difficulties in the DDK task.

It was found that both children with CAS and some of the typically developing children struggled with the multisyllabic task, but those with CAS had greater difficulties. On the DDK task, these children had difficulty with accuracy and consistency, missing syllables, substituting incorrectly, or incorrect DDK sequences.

Table 5.4. *Performance of Both Groups in the Multisyllabic SMR DDK Task*

Group	Age group	T/A	Frequency	Percent
CAS	3;0-3;11	A	2	100
	4;0-4;11	A	2	66.7
		T	1	33.3
	5;0-6;0	A	1	100
Typically developing children	3;0-3;11	A	1	33.3
		T	2	66.7
	4;0-4;11	A	2	16.7
		T	10	83.3
	5;0-5;11	A	2	11.8
		T	15	88.2

6;0-7;0	A	2	18.2
	T	9	81.8

Note. A = atypical; T = typical.

5.1.4 *How Did the Typically Developing Children and CAS Groups Perform in the Articulation Test?*

Table 5.5 shows the minimum and maximum number of errors produced by the children in the articulation test in both groups. In the CAS group, only older participants, aged 4 and 5 years, participated. Two children with CAS at the age of 3 years were unable to take the test because of their severe speech difficulties. However, in the 4-year-old group, there were three children with a minimum of 15 and a maximum of 58 errors; the mean was 35.33 (SD, 21.59). A large SD was observed in the age 4 years old group, indicating wide individual variation. In the 5-year-old group, there was one child with 43 errors.

In the typical developing children group, only two children, aged 3 and 4, were unable to take the test. This is because they had difficulties concentrating and engaging in the articulation test task. In the 3-year-old group, two children were able to participate, with a minimum of 10 and a maximum of 16 errors; the mean was 13, and the SD was 4.24. In the 4-year-old group, there were 11 participants with a minimum of 0 and a maximum of 25 errors; the mean was 8.55, and the SD was 7.97.

In the 5-year-old group, there were 17 children with a minimum of 0 and a maximum of 13 errors; the mean score was 3.82, and the SD was 4.30. Lastly, in the 6-year-old group, there were 11 children with a minimum of 0 and a maximum of 20 errors; the mean score was 2.73, and the SD was 6.47.

Table 5.5. *Minimum, Maximum, Mean, and Standard Deviation of the Number of Articulation Errors Between the CAS and Typical Developing Children Groups*

Group	Age group	*N*	*Min*	*Max*	*M*	*SD*
CAS	4;0-4;11	3	15	58	35.33	21.59

	5;0-6;0	1	43	43	43	
Typical developing children	3;0-3;11	2	10	16	13	4.24
	4;0-4;11	11	0	25	8.55	7.97
	5;0-5;11	17	0	13	3.82	4.3
	6;0-7;0	11	0	20	2.73	6.47

Note. N = number of participants.

5.2 Typically Developing Children Group

5.2.1 *Performance of Typically Developing Children on the Ar-DEMSS Test*

This section presents the results of how typically developing children performed on the Ar-DEMSS test. These results answer the following research questions, as outlined in Chapter 1.

Research Question 1: How do typically developing Arabic-speaking children aged 3 to 7 perform on the Ar-DEMSS in terms of (a) their total score and (b) their subscores related to vowel accuracy, prosody, overall articulatory accuracy, and consistency?

Part one of this section will examine the total scores of typically developing children across four age groups in Ar-DEMSS, vowels, prosodic patterns, overall articulatory accuracy, and consistency variables. Part two will examine how these children perform in all variables in each section of the Ar-DEMSS test.

5.2.1.1 Ar-DEMSS Test Total Scores. Table 5.6 provides information on the performance of typically developing children from different age groups in the Ar-DEMSS test. In this context, the number 384 refers to the total possible score in the Ar-DEMSS test. As shown, the actual scores obtained by children within each age group varied, and the mean scores reported in the table reflect the mean performance of the subjects within each age group.

It is possible for each age group to obtain a score of 384 on the DEMSS test if all the subtests are administered. This table illustrates descriptive statistics—the minimum, maximum, mean, and standard deviation—in different age groups.

Table 5.6. *Performance of Typically Developing Children on the Ar-DEMSS Test: Total Scores*

Group	Age group		*N*	*Min*	*Max*	*M*	*SD*
Typically developing children	3;0-3;11	DEMSS 384	3	382	384	383.0	1.0
	4;0-4;11	DEMSS 384	12	364	384	377.7	8.3
	5;0-5;11	DEMSS 384	17	372	384	382.1	3.1
	6;0-7;0	DEMSS 384	11	351	384	378.9	10.7

Note. N = number of participants in each age group; Min = minimum; Max = maximum; M = mean; SD = standard deviation.

Typically Developing Children Groups. The 3-year-old group had a minimum score of 382 and a maximum score of 384, with a mean of 383 (SD, 1.0). The 4-year-old group had a minimum score of 364 and a maximum score of 384, with a mean of 377.7 (SD, 8.3). In addition, the 5-year-old group had a minimum score of 372 and a maximum score of 384, with a mean of 382.2 (SD, 3.1). The 6-year-old group had a minimum score of 351 and a maximum score of 384 with a mean of 378.9 (SD, 10.7). A six-year-old was the only child to score the lowest in all age groups. Most six-year-olds achieved the maximum score. This child's low score was due to minor vowels, articulation, and consistency difficulties. The child made some phonological and articulation errors in different test sections, affecting his score. He/she could not produce a few words when the words were lengthened due to phonological processes. This affected his/her overall articulatory accuracy and vowel production, resulting in inconsistent performance. As children get older, developmental trends indicate they will perform well on speech tests. The development of speech sound acquisition and maturation of the articulatory system follows these trends. Despite the fact that most children at this age should exhibit accurate articulation, external factors, and individual differences can affect their ability.

5.2.2 Performance of Typically Developing Children in Total Scores and Subscores.

In Table 5.7, the total scores are presented for vowels, prosody, overall articulatory accuracy, consistency, and Ar-DEMSS scores.

Table 5.7. *Total Scores in Vowel, Prosody, Overall Articulatory Accuracy, Consistency, and the Ar-DEMSS Test*

Age group		*N*	*Min*	*Max*	*M*	*SD*
3;0-3;11	V	3	108	108	108	0
	P	3	25	25	25	0
	O	3	215	216	215.67	0.58
	C	3	33	35	34.33	1.15
	Ar-DEMSS	3	382	384	383	1
4;0-4;11	V	12	108	108	108	0
	P	12	21	25	23.92	1.31
	O	12	201	216	213.17	5.15
	C	12	32	35	34.25	1.22
	Ar-DEMSS	12	364	384	377.7	8.3
5;0-5;11	V	17	108	108	108	0
	P	17	22	25	24.53	0.8
	O	17	208	216	215	2.09
	C	17	31	35	34.53	1.01
	Ar-DEMSS	17	372	384	382.1	3.1
6;0-7;0	V	11	102	108	107	2.05
	P	11	21	25	24.18	1.4
	O	11	196	216	213.27	6.21
	C	11	29	35	34.45	1.81
	Ar-DEMSS	11	351	384	378.9	10.7

Note. N = number of participants in each age group; Min = minimum; Max = maximum; M = mean; SD = standard deviation; total possible scores for V= 108; P= 25; O= 216; C= 35; Ar-DEMSS= 384.

5.2.3 *How Did the Typically Developing Children's Groups Perform on Vowel Accuracy in Each Section of the Test?*

The following is an analysis of the vowel accuracy variable across different test sections for groups of typically developing children. Table 5.8 illustrates descriptive statistics—the minimum, maximum, mean, and standard deviation—in different age groups.

Table 5.8. *Performance of Typically Developing Children in the Vowel Variable*

Age Group	Section		*N*	*Min*	*Max*	*M*	*SD*
3;0-3;11	A	V	3	20	20	20	0
	B	V	3	8	8	8	0
	C	V	3	14	14	14	0
	D	V	3	24	24	24	0
	E	V	3	14	14	14	0
	F	V	3	16	16	16	0
	G	V	3	12	12	12	0
4;0-4;11	A	V	12	20	20	20	0
	B	V	12	8	8	8	0
	C	V	12	14	14	14	0
	D	V	12	24	24	24	0
	E	V	12	14	14	14	0
	F	V	12	16	16	16	0
	G	V	12	12	12	12	0
5;0-5;11	A	V	17	20	20	20	0
	B	V	17	8	8	8	0
	C	V	17	14	14	14	0
	D	V	17	24	24	24	0
	E	V	17	14	14	14	0
	F	V	17	16	16	16	0
	G	V	17	12	12	12	0
6;0-7;0	A	V	11	20	20	20	0
	B	V	11	8	8	8	0
	C	V	11	14	14	14	0
	D	V	11	23	24	23.9	0.32
	E	V	11	10	14	13.5	1.27
	F	V	11	16	16	16	0
	G	V	11	9	12	11.5	1.08

Note. N = the number of participants in an age group; A = CV; B = reduplicated syllable; C = CVC1; D = CVC2; E = disyllabic 1; F = disyllabic 2; G = multisyllabic; V = vowel; maximum score = 108.

Typical Developing Children Group. The vowel variable was examined in all Ar-DEMSS test sections—A, B, C, D, E, F, and G. In each section, the maximum scores were 20, 8, 14, 24, 14, 16, and 12, respectively. For the vowel variable, all children from different age groups (3;0, 4;0, 5;0, 6;0) scored the maximum. However, in sections D and E, there were some minor errors made by the 6-year-old participants. As can be noted from the table, there was a mean score of 23.90 (SD, .32) in section D, and the mean score was 13.50 (SD, 1.27) in section E. The results demonstrated that there were no major differences across all age groups as the majority reached the maximum score.

5.2.4 How Did the Typically Developing Children's Groups Perform in the Prosody Variable in Each Section of the Test?

Table 5.9 shows the prosody accuracy variable scores in four different sections (B, E, F, and G). In each section, there was a maximum score (4, 7, 8, and 6). This table illustrates descriptive statistics—the minimum, maximum, mean, and standard deviation—in different age groups.

Table 5.9. *Performance of Typically Developing Children in the Prosody Variable*

Age group	Section		*N*	*Min*	*Max*	*M*	*SD*
3;0-3;11	B	P	3	4	4	4	0
	E	P	3	7	7	7	0
	F	P	3	8	8	8	0
	G	P	3	6	6	6	0
4;0-4;11	B	P	12	4	4	4	0
	E	P	12	5	7	6.58	0.67
	F	P	12	5	8	7.33	1.07
	G	P	12	2	6	5.62	1.12
5;0-5;11	B	P	17	2	4	3.76	0.56
	E	P	17	6	7	6.88	0.33
	F	P	17	7	8	7.94	0.24
	G	P	17	5	6	5.94	0.24
6;0-7;0	B	P	11	3	4	3.7	0.48
	E	P	11	5	7	6.7	0.68
	F	P	11	8	8	8	0
	G	P	11	4	6	5.7	0.68

Note. B = reduplicated syllables; E = disyllabic 1; F = disyllabic 2; G = multisyllabic; P = prosody; maximum score = 25.

Typically Developing Children Groups.

Section B, Reduplicated Syllables Structure (maximum possible score 4): All the children in the younger group as well as the middle group (4 years) obtained the highest score of 4.00. However, the older group (5 years) obtained a minimum score of 2 and a maximum score of 4; the mean was 3.76 (SD, .56). Similarly, the 6-year-old group scored a minimum of 3 and a maximum of 4, with a mean of 3.70 (SD, .48). While the younger and middle group achieved the highest score with no errors, both older groups had a large number of participants who were able to obtain the maximum score.

Section E, Bisyllabic Structure 1 (maximum possible score 7): All the children in the 3-year-old group obtained the highest score of 7. However, the 4-year-old group obtained a minimum score of 5 and a maximum score of 7, with a mean of 6.58 (SD, .67). The 5-year-old group obtained a minimum score of 6 and a maximum score of 7, with a mean of 6.88 (SD, .33). The 6-year-old group obtained a minimum score of 5 and a maximum score of 7, with a mean of 6.70 (SD, .68). As can be seen, the lowest minimum scores were found among children aged 4 and 6.

Section F, Bisyllabic Structure 2 (maximum possible score 8): All the children in the younger and older age groups (3 and 6 years) obtained the highest score of 8. In contrast, some minor errors were noted in the other groups. For example, the 4-year-old group obtained a minimum score of 5 and maximum score of 8, with a mean of 7.33 (SD, 1.07). The 5-year-old group obtained a minimum score of 7 and a maximum score of 8, with a mean of 7.94 (SD, .24). This shows that the mean score increased from age 4 to age 6, meaning that the majority of the children were able to participate with no errors.

Section G, Multisyllabic Structure (maximum possible score 6): All the 3-year-old children obtained the highest score of 6. The 4-year-old group obtained a minimum score of 2 and a maximum score of 6, with a mean of 5.62 (SD, 1.12). Meanwhile, the 5-year-old group obtained a minimum score of 5 and a maximum score of 6; the mean was 5.94 (SD, .24). The

6-year-old children group obtained a minimum score of 4 and a maximum score of 6, with a mean of 5.70 (SD, .68). Children aged 4 demonstrated the lowest performance in multisyllabic structure, among various age groups.

5.2.5 How Did the Typically Developing Children's Groups Perform in Overall Articulatory Accuracy in Each Section of the Test?

The overall articulatory variable was examined in all Ar-DEMSS test sections—A, B, C, D, E, F, and G. In each section, the maximum scores were 40, 16, 28, 48, 28, 32, and 24, respectively. Table 5.10 illustrates descriptive statistics—the minimum, maximum, mean, and standard deviation—in different age groups for the overall articulatory accuracy variable.

Table 5.10. *Performance of Groups of Typically Developing Children in the Overall Articulatory Accuracy Variable*

Age group	Section		N	*Min*	*Max*	*M*	*SD*
3;0-3;11	A	O	3	40	40	40	0
	B	O	3	16	16	16	0
	C	O	3	28	28	28	0
	D	O	3	47	48	47.67	0.58
	E	O	3	28	28	28	0
	F	O	3	32	32	32	0
	G	O	3	24	24	24	0
4;0-4;11	A	O	12	39	40	39.83	0.39
	B	O	12	16	16	16	0
	C	O	12	24	28	27.58	1.17
	D	O	12	46	48	47.67	0.78
	E	O	12	27	28	27.75	0.45
	F	O	12	24	32	30.42	2.39
	G	O	12	13	24	21.92	4.01
5;0-5;11	A	O	17	38	40	39.82	0.53
	B	O	17	16	16	16	0
	C	O	17	27	28	27.94	0.24
	D	O	17	42	48	47.47	1.46
	E	O	17	27	28	27.94	0.24
	F	O	17	31	32	31.94	0.24
	G	O	17	22	24	23.88	0.49
6;0-7;0	A	O	11	38	40	39.8	0.63
	B	O	11	16	16	16	0
	C	O	11	28	28	28	0
	D	O	11	46	48	47.7	0.68
	E	O	11	22	28	27.1	1.91
	F	O	11	30	32	31.7	0.68
	G	O	11	11	24	22.5	4.09

Note. A = CV; B = reduplicated syllable; C = CVC1; D = CVC2; E = disyllabic 1; F = disyllabic 2; G = multisyllabic; O = overall articulatory accuracy; maximum score = 216.

Typically Developing Children Group.

Section A: CV Structure (maximum possible score 40): All the children in the 3-year-old group achieved the maximum score of 40. In the 4-year-old group, the minimum score was 39 and the maximum score was 40; the mean score was 39.83 (SD, .39). In the 5-year-old group, the minimum score was 38 and the maximum score was 40; the mean score was 39.82 (SD,.53). In the 6-year-old group, the minimum score was 38 and the maximum score was 40; the mean score was 39.80 (SD, .63). This finding showed that there were minimal differences between participants, as the lowest mean was 39.80.

Section B: Reduplicated Syllables Structure (maximum possible score 16): All the children from the different age groups attained the maximum score of 16.

Section C: CVC1 Structure (maximum possible score 28)**:** The 3-year-old group, and the 6-year-old group scored the maximum score 28. In the 4-year-old group, the minimum score was 24 and the maximum score was 28; the mean score was 27.58 (SD, 1.17). In the 5-year-old group, the minimum score was 27 and the maximum score was 28; the mean score was 27.94 (SD, .24). It appears that some children at age 4 had a few difficulties in overall articulatory accuracy in the CVC structure.

Section D: CVC2 Structure (maximum possible score 48): The 3-year-old group had a minimum score of 47 and maximum score of 48, with a mean of 47.67 (SD, .58). Also, the 4-year-old group had a minimum score of 46 and a maximum score of 48, with a mean of 47.67 (SD, .78). Additionally, the 5-year-old group had a minimum score of 42 and a maximum score of 48, with a mean of 47 (SD, 1.46). In the 6-year-old group, the minimum score was 46 and the maximum score was 48; the mean score was 47.70 (SD, .68). It can be noted that one 3-year-old child had developmental errors in their speech, which affected the score. However, there is slight variation in scores between participants in the age 5 group.

Section E: Disyllabic 1(maximum possible score 28)**:** The 3-year-old group obtained the maximum score of 28. The 4-year-old group had a minimum score of 27 and a maximum score of 28, with a mean of 27.75 (SD, .45). Furthermore, the 5-year-old group had a minimum score of 27 and a maximum score of 28, with a mean of 27.94 (SD, .24). In the 6-year-old group, the minimum score was 22 and the maximum score was 28; the mean score was 27.10 (SD, 1.91). Children in this age group scored lower, indicating difficulties with disyllabic 1 word.

Section F: Disyllabic 2 (maximum possible score 32): The 3-year-old group scored 32. The 4-year-old group had a minimum score of 24 and a maximum score of 32, with a mean of 30.42 (SD, 2.39). Furthermore, the 5-year-old group had a minimum score of 31 and a maximum score of 32, with a mean of 31.94 (SD, .24). In the 6-year-old group, the minimum score was 30 and the maximum score was 32; the mean score was 31.70 (SD, .68). It was found that disyllabic 2 words were difficult at age 4 years, with a lower minimum score.

Section G: Multisyllabic (maximum possible score 24): The 3-year-old group scored 24. The 4-year-old group had a minimum score of 13 and a maximum score of 24, with a mean of 21.92 (SD, 4.01). The 5-year-old group had a minimum score of 22 and a maximum score of 24, with a mean of 23.88 (SD, .49). In the 6-year-old group, the minimum score was 11 and the maximum score was 24; the mean score was 22.50 (SD, 4.09). It was evident that only a few children aged 4 and 6 experience difficulty with multisyllabic words.

5.2.6 How Did the Typically Developing Children's Groups Perform on Consistency Variables in Each Section of the Test?

Table 5.11 presents the consistency variable scores in four different sections (A, C, D, and G). In each section, there was a maximum score (10, 7, 12, and 6). This table shows the descriptive statistics of the minimum, maximum, mean, and standard deviation in different age groups.

Table 5.11. *Performance of Typically Developing Children in the Consistency Variable*

Age group	Section		N	*Min*	*Max*	*M*	*SD*
3;0-3;11	A	C	3	10	10	10.00	0.00
	C	C	3	7	7	7.00	0.00
	D	C	3	12	12	12.00	0.00
	G	C	3	4	6	5.33	1.16
4;0-4;11	A	C	12	9	10	9.92	0.29
	C	C	12	6	7	6.83	0.39
	D	C	12	10	12	11.58	0.79
	G	C	12	3	6	5.38	1.04
5;0-5;11	A	C	17	9	10	9.94	0.24
	C	C	17	7	7	7.00	0.00
	D	C	17	9	12	11.76	0.75
	G	C	17	5	6	5.82	0.39
6;0-7;0	A	C	11	9	10	9.90	0.32
	C	C	11	6	7	6.90	0.32
	D	C	11	11	12	11.90	0.32
	G	C	11	2	6	5.60	1.27

Note. A = CV; C = CVC1; D = CVC2; G = multisyllabic; C = consistency; maximum score = 35.

Typically Developing Children Group.

Section A, CV Structure (maximum possible score 10): All the children in the 3-year-old group scored the maximum score of 10. In the 4-year-old group, the minimum score was 9 and the maximum score was 10; the mean score was 9.92 (SD, .29). In the 5-year-old group, the minimum score was 9 and the maximum score was 10; the mean score was 9.94 (SD, .24). In the 6-year-old group, the minimum score was 9 and the maximum score was 10; the mean score was 9.90 (SD, .32). As it can be seen, all children had consistent speech production at CV structure.

Section C, CVC1 Structure (maximum possible score 7): All the children in the 3-year-old and 5-year-old groups, attained the maximum score of 7. There were some minor errors in the 4-year-old group, so the minimum score was 6 and the maximum score was 7; the mean score was 6.83 (SD, .39). In the 6-year-old group, the minimum score was 6 and the maximum score was 7; the mean score was 6.90 (SD, .32).

Section D, CVC2 Structure (maximum possible score 12)**:** All the children in the 3-year-old group scored the maximum score 12. In the 4-year-old group, the minimum score was 10 and the maximum score was 12; the mean score was 11.58 (SD, .79). In the 5-year-old group, the minimum score was 9 and the maximum score was 12; the mean score was 11.76 (SD, .75). In the 6-year-old group, the minimum score was 11 and the maximum score was 12; the mean score was 11.90 (SD, .32). The CVC2 structure revealed some children experiencing inconsistent production based on their different minimum scores between age groups.

Section G, Multisyllabic Structure (maximum possible score 6): For all the children in the 3-year-old group, the minimum score was 4 and the maximum score was 6; the mean score was 5.33 (SD, 1.16). In the 4-year-old group, the minimum score was 3 and the maximum score was 6; the mean score was 5.38 (SD, 1.04). In the 5-year-old group, the minimum score was 5 and the maximum score was 6; the mean score was 5.82 (SD, .39). In the 6-year-old group, the minimum score was 2 and the maximum score was 6; the mean score was 5.60 (SD, 1.27). The results show that a lower score was achieved at 6 years of age, which indicates one child had inconsistent multisyllabic word production.

