

Knowledge and practice: Diagnosing and treating Childhood Apraxia of Speech

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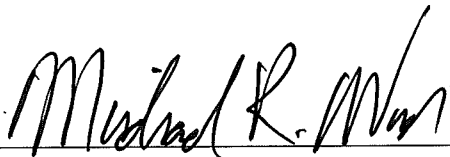


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Knowledge and practice: Diagnosing and treating childhood apraxia of speech

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In the field of speech-language pathology, few topics are more controversial than childhood apraxia of speech (CAS). Because of the lack of agreement on diagnostic criteria and no standardized protocol for diagnosing, CAS can look vastly different from one child to another. Nevertheless, the number of children diagnosed with CAS appears to be on the rise. The purpose of this study is twofold. The first is to investigate the sources from which SLPs gain knowledge about CAS. The second is to investigate SLPs' protocols for diagnosing and making treatment decisions for those diagnosed with CAS. SLPs working in public and charter schools in Wisconsin were sent an electronic survey. This survey gathered information about demographic information and asked questions that fell under three main themes: diagnosing CAS, treating CAS, and learning about CAS. It is important to gauge SLPs' perspectives and practices regarding CAS to better understand potential causes for the apparent rise in the rate of diagnosis. Furthermore, EBP is emphasized in all areas of speech-language pathology and this study is a way to evaluate this movement's impact on a specific disorder.


Thesis Advisor (Signature)


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I. INTRODUCTION

In the field of speech and language pathology, few topics are more controversial than that of childhood apraxia of speech (CAS). As defined by the technical report published by the American Speech-Language-Hearing Association (ASHA) in 2007, CAS is “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. 3). Various referred to as *developmental apraxia of speech (DAS)*, *developmental verbal apraxia*, and *developmental verbal dyspraxia*, the term *childhood apraxia of speech* was only recently adopted as the preferred nomenclature (ASHA, 2007b). The heated debate that has surrounded the terminology acts as a microcosm of the controversy surrounding nearly every aspect of CAS from the early years of speech pathology until the present.

Review of Literature

History and Naming of CAS. In 1954, Morley, Court, and Miller developed a classification system of childhood speech disorders which included a broad category of dysarthria defined as “slow and clumsy articulation arising from dysfunction of the muscles used in speech” (p. 8). However, they noted that not every case of dysarthria shared the same etiology. After observing a number of children who displayed signs of dysarthria but who had no easily identifiable neurological causes, the authors suggested a subcategory for dysarthria “unassociated with abnormal neurological signs elsewhere” (Morley et al., p. 8). Through their examination of these children, they concluded that these cases of dysarthria had developmental origins, thus they promoted the use of the term *developmental dysarthria* to differentiate this disorder from other neurologically-

based speech conditions. Then, in 1955, Morley and colleagues published another paper using the term *articulatory apraxia* which was defined as a “dysarthric difficulty [in which] muscular control appears to be adequate for all purposes other than the highly integrated movements of speech” (Morley, Court, Miller, & Garside, 1955, p. 464). This paper made no mention of the previous terminology or how the two terms differed in meaning. Between that time and when ASHA released the technical report on CAS in 2007, the terminology continued to vary greatly with no real distinctions made among the various terms.

In order to better serve clients and to more easily consolidate information, an ASHA committee selected *childhood apraxia of speech* as a unifying term for this disorder in 2007, although it is still not universally accepted. Each word in this classification term was carefully selected. First, although to some *childhood* and *developmental* may be synonymous, *childhood* was chosen because it was felt that *developmental* may be misinterpreted as something a child will grow out of or solely an educational concern (ASHA, 2007b). Second, *apraxia* was chosen over both *dysarthria* and *dyspraxia*. *Dysarthria* was dismissed due to its accepted definition as “a neuromotor disorder presumed not to involve the planning or programming deficit in apraxia” (ASHA, 2007b, p. 3). *Dyspraxia* was considered because the prefix more accurately describes the child’s level of function as *dys-* means a partial lack of function, while *a-* means a total absence of function. However, the task force chose *apraxia* to reflect the similarities between the childhood form of the disorder and the acquired form in adults which is simply termed *apraxia of speech* (ASHA, 2007b). This same explanation also holds for the use of the last words, *of speech*, rather than another semantically-similar

term such as *verbal* (ASHA, 2007b). While it is true agreement on terminology is helpful, many researchers take issue with the adopted term. As McCauley and Strand (2008b) note, this general application of the label CAS to children exhibiting apraxia due to a known cause (e.g., neurological trauma or genetic or metabolic conditions) and when the cause is unknown (i.e., idiopathic) is contrary to the earlier trend of using developmental apraxia of speech or developmental verbal apraxia to specify idiopathic forms of the disorder. For simplicity's sake, *childhood apraxia of speech (CAS)* will be used throughout this text, even when citing the work of authors who choose to use a different term for the same disorder, unless in a direct quote.