5.2.7 *Reliability*

Inter-rater reliability test was performed by a qualified SLT to evaluate the reliability of the scoring techniques used in the study. The interjudge reliability was determined for eight typically developing children (13.3%) who were randomly selected. Interjudge reliability analysis was conducted by presenting the intraclass correlation coefficient (ICC) of the total score of the Ar-DEMSS and its subscores. The interjudge ICC values for the Ar-DEMSS total score and vowel was 1, but for prosody, the overall articulatory and consistency was .99. This shows that the agreement between the two raters was very high.

Table 5.12. *Reliability*

Variable	Interjudge
Total Ar-DEMSS score	1[.99, 1]
Vowel accuracy sub score	1
Overall articulatory accuracy sub score	.99[.99, 1]
Prosodic accuracy sub score	.99[99, 1]
Consistency sub score	.99[.99, 1]

5.2.8 *Correlations*

The correlation between age, the articulation test, and Ar-DEMSS is provided in Table 5.13.

Table 5.13. *The Correlation Between Age, the Articulation Test, and Ar-DEMSS*

Group			Age	DEMSS 384	Articulation test
Typically developing children		N			
	Age	Correlation Coefficient	1.000	0.205	-.557**
		Sig. (2-tailed)		0.188	0.000

	N	43	43	41
Ar-DEMSS 384	Correlation Coefficient	0.205	1.000	-.615**
	Sig. (2-tailed)	0.188		0.000
	N	43	43	41
Articulation test	Correlation Coefficient	-.557**	-.615**	1.000
	Sig. (2-tailed)	0.000	0.000	
	N	41	41	41

Note.** Correlation is significant at the 0.01 level (2-tailed).

The articulation test score was shown to be positively skewed by inspecting the histogram. A nonparametric test was therefore used for the analysis of the results. Spearman's rho test was conducted. A significance level of alpha level was used at 0.05. The results showed a significant negative correlation of -.557, $p < .001$. This indicates that as age increases, the articulation test score decreases; hence, fewer errors are made. This is in line with expectations based on the assumed accuracy of articulation tests.

In terms of the Ar-DEMSS score, the Spearman's rho test showed a positive correlation between age and the Ar-DEMSS score, .205, $p = .188$. This indicates that, as the age of the child increases, the Ar-DEMSS score also increases; this non-significant trend is in line with developmental expectations.

5.3 Performance of Children with CAS on the Ar-DEMSS Test

This section presents the results of how children in the CAS groups performed in the Ar-DEMSS test in response to the following research questions, as outlined in Chapter 1.

Research question 2: How do Arabic-speaking children with CAS perform on the Ar-DEMSS in terms of (a) their total score and (b) their subscores related to vowel accuracy, prosody, overall articulatory accuracy, and consistency?

5.3.1 *Ar-DEMSS Test Total Scores*

Table 5.14 provides information on the performance of children with CAS from different age groups on the Ar-DEMSS test, as well as the individual scores for each child. In this context, the number 384 refers to the total possible score on the Ar-DEMSS test. As shown, the actual scores obtained by children within each age group varied, and the mean scores reported in the table reflect the mean performance of the subjects within each age group. This table illustrates descriptive statistics—the minimum, maximum, mean, and standard deviation—in different age groups.

Table 5.14. *Performance of Children with CAS on the Ar-DEMSS: Total Score*

Group	Age group	Child's total scores		*N*	*Min*	*Max*	*M*	*SD*
CAS	3;0-3;11	182 209	DEMSS 384	2	182	209	195.5	19.1
	4;0-4;11	257 300 319	DEMSS 384	3	257	319	292	31.8
	5;0-6;0	279	DEMSS 384	1	279	279	279	.

Note. N = number of participants in each age group; Min = minimum; Max = maximum; M = mean; SD = standard deviation.

CAS Group. As shown in Table 5.14, the 3-year-old group had a minimum score of 182 and a maximum score of 209, with a mean of 195.5 (SD, 19.1). The 4-year-old group had a minimum score of 257 and a maximum score of 319, with a mean of 292 (SD, 31.8). In addition, the 5-year-old group scored 279.

5.3.2 *The Performance of Children with CAS: Total Scores and Subscores*

In Table 5.15, the total scores of CAS group are presented for vowels, prosody, overall articulatory accuracy, consistency, and Ar-DEMSS scores.

Table 5.15. *Total Scores in Vowel, Prosody, Overall Articulatory Accuracy, Consistency, and the Ar-DEMSS Test*

Group	Age group		*N*	*Min*	*Max*	*M*	*SD*
CAS	3;0-3;11	V	2	77	78	77.5	0.71
		P	2	3	4	3.5	0.71
		O	2	91	112	101.5	14.85
		C	2	9	17	13	5.66
		Ar-DEMSS	2	182	209	195.5	19.1
	4;0-4;11	V	3	84	104	94.33	10.02
		P	3	11	12	11.67	0.58
		O	3	138	181	162	21.93
		C	3	23	26	24	1.73
		Ar-DEMSS	3	257	319	292	31.8
	5;0-6.0	V	1	100	100	100	.
		P	1	7	7	7	.
		O	1	152	152	152	.
		C	1	20	20	20	.
		Ar-DEMSS	1	279	279	279	.

Note. Ar-DEMSS= 384; N = number of participants in each age group; Min = minimum; Max = maximum; M = mean; SD = standard deviation; total possible scores for V= 108; P= 25; O= 216; C= 35; Ar-DEMSS= 384.

5.3.3 *How Do Children with CAS Perform in Vowel Accuracy in Each Section of the Test?*

The following Table 5.16 is an analysis of the vowel accuracy variable across different test sections for children in the CAS groups. The following table illustrates descriptive statistics—the minimum, maximum, mean, and standard deviation—in different age groups.

Table 5.16. *Performance of Children with CAS in the Vowel Variable*

Age group	Section		*N*	*Min*	*Max*	*M*	*SD*
3;0-3;11	A	V	2	16	17	16.5	0.71
	B	V	2	8	8	8	0
	C	V	2	10	14	12	2.83
	D	V	2	14	21	17.5	4.95
	E	V	2	8	12	10	2.83
	F	V	2	10	11	10.5	0.71
	G	V	2	0	6	3	4.24
4;0-4;11	A	V	3	18	20	19.33	1.16
	B	V	3	8	8	8	0
	C	V	3	14	14	14	0
	D	V	3	9	24	18.33	8.15
	E	V	3	10	12	11.33	1.16
	F	V	3	12	16	14	2
	G	V	3	7	9	8	1.41
5;0-6;0	A	V	1	20	20	20	.
	B	V	1	8	8	8	.
	C	V	1	14	14	14	.
	D	V	1	22	22	22	.
	E	V	1	11	11	11	.
	F	V	1	14	14	14	.
	G	V	1	11	11	11	.

Note. N = number of participants in an age group; A = CV; B = reduplicated syllable; C = CVC1; D = CVC2; E = disyllabic 1; F = disyllabic 2; G = multisyllabic; V = vowel; maximum score = 108; total possible scores for A= 20; B= 8; C= 14; D= 24; E= 14; F= 16; G= 12.

CAS Group

Section A: CV Structure (maximum possible score 20). It can be noted that the children's scores were directly proportional to their ages. In the 3-year-old group, there were two children who had scores with a mean of 16.50 (SD, .71). In the 4-year-old group, three children had scores with a mean of 19.33 (SD, 1.16). In the 5-year-old group, only one child achieved the maximum score of 20. These results indicate that older participants had the highest scores in terms of accurately producing vowels.

Section B: Reduplicated Syllables Structure (maximum possible score 8). All the children across the different age groups attained the maximum score of 8.

Section C: CVC1 Structure (maximum possible score 14). In the 3-year-old group, the mean between participants was 12 (SD, 2.83). In the older group, there were no differences between the participants, as they all attained the maximum score of 14.

Section D: CVC2 Structure (maximum possible score 24). There were clear differences between the age groups in Section D. For example, the 3-year-old group had a minimum score of 14 and maximum score of 21, with a mean of 17.50 (SD, 4.95). Meanwhile, the 4-year-old group had a minimum score of 9 and a maximum score of 24, with a mean of 18.33 (SD, 8.15). In addition, the 5-year-old group had a score of 22. This showed that the older the age of the children, the better their performance in vowels.

Section E: Disyllabic 1(maximum possible score 14). The 3-year-old group had a minimum score of 8 and a maximum score of 12, with a mean of 10 (SD, 2.83). The 4-year-old group had a minimum score of 10 and a maximum score of 12, with a mean of 11.33 (SD, 1.16). In addition, the 5-year-old group scored 11. Hence, no differences were found between all age groups in disyllabic 1 structure in which they were not able to achieve the maximum score of 14.

Section F: Disyllabic 2(maximum possible score 16). The 3-year-old group had a minimum score of 10 and a maximum score of 11, with a mean of 10.50 (SD, .71). The 4-year-old group had a minimum score of 12 and a maximum score of 16, with a mean of 14 (SD, 2.00). In addition, the 5-year-old group scored 14. The results showed that children aged 3 experienced a high number of vowel errors in disyllabic 2.

Section G: Multisyllabic (maximum possible score 12). There were clear differences between the groups in terms of their pronunciation of vowels in multisyllabic words. The younger group had a minimum score of 0, and their highest score was 6; the mean was 3 (SD, 4.24). The second group had a minimum score of 7, and their highest score was 9; the mean was 8 (SD, 1.41). The older group scored 11. Based on these findings, it was determined that children at age 3 had difficulties producing vowels in multisyllabic structures, while other age groups performed slightly better.

5.3.4 *How Do Children with CAS Perform in Prosody in Each Section of the Test?*

Table 5.17shows the prosody accuracy variable scores in four different sections (B, E, F, and G). In each section, there was a maximum score (4, 7, 8, and 6). This table illustrates descriptive statistics—the minimum, maximum, mean, and standard deviation—in different age groups.

Table 5.17. *Performance of Children with CAS in the Prosody Variable*

Age group	Section		*N*	*Min*	*Max*	*M*	*SD*
3;0-3;11	B	P	2	2	4	3	1.41
	E	P	2	0	1	0.5	0.71
	F	P	2	0	0	0	0
	G	P	2	0	0	0	0
4;0-4;11	B	P	3	2	4	3.33	1.16
	E	P	3	2	5	4	1.73
	F	P	3	1	5	2.67	2.08
	G	P	3	1	2	1.5	0.71
5;0-6;0	B	P	1	2	2	2	.

E	P	1	2	2	2	.
F	P	1	1	1	1	.
G	P	1	2	2	2	.

Note. B = reduplicated syllables; E = bisyllabic 1; F = bisyllabic 2; G = multisyllabic; P = prosody; maximum score = 25.

CAS Group

Section B, Reduplicated Syllables Structure (maximum possible score 4). In the 3-year-old group, the minimum score was 2 and the maximum score was 4; the mean score was 3 (SD, 1.41). Similarly, in the 4-year-old group, the mean score was 3.33 (SD, 1.16). The 5-year-old group attained a score of 2.

Section E, Disyllabic Structure 1 (maximum possible score 7). As shown in the table, there was notable variation in the scores among the groups. For instance, the younger group had a minimum score of 0 and a maximum score of 1, with a mean of .50 (SD, .71). The middle group had a minimum score of 2 and a maximum score of 5, with a mean of 4 (SD, 1.73). The older group obtained a maximum score of 2. These results indicate that the children with CAS attained lower scores in prosody accuracy with disyllabic word structure. The middle group achieved the highest scores among all age groups.

Section F, Disyllabic Structure 2 (maximum possible score 8). It was obvious that the younger group had difficulties with disyllabic word structure, as they obtained the lowest score of 0. The middle group achieved a minimum score of 1 and a maximum score of 5; the mean score was 2.67 (SD, 2.08). The older group obtained a maximum score of 1. These findings highlight the difficulties in prosody across multiple syllable shapes.

Section G, Multisyllabic Structure (maximum possible score 6). The younger group achieved a maximum score of 0. On the other hand, the other age groups obtained only a maximum score of 2. As a result, it could be suggested that the more syllables there were in a word, the more difficulties there were in the CAS group among different ages.

5.3.5 *How Do Children in the CAS Groups Perform in Overall Articulatory Accuracy in Each Section of the Test?*

The overall articulatory variable was examined in all Ar-DEMSS test sections—A, B, C, D, E, F, and G. In each section, the maximum scores were 40, 16, 28, 48, 28, 32, and 24, respectively. Table 5.18 illustrates descriptive statistics—the minimum, maximum, mean, and standard deviation—in different age groups for the overall articulatory accuracy variable.

Table 5.18. *The Performance of Children with CAS in the Overall Articulatory Accuracy Variable*

Age group	Section		N	*Min*	*Max*	*M*	*SD*
3;0-3;11	A	O	2	30	31	30.5	0.71
	B	O	2	16	16	16	0
	C	O	2	7	28	17.5	14.85
	D	O	2	13	28	20.5	10.61
	E	O	2	6	20	13	9.9
	F	O	2	4	4	4	0
	G	O	2	0	0	0	0
4;0-4;11	A	O	3	36	39	38	1.73
	B	O	3	15	16	15.67	0.58
	C	O	3	24	27	25	1.73
	D	O	3	28	43	37	7.94
	E	O	3	20	24	22	2
	F	O	3	8	25	16	8.54
	G	O	3	0	12	6	8.49
5;0-6;0	A	O	1	36	36	36	.
	B	O	1	16	16	16	.
	C	O	1	24	24	24	.
	D	O	1	36	36	36	.
	E	O	1	18	18	18	.
	F	O	1	9	9	9	.
	G	O	1	13	13	13	.

Note. A = CV; B = reduplicated syllable; C = CVC1; D = CVC2; E = bisyllabic 1; F = bisyllabic 2; G = multisyllabic; O = overall articulatory accuracy; maximum score = 216.

CAS Group

Section A: CV Structure (maximum possible score 40). For all the children in the 3-year-old group, the minimum score was 30 and the maximum score was 31; the mean score was 30.50 (SD, .71). In the 4-year-old group, the minimum score was 36 and the maximum score was 39; the mean score was 38 (SD, 1.73). In the 5-year-old group, the score was 36. As shown here, no one in this age group attained the maximum score of 40 on this monosyllable structure.

Section B: Reduplicated Syllables Structure (maximum possible score 16). All the children across the different age groups attained the maximum score of 16, with the exception of one 4-year-old child who scored 15. These results show that the reduplicated syllable structure words were easier for children with CAS.

Section C: CVC1 Structure (maximum possible score 28). In the 3-year-old group, the minimum score was 7 and the maximum score was 28; the mean score was 17.50 (SD, 14.85). In the 4-year-old group, the minimum score was 24 and the maximum score was 27; the mean score was 25 (SD, 1.73). In the 5-year-old group, the score was 24. The results showed that there was a visible difference between one of the children and the others, as this child attained the lowest score of 7 with a high standard deviation. These results reveal that the child had difficulties in overall articulatory accuracy in the CVC word's structure.

Section D: CVC2 Structure (maximum possible score 48). There were clear differences between the age groups in Section D. For example, the 3-year-old group had a minimum score of 13 and a maximum score of 28, with a mean of 20.50 (SD, 10.61). The 4-year-old group had a minimum score of 28 and a maximum score of 43, with a mean of 37 (SD, 7.94). The 5-year-old group had a score of 36. These results show that no one obtained the maximum score of 48; therefore, the lowest score was for a child in the 3-year-old age group.

Section E: Disyllabic 1 (maximum possible score 28). The 3-year-old group had a minimum score of 6 and a maximum score of 20, with a mean of 13 (SD, 9.90). The 4-year-old group had a minimum score of 20 and a maximum score of 24, with a mean of 22 (SD, 2.00). In addition, the 5-year-old group scored 18. This indicates that no one in all age groups attained the maximum score.

Section F: Disyllabic 2 (maximum possible score 32). The 3-year-old group scored 4. The 4-year-old group achieved a minimum score of 8 and a maximum score of 25, with a mean of 16 (SD, 8.54). In addition, the 5-year-old group scored 9. All children had difficulty articulating disyllabic words, as evidenced by the results, where they scored low.

Section G: Multisyllabic (maximum possible score 24). The 3-year-old group scored 0, with a mean of 10.50 (SD, .707). The 4-year-old group had a minimum score of 0 and a maximum score of 12, with a mean of 6 (SD, 8.49). In addition, the 5-year-old group scored 13. It can be seen that children with CAS, the longer a word, the more difficult to produce it.

5.3.6 *How Do Children in the CAS Groups Perform on Consistency Variables in Each Section of the Test?*

Table 5.19 presents the consistency variable scores in four different sections (A, C, D, and G). In each section, there was a maximum score (10, 7, 12, and 6). This table provides descriptive statistics of the minimum, maximum, mean, and standard deviation in different age groups.

Table 5.19. *Performance of Children with CAS in the Consistency Variable*

Age group	Section		N	*Min*	*Max*	*M*	*SD*
3;0-3;11	A	C	2	5	6	5.5	0.71
	C	C	2	1	6	3.5	3.54
	D	C	2	3	5	4	1.41
	G	C	2	0	0	0	0
4;0-4;11	A	C	3	9	10	9.33	0.58
	C	C	3	5	7	6	1

	D	C	3	5	9	6.33	2.31
	G	C	3	1	3	2	1.41
5;0-6;0	A	C	1	6	6	6	.
	C	C	1	6	6	6	.
	D	C	1	8	8	8	.
	G	C	1	0	0	0	.

Note. A = CV; C = CVC1; D = CVC2; G = multisyllabic; C = consistency; maximum score = 35.

CAS Group

Section A, CV Structure (maximum possible score 10). In the 3-year-old group, the minimum score was 5 and the maximum score was 6; the mean score was 5.50 (SD, .707). In the 4-year-old group, the minimum score was 9 and the maximum score was 10; the mean score was 9.33 (SD, .577). In the 5-year-old group, the maximum score was 6. CV structure showed more consistent production among 4-year-olds.

Section C, CVC1 Structure (maximum possible score 7). In the 3-year-old group, the minimum score was 1 and the maximum score was 6; the mean score was 3.50 (SD, 3.536). In the 4-year-old group, the minimum score was 5 and the maximum score was 7; the mean score was 6 (SD, 1.00). In the 5-year-old group, the maximum score was 6. These results demonstrate that scores varied among participants, which indicates more inconsistent production in the CAS group.

Section D, CVC2 Structure (maximum possible score 12). In the 3-year-old group, the minimum score was 3 and the maximum score was 5; the mean score was 4 (SD, 1.414). In the 4-year-old group, the minimum score was 5 and the maximum score was 9; the mean score was 6.33 (SD, 2.309). In the 5-year-old group, the maximum score was 8. These results reveal that the CAS group had more errors and varied scores; however, there was a slight increase in its consistency scores with age.

Section G, Multisyllabic Structure (maximum possible score 6). The 3-year-old and 5-year-old groups scored 0 in this section. However, in the 4-year-old group, the minimum score was 1 and the maximum score was 3; the mean score was 2 (SD, 1.414). These scores show that pronunciation of the multisyllabic words was the most difficult task for the children in the CAS groups.

5.4 Performance of Typically Developing Children and Children with CAS on the Ar-DEMSS Test

In this section, I will provide figures representing boxplots, commonly used in statistics to visually display data distribution. The following charts aim to present the performance of typically developing children and children with CAS on the Ar-DEMSS test in terms of (a) their total score, (b) their subscores related to vowel accuracy, prosody, overall articulatory accuracy, and consistency.

5.4.1 Components of the Boxplot

- Vertical axis: Represents the scores obtained by the children in vowel accuracy, prosody, overall articulatory accuracy, consistency, and total score on the Ar-DEMSS.
- Horizontal axis: Represents the age groups (3, 4, 5, 6 years).
- Boxes: Represent the interquartile range (IQR) of scores for children in each age group, covering the range between the first quartile (Q1) and the third quartile (Q3).
- Horizontal line inside the box: Represents the median (middle score) for children in each age group.
- Whiskers: Represent the minimum and maximum values.
- Black dots: Represent outliers which is an extreme than the expected variation of the data.

5.4.2 How Do Children with CAS Perform on the Ar-DEMSS Total Score in Comparison to Typically Developing Children?

The following figures compare the Ar-DEMSS total score across different age groups. Figure 5.1 presents boxplots for the performance of typically developing children at different ages 3, 4, 5, 6 years in the Ar-DEMSS total score. Figure 5.2 shows boxplots for the performance of children with CAS at different ages 3, 4, 5 years in the Ar-DEMSS total score. A comparison will then be made between the total scores of Ar-DEMSS from a typically developing group and those from a child with CAS in the same age group.