Diagnostic Criteria for CAS. Any disorder classification must include a list of diagnostic features in order to be considered valid. There is no authoritative list of diagnostic features for CAS, but there is some agreement on three features of speech movement planning deficits: “(a) inconsistent errors on consonants and vowels in repeated productions of syllables or words, (b) lengthened and disrupted coarticulatory transitions between sounds and syllables, and (c) inappropriate prosody, especially in the realization of lexical or phrasal stress” (ASHA, 2007b, p. 4). Despite this agreement, complications arise when it is recognized that these signs are neither necessary nor sufficient to diagnose CAS because the features exhibited by a child may vary widely according to task, severity, and age (ASHA, 2007b; Guyette & Deidrich, 1981). For example, whereas prosodic abnormalities may be observable in children with CAS who have attained a certain level of speech production skill, such abnormalities may not be apparent in children who are more severely affected and produce limited speech. Similarly, deficits in production of multisyllabic words may be particularly significant in

some older children suspected of having CAS (Shriberg, Aram, & Kwiatkowski, 1997b), but such abnormalities may be very difficult to identify in younger and/or severely affected children who may produce only monosyllabic words or almost no speech at all (McCauley & Strand, 2008).

Because of this, Velleman and Strand (1994) proposed that it would perhaps be more prudent to consider CAS as a “symptom complex” rather than a discrete disorder, which would allow for more variety in characteristics and for changing characteristics even within a child over time. Nevertheless, some validated characteristics are necessary in order to properly evaluate research on the disorder (Shriberg, Aram, & Kwiatkowski, 1997a). Several studies have been conducted to accomplish this.

In 1997, Shriberg, Aram, and Kwiatkowski published a three-part series on childhood apraxia of speech with the dual purposes of reviewing the descriptive and theoretical perspectives of the disorder and of sharing research results concerning potential diagnostic markers. Without a diagnostic marker, the authors note that any claims made about the nature of CAS or the theoretical underpinnings are tortuous by default.

In the second part of the series, the authors completed two studies with the purpose of finding a characteristic or characteristics that would differentiate children with CAS from other children with severe speech sound disorders (Shriberg et al., 1997b). In the first of those studies, the authors compared the speech and prosody profiles of 14 children with suspected CAS to 73 children with speech delay (SD). As part of this study, the authors used the Prosody-Voice Screening Profile (PVSP) to analyze phrasing, rate, stress, loudness, pitch, and laryngeal and resonance quality. Speech samples were

collected from each child and each utterance was scored as appropriate or inappropriate for each of the seven prosody-voice variables listed above. They found that the only measure that effectively separated the two groups was linguistic stress, with the group of children with suspected CAS earning significantly lower percentages of appropriate utterances on this measure than the comparison group of children with SD. However, this criterion only gave a 43% true positive rate for the children with suspected CAS. Measures that did not differentiate the two groups included speech consistency, vowel/diphthong production, consonant production, and phonological process use. In the second study in this part of the series, the authors attempted to substantiate inappropriate stress as a diagnostic marker for CAS by completing a retrospective analysis of the speech of 20 children referred for suspected CAS. The authors found that using this marker to diagnose CAS would result in a 58% true positive rate for the children referred to them for suspected CAS, consistent with the true positive rate found in the first study.

In the third part of the series, the authors completed a third study to investigate whether inappropriate stress could be used as a diagnostic criteria within a group of children deemed to have CAS by other researchers in the field (Shriberg, Aram, & Kwiatkowski, 1997c). The results of this study corroborated the results of the previous two studies finding inappropriate stress to be a potential diagnostic characteristic for CAS. However, the use of inappropriate stress in diagnosing CAS has several potential implications as noted by the authors. The first is that if all of the children referred for suspected CAS do in fact have CAS, then inappropriate stress is only sensitive enough to identify about 52% of cases. The second implication is that perhaps there are multiple subtypes of CAS and one subtype is marked by inappropriate stress and that subtype

accounts for 52% of cases of CAS. The final potential implication of the results of these studies is that 48% of children with suspected CAS are actually false positives, and those children do not have CAS. This final possibility constitutes the driving reason for continued research in finding a “gold standard” of diagnostic markers (McCauley & Strand, 2008b).

Recently, Shriberg has published several papers that continue the search for a diagnostic marker of CAS. These studies are in part in response to the widespread use of diagnostic checklists to give the label of CAS to a child. The validity of such checklists is questioned because they contain too wide a variety of features of speech as consistent with CAS. In this way these checklists may have sensitivity but they lack specificity; that is, the checklists contain such broad criteria that too many children without CAS will qualify for the label (Shriberg, Campbell, Karlsson, Brown, McSweeny, & Nadler, 2003). Two of Shriberg’s efforts to find a diagnostic marker for CAS are discussed below which highlight this potential problem.

The accepted understanding of apraxia of speech implies that it is caused by impaired praxis. Shriberg and his colleagues adopt Ayre’s (1985) definition of praxis: “the generation of volitional movement patterns for the performance of a particular action, especially the ability to select, plan, organize, and initiate the motor pattern...” (as cited in Shriberg, Campbell, et al., 2003). Therefore, these authors purport that only those descriptive features of speech that point to praxis deficits should be considered as possible diagnostic markers. For example, descriptive features of a praxis deficit at the segmental level of speech include articulatory struggle, transpositional substitution errors, marked inconsistencies on repeated tokens of the same word type, proportionally

increased sound and syllable deletions, and proportionally increased vowel/diphthong errors. The authors' descriptive features of a praxis deficit at the suprasegmental level of speech include inconsistent realization of stress, inconsistent realization of temporal constraints on speech and pause events, and inconsistent oral-nasal gestures resulting in the perception of heightened nasal resonance. Based on the results of previous studies, in this study, the authors chose to specifically study inconsistent lexical stress as a possible diagnostic marker for CAS. First, SLPs were asked to refer two or more siblings with speech delays, of whom at least one was felt to have CAS. The authors separated the children into two groups based on perceptual analyses of their speech: Speech Delay (SD) and suspected Apraxia of Speech (sAOS). The authors found that some children in the sAOS group could be distinguished from the SD group by performing a lexical stress task and using the acoustic features of frequency, amplitude, and duration to calculate a lexical stress ratio. However, this ratio did not distinguish all children in the sAOS group, prompting the authors to discuss the possibilities of the existence of more than one subtype of CAS or CAS being a spectrum or continuum of signs and symptoms. Although the results were promising, the authors maintained that the current level of understanding of CAS necessitates the use of terms such as "suspected apraxia of speech" rather than a definitive diagnosis. Cross-validation studies on deficient stress and praxis disorders are needed to bolster its use as a diagnostic marker for CAS.

Shriberg led a second study to find a way to measure another praxis deficit, inconsistent realization of temporal constraints on speech and pause events, which could be indicative of CAS or a possible subtype of CAS (Shriberg, Green, Campbell, McSweeny, & Scheer, 2003). In this study, conversational speech samples of 15 children

suspected of having CAS and 30 children with moderate-to-severe speech delay were analyzed. The selection of children for the CAS group was based on perceptual observations of reductions in temporal variation such as the perception of “isochronous (similarly timed)” and “segmented (non-coarticulated)” syllables and words within their speech (Shriberg, Green, et al., 2003). The speech samples were analyzed and the duration of speech and pause events was measured. The measures of speech and pause durations were then divided to yield a metric termed by the authors as the coefficient of variation ratio. The coefficient of variation ratio was higher for the children suspected of having CAS than for the children with speech delay. The authors caution readers that the subject selection method of grouping the children based on perceptually irregular temporality in their speech limits the generalizability of this measure as a diagnostic marker of CAS. The study does provide a new way to measure temporality, and thus may lead to a diagnostic marker in the future.