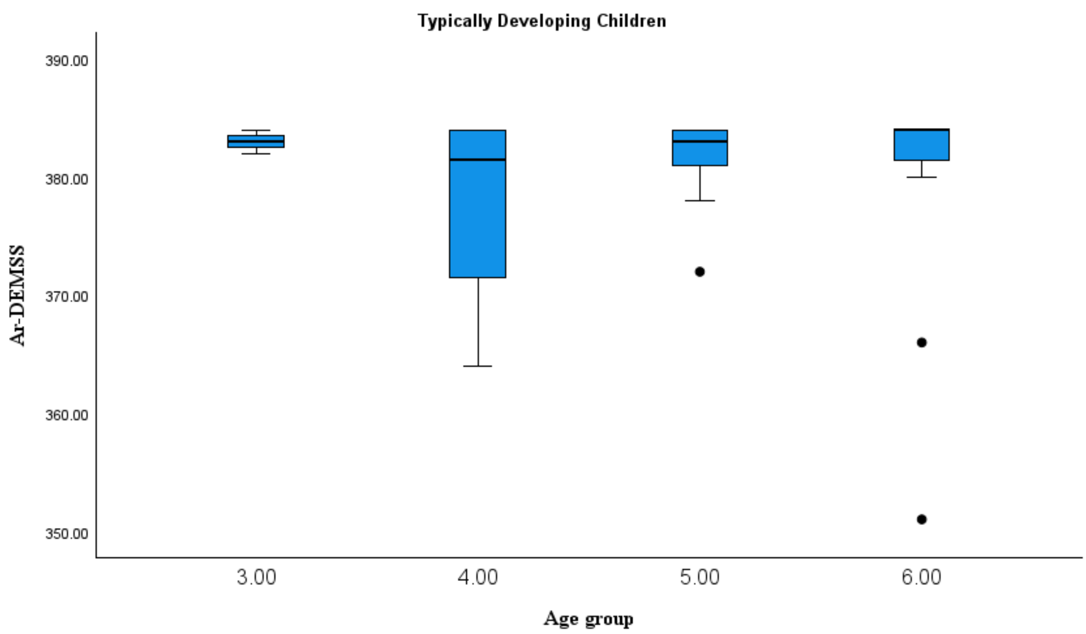

Figure 5.1. *Boxplots for the Ar-DEMSS total score among typically developing children from different age groups (Maximum score= 384)*

5.4.2.1 Boxplots for Typically Developing Children (Ages 3- 4- 5- 6)

- The boxplot indicates that typically developing children consistently achieve high scores on the Ar-DEMSS test (384) across all age groups.
- The median score for typically developing children is relatively high, indicating that most children score near the upper range.

- The IQR is narrow, suggesting little variation in scores among typically developing children.
- Few outliers are present, indicating that the majority of children perform similarly well.

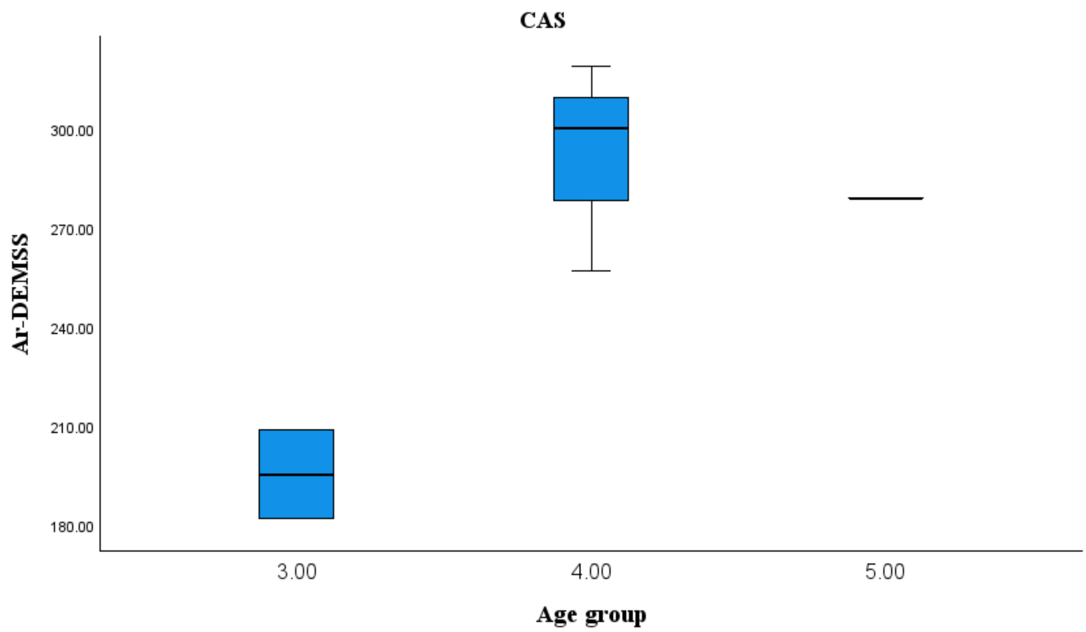

Figure 5.2. *Boxplots for the Ar-DEMSS total score among children with CAS from different age groups (Maximum score= 384)*

5.4.2.2 Boxplots for Children with CAS (Ages 3-4-5)

Age 3: Children with CAS had total scores of 209 and 182, lower than typically developing children, highlighting initial challenges in the test. For typically developing children, the scores show minimal variation, as indicated by the small spread in the boxplot. This suggests a consistent Ar-DEMSS test performance among children in this age group.

Age 4: For children with CAS, three scores were recorded: 319, 300, and 257. These scores are notably higher compared to age 3, indicating some progress but still not reaching the levels of typically developing children. For typically developing children, there is a wider spread of scores, as seen by the larger IQR compared to age 3. This indicates more variability in their performance.

Age 5: Children with CAS had a score of 279. While this score reflects improvement over the younger age group, it still falls behind typically developing children. For typically developing children, the median and range of scores remain high, with a small IQR, indicating consistent high performance.

5.4.2.3 Comparison Between Both Groups

- **Age 3**: Two children scored 209 and 182, significantly lower than the scores of typically developing children.
- **Age 4**: Three different scores were recorded: 319, 300, and 257. These scores show variability in performance, with the highest score still below the median for typically developing children.
- **Age 5**: The recorded score of 279 shows continued improvement but remains below the median for typically developing children.

5.4.2.4 Summary of the Results

- Variation in scores: Typically developing children exhibit minimal variation in their scores, suggesting consistent high performance across all ages. On the other hand, for children with CAS the scores show variability, indicating differences in individual performance and progress. While some improvement has been seen over the years, their scores remain lower compared to typically developing children.

5.4.3 How Do children with CAS Perform on Vowel Accuracy in Comparison to Typically Developing Children?

The following figures compare the vowel accuracy across different age groups. Figure 5.3 presents boxplots for the performance of typically developing children at different ages 3, 4, 5, 6 years in the vowel accuracy. Figure 5.4 shows boxplots for the performance of children with CAS at different ages 3, 4, 5 years in the vowel accuracy. A comparison will then be made between the total scores of vowel accuracy from a typically developing group and those from a child with CAS in the same age group.

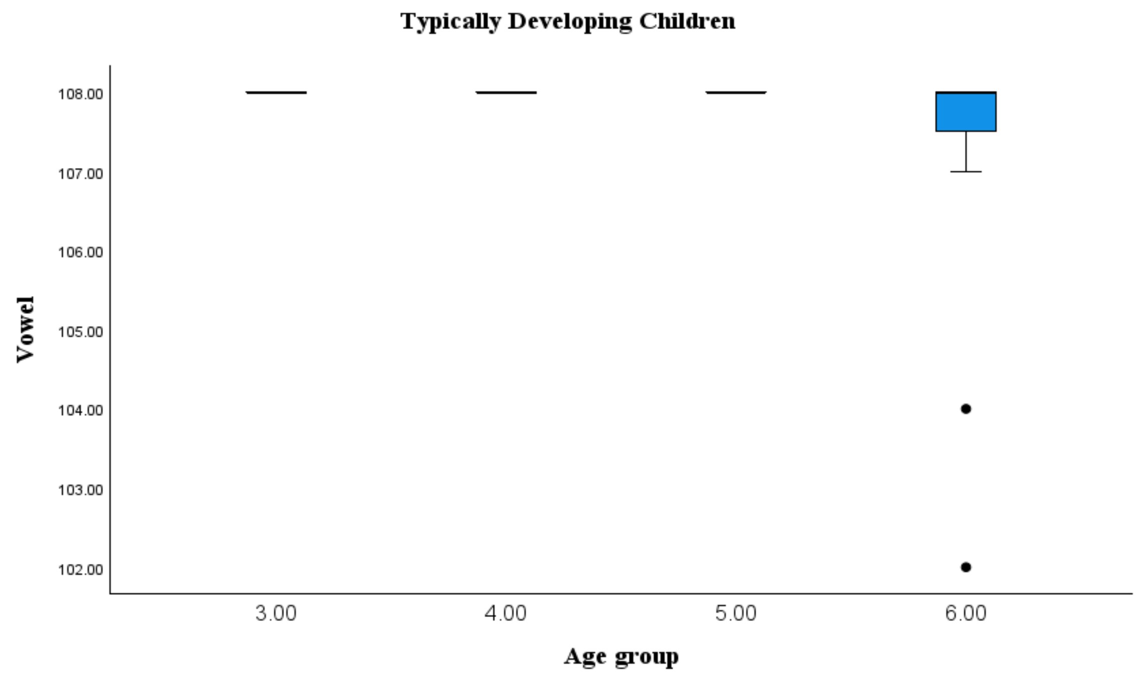

Figure 5.3. Boxplots for the vowel variable scores among typically developing children from different age groups (Maximum score= 108)

5.4.3.1 Boxplots for Typically Developing Children (Ages 3-4-5-6)

- The box plot shows consistency and stability in vowel accuracy scores for typically developing children across different ages.
- The median is very close to 108, indicating that the majority of children in this age group achieve near or at the maximum scores.
- The IQR is very narrow, suggesting minimal variation in scores among children.

- The short whiskers indicate a few outliers, reinforcing that most children achieve similarly high scores.

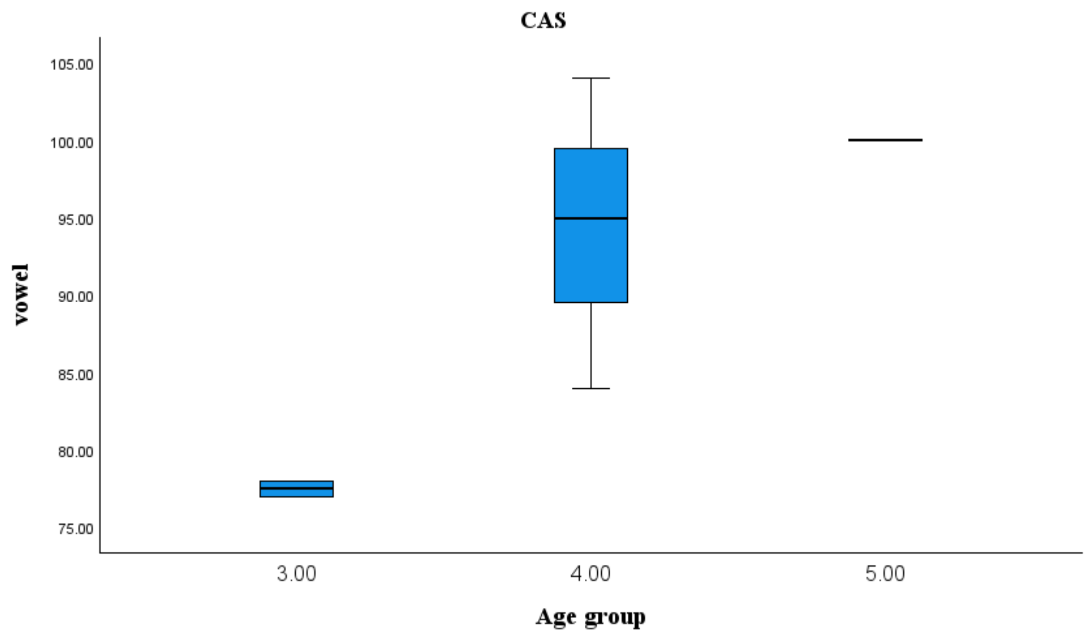

Figure 5.4. *Boxplots for the vowel variable scores among children with CAS from different age groups (Maximum score= 108)*

5.4.3.2 Boxplots for Children with CAS (Ages 3-4-5)

- **Age 3:** Two children scored 77 and 78, which are lower than the scores of typically developing children indicating a weak start in vowel accuracy. The narrow range of scores for children with CAS suggests limited vowel accuracy variability at this age. The low scores highlight significant challenges faced by these children compared to their typically developing peers, whose scores are generally higher and they achieved the maximum score.
- **Age 4:** Three different scores: 104, 95, and 84. These scores demonstrate a notable variation in performance, with the child scoring 104 approaching the scores of typically

developing children, while the others scored lower. Scores improved, ranging from 84 to 104, reflecting positive progress. The noticeable improvement in scores for children with CAS indicates that they benefit from interventions or natural developmental progress.

- **Age 5:** One child scored 100, still below the median for typically developing children but better than scores recorded in younger age groups. Scores continue to improve, reaching up to 100, indicating substantial improvement in articulation skills. The noticeable improvement in scores for children with CAS indicates that they are benefit from interventions or natural developmental progress.

5.4.3.3 Comparison Between Both Groups

The box plot shows that typically developing children consistently achieve high and stable scores in vowel accuracy across different ages. The median is approximately at 108, indicating that most children in this group achieve scores at or near the maximum. Additionally, the IQR is very narrow, reflecting little variation in scores among these children. However, children with CAS performed lower scores in compared to typically developing children.

5.4.3.4 Summary of the Results

- Variation in scores: Typically developing children have less variation in their scores, indicating that most of them achieve similar levels of performance. On the other hand, children with CAS show greater variability in performance, reflecting larger differences in their vowel production abilities.

5.4.4 How Do children with CAS Perform on Prosody in Comparison to Typically Developing Children?

The following figures compare the prosody across different age groups. Figure 5.5 presents boxplots for the performance of typically developing children at different ages 3, 4, 5, 6 years in the prosody. Figure 5.6 shows boxplots for the performance of children with CAS at different ages 3, 4, 5 years in the prosody. A comparison will then be made between the total scores of prosody from a typically developing group and those from a child with CAS in the same age group.

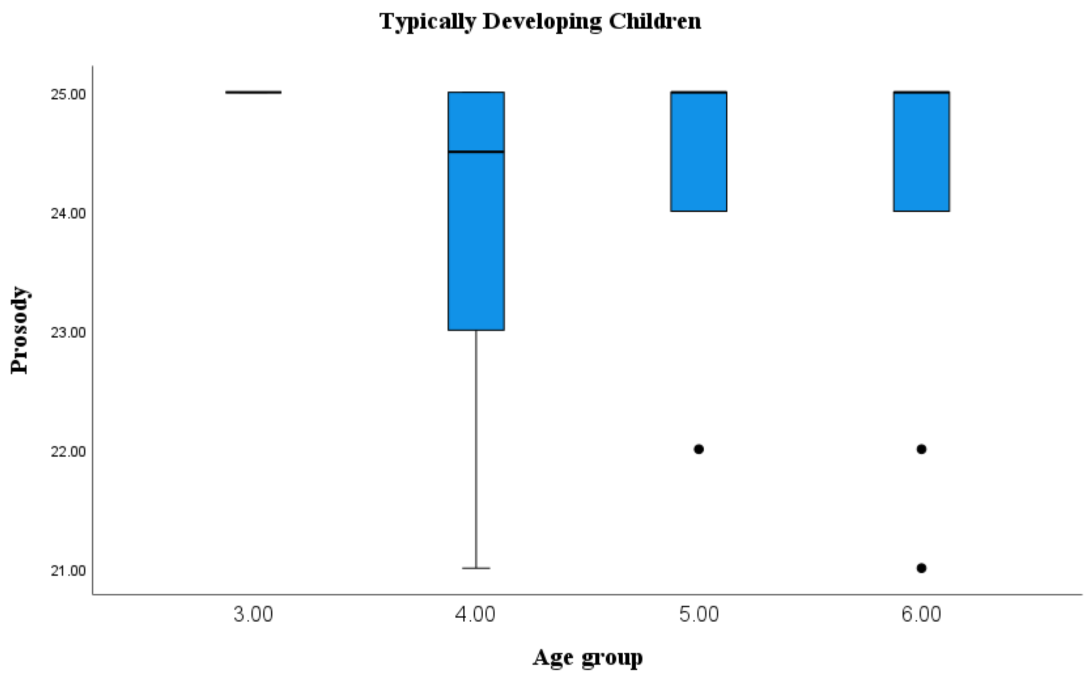

Figure 5.5. *Boxplots for the prosody variable scores among typically developing children from different age groups (Maximum score= 25)*

5.4.4.1 Boxplots for Typically developing children (Ages 3-4-5-6)

- The boxplot shows consistent and stable performance in prosody scores among typically developing children across the age groups.
- The median score is close to the high end, indicating that most children achieve high scores.

- The IQR is relatively narrow, suggesting minimal variation in prosody scores among typically developing children.
- The presence of a few outliers indicates that most children perform similarly well.

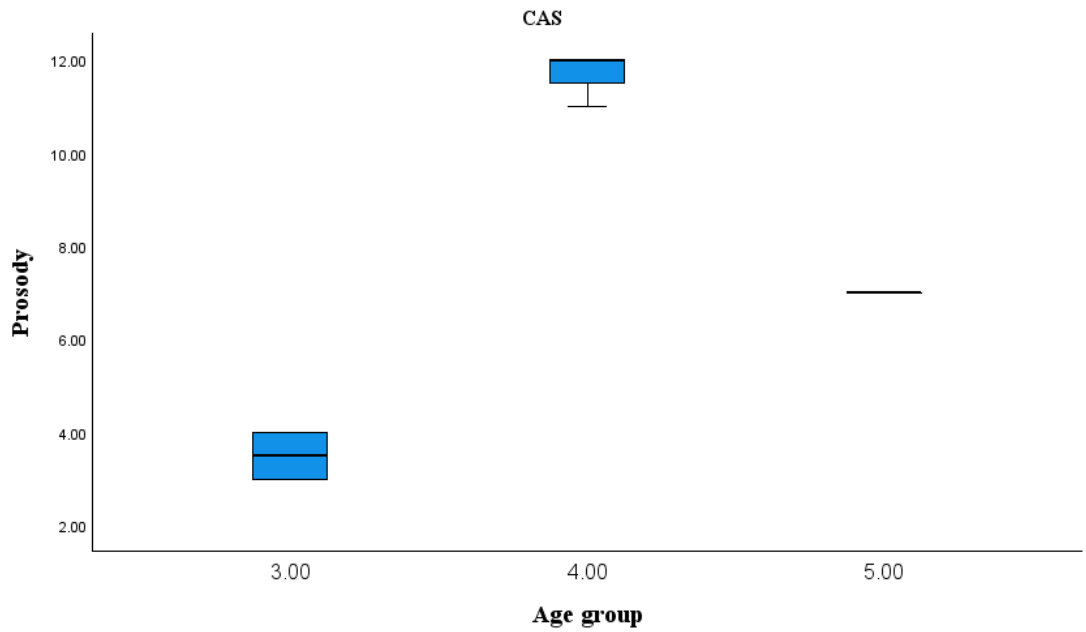

Figure 5.6. *Boxplots for the prosody variable scores among children with CAS from different age groups (Maximum score= 25)*

5.4.4.2 Boxplots for Children with CAS (Ages 3-4-5)

- **Age 3:** Children with CAS performed poorly in prosody, with one scoring a total of 3 and another scoring 4. These low scores highlight the challenges faced by children with CAS in prosody compared to their typically developing peers, who generally have higher and more consistent scores.
- **Age 4:** The scores for children with CAS at this age range widely. Only three children had prosody scores nearing the half-way mark for the possible maximum score of 25, with one scoring 11, another scoring 12, and a third scoring 12. This indicates that while

some children with CAS show improvements, there is considerable variability in their prosody scores.

- **Age 5:** One child with CAS scored 7, showing some progress but still lagging behind typical scores for typically developing children.

5.4.4.3 Comparison Between Both Groups

Typically developing children demonstrate consistent and high prosody scores across all age groups, with minimal variation. The boxplot for typically developing children shows a narrow IQR and a median score close to the upper limit. This indicates that most typically developing children achieve similar and relatively high prosody scores. Outliers are few, suggesting deviations from the norm are rare in this group.

In contrast, children with CAS exhibit more variability and generally lower scores in prosody. At age 3, children with CAS scored significantly lower compared to their typically developing peers, with scores of 3 and 4. At age 4, although there is some improvement with scores ranging from 11 to 12, the scores are still less than the typical range for typically developing children. At age 5, a child with CAS scored 7, showing some progress but still below the median scores for typically developing children. Overall, typically developing children maintain consistently higher prosody scores with less variability. On the other hand, children with CAS show a broader range of scores and generally lower performance, indicating challenges in prosody development.

5.4.4.4 Summary of the Results

- Variation in scores: Typically developing children exhibit less variation in their scores, indicating consistent prosody performance. However, children with CAS show greater variability in performance, reflecting larger differences in their prosody abilities.

5.4.5 How Do children with CAS Perform on Overall Articulatory Accuracy in Comparison to Typically Developing Children?

The following figures compare the overall articulatory accuracy across different age groups. Figure 5.7 presents boxplots for the performance of typically developing children at different ages 3, 4, 5, 6 years in the overall articulatory accuracy. Figure 5.8 shows boxplots for the performance of children with CAS at different ages 3, 4, 5 years in the overall articulatory accuracy. A comparison will then be made between the total scores of overall articulatory accuracy from a typically developing group and those from a child with CAS in the same age group.