A recent study by Iuzzini and Forrest (2012) attempted to find a method to quantify another characteristic of praxis deficit, inconsistent productions. These authors explain that there are two types of speech inconsistency: token-to-token inconsistency, which is the inconsistency of a word across multiple productions (e.g., “elephant” as /ɛpədən/, /ɛdæn/, /ʌpfæn/), and phonemic inconsistency which is the inconsistency of a phoneme across multiple productions, words, and word positions (e.g., /s/ as /s, t, d, ʃ, dz/). This study sought to determine which of these two types of inconsistency best differentiates speakers with CAS from those with a phonological disorder (PD). The authors used multiple measures for each type of inconsistency on single-word productions obtained from 58 preschool children, some of whom were normal speakers,

some of whom were determined to have CAS, and some of whom were determined to have PD. They found that one measure, the Inconsistency Severity Percentage (ISP), which is a measure of phonemic inconsistency, was the only one capable of reliably differentiating the two groups. This percentage is found with the following formula:

$$\left(\frac{\text{\# of different substitutions across all targets}}{\text{\# of opportunities}} \right) \times 100$$

When the ISP was greater than 17%, it was a reliable indicator that a child belonged in the CAS group. Based on this, the authors recommend the use of the ISP to help diagnose preschoolers with CAS as part of a diagnostic protocol. As this research is in its early stages, the findings require peer review and replication, but this may prove to be a useful tool to reduce ambiguity for clinicians diagnosing CAS.

Differential diagnosis of CAS. Some authors have proposed the use of differential diagnosis in response to the paucity of data to support a set of distinguishing characteristics of CAS. Differential diagnosis is purported to help discriminate CAS from other disorders that have similar characteristics such as phonological impairment or dysarthria (Strand & McCauley, 2008). Several researchers have explored its utility.

In 1998, Davis, Jakielski, and Marquardt conducted a study on twenty-two children referred to them for suspected CAS to identify potentially important characteristics for differentiating CAS from other speech sound disorders. They posit that although there are no established core criteria for diagnosis, the frequently-cited symptoms in research, in conjunction with some noted co-occurring deficits, can be useful in conducting differential diagnosis. Rather than looking for a certain combination of characteristics, the authors suggest that because the commonly-accepted features of CAS overlap with several other speech disorders, clinicians must consider the relative

prominence of each of the features of a child's speech to make diagnostic decisions. To exemplify this approach, the authors presented the information found for five children referred to them as having CAS or suspected CAS. The following characteristics were deemed particularly useful in making the differential diagnosis: "(1) limited consonant and vowel phonemic repertoire; (2) inconsistent production of complex word shapes; (3) highly variable consonant and vowel errors in conversational speech and single words; and (4) multiple suprasegmental differences" (Davis et al., 1998, p. 42).

Strand & McCauley (2008) also support a differential diagnosis approach to CAS because of the lack of established diagnostic criteria and the difficulty in distinguishing it from other disorders. They outline a protocol that they feel will help determine the relative contribution of phonologic problems, motor planning problems, and motor execution problems and will allow clinicians to diagnose and treat more effectively. However, these authors also recognize that even their differential diagnosis protocol does not allow a clinician to distinguish between disorders with certainty. Observing these children over longer periods of time, they have found that a child's classification may change. Whether this is due to neural maturation, appropriate treatment, or an initial misdiagnosis is not clear. To best serve these clients, Strand and McCauley (2008) purport that differential diagnosis not be an event, but rather an ongoing evaluation of the skills and challenges demonstrated by the client. Therefore, a label of CAS using this (or any other) approach must be considered with caution.

In 2000, Davis and Velleman explored controversies in differentially diagnosing very young children with CAS. First, these authors considered the common diagnostic criteria for CAS in preschool-age and older children and how they might be applied to

younger populations. The authors conclude that the wide range of acceptable behaviors in infants and toddlers nullifies the extrapolated use of the common diagnostic criteria from the older populations. In fact, the authors state that the “use of developmental apraxia of speech as a label for infants and toddlers who are prelinguistic may prematurely label a young child when not all clinical indicators are available for valid differential diagnosis” (Davis & Velleman, 2000, p. 190).

Another problematic issue in the differential diagnosis of CAS identified by Davis and Velleman (2000) is the issue of using “co-occurring characteristics of CAS” as primary diagnostic criteria. Examples include the use of gestures to communicate, delays in fine and gross motor skills, general motor clumsiness, diadochokinetic rates, and others. The authors note that in all studies that cite such co-occurring characteristics, there is no clear specification of the range of expression of these characteristics. Thus, these authors propose that these characteristics be considered corollary to CAS rather than principal for the diagnosis.

One differential diagnosis assessment framework for children suspected of having CAS has been developed by clinicians at Mayo Clinic in Rochester, MN. It includes five main components: 1) identification of relevant history (e.g., developmental issues), 2) physiologic observations (evaluation of structure/function and subsystems such as respiration, phonation, resonance, prosody, and articulation), 3) language assessment (formal measures and spontaneous language sample), 4) documentation of phonetic/phonemic inventory (including independent and relational analyses), and 5) a motor speech exam (R. Stoeckel, personal communication, May 13, 2012). These findings along with considerable clinical experience allow the clinicians at Mayo to

diagnose children with CAS with high levels of confidence. This full diagnostic protocol is lengthy; however, without some evaluation of each of these areas, it is not likely that a reliable diagnosis of CAS could be made (R. Stoeckel, personal communication, May 13, 2012).

Due to the current diagnostic limitations, the authors of the technical report of CAS recommend that even after the most thorough evaluations, professionals consider using language such as “*CAS cannot be ruled out, signs are consistent with CAS, or suspected to have CAS*” (ASHA, 2007b, p. 54) instead of giving a definitive diagnosis of CAS. The well-documented difficulty with diagnosing CAS calls into question whether there is enough clinical evidence to support categorizing CAS as a discrete disorder. The technical report published by ASHA (2007b) provides an answer but reserves final judgment in saying, “...the Committee concludes that the weight of literature findings support the research utility of this type of speech sound disorder” (p. 6). In essence, ASHA acknowledges the value of using CAS as a diagnosis for children exhibiting some or all of the signs mentioned as a means to gain a clearer understanding of the nature of this disorder through continued research.

Etiology and Theoretical Constructs of CAS. Without established diagnostic features, it is difficult to discuss possible etiologies and theoretical constructs to explain observed behaviors with any confidence. Nevertheless, some attempts have been made to narrow the field of possible explanations. The technical report on CAS published by ASHA (2007b) reflects that there is strong agreement only on the broadest viewpoints: first is the explanation that CAS is a result of neurological deficits and second is the conclusion that CAS does not share the underlying neural factors of dysarthria. Other

theories have significantly restricted acceptance, but as Strand and Skinder (1999) attest, “the distinction among these various perspectives is not trivial because clinicians choose specific approaches to treatment depending on what they believe to be the primary processing impairment” (p. 111).

One theory cites deficits in motor planning or programming as the basis of the problems seen in CAS (Hall, 1992; Robin, 1992). Hall (1992) presents the firm opinion that by including “apraxia” in the name of the disorder, one is effectively defining it as a movement disorder. His theory is that CAS is a general insufficiency of motor control that affects speech and non-speech usage of the speech mechanisms, as seen through anecdotal evidence of children suspected of having CAS also having difficulty with complex non-speech oral tasks such as chewing. Robin (1992), while agreeing that CAS is a motor-based disorder, takes issue with Hall’s expansion of the motor control problem to non-speech tasks. She posits that the disorder is confined to the motor-programming specific for speech.

In contrast, a linguistic theory to explain CAS is presented by Marquardt, Sussman, Snow, and Jacks (2002). This theory is based in part on findings that children labeled as having CAS perform more poorly on phonological awareness tasks (e.g., rhyming) than do their typically-developing peers. These authors consider motor programming deficits unsatisfactory in explaining these linguistic deficits. The resultant theory takes the position that the motoric behaviors seen in CAS are symptoms of an underlying language deficit which causes the child’s phonological framework to be disrupted, insufficient, or otherwise maldeveloped. This means that the child with CAS

cannot effectively sequence phonetic segments because there is no governing syllabic framework.

Crary (1993) gives another theoretical perspective on CAS, which he refers to as “motolinguistic,” meaning that CAS is the result of an overlap of motor deficits and speech sound deficits. He posits that the planning of speech and oral motor behavior are impaired due to a disruption of the sensorimotor processes. This theory categorizes CAS as a phonological disorder because of this disruption in the linguistic sound (phonological) system. This categorization also implies that the motor planning/processing disorder occurs at a higher organizational level than where direct motor impairments (e.g., dysarthria) would originate. The underlying sensorimotor deficit results in a motor-learning deficit that in turn produces disorganized output phonology.

Marquardt and Sussman (1991) propose that CAS is due to a deficit in the child’s auditory/perceptual processing and internal representation mechanisms. In a typically-developing child, the auditory and visual input received form the basis for the internal representation needed to form the morphological output. If this ability to perceive and categorize speech is impaired, it follows that the child will have missing or incomplete internal representations of speech and therefore also have difficulty with production. However, the authors acknowledge that this theory alone does not solely account for the deficits seen in children with CAS.