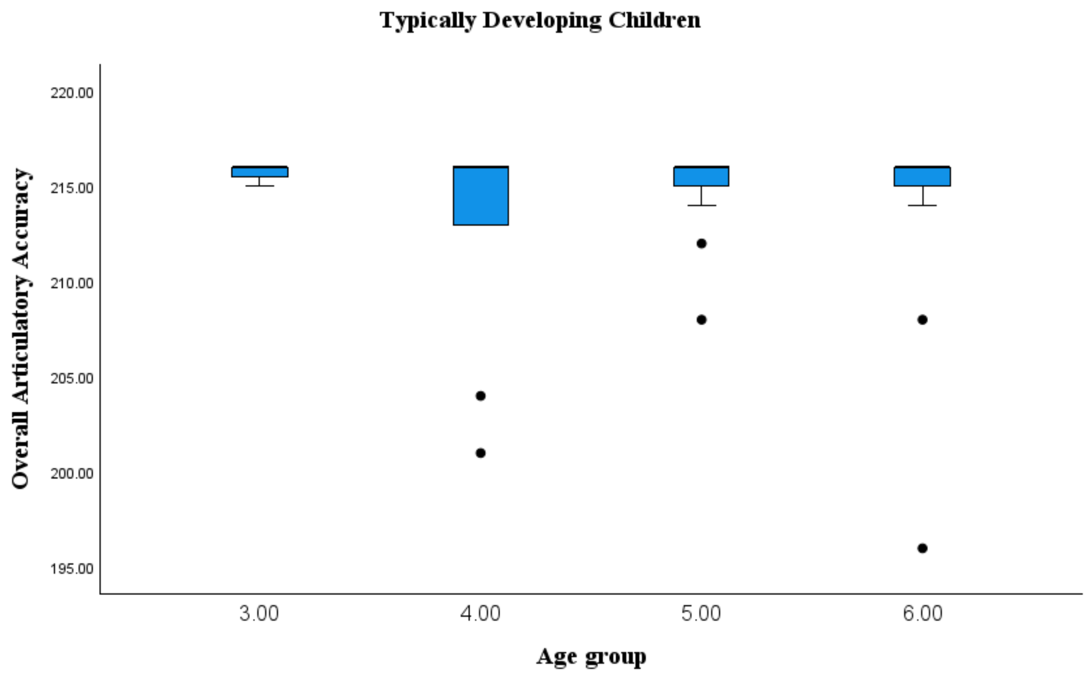

Figure 5.7*. Boxplots for the overall articulatory accuracy variable scores among typically developing children from different age groups (Maximum score= 216)*

5.4.5.1 Boxplots for Typically developing children (Ages 3-4-5-6)

- The boxplot shows consistency and stability in overall articulatory accuracy scores for typically developing children across different age groups.

- The median score is consistently high, indicating that the majority of typically developing children achieve near or at the maximum scores.
- The IQR is narrow, suggesting minimal variation in scores among typically developing children.
- The short whiskers and few outliers indicate that most typically developing children perform similarly well.

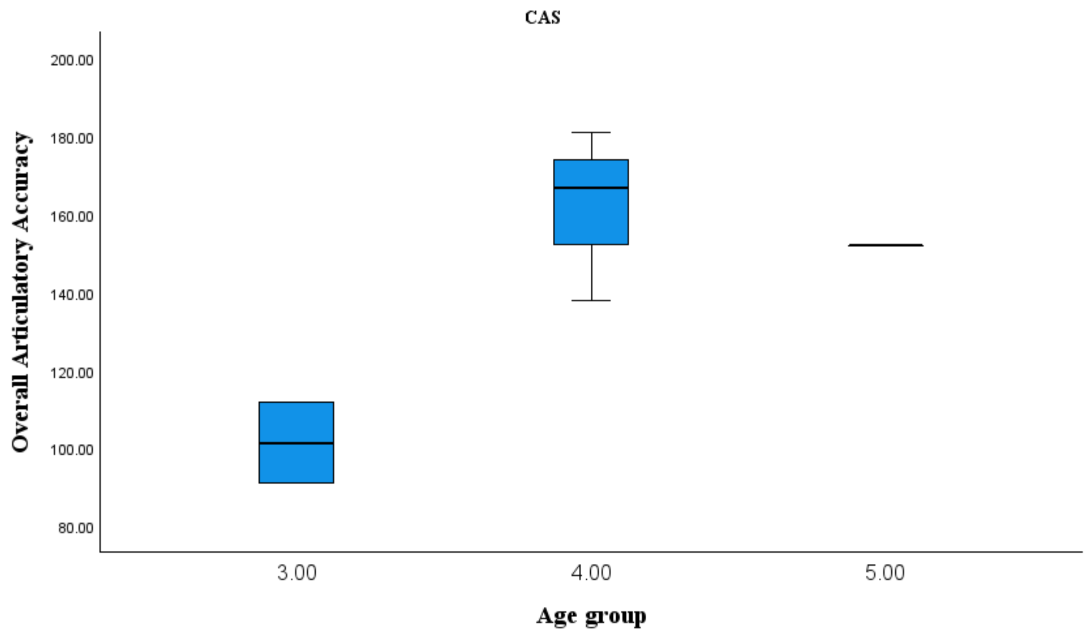

Figure 5.8. *Boxplots for the overall articulatory accuracy variable scores among children with CAS from different age groups (Maximum score= 216)*

5.4.5.2 Boxplots for Children with CAS (Ages 3-4-5)

Age 3: Children with CAS showed low scores in overall articulatory accuracy, with one child scoring 112 and another child scoring 91. These scores are lower than those of their typically developing peers, indicating initial challenges in articulatory skills.

Age 4: Scores among children with CAS ranged more widely, with one child scoring 181, another 167, and a third 138. This variation suggests that while some children with CAS show improvement, their scores remain below the average for typically developing children.

Age 5: Only one child with CAS scored 152, demonstrating some developmental progress in articulatory accuracy but still falling short of the typical scores for typically developing children.

5.4.5.3 Comparison Between Both Groups

Typically developing children consistently achieve high and stable scores in overall articulatory accuracy, usually ranging between 210 and 216, with minimal variation. In contrast, children with CAS show greater variability in their scores and generally lower performance. For example, at age 3, children with CAS scored as low as 112 and 91. At age 4, their scores ranged from 138 to 181, and at age 5, the highest score recorded was 152. This reflects ongoing challenges in developing articulatory skills compared to their peers.

5.4.5.4 Summary of the Results

- Variation in Scores: Typically developing children exhibit less variation in their scores, indicating similar levels of performance across the group. However, children with CAS show greater variability and generally lower scores. This highlights the diversity in their articulatory abilities and the challenges they face.

5.4.6 How Do children with CAS Perform in consistency in Comparison to Typically Developing Children?

The following figures compare the consistency variable across different age groups. Figure 5.9 presents boxplots for the performance of typically developing children at different ages 3, 4, 5, 6 years in the consistency variable. Figure 5.10 shows boxplots for the performance of children with CAS at different ages 3, 4, 5 years in the consistency variable. A comparison will then be made between the total scores of consistency from a typically developing group and those from a child with CAS in the same age group.

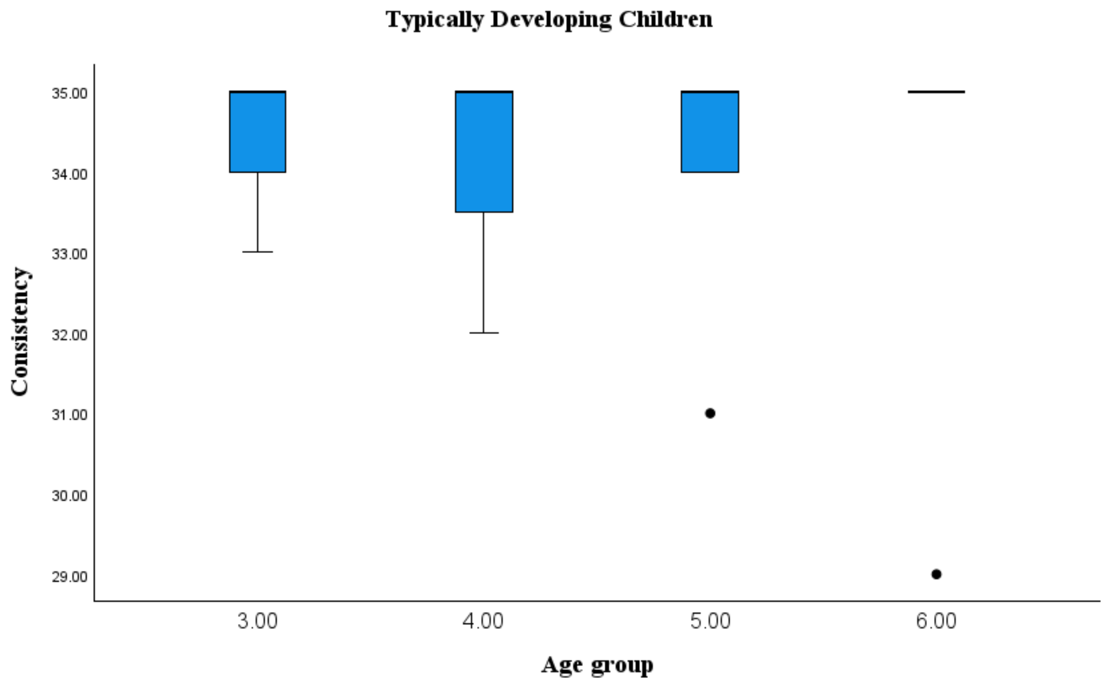

Figure 5.9. *Boxplots for the consistency scores among typically developing children from different age groups (Maximum score= 35)*

5.4.6.1 Boxplots for Typically developing children (Ages 3-4-5-6)

- The boxplot shows relatively consistent and high scores in speech consistency for typically developing children across different ages, with minimal variation.
- The median score is close to 35, indicating that the majority of children in this group achieve near-maximum consistency scores.
- The narrow IQR suggests minimal variation in scores among typically developing children.
- The presence of a few outliers indicates that most typically developing children have similar speech consistency levels

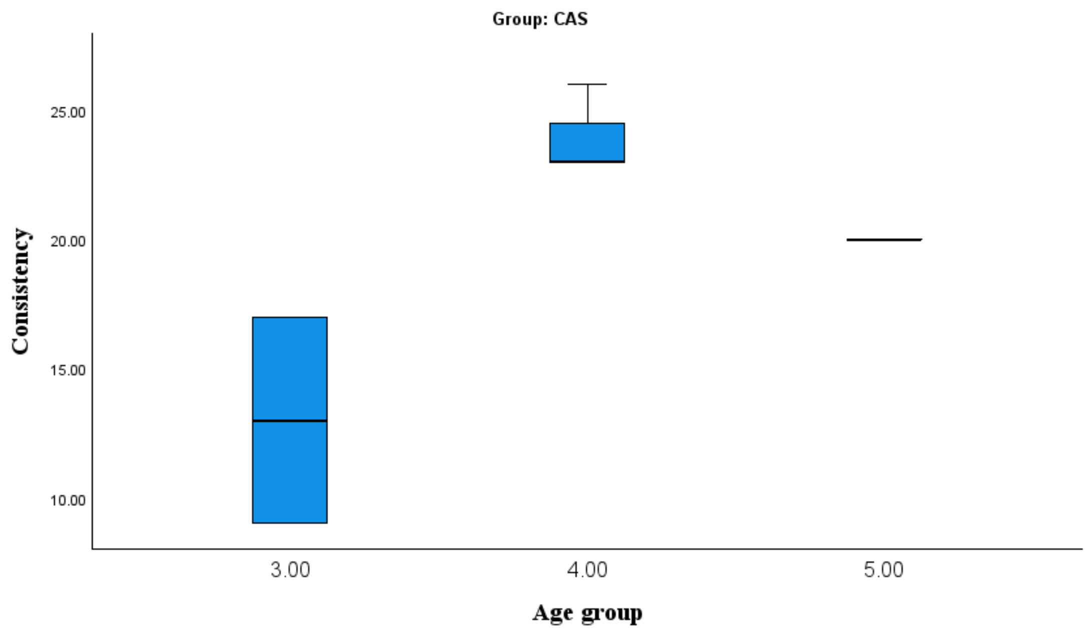

Figure 5.10. *Boxplots for the consistency scores among children with CAS from different age groups (Maximum score= 35)*

5.4.6.2 Boxplots for Children with CAS (Ages 3-4-5)

Age 3: Children with CAS have lower scores in consistency, with values at 17 and 9. This suggests early challenges in achieving consistent speech patterns compared to typically developing peers, whose scores are generally higher and more consistent.

Age 4: Scores for children with CAS improve to some extent, ranging from 23 to 26. This increase indicates some developmental progress, but there remains a notable difference compared to typically developing children's consistency scores.

Age 5: Children with CAS scored 20 in consistency, still below the typical range for typically developing children but showing improvement over younger age groups.

5.4.6.3 Comparison Between Both Groups

The boxplot demonstrates that typically developing children consistently achieve high and stable scores in speech consistency across different ages. The median is around 35, reflecting minimal variation among these children.

In contrast, children with CAS exhibit more variability and generally lower scores in consistency.

- **Age 3:** Scores are lower, with children scoring 17 and 9.
- **Age 4:** Scores vary from 23 to 26, showing some improvement but still below typically developing children's scores.
- **Age 5:** The score reaches 20, indicating ongoing challenges but some developmental progress.

5.4.6.4 Summary of the Results

- Variation in Scores: Typically developing children show less variation in their scores, indicating consistent speech performance. In contrast, children with CAS show greater variability and generally lower scores, reflecting ongoing challenges in achieving speech consistency.

5.5 Chapter Summary

The previous sections provided a detailed analysis of the study and scores for all participants. A descriptive statistic was used to present the overall Ar-DEMSS score and subscores for each variable vowel accuracy, prosody, overall articulatory accuracy, and consistency for typically developing children and children with CAS. The data were visualized using boxplots. In the next chapter 6 it will present case studies of three CAS children (aged 3;9, 4;5, and 5;10) and provide details on their scores on the Ar-DEMSS, in particular their performance on vowels and prosody, overall articulatory accuracy, and consistency.

Chapter 6 - Case Studies

There are currently no studies that discuss CAS features among the Saudi population. ASHA (2007) identified three main features consistent with a deficit in planning and programming movements for speech: inconsistent errors in vowels and consonants on repeated attempts, coarticulatory deficits between sounds and syllables, and prosodic disturbances. While CAS has yet to be researched in the context of Saudi Arabia, this chapter will provide a preliminary overview of three Saudi children with CAS. The profiled children were selected based on their age, speech characteristics, and total scores.

This chapter will be divided into three sections and will explore the Ar-DEMSS results in the three case studies, as well as their scores in oral-facial examination, Nonverbal Oral Apraxia, SMR for individual syllables, AMR, and articulation test JISH. I will discuss each individual's scores on vowel accuracy, prosody, overall articulatory accuracy, and consistency in all sections of the Ar-DEMSS test. I will also provide examples of the child's productions and an individual summary.

6.1 Child 1

6.1.1 *Background Information*

Child 1 is a young Saudi male aged 5 years and 10 months. He was diagnosed with CAS by a certified speech therapist at a clinic in Saudi Arabia. In this study, he was assessed during two sessions: the first lasted 35 minutes, and the second lasted 25 minutes. As a result of his fatigue, the child could not complete all the tests in one session, so his mother suggested another day. The child interacted and collaborated in both sessions. He was receiving speech therapy during the participation period.

6.1.2 *Assessment Procedures*

A comprehensive assessment was conducted to determine Child 1's speech abilities. During the assessment, several tests were used, including oral-facial examination, nonverbal oral apraxia, AMR of individual syllables (e.g., pa, ta, ka), SMR (e.g., pataka), and the articulation test JISH. The Ar-DEMSS was also performed to examine CAS speech characteristics. All test instructions and materials were in Arabic.

6.1.3 *Main Findings*

6.1.3.1 Oral-Facial Examination. An oral-facial examination was administered to assess the appearance and function of Child 1's oral musculature for speech purposes. A jaw evaluation revealed a normal range of motion, symmetry, and movement. His dentition showed that all teeth were present and arranged normally. He had a normal range of motion, symmetry, and sufficient strength in his lips and cheeks.

A tongue evaluation revealed that Child 1's tongue was of normal surface colour, movement, and size. He showed normal excursion, range, and speed of motion, and strength of tongue tip when he was asked to protrude and retract his tongue and move it in different directions right, left, up, and down. Furthermore, the rapid side-to-side movement of his tongue was also acceptable. There was no attempt to examine the child's pharynx, soft palate, and hard palate. The results indicated adequate oral motor structures and functions for speech.

6.1.3.2 Nonverbal Oral Apraxia. Nonverbal oral apraxia is characterised by difficulties sequencing voluntary movements of the tongue, jaw, and other orofacial structures. Based on the results, Child 1 exhibited mild nonverbal oral apraxia, characterised by groping and pausing. In particular, he had difficulty achieving the correct initial articulatory configuration when asked to pucker.

6.1.3.3 DDK.

AMR. The child was able to repeat each single syllable /pa/, /ta/, and /ka/ accurately for 10 s.

SMR. The child was unable to repeat the sequence of the syllables /pataka/ accurately for 10 s. Although he could produce each syllable independently, he struggled to combine them in the same order (i.e., [ptata], [pkaka], and [pkta]). His production was also inconsistent in each trial.

6.1.3.4 Articulation Test. The results indicate that he performed the test by imitation with 43 errors. Speech production was unintelligible, with many deletions of initial consonants, final consonants, syllables, and emphatic sounds being replaced with non-emphatic sounds.

6.1.3.5 Ar-DEMSS. Despite completing all Ar-DEMSS subtests, Child 1 made many errors in vowels, prosody, and overall articulation. Vowel production was accurate only in CV, reduplicated syllables, and CVC1. Child 1's prosody, overall articulation, and consistency was inaccurate in numerous trials. In this section, I provide an overview of Child 1 productions in the Ar-DEMSS test, including examples and a summary.

6.1.4 *Overview of Child 1*

Vowel Accuracy. In Child 1's speech, there were some distortions and substitutions of vowels. As can be seen in the following Table 6.1, he had difficulty producing the long vowel /u:/. Segmentation and groping were observed.

Table 6.1. *Examples of Vowel Errors in Child 1*

Word shape	Target	Transcription of child's production
CVC2	/fu:l/	[ful]
Disyllabic 1	/ku:ki:/	[ko:ki:]
Disyllabic 2	/lajmu:n/	[li.nun]

Note. Segmentation = (.)

Prosody. In Child 1, several prosody errors were present, including equal stress error, segmentation, deletion of weak syllables, and incorrect stress. Equal stress was found in reduplicated syllables /ma:ma:/ and /nu:nu:/, and in disyllabic 1 /ba:bi:/ and /ku:ki:/. Segmentation was evident in disyllabic 1 in /ʃa:hi:/, disyllabic 2 in /lajmu:n/, /mufta:ħ/, /kita:b/, and /fusta:n/, and multisyllabic in /tufa:ħa/. Incorrect stress patterns were observed in /ʔuðun/, /ħali:b/, and /ħala:wa/. A weak syllable was deleted from /hi**la:l**/. Examples are provided in the following Table 6.2.

Table 6.2. *Examples of Prosody Errors in Child 1*

Target	**Transcription of child's production**	**Prosody errors**
/kita:b/	[ki.ba:b]	Segmentation
/lajmu:n/	[li.nun]	
/mufta:ħ/	[mu.ta:ħ]	
/hila:l/	/la:l/	Weak syllable deletion

Note. Segmentation = (.)

Table 6.3. *Prosodic Score Types are for Descriptive Purposes*

Prosodic error types	**Segmentation**	**Equal stress**	**Incorrect stress**	**Weak syllable deletion**	**Added syllable**
Reduplicated syllables (4)		☑			
Disyllabic 1 (7)	☑	☑			☑
Disyllabic 2 (8)	☑		☑	☑	
Multisyllabic (6)	☑		☑		

Overall Articulatory Accuracy. The overall articulatory accuracy was examined in all subtests. The performance of Child 1 in disyllabic (1 and 2) and multisyllabic was poor. Consequently, he scored low, as shown in Table 6.4 below.

Table 6.4. *Total Scores in Overall Articulatory Accuracy*

Summary scores	Number of words	Overall articulatory accuracy score
Consonant-vowel	10	36/**40**
Reduplicated syllables	4	16/**16**
CVC1	7	24/**28**
CVC2	12	36/**48**
Disyllabic 1	7	18/**28**
Disyllabic 2	8	9/**32**
Multisyllabic	6	13/**24**

Overall Articulatory Accuracy Examples.

CV Words

/law/ After producing the correct vowel alone, visual and tactile cues were provided. Although the child could not say the word as a whole, he segmented it into two sounds. He produced the correct response in an uncued trial via direct imitation **(/law/**→[aw], [la:], [lo], and [law]. However, the child pronounced the vowel correctly the first time, but the movement from /l/ was awkward, with mild groping.

/di:/ The child said [ti:] for /di:/ at a normal rate and with accurate movement. The t/d substitution was observed to be consistent with his developmental consonant errors.

CVC1 Words

/du:d/ The child struggled to say the word accurately, so he added an extra syllable at the end of the word [tu:tta:], [du:], [tu:t], and [du:t].

CVC2 Words

/ħu:t/ The child said [hu:t] for **/ħu:t/** at a normal rate and with accurate movement. The h/ħ substitution was observed to be consistent with his developmental consonant errors.

/fu:l/ During the first attempt, the child distorted the vowel /u:/. While cues were provided, he received a score of 0 for overall articulation.

/di:k/ Despite the correct vowel, this word was produced incorrectly, for example, [ti:t], [ki:k], [ki:t], and [ti:k].

Disyllabic 1 Words

/ʃa:hi:/ Despite all cueing trials, the child had difficulty producing the word (e.g., [ʃa:hli:], [ʃa:ti:], [ʃa:hli:], and [ʃa:ni].

/ku:ki:/ In the child's speech, the vowels were distorted and the prosody was incorrect.

Disyllabic 2 Words

/kita:b/ The child was unable to say the word as a whole; he segmented the words into two syllables with a short pause (e.g., [ki:.ka:b] and [ki:ba:b]). The vowels were correct in all trials.

/hila:l/ The child produced the second syllable correctly, but the initial syllable was deleted. The child continued to delete the first syllable during all cued trials. He scored 0 on the final uncued production for scoring (e.g., [la:l]).

/lajmu:n/ With incorrect lexical stress on [mu:n], he produced inaccurate vowels and segmented the target word (e.g., [li.nun].

/mufta:ħ/ In the child's first attempt, he segmented the word [mu.ta:ħ] then provided cued until he achieved accurate production.

/ħali:b/ The child had developmental errors; he substituted the h/ħ [hali:b].

/fusta:n/ It was difficult for the child to produce the entire word.

Multisyllabic Words

/tufa:ħa/ As a result of the cueing, the child produced the word accurately, scoring 1 on the item.

/ħala:wa/ The child had developmental errors; he substituted the h/ħ [hala:wa].

Consistency

Child 1 experienced inconsistency over repeated attempts. Examples are provided in the following table 6.5.