Velleman and Strand (1994) describe the cause of CAS as an impaired ability to organize information into appropriate hierarchies. Their theory stems from those of “nonlinear phonology” which describes a hierarchy of phonology that includes individual sounds, groups of sounds, words, phrases, stress, and intonation as well as the varying

contexts affecting and encompassing them. These units fall into a frame, a hierarchy of multiple levels that are organized, so as to be efficiently perceived and produced. The theory, then, is that children with CAS are less able to create and use frames than their typically-developing peers. This affects their ability to use information from their motor, sensory, and linguistic systems. Therefore, the theory poses that due to insufficient frame development and use, children with CAS are unable to devise the necessary motor plan to produce speech. In this way, in contrast to those who view CAS as strictly a motor planning disorder, the authors propose that CAS affects both movement and linguistic development.

Caruso and Strand (1999) present a model of speech production that includes a possible underlying cause of CAS. In this model, three steps are necessary for the motor aspects of speech production. First is sensorimotor planning which turns the cognitive/linguistic idea into a template for speech. Next is the sensorimotor programming which regulates initiation as well as the timing and magnitude of all of the movements needed for speech. The final step is sensorimotor execution which is the actual production of speech but also includes the processes necessary to make adjustments to the output while it's being produced. These authors feel that children exhibiting signs of CAS have a disruption somewhere in the sensorimotor planning or the sensorimotor programming. The exact location of the disruption can vary from child to child; in this way, the authors propose that CAS encompasses a continuum between these processes rather than being a discrete disorder. This aligns with the thinking of other researchers (see Shriberg et al., 1997c) who have considered the possibility of multiple subtypes of CAS.

The reasons for this lack of agreement on a theoretical basis for CAS go beyond personal opinion. As Davis et al. (1998) note, there must be a tight link between theory and behavioral characteristics in order for a theory to be considered adequate, yet no current theories are able to accurately predict and explain all of the observed behavioral characteristics associated with CAS. Thus, researchers continue to modify theories with the aim of establishing strong agreement between what is predicted and what is observed. This need for significant progress toward understanding the etiology of and theoretical basis for CAS is one of the main foci of the recommended CAS research agenda presented in the technical report published by ASHA (2007b).

Recent research in computational neural modeling may inform future theories. In a study by Terband, Maassen, Guenther, and Brumberg (2009), computer simulations were used to examine the effects of varying ratios of feed-forward and feedback control on four symptoms believed to be characteristic of CAS: deviant coarticulation, speech sound distortion, searching articulation, and increased variability. In typically-developing speech, auditory-feedback control allows a child to perceive production errors as or just after they occur. Feed-forward control allows the child to use the information about the production error to correct future productions of the same target, eventually producing it with sufficient accuracy as to no longer require the auditory feedback. In their simulations, the authors found that when they increased the computer's reliance on feedback control, the characteristics of CAS increased. The authors concluded that CAS may be due to poor feed-forward control in the brains of affected children. Further research is needed to both substantiate the claims with human subjects and to discover the reasons for the poor feed-forward control.

Standardized Assessments for CAS. Despite difficulties in defining the features and etiology of CAS, attempts have been made to create standardized assessment measures for diagnosis. McCauley and Strand (2008a) completed a systematic review of six current standardized tests marketed for use in the diagnosis of CAS. The following tests were reviewed: the Apraxia Profile (AP) Preschool and School-Age Versions (Hickman, 1997); the Kaufman Speech Praxis Test for Children (KSPT) (Kaufman, 1995); the Oral Speech Mechanism Screening Examination – Third Edition (OSMSE – 3) (St. Louis & Ruscello, 2000); the Screening Test for Developmental Apraxia of Speech – Second Edition (STDAS-2) (Blakely, 2001); the Verbal Dyspraxia Profile (VDP) (Jelm, 2001); and the Verbal Motor Production Assessment for Children (VMPAC) (Hayden & Square, 1999). Each of these tests addresses nonverbal oral motor function, motor speech function, or both with stated purposes of screening or diagnosis, and all but the OSMSE – 3 also had additional stated purposes of treatment planning and assessing change over time. The authors found that although the tests had intersecting purposes, the test content varied widely. The review of these tests also looked at the adequacy of the psychometric characteristics including normative data, behavioral standards, reliability (test-retest and interexaminer), and validity (content, criterion-related, and construct). The authors of this review concluded that all of the tests were inadequately developed in their current forms.

Perhaps the greatest difficulty in creating a standardized test capable of diagnosing CAS is the issue of validity. Validity “refers to the extent to which a test measures what it purports to measure” and content validity “concerns whether the instrument measures the theoretical construct it was designed to measure” (Paul, 2007, p. 41). In reviewing the literature, there is no solid theoretical construct upon which the

diagnosis of CAS is based, therefore all tests currently available are operating on theories that are at best untested and at worst incorrect. This problem can be seen in the fact that each test considers the presence of different features to be necessary to diagnose CAS. For example, the publisher's website for the STDAS –2 explains that atypical speech-language problems, associated oral performance, and a discrepancy between expressive language and receptive language (as determined by age equivalency scores) are three reasons to suspect CAS in a child, with the final reason being “the best indicator for further testing of developmental apraxia of speech” (“STDAS—2”, n.d.). In comparison, the publisher's website for the KSPT lists the vague categories of “imitative responses to the clinician” and “motor-speech proficiency” as the determining criteria for CAS (“The Kaufman,” 2011).

One test not reviewed by McCauley and Strand (2008a) that takes a slightly different approach is the Diagnostic Evaluation of Articulation and Phonology (DEAP) (Dodd, Hua, Crosbie, Holm, & Ozanne, 2000). The DEAP, according to the publishers, is capable of *differentially diagnosing* speech disorders in children (ASHA, 2011b). Subtests on this test that might lead a clinician to suspect CAS are the “Oral Motor Screen” which assesses sequencing and fluent production of speech and the “Word Inconsistency Assessment” which assesses a child's repeated productions of words for consistency (“Diagnostic Evaluation of Articulation and Phonology,” n.d.). Although the different approach taken by this test may be promising, the same issues of validity arise as with the tests mentioned previously.

Recently, researchers at Mayo Clinic in Rochester, MN and Ohio State University have been studying the reliability and validity of a new motor speech assessment called

the Dynamic Evaluation of Motor Speech Skill (DEMSS) (Strand, McCauley, Weigand, Stoeckel, & Baas, in press). According to the authors, this test is a way to use dynamic assessment to differentially diagnose childhood apraxia of speech from other speech disorders by identifying those children who have speech praxis deficits. It includes a motor speech examination which “systematically varies the length, vowel content, prosodic content, and phonetic complexity within sampled utterances” (Strand et al., in press). The scoring system devised for the DEMSS examines the characteristics purported to be indicative of CAS that are frequently cited in published literature such as lengthened and disrupted coarticulatory transitions, inconsistency of speech errors across repetitions, and prosody errors including lexical stress. The assessment protocol also includes cueing and other strategies similar to the DTTC treatment approach (Strand & Debertine, 2000; Strand, Stoeckel, & Baas, 2006) to allow even children with few sounds, syllables, and/or words to participate in testing and to assist the SLP in making decisions regarding severity, prognosis, and treatment planning. The authors assessed the reliability and validity of the DEMSS by using it as well as a standard speech and language test battery with 81 children referred for speech sound disorders. The DEMSS was shown to have acceptable levels of test-retest, intrajudge, and interjudge reliability. It was also shown that the DEMSS could differentiate most children diagnosed with CAS from those with other disorders as found by the clinicians through the speech and language test battery. The test had high specificity, but somewhat lower sensitivity. Although an ideal test would be high on both measures, considering the apparent trend to over-diagnose CAS, this feature of the test may provide the specificity that seems to be missing from other diagnostic protocols. SLPs may have a particularly difficult time

classifying difficulties with praxis due to a lack of knowledge of what signs to look for (see following chapters); therefore, the DEMSS might also help to improve this area of diagnostics. This test appears promising at this early stage of development, but replication by other SLPs is essential.

The limitations of standardized tests are not unique to CAS. All standardized tests are limited to show only how a child is different from his or her peers; they cannot take the place of a conscientious clinician when determining baseline function, establishing treatment goals, or evaluating progress (Paul, 2007). Despite limitations, these tests and future tests can be used by responsible professionals to gain a better understanding of a child's speech abilities when taken in conjunction with other sources of information. As McCauley and Strand (2008a) explain, until a "gold standard" exists on which standardized tests can be based, "clinicians' knowledge of [motor speech] disorders and clinical experience with them assume primary importance in determining the quality of decision making" (p. 89).