Table 6.5. *Examples of Consistency Errors in Child 1*

Word shape	Target	First attempt	Additional attempts
CV	**/kaj/**	[kaj]	[kayk]
	/law/	[aw]	[la:]and [law]
	/di:/	[ti:]	[di] and [ti:]
	/mu:/	[mu:]	[bu:]
CVC1	**/du:d/**	[tu:ta:]	[du:da]
CVC2	**/fu:l/**	[full]	[fu:.l]
	/fi:l/	[fi:l]	[fil], and [fəl]
Multisyllabic	**/kataba/**	[kakaba]	[tataba] and [kababa]

/kanaba/	[kanaba]	[kanama]
/samaka/	[samaka]	[samama] and [sakama]
/tufa:ħa/	[tu-fala]	[tufa:ħa]
/ħalawa/	[ħalawa]	[ʔalawa] and [halawa]

6.1.5 Ar-DEMSS Summary.

The findings indicate that Child 1 demonstrated segmental and suprasegmental deficits associated with CAS features. Inconsistencies in vowel production were observed at the segmental level, mainly in the vowel /u:/ in some contexts, specifically CVC2 and disyllabic (1 and 2). With cues, he closed the approximate production. The /a/, /a:/, and /i:/ sounds were produced correctly. Additionally, there were developmentally consistent consonant errors primarily in t/d.

As noted in the previous section, prosodic disturbances were observed at the suprasegmental level through syllable segmentation, weak syllable deletions, equal stress, incorrect stress, and syllable segregation. In particular, he segmented and paused between syllables in disyllabic and multisyllabic words, which affected syllable transitions.

A disruption in coarticulatory transitions between sound and syllable was noted, as evidenced by articulatory groping, difficulties with accurate and smooth movements from one sound to the next, and increased difficulties with more complex syllables and word shapes. The child made numerous attempts at production and benefited from visual and tactile cues. Moreover, there was inconsistent production at the phonemic or word level across multiple attempts in consonants and vowels. Total scores are provided in the following table 6.6.

Table 6.6. *Total Scores of Child 1 in the Ar-DEMSS*

Summary scores	Number of words	Vowel accuracy	Prosodic accuracy	Overall articulatory accuracy	Consistency
CV	10	20	[redacted]	36	6
Reduplicated syllables	4	8	2	16	[redacted]
CVC1	7	14	[redacted]	24	6
CVC2	12	22	[redacted]	36	8
Disyllabic 1	7	11	2	18	[redacted]
Disyllabic 2	8	14	1	9	[redacted]
Multisyllabic	6	11	2	13	0
Maximum scores		108	25	216	35
Totals		**100**	**7**	**152**	**20**
Overall total score				**279**	

Comparison Between Child 1 and Typically Developing Children. This section presents a comparison between Child 1, with CAS, and typically developing children in the same age group 5;0-5;11 years old. Table 6.7 provides an overview of Ar-DEMSS scores. Ar-DEMSS scores ranged from 372 to 384, with a mean of 382 in typically developing children. When compared with typically developing children, Child 1 had the lowest total scores (279), and there was a big difference between both groups in vowel accuracy, prosody, overall articulatory accuracy, and consistency. Table 6.7 will provide a mean between child 1 and typically developing children.

Table 6.7. *Comparison Between Child 1 and Typically Developing Children in the same age group 5;0-5;11*

	Typically developing children (mean)	Child 1 with CAS (score)	Ar-DEMSS total scores
Vowel accuracy	108	100	108
Prosody	24.53	7	25
Overall articulatory accuracy	215	152	216
Consistency	34.53	20	35
Total scores	382	279	384

6.2 Child 2

6.2.1 *Background information*

Child 2 is a young Saudi male aged 4 years and five months. He was diagnosed with CAS by a certified speech therapist at a clinic in Saudi Arabia. In this study, the child participated in an assessment session with his mother and was cooperative throughout. The session lasted 40 min. The child could not complete the articulation test due to his limited speech output. He was receiving speech therapy during his participation in the study.

6.2.2 *Assessment Procedures*

A comprehensive assessment was conducted to determine Child 2's speech abilities. In the assessment, several tests were used, including the oral-facial examination, nonverbal oral apraxia, AMR of individual syllables (e.g., pa, ta, ka), and SMR (e.g., pataka). The Ar-DEMSS was also performed to examine CAS speech characteristics. All test instructions and materials were in Arabic.

6.2.3 *Main Findings*

6.2.3.1 Oral-Facial Examination. An oral-facial examination was administered to assess the appearance and function of Child 2's oral musculature for speech purposes. A jaw evaluation revealed a normal range of motion, symmetry, and movement. His dentition showed that all teeth were present and arranged normally. He had a normal range of motion, symmetry, and sufficient strength in his lips and cheeks.

A tongue evaluation revealed that Child 2's tongue was of normal surface colour, movement, and size. He showed normal excursion, range and speed of motion, and strength of tongue tip when he was asked to protrude and retract his tongue and move it in different directions right, left, up, and down. Furthermore, the rapid side-to-side movement of the child's tongue was also acceptable. There was no attempt to examine the child's pharynx, soft palate, and hard palate. The results indicated adequate oral motor structures and functions for speech.

6.2.3.2 Nonverbal Oral Apraxia. Nonverbal oral apraxia is characterised by difficulties sequencing voluntary movements of the tongue, jaw, and other orofacial structures. According to the results, Child 2 exhibited mild nonverbal oral apraxia, as indicated by his groping and pausing, particularly when he was asked to pucker or move his tongue rapidly. He had difficulty achieving the correct initial articulatory configuration.

6.2.3.3 DDK.

AMR. The child repeated each single syllable /pa/,/ta/, and /ka/ accurately for 10 s.

SMR. The child could not repeat the sequence of syllables /pataka/ accurately for 10 s. Although he could produce each syllable independently, he struggled to combine them in the same order (i.e., [kaka], [akaka], and [gaga]). His production was also inconsistent in each trial.

6.2.3.4 Articulation Test. At the assessment session, the child was unable to complete all the articulation tasks. However, his mother provided a report about a previous articulation test (JISH), and the SLT noted that he performed the test by imitation. Among the findings were deletion of an initial consonant, assimilation, stopping, changing emphatic sounds to non-emphatic ones, alveolarisation, and syllable deletion.

6.2.3.5 Ar-DEMSS. Child 2 completed all Ar-DEMSS subtests. In spite of this, a number of errors were found in the vowels, prosody, overall articulation, and consistency. Vowel production was accurate only in reduplicated syllables and CVC1. In the majority of trials, the prosody, overall articulation, and consistency was inaccurate. The following section will provide a brief overview of Ar-DEMSS performance production by Child 2, some examples, and a summary.

6.2.4 *Overview of Child 2*

Vowel Accuracy. Several vowel errors were made by Child 2, including distortion and substitution. Although cueing was used, he still had difficulty producing the diphthongs /aw/ and /aj/. Below are a few examples in Table 6.8.

Table 6.8. *Examples of Child 2's Vowel Errors*

Word shape	Target	Transcription of Child's production
CV	/kaj/	[ka] and [k] with distorted vowel
	/law/	[wah]

Moreover, Child 2 was able to produce most of the vowels /a:/, /a/, /u:/, /i/, and /i:/ in CV, reduplicated syllable and CVC (1 and 2), although he distorted them with increasing word shapes, such as disyllabic words (1 and 2) and multisyllabic words. In words with more syllables, he would distort, omit, or replace the vowel with another easier vowel, such as /a/ (i.e., /u:/→/a/). The following table 6.9 provides some examples. Additionally, it was evident that Child 2's vowel production was inconsistent in two different attempts, and groping and segmentation were noted.

Table 6.9. *Child 2's Vowel Productions in Different Word Shapes*

Word shape	**Target**	**Transcription of child's production**
Disyllabic 1	/du:da:/	[ada] and [da:.da]
	/lajla/	[lala]
	/li:lu:/	[alu]
	/ku:ki:/	[ka:ki:]

Prosody. Prosody errors were present in Child 2's performance, including equal stress error, segmentation, weak syllable deletion, and incorrect stress. The stress was equal in the reduplicated syllables /nu:nu:/. Segmentation was also observed in disyllabic 1 in /ʃa:hi:/ and /du:da:/, and in disyllabic 2 in /hila:l/, and /lajmu:n/. There was a weak syllable deletion in /fus**ta:n**/, and /ki**ta:b**/, and there was an incorrect stress pattern in /ba:ba:/ and /ba:bi:/. His speech was also perceived as monotonous, monopitch, and staccato in some contexts. Table 6.10 will provide prosodic errors in child 2.

Table 6.10. *Types of Child 2's Prosodic Errors*

Target	**Child's production**	**Prosodic error types**
/hi**la:l**/	[hi.la:l]	Segmentation
/ba:ba:/	[ba:**ba:**]	Incorrect stress pattern
/fus**ta:n**/	[ata:n]	Weak syllable deletion

Note. Segmentation = (.)

Table 6.11. *Prosodic Error Types for Descriptive Purposes*

Prosodic error types	Segmentation	Equal stress	Incorrect stress	Weak syllable deletion	Added syllable
Reduplicated syllables (4)			☑		
Disyllabic 1 (7)	☑		☑		
Disyllabic 2 (8)	☑			☑	☑
Multisyllabic (6)				☑	

Overall Articulatory Accuracy. Each section examined the overall accuracy of the articulation. Child 2 performed poorly in CVC2, disyllabic (1 and 2), and multisyllabic words. Consequently, he scored extremely low, as shown in the table 6.12 below.

Table 6.12. *Total Scores of Overall Articulatory Accuracy in Each Section*

Summary Scores	Number of words	Overall articulatory accuracy score
Consonant-vowel	10	30/**40**
Reduplicated syllables	4	16/**16**
CVC1	7	28/**28**
CVC2	12	28/**48**
Disyllabic 1	7	8/**28**
Disyllabic 2	8	4/**32**
Multisyllabic	6	0/**24**

Overall Articulatory Accuracy Examples.

CV Words. In the CV syllable structure, Child 2 made a few errors. In the first attempt, the child substituted [s] for /t/ and then produced the /t/ sound in the second attempt. Also, the child had difficulty producing the diphthong vowels /aj/ and /aw/, so visual and tactile cues were provided. However, he still struggled to join the consonant with the vowel. For instance, ***/kaj***/ was produced as [ki:] and [si:], while ***/law***/ was produced as [ja:].

CVC2 Words. Child 2 made several errors, such as distortions of vowels and consonants. For example, the word ***/di:k/*** was produced as [ta:ka], [ti:k], and [di:tʃ] and the word ***/fi:l/*** was produced as [ti:], [fi:l], and [ti:l]. In addition, the word ***/mawz/*** was also accepted in dialect as ***/mo:z/***, but the child produced it incorrectly in all trials with inconsistent production such as [tu:z] and [nu:z]. Moreover, Child 2 substituted the sound t/k on both attempts. However, he could produce the sound /k/ at sound level, or at other syllable or word levels. Child 2 used phonological processes such as assimilation, as ***/ħu:t/*** became [tu:t], and ***/fu:l/*** became [lu:l].

Disyllabic 1 Words. Child 2 made a vowel error in his speech, so cueing was provided, but he could not correctly articulate the word. He was observed to be able to produce /u:/ in CV and CVC1, but he had difficulty producing its disyllabic structure, particularly for the word ***/du:da:/***, which was produced as [da:.da:], [da:da:], and [ada]; ***/ku:ki:/***, which was produced as [ki:ki:] and [ka:ki:]; and ***/li:lu:/***, which was produced as [alu].

Disyllabic 2 Words.

/kita:b/ As a result of the initial syllable deletion, the child was not able to say the word as a whole. (e.g., [ta:b]).

/lajmu:n/ There was an initial syllable deletion, inaccurate vowels, and segmentation in the child's word (e.g., [j.u:n]).

/mufta:ħ/ The child segmented the word first [mu.ta:ħ], and then cues was provided it until he produce [ata:ħ].

/tu:na/ It was produced as [ata] and [ʃu:na].

/ħali:b/ Due to developmental consonant errors, he substituted the h/ħ.

/fusta:n/ With the initial syllable deletion [ata:n], the child had difficulty producing the whole word.

Multisyllabic Words. Child 2 scored 0 on all components of the multisyllabic words task. Despite cues, he was unable to imitate the tester. His responses mostly used VCV shapes: ***/samaka/*** was [ada], ***/tufa:ħa/*** was [ata], and ***/kataba/*** was [aba].

Consistency. The performance of Child 2 was inconsistent over repeated attempts. Examples are provided in the following table 6.13.

Table 6.13 *Examples of Child 2's Consistency Errors*

Word shape	Target	First attempt	Additional attempts
CV	**/fi:/**	[fi:]	[si:]
	/kaj/	[ki:]	[si:]
CVC2	**/fu:l/**	[lu:l]	[tu:l]
	/di:k/	[ta:ka]	[ti:k]
	/fam/	[fam]	[tam]
	/mawz/ accepted in dialect as /mo:z/	[tu:z]	[nu:z]
Multisyllabic	**/kanaba/**	[aba]	[kaba]
	/samaka/	[ata]	[ada]
	/tufa:ħa/	[ata]	[tutu]

6.2.5 Ar-DEMSS Summary

The findings reveal that Child 2 demonstrated segmental and suprasegmental deficits associated with CAS features. At the segmental level, vowel errors were observed in many contexts, specifically in CVC2 /aw/, /u:/, and /i:/, but these vowels were accurate in CV structure. Even though the short and long vowels /a/ and /a:/ were produced correctly, they were sometimes substituted for difficult vowels, such as /u:/. There were developmentally consistent consonant errors, mainly in b/f. Some items were not produced correctly, which required tactile (mother's help) and visual cueing.

As shown in the previous section, prosodic disturbances were observed at the suprasegmental level through syllable segmentation, weak syllable deletions, syllable additions, equal stress, incorrect stress, and syllable segregation. Child 2's main challenge was that he segmented and paused between syllables, which affected the transition between syllables.

A disruption in coarticulatory transitions between sound and syllable was observed, as evidenced by schwa insertion, articulatory groping, and difficulties with accurate and smooth movements from one sound to the next. Additionally, Child 2 had increased difficulties with more complex syllables and word shapes, as he would produce open syllables, such as CV or VCV, instead of CVC2, disyllabic, or multisyllabic words.

Furthermore, Child 2 demonstrated inconsistent production at the phonemic or word level across multiple attempts in consonants and vowels.

Table 6.14. *Child 2's Total Scores in the Ar-DEMSS*

Summary scores	Number of words	Vowel accuracy	Prosodic accuracy	Overall articulatory accuracy	Consistency
CV	10	16		30	6
Reduplicated syllables	4	8	2	16	
CVC1	7	14		28	6
CVC2	12	21		28	5
Disyllabic 1	7	8	1	6	
Disyllabic 2	8	10	0	4	
Multisyllabic	6	0	0	0	0
	Maximum scores	108	25	216	35
	Totals	**77**	**3**	**112**	**17**
	Overall total score			**209**	

Comparison Between Child 2 and Typically Developing Children. This section presents a comparison between Child 2, with CAS, and typically developing children in the same age group 4;0-4;11 years old. Table 6.15 provides an overview of Ar-DEMSS scores. The results indicate that the Ar-DEMSS scores ranged from 364 to 384, with a mean of 377.7 in typically developing children. When compared with typically developing children, Child 2, with CAS, had the lowest scores (209), and there was a substantial difference between both groups in vowel accuracy, prosody, overall articulatory accuracy, and consistency.

Table 6.15. *Comparison Between Child 2 and Typically Developing Children in the same age group 4;0-4;11*

	Typically developing children (mean)	Child 2 with CAS (score)	Total scores
Vowel accuracy	108	77	108
Prosody	23.92	3	25
Overall articulatory accuracy	213.17	112	216
Consistency	34.25	17	35
Total scores	377.7	209	384

6.3 Child 3

6.3.1 *Background information*

Child 3 is a young Saudi male aged 3 years and nine months. He was diagnosed with CAS by a certified speech and language therapist at a clinic in Saudi Arabia. The child attended the session with his mother, and he was attentive and engaged throughout. The session lasted 50 min. Due to his limited speech output, the child was unable to complete the articulation test. He was receiving speech therapy during his participation in the study.

6.3.2 *Assessment Procedures*

A comprehensive assessment was conducted to determine Child 3's speech abilities. In the assessment, several tests were used, including oral-facial examination, nonverbal oral apraxia, AMR of individual syllables (e.g., pa, ta, ka), and SMR (e.g., pataka). The Ar-DEMSS was also performed to examine CAS speech characteristics. All test instructions and materials were in Arabic.

6.3.3 *Main Findings*

6.3.3.1 Oral-Facial Examination. An oral-facial examination was administered to assess the appearance and function of Child 3's oral musculature for speech purposes. A jaw evaluation revealed a normal range of motion, symmetry, and movement. His dentition showed that all teeth were present and arranged normally. He had a normal range of motion, symmetry, and sufficient strength in his lips and cheeks.

A tongue evaluation revealed that Child 3's tongue had normal surface colour, movement, and size. He showed normal excursion, range and speed of motion, and strength of tongue tip when he was asked to protrude and retract his tongue and move it in different directions right, left, up, and down. The rapid side-to-side movement of the child's tongue was also acceptable. There was no attempt to examine the child's pharynx, soft palate, and hard palate. The results indicated adequate oral motor structures and functions for speech.

6.3.3.2 Nonverbal Oral Apraxia. Nonverbal Oral Apraxia is characterised by difficulties sequencing voluntary movements of the tongue, jaw, and other orofacial structures. According to the results, Child 3 exhibited mild nonverbal oral apraxia, as indicated by groping and pausing, particularly when he was asked to pucker or move his tongue. He had difficulty achieving the correct initial articulatory configuration.

6.3.3.3 DDK.

AMR. Child 3 repeated each syllable /pa/ and /ta/ accurately for 10 s. The child, however, was unable to repeat the monosyllable /ka/ in the DDK task. His mother reminded him to produce the /k/ sound with the word /maka:ni:/ means (my place), so he produced [ka.ni] with segmentation. I asked him to repeat /ka/, and he said [tata]. A later observation revealed that he was able to produce the /k/ sound inconsistently in different positions in the words.

SMR. Child 3 could not repeat the sequence of syllables /pataka/ accurately for 10 s. In one attempt, he produced [pa], [ta], and [ka]. Afterward, he continued to produce [tatata]. Although he could repeat each syllable independently, he struggled to combine them in the same order. His production was inconsistent in each trial.

6.3.3.4 Articulation Test. During the assessment session, Child 3 was unable to complete all the tasks in the articulation test. However, his mother provided a report about a previous articulation test (JISH), in which the SLT reported that he had performed the test by imitation. Phonological errors were found, including initial syllable deletion, final consonant deletion, medial consonant deletion, cluster reduction, assimilation, stopping, reduplication, alveolarisation, and syllable deletion.

6.3.3.5 Ar-DEMSS. Child 3 completed all the Ar-DEMSS subtests. Despite this, he made many errors in vowels, prosody, overall articulatory, and consistency. The most difficulties were encountered in CVC (1 and 2), disyllabic (1 and 2), and multisyllabic words. The vowel production, prosody, overall articulatory, and consistency were accurate only in reduplicated syllables. Vowel, prosody, overall articulatory, and consistency was inaccurate in the majority of the sections. The following section will provide a brief overview of Child 3's Ar-DEMSS performance productions, as well as some examples and a summary.

6.3.4 *Overview of Child 3*

Vowel Accuracy. The following section describes Child 3's performance in vowel accuracy in all different sections of the test. For example, Child 3 experienced several vowel errors, such as distortion. Vowel errors were found in CV, CVC (1 and 2), disyllabic (1 and 2), and multisyllabic words. Additionally, Child 3's vowel production was inconsistent during different attempts. In most of his productions, groping and segmentation were noted. A few examples of his speech productions are provided in table 6.16.

Table 6.16. *Examples of Vowel Errors in Child 3*

Word shape	Target	Transcription of child's production
CV	/kaj/	[ke]
CVC1	/lajl/ accepted /le:l/	[la]
CVC2	/ħu:t/	[o:]

Prosody. In this section, we describe how Child 3 performed in prosody in all sections of the test. Child 3 made several major errors in prosody, including equal stress error, segmentation, weak syllable deletion, added syllable, and incorrect stress. Additionally, segmentation was extremely evident in all test tasks, including CV, CVC1, and CVC2, and it was also observed in all disyllabic 1 words, such as /ba:bi:/, /du:da:/, /ʃa:hi:/, and /li:lu:/, as well as disyllabic 2 /lajmu:n/. Weak syllable deletion was noted in /mufta:ħ/, and /kita:b/. Incorrect stress patterns were observed in /layla/, /ba:bi:/, and /hila:l/. A syllable was added to the words /mi:n/ and /fi:/. Furthermore, Child 3's speech was perceived as monotonous, monopitch, and staccato in some contexts.

Table 6.17. *Types of Child 3's Prosodic Errors*

Target	Child's production	Prosodic error types

/ba:bi:/	[ba:.bi:]	Segmentation
/hi**la:l**/	/hila:l/	Incorrect stress pattern
/ki:**ta:b**/	[ta:b]	Weak syllable deletion
/mi:n/	[mila] and [mina]	Added syllables

Table 6.18. *Prosodic Error Types for Descriptive Purposes*

Prosodic error types	**Segmentation**	**Equal stress**	**Incorrect stress**	**Weak syllable deletion**	**Added syllable**
Reduplicated syllables (4)					
Disyllabic 1 (7)	☑		☑	☑	☑
Disyllabic 2 (8)	☑	☑	☑	☑	☑
Multisyllabic (6)	☑	☑	☑	☑	☑

Overall Articulatory Accuracy. The following section illustrates Child 3's overall articulatory accuracy across all subtests. Child 3 performed poorly in CVC (1 and 2), disyllabic (2), and multisyllabic words. As a result, his score was extremely low, as shown in the table 6.19below.

Table 6.19. *Total Scores of Overall Articulatory Accuracy in Each Section*

Summary Scores	**Number of words**	**Overall articulatory accuracy score**
Consonant-vowel	10	31/**40**
Reduplicated syllables	4	16/**16**
CVC1	7	7/**28**
CVC2	12	13/**48**
Bisyllabic 1	7	20/**28**
Bisyllabic 2	8	4/**32**
Multisyllabic	6	0/**24**

Overall Articulatory Accuracy Examples.

CV Words. A number of CV words were incorrectly pronounced by Child 3:

/fi:/ Due to a developmental consonant error, the child consistently substituted b/f.

/bu:/ The child produced an inaccurate vowel in isolation. He was then given cues until he produced the entire word correctly.

/law/ Although both the vowel and consonant were accurate, there was a short pause between the consonant and vowel that affected the smooth transition. Afterwards, he received cues until the entire word was correctly produced.

CVC1 Words.

/du:d/ On the first attempt, the final consonant was deleted [du:]. Afterwards, the final consonant was replaced with t/d → [du:t]. Segmentation was noted.

/kajk/ *accepted as /ke:k/* The final consonant was deleted [ke]. He scored 0 despite cues being provided.

/lajl/ *accepted as* ***/le:l/***→ [la] This represents the final deletion of a consonant.

/ba:b/ This was produced as [ba:], [ba:.ba:], and [ba:b].

CVC2 Words.

/kawb/ *accepted as* ***/ko:b/*** A slow rate of production with inaccurate vowels and consonants was evident, as well as groping and segmentation.

/ ħu:t/ and /fu:l/ The vowel was distorted, and the initial and final consonants were deleted. (e.g., [o:]). Groping was observed. For many words, Child 3 had difficulty with the vowel /u:/.

He could produce sounds in isolation, such as in /**fu:l**/ →[l] and [aul], but he could not blend them together into a word.

/di:k/ Groping and segmentation were evident; the words were produced slowly with inaccurate vowels and consonants, as well as with the addition of schwa. For example, [ti] and [ti:t], [ti:k] and [di:əka].

/fi:l/ → [la] Child 3's production improved after cueing [ti:l] and [filla]. In the uncued trial, he scored 0.

/mi:n/ The production was slow, with final consonant deletion [mi:], [mi:m], [mi:l], and [mi:la].

/fam/ Due to a developmental consonant error, [b] was substituted for /f/.

Disyllabic 1 Words.

/ba:bi/ Production was slow with segmentation and schwa added (e.g., [ba:-əb]). Cueing was provided until an accurate result was achieved.

Disyllabic 2 Words.

/kita:b/ He was unable to pronounce the word as a whole; he deleted the initial syllable (e.g., ta:b/).

/hi:lal/ → [hi:.la] Final consonant deletion and segmentation were evident.

/laymu:n/ There was deletion of the first syllable, an inadequate pause, and segmentation of the word (e.g., [ə-mu:] and [lə-mu:]).

/mufta:ħ/ It was difficult to transition between syllables, as evidenced by segmentation, pauses, and the deletion of initial syllables [ət.a:ħ] and [ta:ħ].

Multisyllabic Words. Child 3 scored 0 on all components of the multisyllabic words task. Although he was given cues, he was unable to imitate them. For instance, ***/tilifu:n/***→[ti-mu]; /**kataba/**→ [ta-ta-ta]; ***/kanaba/***→ [ka.na], [ka.na.na], and [ka]; and ***/ħalawa/***→ [awa] and [wa-wa]. Observations showed that the child produced multisyllabic words in VCV or CV shapes.

Consistency. Child 3 experienced inconsistency over repeated attempts. Often, he would omit the final consonant or add syllables. The following table 6.20 provide examples.

Table 6.20. *Examples of Child 3's Consistency Errors*

Word shape	Target	First attempt	Additional attempts
CV	**/mu:/**	[mu:]	[bu:]
CVC1	**/du:d/**	[du:]	[du:.d]
	/lajl/	[li]	[la]
	/nu:n/	[nu:]	[nu:na:]
CVC2	**/di:k/**	[ti:]	[ti:t]
	/fi:l/	[la]	[ti:l] and [fi:la]
	/mi:n/	[mi:]	[mi:m]
	/jad/	[ad]	[da:]

Note. Segmentation= (.).

Table 6.21. *Child 3's Total Scores in the Ar-DEMSS*

Summary scores	Number of words	Vowel accuracy	Prosodic accuracy	Overall articulatory accuracy	Consistency
CV	10	17	[redacted]	31	5
Reduplicated syllables	4	8	4	16	[redacted]
CVC1	7	10	[redacted]	7	1
CVC2	12	14	[redacted]	13	3
Disyllabic 1	7	12	0	20	[redacted]

Disyllabic 2	8	11	0	4	[redacted]
Multisyllabic	6	6	0	0	0
Maximum scores		108	25	216	35
Totals		**78**	**4**	**91**	**9**
Overall total score			**182**		

6.3.5 Ar-DEMSS Summary

The findings reveal that Child 3 demonstrated segmental and suprasegmental deficits that were associated with CAS features. At the segmental level, vowel errors were noticed in many contexts, specifically in CVC2 /aw/, /u:/, and /i:/, but these sounds were accurate in CV structure. While the short and long vowels /a/ and /a:/ were produced correctly, they were sometimes substituted or used in incorrect places.

At the suprasegmental level, prosodic disturbances were observed through syllable segmentation, weak syllable deletion, added syllable, equal stress, incorrect stress, and syllable segregation, as shown in the previous section. Child 3’s main challenges were segmentation and pauses between syllables, which affected his smooth transition between syllables.

The overall articulatory accuracy showed developmentally consistent consonant errors, mainly in b/f. There were some items with inaccurate production, which required cueing gestures simultaneously by me, both visually and tactilely, and with his mother’s help. A disruption in coarticulatory transitions between sound and syllable, as noted by schwa insertion, articulatory groping, and difficulties with accurate and smooth movements from one to the next, increased Child 3’s difficulties with more complex syllables and word shapes as he would produce open syllables, such as CV or VCV, instead of CVC2, disyllabic, or multisyllabic words.

In addition, there were inconsistent errors in the production of consonants and vowels at the phonemic or word level across multiple attempts.

Comparison Between Child 3 and Typically Developing Children. This section presents a comparison between Child 3, with CAS, and typically developing children in the same age group 3;0-3;11 years old. Table 6.22 provides an overview of the Ar-DEMSS scores. The results indicate that Ar-DEMSS scores ranged from 382 to 384, with a mean of 383 in typically developing children. When compared with typically developing children group, Child 3, with CAS, had the lowest scores (182), and there was a substantial difference between both groups in vowel accuracy, prosody, overall articulatory accuracy, and consistency.

Table 6.22. *Comparison Between Child 3 and Typically Developing Children in the same age group 3;0-3;11*

	Typically developing children (mean)	Child 3 with CAS (score)	Ar-DEMSS total scores
Vowel accuracy	108	78	108
Prosody	25	4	25
Overall articulatory accuracy	215.67	91	216
Consistency	34.33	9	35
Total scores	383	182	384

6.4 Chapter Summary

In this section, children of different ages were evaluated, and the differences between them were discussed. According to table 6.23, the Ar-DEMSS subscores and the total scores of each case study are compared with the mean for the same age group in the typically developing group. Among CAS group, Child 1 scored the highest at 279, as he had fewer errors in all the components of the test in comparison to Child 2 and Child 3. This study concluded that children of different ages with CAS show common characteristics of CAS. The main features are as follows:

1. Inconsistent errors in consonants and vowels.
2. Inappropriate prosody.
3. Disrupted coarticulatory transition between sounds and syllables.

It was also observed that initial consonants were deleted, articulatory groping occurred, vowels and consonants were distorted or substituted, syllables were segregated, short pauses between sounds and syllables affected smooth transition, difficulty increased with longer words, and additional schwas were added between words and consonants.

Table 6.23. *The comparison of Ar-DEMSS subscores and total scores between children with CAS and typically developing children*

	Age	**Vowel accuracy (108)**	**Prosody (25)**	**Overall articulatory accuracy (216)**	**Consistency (35)**	**Total scores (384)**
Child 1 with CAS	5;10	100	7	152	20	279
Typically developing children	5;0-5;11	108	24.53	215	34.53	382
Child 2 with CAS	4;5	77	3	112	17	209
Typically developing children	4;0-4;11	108	23.92	213.17	34.25	377.7
Child 3 with CAS	3;9	78	4	91	9	182
Typically developing children	3;0-3:11	108	25	215.67	34.33	383

Chapter 7 - Discussion and Conclusion Chapter 7

7.1 Introduction

As previously mentioned, there is no literature on CAS among Arabic-speaking Saudi children. There is also a lack of assessment procedures and treatment protocols for Saudi children with CAS. Despite this gap in the research, it is important to develop culturally appropriate assessment and treatment protocols for this group. The Ar-DEMSS was therefore developed, providing a general overview of both how typically developing children would perform on all of the Ar-DEMSS test tasks and how Saudi children with CAS would perform on all of the test tasks, making particular note of any specific characteristics associated with CAS.

The Ar-DEMSS was designed for children with limited speech output or no functional verbal communication but who can at least imitate sounds. The test assesses the speech movement of young children and those with severe speech impairments using early syllable structures, consonants, and vowels. In the Ar-DEMSS, four variables are examined: vowel accuracy, prosody, overall articulatory accuracy, and consistency. The Ar-DEMSS does not, however, assess phonological proficiency or articulation in a language (Usha & Alex, 2023). In the following section, the research questions guiding this study are first presented, followed by a discussion of how typically developing children perform on the Ar-DEMSS test in terms of vowels, prosody, overall articulatory accuracy, and consistency.

7.2 Research Questions

This study sought to answer the following research questions:

Research Question 1: How do typically developing Arabic-speaking children aged 3 to 7 perform on the Ar-DEMSS in terms of (a) their total score and (b) their subscores related to vowel accuracy, prosody, overall articulatory accuracy, and consistency?

Research Question 2: How do Arabic-speaking children with CAS perform on the Ar-DEMSS in terms of (a) their total score and (b) their subscores related to vowel accuracy, prosody, overall articulatory accuracy, and consistency?

Research Question 3: What are the speech characteristics of Arabic-speaking children with CAS aged 3 to 5?

7.3 Performance of Typically Developing Children on the Ar-DEMSS

This section will explore the performance of typically developing children aged 3 to 7 on the Ar-DEMSS in terms of their total score and their subscores related to vowel accuracy, prosody, overall articulatory accuracy, and consistency.

7.3.1 *How Do Typically Developing Children Perform in Vowel Accuracy?*

The test evaluated vowel proficiency across all sections (i.e., the CV, reduplicated syllable, CVC1 and CVC2, disyllabic 1 and 2, and multisyllabic word groups; see Table 5.8). As part of the test, the vowels used included the six Modern Standard Arabic short and long vowels /a/, /i/, /u/, /a:/, /i:/, and /u:/, as well as the diphthongs /aw/ and /aj/, which were accepted as /o:/ and /e:/ in dialectical versions.

According to the study, the children in the typically developing group reached the ceiling of vowel competency across all ages (i.e., 3;0, 4;0, 5;0, and 6;0). Based on these results, it is apparent that the typically developing children performed very well in all sections of the test regarding vowels. The age groups of 3-, 4-, and 5-year-olds each had a high mean score, which was the maximum score for each age group; therefore, there was no major difference in the mean scores between these three groups. However, the mean score for the 6-year-old group was slightly lower.

There is a potential explanation for this, as only two children aged 6.0 had vowel errors in two sections of the test—disyllabic and multisyllabic words. Furthermore, they were unable to produce a few words when the words were lengthened, affecting their overall articulatory accuracy as well as their vowel production; they attempted to imitate the target words inaccurately, causing listeners to perceive vowels incorrectly. Despite this, the mean decreased as a result of a gradual development trend. Because there are few studies exploring vowel development in Arabic-speaking children, we interpret our small decrease in vowel performance as the result of individual variability within older age groups.

According to these findings, most typically developing children produced accurate vowels across all sections. The findings are consistent with a study that found that children acquired Modern Standard Arabic vowels (i.e., /a/, /a:/, /i/, /i:/, /u/, and /u:/), in addition to /e:/ and /o:/, by the age of 2.0 (Amayreh & Dyson, 2000). Moreover, Owaida (2015) found that Syrian children acquire vowels to an accuracy level of 90% by age around the age of 2 years and 6 months to 2 years and 11 months. A study of Swedish-speaking children aged 37 to 106 months was performed using the DYMTA, a Swedish dynamic motor speech assessment, and the researchers found that children reached a ceiling for vowel accuracy across all studied ages (Rex et al., 2021a). In addition, studies of American English have found that all English vowels are acquired by 36 months (Selby et al., 2000) or by 14 months or earlier (Buhr, 1980; Davis & MacNeilage, 1990). These findings confirm the results of the present study, that typically developing children have high vowel proficiency at all studied ages.

7.3.2 *How Do Typically Developing Children Perform in Prosody?*

Only four sections of the Ar-DEMSS measure prosodic performance (i.e., the reduplicated syllable, disyllabic 1 and 2, and multisyllabic word groups; see Table 5.9). In words and phrases, 'stress' refers to how much emphasis is given to a syllable or word. The results showed that the group of children aged 3;0 had the highest mean score (the maximum score) among the age groups. As a result of difficulties presented by one child, the mean value for the age 4;0 group was slightly reduced. Additionally, most of the older group, between ages 5;0 and 7;0, reached the maximum score in prosody. Thus. prosody accuracy seems to improve as children get older. This signifies that prosodic development and abilities are related to the development of other linguistic aspects—specifically, semantics, syntax, and pragmatics (Azab & Ashour, 2015). According to McCann et al. (2007), the prosodic test scores of typically developing English-speaking children increase with age. Their results showed that there are statistically significant differences between different age groups when it comes to the appropriateness of responses.

Due to a lack of studies on prosody development in Arabic-speaking children and the fact that our study had a small sample size, we interpret the small decrease in performance in our study as being due to individual variability within age groups. Therefore, further research with a larger sample size is needed to determine whether this decrease in performance is a general trend.

As shown in Table 5.9, one child, aged 4;0 years, had difficulties with multisyllabic words. During the production of multisyllabic words, this child exhibited phonological processes such as syllable deletion, unstressed syllable deletion, and assimilation. Al Huneety et al. (2023) studied Jordanian Arabic-speaking children aged 3 to 5 years regarding syllable structure, phonological processes, and stress assignments associated with multisyllabic words in their speech. According to the authors, Jordanian children omit unstressed syllables between the ages of 3 years and 4 years and 6 months. This is in agreement with Ingram (1989) and

Grunwell (1987), who found that weak syllable deletion affects children until age 4. In English-speaking children, assimilation stops by age 3 (Stoel-Gammon & Dunn, 1985; Bowen, 2011), while in Arabic-speaking children, non-contiguous assimilation stops by age 2. Mashaqba et al. (2019) found that children who attempted trisyllabic words at an older age preserved assimilation. However, it was also found that assimilation was preserved at younger ages but gradually decreased at older ages, suggesting that the children were moving towards accurate syllable boundary segments (Al Huneety et al., 2023).

7.3.3 How Do Typically Developing Children Perform in Overall Articulatory Accuracy?

Across all sections, overall articulatory accuracy was examined to evaluate the overall accuracy in the movements made when producing words (see Table 5.10). Systematic cueing was provided throughout this evaluation section, to enable the children to produce the target words correctly on repeated productions. The cueing revealed each child's emerging skills as their performance progressed. When a child had difficulties producing a word and experienced phonological processes such as consonant omissions, final consonant deletions, or syllable reductions, cueing was provided.

In this study, children between the ages of 3 and 5 years had the highest mean, while the oldest group had a lower mean, with some variation within the age group in the total score. In spite of this, the highest scores were achieved by several children, spanning all the age groups. This finding is consistent with another study, which found that typically developing children aged 4 years and 6 months to 5 years and 8 months performed well on the Brazilian Portuguese version of the DEMSS but had some difficulty with the VV, CV, CVC, and multisyllabic sections (Keske-Soares et al., 2018). In addition, Rex et al. (2021a) reported that typically developing children had a mean score of over 90% for all age groups but that the ceiling was reached by those aged 5.

It is also significant to note that the sample sizes of typically developing children in this study (43) and in the Brazilian study (6 children) are relatively small compared to the sample size in the Swedish study (94 children). Moreover, the previous studies covered different age ranges: in the Swedish study, the children ranged in age from 3 years and 3 months to 8 years and 8 months, whereas in the Brazilian study, the children ranged in age from 4 years and 6 months to 5 years and 8 months. In the current study, as a result of the careful selection of words that match the phonological system of young children, those aged 3 with typical speech development could articulate perfectly the consonants in the instrument. This test is also intended for children who have limited output or no functional verbal communication but who can, at least, attempt imitation. For more information, see Chapter 3, which discusses Arabic phonological development.

Despite minor errors in some children's speech production, it was evident that these children were making developmental errors, such as consistent substitutions. This occurred when the children failed to produce the correct form of a target word. In addition, some children made systematic use of phonological processes such as omission, the deletion of initial and final consonants, weak syllable reduction, and vowel errors. These errors mostly occurred when the children were producing multisyllabic and disyllabic words. It was found, however, that visual, auditory, and articulatory cues could improve the children's speech production. Although they did not always produce the target correctly, their substitutions were consistent, or it was possible for them to reach the target.

A number of previous studies have examined the phonological processes that occur in different Arabic dialects; certain phonological processes were found to disappear at the age of 4 years and 4 months for Jordanian children (Dyson & Amayreh, 2000), at the age of 5.0 for

Egyptian children (Ammar & Morsi, 2006; Abou-Elsaad et al., 2019), by age 3 years and 7 months for Kuwaiti and Qatari children (Alqattan, 2015; Albuainain, 2012), by age 6 years and 6 months for Syrian children (Owaida, 2015), and by age 4 years and 2 months in the Najdi Saudi dialect (Alajroush, 2020). In these findings, few children over age 4 years had developmental and phonological errors, while only one child aged 6 years continued to exhibit phonological processes that affected the general score.

In the current study, there was a difference in the number of participants within each age group. The age group of 3-year-olds, for example, contained only three children. Surprisingly, only one development error was detected in this group, for the sound /h/ in the word / ħu:t/. Some groups included more participants, however, and in these groups, some children experienced phonological processes when words became longer—especially with disyllabic and multisyllabic words such as /kita:b/ ('book'), /mufta:ħ/ ('key'), and /fusta:n/ ('dress')—until the age of 7.

In terms of overall articulatory accuracy, a score of 2 out of 4 indicates that an additional model was provided or that the child self-corrected without an additional model. The results indicate that a child's total score is influenced by many factors, including incorrect imitation, the presence of phonological processes, the provision of additional models, and self-correction.

7.3.4 *How Do Typically Developing Children Perform in Consistency?*

Four sections of the test were used to assess consistency: CV, CVC1, CVC2, and multisyllabic words (see Table 5.11). Each age group had the same mean in the consistency variable, which was high in all sections. Only when pronouncing multisyllabic words were there some differences in performance between children in different age groups, but these children improved their performance with cueing. This is in line with Rex et al.'s (2021a) finding that Swedish children reached the ceiling from age 5. In contrast, Keske-Soares et al.

(2018) found that typically developing children reached the ceiling in this variable with no errors in all components of the test.

Stackhouse and Wells (1997) reported that children's speech is subject to variability, particularly during the early stages of speech development. However, Williams and Stackhouse (2000) found that typically developing children's pronunciation is highly consistent on DDK tasks. A longitudinal study by Ferguson and Farwell (1975) investigated the acquisition of 50 words by 3 children. In their view, children learning the same language may differ based on the strategies they use to learn it. The strategies they observed varied based on preferences for sounds, sound classes, features, markers for classes of words, lexical expansion, and phonological differentiation, as well as the preference for avoiding particular sounds. Furthermore, Vihman (1993) mentioned a few internal factors that can contribute to this variability, including anatomical differences, physiological maturation rates, attention, memory, learning style, and integration of input.

Yet these factors do not explain why children may repeat the same words differently (Holm et al., 2007). It is possible that some phonetic variability in young children is due to the motor variability inherent to the development of their speech motor systems. For instance, Green et al. (2002) examined the sequential development of the articulators by observing how the upper lip, lower lip, and jaw move during speech. The researchers found that mandible movement patterns mature earlier than do upper- and lower-lip movement patterns. The occurrence of inconsistent productions in children with typical speech and language development has been attributed to two possible explanations: 1) incomplete underlying representations, in which a child's pronunciation of a phoneme or word varies from utterance to utterance because of a lack of sufficient detail, or 2) a child's inability to produce the correct surface form due to inadequate articulation abilities (i.e., for the correct articulation of a word, all the necessary information is contained in the underlying representation).

There is no doubt that inconsistency exists in typically developing children's speech, but the underlying causes are difficult to determine, and they may differ from child to child (Betz & Stoel-Gammon, 2005). It has been shown that children exhibit three types of inconsistency: the inconsistent use of phonemes based on word position, the inconsistent use of phonemes based on lexical target (Ferguson & Farwell, 1975), and the inconsistent pronunciation of the same word multiple times which usually known as token-to-token inconsistency. This variability in speech decreases with increasing age when repeated sounds or words are produced (Iuzzini-Seigel, 2012; Preston & Koenig, 2011).

7.4 Performance of Children with CAS on the Ar-DEMSS

This section will provide an overview of the preliminary findings about Saudi children with CAS at different ages (i.e., 3;0, 4;0, 5;0, and 6;0). It seeks to answer the second research question of this study: How do Arabic-speaking children with CAS perform on the Ar-DEMSS in terms of their total score and their subscores related to vowel accuracy, prosody, overall articulatory accuracy, and consistency? Despite the small number of participants, some preliminary conclusions were drawn about the children's ability in relation to four variables: vowels, prosody, overall articulatory accuracy, and consistency. Our discussion will include the potential occurrence of certain features in Saudi children in comparison with other existing literature, as well as how children with CAS perform on the Ar-DEMSS.

This study included only six Saudi participants who spoke Arabic as their first language and who had suspected CAS, as diagnosed by SLTs in Saudi Arabia. They were all receiving speech and language therapy at the time of the study. The number of participants was expected to be low, as previous studies have shown that the prevalence of CAS is itself very low, with one or two children per thousand being affected (Shriberg et al., 1997a, 2019). Forrest (2003), however, claimed that the prevalence of CAS is unknown.

The current study provides insight into the abilities of Saudi children with CAS with regard to vowel accuracy, prosody, overall accuracy of articulation, and consistency of articulation. According to ASHA (2007), these are the most significant features associated with CAS. As such, the following sections will describe these features in children with CAS and compare the results to those observed in other studies, to provide greater insight into their possible occurrence among Saudi children.

7.4.1 *How Do Children With CAS Perform in Vowel Accuracy?*

During the development of speech, vowels appear early (Donegan, 2013; Vorperian & Kent, 2007; Oller, 2000), and the adult accuracy level is reached well before it is for consonants (Pollock, 2002). Numerous studies have indicated that vowel errors or difficulties could be represented as distortions or omissions in children with CAS (McCabe et al., 1998; Davis et al., 1998; Lewis et al., 2004; Peter & Stoel-Gammon, 2005; ASHA, 2007).

The current study shows that although children with CAS had low scores in vowel accuracy compared to the typically developing children, their performance improved with increased age. As shown in Table 5.16, in chapter 5, there was an increase in the mean value of vowel accuracy from age 3 to age 5 years. Among all the children with CAS, of various ages, only one child (aged 5;0 years) experienced very few vowel errors. It should be noted that while all the children with CAS were receiving speech and language therapy at the time of the study, it was not known whether intensive speech therapy was provided, when the intervention began, what the treatment methods were, or at what age therapy was started. It should also be noted that this is a finding based on a very small sample of children and cannot be generalised. Many auditory and acoustic studies have investigated the difficulties experienced by children with CAS with vowel production, as these children tend to make many vowel errors (Lenoci et al., 2021).

As shown in the Results section (see tables 5.16 in chapter 5), a lower mean vowel accuracy value was presented in younger age groups, followed by an increase in the value for the 4.0-year-old group and another increase at 5;0 years old. At age 3;0, the most vowel errors were observed when the participants were pronouncing CV, CVC1 and CVC2, disyllabic 1 and 2, and multisyllabic words. At age 4;0, the most vowel difficulties occurred for CVC2, disyllabic 2, and multisyllabic words, and at age 5;0, the most vowel errors were present for disyllabic 1 and 2 words. All children with CAS had the most difficulties with CVC2, disyllabic 1 and 2, and multisyllabic words.

Despite these findings, we cannot anticipate whether a child will make vowel errors due to the complexity of the word being produced. This is similar to the findings of Davis et al. (2005), who reported that studies have not yet examined the effects of word and utterance complexity on vowel errors caused by deficient sequential movement patterns. However, it has been shown that long words tend to have greater articulatory complexity and less detailed phonological representations than do short words, leading to poorer speech production in multisyllabic contexts (Brosseau-Lapré & Roepke, 2019).

Interestingly, some children were able to produce the short and long vowels /a/, /i/, /u/, /a:/, /i:/, and /u:/ in CV, reduplicated syllable, and CVC1 syllable structure words. However, vowels difficulties were present when long vowels such as /u:/, /i:/, and /a:/ were replaced with their short versions—/u/, /i/, and /a/, respectively. The two diphthongs /aw/ and /aj/ were also difficult to pronounce and misarticulated in many contexts, even when /o:/ and /e:/ were accepted as dialect productions. Moreover, most of the children replaced the high back rounded long vowel /u:/ and the high front unrounded long vowel /i:/ with the short vowel /a/.

Additionally, the diphthongs /aj/ and /aw/ were distorted or replaced with the vowel /a/ due to the difficulty in transitioning from one tense position to another lax position. This is similar to studies that have found that children with CAS have problems with diphthongs as well as rhotacised vowels. In this study, we found that the children with CAS were capable of producing most vowels, but they still displayed several errors, showing less accuracy than what was expected for their age group (Davis et al., 2005). However, compared to consonants, there is limited evidence of the expected vowel production in typically developing children or children with SSDs (and specifically CAS) in the Arabic language, and only a few that have discussed the accuracy of vowel production in children with SSDs (Pollock & Keiser, 1990). Because vowels are typically acquired early in speech development, little research has been conducted on vowel production (Roepke & Brosseau-Lapre, 2021).

Specific examples of this finding can be seen in the case studies. In particular, vowel difficulties were present in a child in the 5-year-old age group, specifically when pronouncing long vowels such as /u:/. The child would produce the short version of the phoneme, /u/, instead of /u:/ or would distort the vowel in different situations. In addition, a child in the 4-year-old age group, despite being able to produce the vowels /a/, /a:/, /u/, /u:/, /i/, and /i:/ in easy syllable structure shapes such as CV, CVCV, CVC1, and CVC2, the child demonstrated difficulty in producing them when the word was longer, even when cues were provided. Also, the long vowel /u:/ was distorted, omitted, or replaced with the short vowel /a/ in different situations. In a study by Amayreh and Dyson (2000), which collected spontaneous speech samples from children aged between 14 and 24 months, the participants most often produced the open front vowel /a/.

The inconsistent production of vowels in different attempts was noticed also in the current study. This is consistent with several studies that have reported that inconsistent production is a feature of CAS (Lewis et al., 2004; Forrest, 2003; ASHA, 2007; Iuzzini-Seigel et al., 2017). Additionally, it may be indicative of CAS when multiple repetitions of vowels in isolation and in real words exhibit an increased degree of variability (Smith et al., 1994). Several vowel errors were made by a child in the 3-year-old age group in all sections of the test, including the simple syllable shape words (e.g., CV and CVCV). In contrast, typically developing children from various age groups have a higher mean value and reached a ceiling in vowel competency. In accordance with previous studies (e.g., Amayreh & Dyson, 2000), all the children in their study were shown to have acquired all 6 Modern Standard Arabic vowels by the age of 2.0 (i.e., the short and long vowels /a/, /i/, /u/, /a:/, /i:/, and /u:/).

7.4.2 *How Do Children With CAS Perform in Prosody?*

It has been reported that prosodic disturbances are the most important hallmark of CAS (Shriberg et al., 1997a, 1997b, 2003a, 2003b; Odell & Shriberg 2001). Prosody performance is measured on the Ar-DEMSS because it was recognised that prosody could be used to differentiate between CAS and other SSDs. As such, it is evaluated in four sections: reduplicated syllables, disyllabic 1 and 2, and multisyllabic words.

The results demonstrate that the age groups of 3;0- and 5;0-year-olds had the lowest mean value in comparison to age group of 4;0-year-olds. A number of factors could have contributed to this result, including speech errors that differ between children with CAS, such as vowel and consonant errors, poor intelligibility, deletions of syllable structures, as well as difficulties with coarticulation, which interfere with effective prosody. As described earlier, the age 3;0 group contained two children, the age 4;0 group contained three, and the 5;0 group only contained one. Considering this, the age 4;0 group had the highest mean value among other age groups, with a high variability between the participants (See Table 5.17). Additionally, Shriberg et al. (2003a) reported that stress errors can change over time in children with CAS.

Looking at the most difficult sections of the test with regard to word shape structure, the children with CAS experienced difficulties in both disyllabic and multisyllabic words. However, the major problems related to prosody were characterised by segmentation, equal stress, weak syllable deletion, incorrect stress, added syllables, syllable segregation, and short pauses. Similar to Abdou et al. (2020), who found that Egyptian children with CAS had lower scores in prosody assessment tests than did children in the typically developing and phonological disorder groups. Moreover, a previous study by Shriberg et al. (1997a, 1997b), reported that 52% of children with CAS revealed an equal, excess, or misplaced stress pattern on one or more words within a phrase, or misplaced stress on one or more words. In their study (1997a, 1997b, 1997c), Shriberg et al. found that inappropriate stress differentiated children with speech delay and those with CAS. However, their methodology for assessing listeners' perceptions of stress had some limitations.

Kent (1996) argued that perceptions of voice and speech are limited due to differences in definitions, lack of agreement, and poor reliability among listeners. Stress perception is problematic due to several phonetic parameters associated with it, including fundamental frequency (F0), duration, intensity, and vowel articulation (Fry, 1958). As well as interacting with other phonetic and pragmatic factors, these cues may also be subtle. For instance, children with CAS may produce inappropriate phrasal stress, but this does not imply that the problem is with phonetics, such as incorrectly articulating the target stress pattern, or pragmatics when choosing a stress pattern.

Using both acoustic analysis and perceptual judgments, Skinder et al. (1999) examined the speech of five children with CAS and five typically developing children in terms of lexical and phrasal stress. For both groups, the acoustic analyses showed that the children controlled the F0, intensity, and duration appropriately when producing target words in declarative and interrogative sentences. In addition, listeners perceived the children with CAS as producing less accurate stress when pronouncing words and sentences compared with the typically developing children. The results of this study were, however, limited by a number of factors.

According to Forrest and Morrisette (1999) and Shriberg et al. (1997b, 1997c), the contrast between children with CAS and children with phonological disorders is more relevant to clinical practice than the comparison between typically developing children and children with CAS. Different groups of children may have different levels of familiarity with real words, which may lead to different inaccuracies in stress production. Numerous studies have examined the acoustic correlates of stress in children with CAS. There are numerous methodological differences between these studies that make it difficult to compare them directly, but the main goal of the research has been to determine whether acoustic stress measures differentiate children with CAS from those without (Munson et al., 2003; Shriberg et al., 2003b; Skinder et al., 1999). A number of factors differ between the studies, such as the stimulus types, participant groups studied compared to children with CAS, and lexical stress analysis performed (e.g., using separate analyses of each acoustic variable versus a composite measure). However, when Shriberg et al. (2003a) used the acoustic measure and asked their participants to imitate 24 disyllabic words, they found that 5 children out of 11 exhibited an atypical lexical stress pattern. This stood in contrast to Skinder et al. (1999), Munson et al. (2003), and Kopera and Grigos (2020), whose findings suggested that there are acoustic differences between children with CAS and children with speech delays.

The speech of children with CAS is perceived as being monotone, monopitch, and staccato in some contexts. Most children with CAS experience prolonged pauses between syllables or sounds, lacking a smooth transition to other structural units. In line with Shriberg et al.'s (2003b) findings, the current study determined that children with CAS have reduced pitch range and loudness, which causes listeners to perceive their speech as monotone or monoloud.

7.4.3 *How Do Children With CAS Perform in Overall Articulatory Accuracy?*

'CAS' has previously been defined as a neurological-based disorder in the programming of articulatory movements. The Ar-DEMSS thus measures the overall articulatory accuracy in all sections—CV, CVCV, CVC1 and CVC2, disyllabic 1 and 2, and multisyllabic words—reflecting the accuracy of the movement for each word as a whole. Scoring is based on performing the correct movements for accurate sound production. The findings reveal that all children experienced difficulties in overall articulatory accuracy (see Table 5.18 in the results section); the highest mean value was observed in the age group of 4;0, followed by age 5;0 and, last, age 3;0, with high variability in each age group.

Only in the reduplicated syllable words group were difficulties related to overall articulatory accuracy not observed. In comparison, a study of Brazilian children with CAS reported difficulties with VV, CV, reduplicated syllable, CVC, same-consonant, varied-form disyllabic, and multisyllabic words (Keske-Soares et al., 2018). Ar-DEMSS tasks include simple words with different syllable structures; however, when a child is asked to imitate words containing multiple syllables, they found it particularly challenging, due to their struggle to achieve a continuous sequence of movement. For example, some children with CAS can produce a vowel correctly in isolation but struggle when joining it with the previous and the following consonant.

Furthermore, initial and final consonant deletion occurred in this study. The children experienced vowel and consonant distortion, with inconsistent production in different attempts (as in many trials, they were able to produce the vowels and consonants accurately). Additionally, initial syllable deletion, extra syllable addition, the segmentation of words, evidence of groping, pauses between syllables, and awkward movements and transition from one sound to another were observed. Previous studies support these findings, as several have included the following the characteristics as diagnostic criteria for CAS: inability to imitate sounds, groping-effort production, general oral motor difficulties, inconsistent productions, difficulties sequencing phonemes, and increased difficulty with sound production when the utterance length increases (Forrest, 2003; McCabe et al., 1998).

Abnormal prosody, and limited phonemic inventory were also observed in the present study, consistent with previous research (Peter & Stoel-Gammon, 2005; Davis et al., 1998). Children with CAS exhibit a decreased differentiation of vowels and a variable idiosyncratic coarticulation pattern (Nijland et al., 2002). Nijland et al. (2003) indicated that the vowel production and coarticulation quality of children with CAS improved in response to a bite block when it was placed between their teeth.

Most of the children with CAS in this study replaced the CVC, disyllabic, and multisyllabic words with simple structures such as CV, VCV, and CVCV. For instance, the word /samaka/ (CVCVCV; 'fish') was produced as [ada] (VCV), while the word /kanaba/ (CVCVCV; 'coach') was produced as [ka] (CV), followed by [ka.na] (CVCV). These findings are consistent with Davis and Velleman (2000), who reported that children with CAS use incomplete syllables for consonants or vowel structures, and they use few word shapes. Also, Highman et al. (2013) mentioned that children with CAS use small or different syllable structures.

According to Lewis et al. (2004), children with CAS have difficulties in repeating non-words and multisyllabic words, as they observed vowel errors, voicing errors, the deletion of initial consonants, and syllable reduction; 100% of their CAS group deleted final consonants, while 90% deleted syllables. Many studies have also suggested that consonant errors can affect syllable structure, such as the deletion of initial or final consonants and the reduction of syllables (Lewis et al., 2004; Shriberg et al., 1997). It has been found that children with CAS are unable to form appropriate syllable frames for target words, resulting in high levels of omission (Marquardt et al., 2002; Jacks et al., 2006).

Davis and MacNeilage (1995) reported that infants produced common syllables without changing their lip or tongue position because infants can open and close their jaws at an early age, resulting in CV alternations. Based on this finding, it may be that children with CAS exhibit immature behaviour patterns (Velleman, 1994). As a result of successfully producing interdependent, inflexible patterns, children are able to produce a variety of syllables and prosody patterns (ASHA, 2007). Speech errors are less predictable in children with CAS compared to typically developing children (Maassen et al., 2002).

7.4.4 *How Do Children With CAS Perform in Consistency?*

Inconsistency is always mentioned as one of the diagnostic hallmarks in children with CAS (Davis et al., 1998; Forrest, 2003; Iuzzini-Seigel et al., 2017). 'Consistency' has been defined as the number of errors produced by a child across multiple productions of the same target word (Betz & Stoel-Gammon, 2005). In the current study, children with CAS had low scores in the consistency variable; however, the 4;0 age group achieved the highest mean value compared to the other age groups. However, the small sample size in each age group may affect the overall result, as the group with the higher number of children (i.e., the 4;0 age group) also had a higher mean, with low variability among the group. In contrast, the 3;0 age group, which contained only two children, had the lowest score and highest variability between the children.

Children with CAS experienced the most difficulties with CV, CVC1, CVC2, and multisyllabic words. The youngest age group had the lowest score in all of the sections. Multisyllabic words were the most difficult for children in all the age groups. As was also demonstrated in a study by Keske-Soares et al. (2018), it was clear that children with CAS had difficulties in being consistent on CV, reduplicated syllable, CVC, disyllabic, and multisyllabic words. Our findings are in agreement with Keske-Soares et al. (2018) in that that no child reached the maximum subscore in the consistency variable. A study by Iuzzini-Seigel et al. (2017) reported that children with CAS had greater inconsistency in the repeated production of monosyllabic words and phrases, in comparison to children with speech disorders and typically developing children.

ASHA (2007) mentioned in its technical report that inconsistency is one of the main features of CAS. Thus, as one of the most common diagnostic features used by clinicians to identify CAS (Forrest, 2003), token-to-token inconsistency is also commonly used as a requirement for inclusion in the CAS group of research studies (e.g., Ballard et al., 2010; Maas & Farinella, 2012). However, in the age group of 4 to 6 years, Shriberg et al. (1997) found no differences between children with CAS and children with other types of developmental SSDs. Unlike previous studies, this one measured inconsistent speech production using conversational samples. Accordingly, token-to-token inconsistency might not be the best indicator of speech motor deficits in these children.

A recent study found that inconsistency scores alone could only differentiate CAS from other SSDs with a modest level of accuracy (Murray et al., 2015), using the Diagnostic Evaluation of Articulation and Phonology (DEAP) inconsistency subtest (Dodd et al., 2002.). As such, Bradford and Dodd (1996) believed that inconsistency alone might not be sufficient for differential diagnosis. However, children with severe SSDs or inconsistent phonological disorders may have high scores for word-level inconsistency, which suggests that inconsistency has a greater impact on severity than it does on just the classification of the disorder (Bradford & Dodd, 1996; Iuzzini-Seigel, 2012; Tyler et al., 2006).

To understand the causes of inconsistent productions, researchers need to agree on definitions and measures of consistency. While several studies have provided explicit definitions and formulas for error consistency, there is a need for future research including children with CAS and phonological disorders to determine whether error consistency is one of the defining characteristics of CAS (Betz & Stoel-Gammon, 2005). For example, Chenausky et al. (2020) define variable errors as words produced by children with different errors than previous ones. To give an example, the child produced the word 'baby' differently each time he attempted to pronounce it [abʌndi] and [bʌndun]. To this end, the following are some examples of production inconsistencies. As shown in the Results section, child 3 had inconsistent production when trying to repeat the target word:

- **/mu:/** → [mu:] then [bu:] → The child produced the word correctly at the first attempt but then produced the target word incorrectly.
- **/du:d/** → [du:] then [du: d]→ Last consonant deletion occurred on the first attempt, but the second was correct, with segmentation.

7.5 General Discussion

This section will compare the vowel accuracy, prosody, overall articulatory accuracy, and consistency of the CAS group and with those of the typically developing children group.

7.5.1 *How Do Children With CAS Perform in Vowel Accuracy in Comparison to Typically Developing Children?*

The Ar-DEMSS was designed to investigate the possible characteristics of CAS among Saudi children and compare to their results with those reported in the existing literature. Children with CAS struggle to achieve vowel accuracy more often than do typically developing children. In the current study, the children with CAS performed poorly in relation to vowel accuracy in all sections of the test. Sometimes, vowels would be produced correctly in one situation and incorrectly in another. These results indicate a mean difference between the CAS and typically developing children’s groups in their vowel-related total scores. While the complexity of the words affected the vowel production of the typically developing children in some contexts, this was improved with cueing.

7.5.1.1 *Summary of CAS group vowel errors*

- The long vowels /u:/ and /i:/
- The diphthongs /aj/ and /aw/, even when changed to /e:/ and /o:/, to allow for dialect

- Cueing up to six times to reshape incorrect responses
- Inconsistent productions of vowels
- Groping evident in long, high back rounded vowel /u:/ and high front vowel /i:/
- Particular difficultly with CVC2, disyllabic 1 and 2, and multisyllabic words
- Inconsistent production despite cueing

7.5.2 How Do Children With CAS Perform in Prosody in Comparison to Typically Developing Children?

Children with CAS present prosody deficits more often when compared to typically developing children. In all sections of the Ar-DEMSS, the children with CAS performed poorly in terms of prosody. The results revealed that there was a mean difference between the CAS and typically developing children's groups in their prosody-related total scores. The total prosody scores of typically developing children increased with age. Among the CAS groups, the age 4;0 group had the highest mean. Further, even among the typically developing children, some phonological processes affected the prosody, such as syllable deletion and assimilation.

7.5.2.1 *Summary of CAS group prosody errors*

- Equal stress
- Segmentation
- Incorrect stress
- Weak syllable deletion
- Added syllables
- Syllable segregation
- Pauses between sounds or syllables

7.5.3 How Do Children With CAS Perform in Overall Articulatory Accuracy in Comparison to Typically Developing Children?

Children with CAS exhibit overall articulatory problems more often than do typically developing children. The children with CAS performed poorly in all sections of the Ar-DEMSS in this study in terms of overall articulatory accuracy. The results revealed a mean difference between the CAS and typically developing children's groups in their overall articulatory accuracy total scores. Typically developing children increase in their overall articulatory accuracy total scores as age increases, and many of the children reach the ceiling. However, phonological processes were noticed in some typically developing children, including omission, initial and final consonant deletion, weak syllable reduction, vowel errors, and substitutions; these errors were observed in longer words.

The children with CAS had many articulatory errors, in words ranging from those with a simple syllable structure to those that are more complex. Cueing was more beneficial to typically developing children than it was to children with CAS. Even though the typically developing children sometimes did not reach the target correctly, they were consistent with their substitutions, or they could have achieved the target. It was evident that the typically developing children could easily transition between sounds and syllables. In contrast, the children with CAS had difficulties with sequencing phonemes, imitating sounds, and with producing more complex words, and they were more likely to exhibit groping behaviours, omission errors in many contexts, syllable reduction, segmentation, and using simple syllable shapes.

7.5.3.1 *Summary of CAS group overall articulatory errors*

- Vowel and consonant distortion
- Omissions

- Difficulties sequencing phonemes
- Syllable reduction
- Simple syllable shapes
- Groping

7.5.4 How Do Children With CAS Perform in Consistency in Comparison to Typically Developing Children?

Children with CAS present with inconsistent production in repeated attempts more often than do typically developing children. In the current study, the children with CAS performed poorly in all sections of the Ar-DEMSS. The results revealed a mean difference between the CAS and typically developing children groups in their consistency-related total scores. This result is consistent with previous studies; for example, Iuzzini-Seigel et al. (2017) reported that children with CAS performed worse than did typically developing children in terms of consistency. The results of the current study also indicate that, sometimes, typically developing children also show inconsistencies in their speech, but the underlying causes are unclear and can differ between children (Betz & Stoel-Gammon, 2005).

7.5.4.1 *Summary of CAS group consistency errors*

- Different syllable shapes in CV, CVC, and multisyllabic words
- Different productions of the target word

7.6 Limitations of the Study

The current study aimed to create an Arabic version of the DEMSS that is adapted to the Saudi dialect. Due to the lack of an assessment tool for assessing severe speech disorders in Arabic-speaking children, a preliminary version of the DEMSS was developed (i.e., the Ar-DEMSS), which will assist SLTs in planning effective interventions for SSDs and which can be used as form of dynamic assessment in differential diagnosis among Arabic-speaking children. It is, however, important to consider some limitations of this study.

First, the English version of the DEMSS has eight subtests consisting of words with different syllable structures and levels of phonetic complexity (Strand et al., 2013; Strand & McCauley, 2019). Stimuli were selected for inclusion in the Ar-DEMSS based on the structure of the original test (Strand et al., 2013). The DEMSS focussed on early developing sounds, but there were also a number of later developing sounds among the target words. Phonemes in the Arabic sound system that are developed early were prioritised in the Ar-DEMSS, including those that can be articulated by children as young as 3 years old (Amayreh & Dyson, 1998; Saleh et al., 2007). However, it is rare for real words to be composed of a monosyllabic (CV) structure, so Arabic constructions containing with long or short vowels and prepositions were used in place of real words; the aim of this subtest (i.e., of monosyllabic words) was not to assess articulation or language but rather the movement between sounds or syllables. The results revealed that the majority of the typically developing children performed well in this subtest.

Second, it was difficult to find Arabic words to fit the CVC structure, which have the same initial and final consonants. As a result, only six words were added to this category, including the names of fruits, animals, and objects. The words chosen had to be familiar to the children and functional, when possible. Therefore, they had to be common and frequently used, based on the JISH Arabic Communicative Development Inventory: Saudi (Dashash & Al-Safi, 2014). It should also be noted that gradual changes occur in languages over time. A popular word in children's vocabularies at a certain point in time can become dated some years later because of cultural change or technological advances (Rex et al., 2021b).

Third, the process of developing and administering this current test was affected by the coronavirus (COVID-19) pandemic. During the lockdown, many schools and speech clinics were closed, making it difficult to find participants. As these places prohibited physical contact, all information and project descriptions were sent via email. In addition, although many Saudi parents were willing to participate in this study, they preferred face-to-face communication, which was not allowed at that time for safety reasons. In today's world, technology allows us to communicate very well, but some parents were concerned about technical difficulties caused by poor internet connections and old devices, or they did not have access to headphones or microphones. Other parents were unable to participate due to cultural considerations, as they would not allow their child to be recorded.

Fourth, some parents worried that the assessment was too long and that their child would get exhausted be unable to concentrate. Many toys and some blocks were used during the assessments to grab the attention of the children. However, the assessment involves a single session of 60 minutes, with a short break in the middle, and it includes many assessment procedures, such as an orofacial examination, test of Nonverbal Oral Apraxia, DDK test, articulation test, and the Ar-DEMSS itself. The children may have become tired and performed poorly as a result.

Last, there was a relatively small number of participants. In total, 43 typically developing children were included, divided (although not evenly) into 4 age groups, as follows: age 3;0 (n = 3), age 4;0 (n = 12), age 5;0 (n = 17), and age 6;0 (n = 11). In contrast, the CAS group had only six participants. Although all of the CAS groups were smaller than the typically developing groups, this study was not designed to provide age norms for the variables examined; the purpose was to examine how typically developing children and children with CAS perform on the Ar-DEMSS.

7.7 Clinical Implications of the Study Findings

In this study, information was provided about the characteristics of CAS in Arabic-speaking children, filling a gap in the literature. The majority of literature on CAS focuses on

English-speaking children, yet the results of this study demonstrate similar CAS characteristics across different languages such as English, Brazilian-Portuguese, and Swedish, with regard to vowels errors, prosodic disturbances, inconsistent errors in consonant and vowel production when repeated attempts are made, or lengthened and disrupted coarticulatory transitions between sounds and syllables (Abdou et al., 2020; ASHA, 2007; Forrest, 2003; Shriberg et al., 1997a, 1997b; Davis et al., 1998).

This study is the first to examine the characteristics of CAS in the Saudi children population. It provides an overview of the preliminary findings about how Saudi children with CAS perform on the Ar-DEMSS, with specific regard to the variables of vowel accuracy, prosody, overall articulatory accuracy, and consistency. The results indicate that children with CAS perform poorly in all variables compared to typically developing children. To understand how linguistic and motor deficits contribute to speech disorders, it is important to remember that the Ar-DEMSS is only one component of a comprehensive speech and language diagnostic assessment. Similarly, to understand how phonological errors contribute to speech disorders, it is necessary to examine both phonological errors and speech motor skills. To determine a child's phonology, a phonology test should be administered before the Ar-DEMSS. The Ar-DEMSS should be used to understand a child's motor skills and to track progress over time. It should be used in combination with other assessments to gain a more complete view of a child's language and speech development.

The requirements of most standard tests are beyond the capabilities of young children with limited output. As such, the Ar-DEMSS is a valuable tool for these young children because of its dynamic nature, which combines the direct imitation of simple phonetic content and syllable structures with cueing.

The administration of speech tests online via webcam/microphone (i.e., telehealth) is challenging. Although some useful speech data may be captured, things can go wrong, placing a heavy burden on the test administrator and, possibly, the parents. Remote speech recording is feasible, but it has inherent technical limitations and potential disruptions that limit this method's usefulness. According to Werfel et al. (2021) also mentioned that parents were worried about undertaking teleassessments while unsure of a child's capacity to engage in meaningful remote assessments. These parents were concerned with issues such as the child's ability to stay focused, how distractible or difficult the child was, and even issues with technology that, in turn, could impact and bias the results (Werfel et al., 2021). With both limited time and other potentially related variables, SLTs need to be cautious about monitoring the quality of audio and video in order to record children's responses accurately. Furthermore, challenges such as poor broadband and technology breakdowns are other factors that reduce the validity of speech sound assessment through the Internet (Freckmann et al., 2017). Remote speech recording is feasible, but it has inherent technical limitations and potential disruptions that limit this method's usefulness.

7.8 Suggestions for Future Research Directions

As a result of this study, a deeper understanding has been gained of the characteristics associated with CAS in Saudi Arabic-speaking children. Future research should address several issues arising from this study, which have been discussed in the previous section:

- Research using a larger sample size is needed to examine the vowel accuracy, prosody, overall articulatory accuracy, consistency, and other features of the speech of Arabic-speaking children with CAS and specifically the Saudi children population.

- The creation of a phonological assessment will contribute important information in the analysis and comparison of children with CAS, children with typical speech, or children with other speech difficulties. A tool should be created for the assessment and comparison of the speech production of Arabic-speaking children with CAS and those with other SSDs. The tool should be designed to measure the accuracy of sound production in Arabic and to identify any impairments that may be present. It should also be able to provide feedback on the progress of a child's speech production. Because many assessment instruments exist that translate from other languages, such as English, they do not accurately describe Arabic's phonological nuances and specific challenges. Further, the available assessment tools in Arabic are not standardized for Arabic-speaking populations across different ages and dialects, which reduces intra-test validity and reliability. For the identity of the checklist for a large geographical area, the tools for phonological assessment must address dialectal differences. To counter these shortcomings in examining phonology in Arabic, there is a need to develop reliable, valid, and culturally appropriate phonological assessment tools for Arabic.

- Further research is needed on the effects of speech interventions on the production of speech in children with CAS.
- The Ar-DEMSS should also be administered to children with SSDs other than CAS, to compare their performance with that of typically developing children. This will enhance the clinical value of this test for diagnosing children with CAS.
- A repeat administration of the Ar-DEMSS in person would be beneficial to compare the performance of children with CAS, typically developing children, and those with other SSDs.
- This study represents the first adaption of the DEMSS into a Semitic language that was successfully delivered online. This indicates that the Ar-DEMSS has the potential to be further validated for use in Saudi Arabia to assist with the identification of children with CAS.

7.9 Conclusion

This study aimed to develop an adapted version of the DEMSS in the Saudi dialect of Arabic (the Ar-DEMSS). This tool can assist Saudi SLTs in the differential diagnosis of SSDs in children aged three years and older who have speech impairment. This test was designed for children who have limited speech output or no functional verbal communication but who can at least attempt imitation.

Research questions were posed to explore how typically developing children and children with CAS perform on the Ar-DEMSS. Case studies were also presented to highlight key features associated with CAS among Saudi Arabic-speaking children. The findings showed that typically developing children performed better than those with CAS in all sections of the test. In addition, the children with CAS demonstrated vowel errors, prosody deficits, overall articulatory problems, and inconsistent productions across their attempts. There were some features highlighted in the Saudi child population, such as vowels and consonants being distorted/omitted, syllables being reduced, pauses, lexical stress errors, and inconsistent productions. Difficulties with CV, CVC, disyllabic, and multisyllabic words were also observed among the children with CAS.

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Appendices

Appendix A

The University Of Sheffield.

Downloaded: 31/10/2023
Approved: 17/08/2021

Rawan Alamoudi
Registration number: 190196291
Human Communication Sciences
Programme: Human communication sciences

Dear Rawan

PROJECT TITLE: Developing of an adapted Dynamic Evaluation of Motor Speech Skills in Arabic
APPLICATION: Reference Number 037311

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 17/08/2021 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- University research ethics application form 037311 (form submission date: 09/08/2021); (expected project end date: 01/10/2023).
- Participant information sheet 1084785 version 7 (09/08/2021).
- Participant information sheet 1092408 version 4 (09/08/2021).
- Participant information sheet 1092407 version 4 (09/08/2021).
- Participant information sheet 1092406 version 5 (09/08/2021).
- Participant consent form 1084786 version 3 (25/03/2021).

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since written approval will be required.

Your responsibilities in delivering this research project are set out at the end of this letter.

Yours sincerely

Kate Chadwick
Ethics Administrator
School of Allied Health Professions, Nursing and Midwifery

Please note the following responsibilities of the researcher in delivering the research project:

- The project must abide by the University's Research Ethics Policy: https://www.sheffield.ac.uk/research-services/ethics-integrity/policy
- The project must abide by the University's Good Research & Innovation Practices Policy: https://www.sheffield.ac.uk/polopoly_fs/1.671066!/file/GRIPPolicy.pdf
- The researcher must inform their supervisor (in the case of a student) or Ethics Administrator (in the case of a member of staff) of any significant changes to the project or the approved documentation.
- The researcher must comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data.
- The researcher is responsible for effectively managing the data collected both during and after the end of the project in line with best practice, and any relevant legislative, regulatory or contractual requirements.

Appendix B

Oral Facial Examination and Nonverbal Oral Apraxia Test

Name: Age: Date:

<u>**Check and circle each item noted, describe any comments.**</u>

Evaluation of face			**comments**
symmetry		Normal, droops on right, droops on left	
Abnormal movements		None, grimaces, spasms	

Evaluation of Jaw and Teeth ***Tell the client to open and close mouth***			**comments**
Range of motion		Normal, reduced	
symmetry		Normal, deviated to right, deviates to left	
movement		Normal, jerky, groping, slow, asymmetrical	

Observe dentition			**comments**
Occlusion (molar relationship)		Normal Distoclusion, mesioclusion	
Occlusion (incisor relationship)		Normal, overbite, underbite, crossbite	
teeth		All present, dentures, teeth missing (specify)	
Arrangement of teeth		normal , jumbled, spaces, misaligned	

Evaluation of lips **Tell client to pucker**			**comments**
Range of motion		Normal, reduced	
symmetry		Normal, droops bilaterally,	

		droops right, droops left	

Tell client to smile			**comments**
Range of motion		Normal, reduced	
symmetry		Normal, droops bilaterally, droops right, droops left	

Tell client to puff cheeks and hold air			**comments**
Lip strength		Normal, reduced	

Evaluation of tongue			**comments**
Surface color		Normal, abnormal (specify)	
Abnormal movements		Absent, jerky, spasms, writhing, fasciculations	
size		Normal, small, large	

Tell client to protrude the tongue			**comments**
excursion		Normal, deviates to right, deviates to left	
Range of motion		Normal, reduced	
Speed of motion		Normal, reduced	

Tell client to retract the tongue			**comments**
excursion		Normal, deviates to right, deviates to left	
Range of motion		Normal, reduced	
Speed of motion		Normal, reduced	

Tell client to move tongue tip to the right			**comments**

excursion		Normal, incomplete, groping	
Range of motion		Normal, reduced	

Tell client to move tongue tip to the left			**comments**
excursion		Normal, incomplete, groping	
Range of motion		Normal, reduced	

Tell client to move tongue tip up			**comments**
movement		Normal, groping	
Range of motion		Normal, reduced	

Tell client to move tongue tip down			**comments**
movement		Normal, groping	
Range of motion		Normal, reduced	

Observe rapid side to side movements			**comments**
rate		Normal, reduced, slows down progressively	
Range of motion		Normal, reduced on left, reduced on right	

Appendix C

Diadochokinetic rate

Repeat the following as fast and as steadily as possible *<u>for 10 seconds</u>*

/p^p^p^p^.../ --
/t^t^t^t^..../ ---
/k^k^k^k^.../ ---
Alternate motion rate /p^t^k^p^t^k^.../ ---

Summary of findings:

Appendix D

Dynamic Evaluation of Motor Speech Skill -Arabic version-

A. consonant-vowel

After cueing		Initial attempt		
Consistency (score 1 or 0)	**Articulatory accuracy (score 2, 1, or 0)**	**Articulatory accuracy (score 4, 3, or 2)**	**Vowel accuracy (2, 1, or 0)**	
				في
				تا
				بو
				كي
				لو
				لا
				ب
				دي
				مو
				نا
				Total score

Note

Inconsistent voicing errors		Vowel or consonant distortion	
Groping		Lexical stress errors	
Intrusive schwa		Segmentation	
Slow rate		Difficulty with multisyllabic words	
Trial or error		Awkward movement transitions	

Optional transcription

B. Reduplicated syllables

After cueing	Initial attempt			
Articulatory accuracy (score 2, 1, or 0)	**Articulatory accuracy (score 4, 3, or 2)**	**Prosodic accuracy (score 1 or 0)**	**Vowel accuracy (2, 1, or 0)**	
				ماما
				بابا
				نونو
				كوكو
				Total score

Note

Inconsistent voicing errors		Vowel or consonant distortion	
Groping		Lexical stress errors	
Intrusive schwa		Segmentation	
Slow rate		Difficulty with multisyllabic words	
Trial or error		Awkward movement transitions	

Optional transcription.	**Prosodic Error Types.**	
	Segmented	
	Equal stress	
	Incorrect stress	
	Weak syllable deletion	
	Added syllable	

C. Consonant- vowel- Consonant (same first and last phoneme)

After cueing		Initial attempt		
Consistency (score 1 or 0)	Accuracy (score 2, 1, or 0)	Articulatory accuracy (score 4, 3, or 2)	Vowel accuracy (2, 1, or 0)	
				توت
				دود
				كيك
				ميم
				نون
				ليل
				باب
				Total score

Note

Inconsistent voicing errors		Vowel or consonant distortion	
Groping		Lexical stress errors	
Intrusive schwa		Segmentation	
Slow rate		Difficulty with multisyllabic words	
Trial or error		Awkward movement transitions	

Optional transcription

D. Consonant- vowel- Consonant (different first and last phoneme)

After cueing		Initial attempt		
Consistency (score 1 or 0)	Accuracy (score 2,1, or 0)	Articulatory accuracy (score 4, 3, or 2)	Vowel accuracy (2, 1, or 0)	
				كوب
				حوت
				فول
				ديك
				فيل
				مين
				يد
				موز
				بيت
				دب
				تين
				فم

Note

Inconsistent voicing errors		Vowel or consonant distortion	
Groping		Lexical stress errors	
Intrusive schwa		Segmentation	
Slow rate		Difficulty with multisyllabic words	
Trial or error		Awkward movement transitions	

Optional transcription

E. Bisyllabic (One Consonants, Two Vowels)

After cueing	Initial attempt			
Articulatory accuracy (score 2, 1, or 0)	Articulatory accuracy (score 4, 3, or 2)	Prosodic accuracy (score 1 or 0)	Vowel accuracy (2,1, or 0)	
				بابي
				كيكة
				دودا
				ليلى
				شاهي
				ليلو
				كوكي
				Total score

Note

Inconsistent voicing errors		Vowel or consonant distortion	
Groping		Lexical stress errors	
Intrusive schwa		Segmentation	
Slow rate		Difficulty with multisyllabic words	
Trial or error		Awkward movement transitions	

Optional transcription.	Prosodic Error Types.	
	Segmented	
	Equal stress	
	Incorrect stress	
	Weak syllable deletion	
	Added syllable	

F. Bisyllabic (more varied syllabic shapes)

After cueing	Initial attempt			
Articulatory accuracy (score 2, 1, or 0)	Articulatory accuracy (score 4, 3, or 2)	Prosodic accuracy (score 1 or 0)	Vowel accuracy (2, 1, or 0)	
				كتاب
				هلال
				أذن
				ليمون
				مفتاح
				تونة
				حليب
				فستان
				Total score

Note

Inconsistent voicing errors		Vowel or consonant distortion	
Groping		Lexical stress errors	
Intrusive schwa		Segmentation	
Slow rate		Difficulty with multisyllabic words	
Trial or error		Awkward movement transitions	

Optional transcription.	Prosodic Error Types.	
	Segmented	
	Equal stress	
	Incorrect stress	
	Weak syllable deletion	
	Added syllable	

G. Multisyllabic Words

After cueing	Initial attempt			
Articulatory accuracy (score 2, 1, or 0)	Articulatory accuracy (score 4, 3, or 2)	Prosodic accuracy (score 1 or 0)	Vowel accuracy (2, 1, or 0)	
				تلفون
				كتب
				كنبة
				سمكة
				ثلاثة
				حلاوة
				Total score

Note

Inconsistent voicing errors		Vowel or consonant distortion	
Groping		Lexical stress errors	
Intrusive schwa		Segmentation	
Slow rate		Difficulty with multisyllabic words	
Trial or error		Awkward movement transitions	

Optional transcription.	Prosodic Error Types.	
	Segmented	
	Equal stress	
	Incorrect stress	
	Weak syllable deletion	
	Added syllable	

Summary scores	Number of words/items	Vowel accuracy	Prosodic accuracy	Overall accuracy	consistency
A. Consonant-vowel	(10)				
B. Reduplicated syllables	(4)				
C. CVC1	(7)				
D. CVC2	(12)				
E. Bisyllabic 1	(7)				
F. Bisyllabic 2	(8)				
G. Multisyllabic	(6)				
Number of items		(54 items)	(25 items)	(54 items)	(35 items)
Range of scores		(0-108)	(0-25)	(0-216)	(0-35)
Totals					
			Overall total score	Total possible score = 384	

(Prosodic score types are for descriptive purposes)

Prosodic error types	segmentation	Equal stress	Incorrect stress	Weak syllable deletion	Added syllable
Reduplicated syllables (4)					
Bisyllabic 1 (7)					
Bisyllabic 2 (8)					
Multisyllabic (7)					

Observation for additional evidence to consider in diagnosis
Mark each subtest in which observations of the characteristic were made.

subtest	CV	RS	CVC1	CVC2	Bisyllabic 1	Bisyllabic 2	multisyllabic	Total number of subtests	Spontaneous speech
Observation									
Inconsistent voicing errors									
Groping									
Intrusive schwa									
Slow rate									
Trial or error									
Vowel or consonant distortion									
Lexical stress errors									
segmentation									
Difficulty with multisyllabic words									
Awkward movement transitions									

Observations of speech characteristics across context: Number of features noted__________Number of subtests onwhich features noted__________comments on severity of any pertinent characteristics

List any aspects of the medical and developmental history that may be pertinent.

Summary of other related testing or other observations (e.g., DDK, NVOA testing if completed).

Diagnostic statement, including CAS severity

Appendix E

Ar-DEMSS's words list

CV words	**Transcription**	**CVCV words**	**Transcription**
في	/fi:/	ماما	/ma:ma:/
تا	/ta:/	بابا	/ba:ba:/
بو	/bu:/	نونو	/nu:nu:/
كي	/kaj/	كوكو	/ku:ku:/
لو	/law/	**CVC1 words**	**Transcription**
لا	/la:/	توت	/tu:t/
ب	/ba/	دود	/du:d/
دي	/di:/	كيك	/kajk/ or /ke:k
مو	/mu:/	ميم	/mi:m/
نا	/na:/	نون	/nu:n/
CVC2 words	**Transcription**	ليل	/lajl/ or /le:l/
كوب	/kawb/ or /ko:b/	باب	/ba:b/
حوت	/ħu:t/	**Disyllabic (1) words**	**Transcription**
فول	/fu:l/	بابي	/ba:bi:/
ديك	/di:k/	كيكة	/ke:ka:/
فيل	/fi:l/	دودا	/du:da:/
مين	/mi:n/	ليلى	/lajla/
يد	/jad/	شاهي	/ʃa:hi:/
موز	/mawz/ or /mo:z/	ليلو	/li:lu:/
بيت	/bajt/ or /be:t/	كوكي	/ku:ki:/
دب	/dub/	**Disyllabic (2) words**	**Transcription**
تين	/ti:n/	كتاب	/kita:b/
فم	/fam/	هلال	/hila:l/
Multisyllabic Words	**Transcription**	أذن	/ʔuðun/
تلفون	/tilifu:n/	ليمون	/lajmu:n/
كتب	/kataba/	مفتاح	/mufti:
كنبه	/kanaba/	تونة	/tu:na/
سمكه	/samaka/	حليب	/ħali:b/
تفاحه	/tufa:ħa/	فستان	/fusta:n/
حلاوه	/ħala:wa/		