Treatment of CAS. The role of the speech and language pathologist (SLP) does not end with assessment; rather, assessment is the first step in intervention, which is yet another topic surrounded by controversy. Many approaches have been taken to treat suspected cases of CAS, and they each have varying levels of research support. In a recent Cochrane review of the interventions for CAS which searched for randomized controlled trial studies and quasi-randomized studies, no studies met inclusion criteria for analysis (Morgan & Vogel, 2008). The dearth of efficacy data on treatments for CAS brings the issue back to the diagnostic label, as Jaffe (1986) states, "...one has to wonder about the value of providing a diagnostic label from which no specific treatment has yet

evolved” (as cited in Helfrich-Miller, 1994, p. 179). Morgan and Vogel (2008) concluded that well-designed individual case studies will be crucial to implementing larger-scale randomized controlled trial studies sometime in the future to amend this problem. A discussion of current efforts to determine the efficacy of treatments for CAS is warranted.

In reading treatment research studies for CAS, it is important to remember to accept conclusions with caution due to the question of subject selection methods. Until there is at least one validated characteristic necessary and sufficient for the diagnosis of CAS, it is impossible to gauge the reliability of any findings that claim to apply to children with CAS (Shriberg et al., 1997a). With these caveats in mind, some treatment approaches are presented below along with efficacy data, where available. The interventions can be divided into two types, as delineated by Morgan and Vogel (2008): perceptually-based therapy which is “intervention using traditional drill exercises, typically in the absence of instrumentation, and often without feedback other than auditory feedback” and instrumentally-based biofeedback approaches which are “interventions that use some form of instrumentation and that typically also provide visual or other forms of biofeedback in addition to auditory feedback” (p. 4).

The integral stimulation method has been used to treat acquired apraxia of speech and Strand and Skinder (1999) promote its usefulness in treating childhood motor planning deficits like those seen in CAS. The authors propose that integral stimulation provides children opportunities to practice motor planning which will improve motor planning. The approach is based on established principles of motor learning (PML) which come from studies of limb movement and include “repetitive production of targeted

stimuli, manipulation of rate, and the gradual lengthening of the retention span for programming the articulatory movements” (Strand & Skinder, 1999, p. 118).

Strand and Skinder (1999) describe the basic components of the integral stimulation treatment approach. First, the stimuli are functional words and phrases that are carefully chosen to target specific movement gestures for speech. Second, a distributed practice schedule is used; that is, children are seen for shorter sessions more often, consistent with the principles of motor learning. Third, the authors discuss the difference between blocked versus random practice. Blocked practice is the completion of all practice trials of one stimulus at a time. Random practice is the completion of stimuli in a random order throughout the session. Strand and Skinder (1999) draw from studies investigating the principles of motor learning and note that these studies have shown that blocked practice improves performance of the targeted movement in the moment, but that random practice leads to better retention over time. Studies done on the benefits of blocked versus random practice have been in the realm of non-speech motor movements and as such the effects that each of these practice schedules may have on speech is unknown. As such, the authors suggest an amalgamation of the two schedules by varying the presentation of stimuli in a session, but purposefully targeting one or two stimuli for more practice relative to the others. Once these decisions have been made, the hierarchy of support presented during treatment sessions follows the needs of the child. Slow, simultaneous production of target words or phrases along with tactile and gestural cues leads to delayed imitation and eventual independent production. As Strand and Skinder (1999) state, “This offers the nervous system a chance to practice the sensorimotor speech processing, first with maximal support, then with gradually faded

cues, so that the child takes increasing responsibility for the processing” (p. 113).

Throughout the treatment period, a high rate of practice is recommended consistent with the principles of motor learning. Edeal and Gildersleeve-Neumann (2011) completed a study to help define the “high rate of practice” principle for working with children diagnosed with CAS. In a single-subject alternating treatment design, the authors compared the effectiveness of 30-40 productions in a session to 100 or more productions in a session. They found that the children acquired the targets faster with the higher rate of practice and also had higher rates of generalization to untrained utterances.

The efficacy of the integral stimulation approach described by Strand and Skinder (1999) was examined by Strand and Debertine (2000) in a single-subject, multiple-baseline design. The participant was a young girl who exhibited severe motor planning deficits. After collecting baseline data on the production of target stimuli and control stimuli, integral stimulation was used and a rapid, positive change in performance was seen for target stimuli as well as for untreated, control stimuli. As with any single-subject design, the generalizability of this treatment cannot be determined by this study alone. In addition, although this study suggests that integral stimulation may be effective for some children diagnosed with CAS, it is not clear to what degree each of the elements incorporated into the treatment (e.g., random vs. blocked practice, feedback schedules, etc.) contributed to the improvement.

The integral stimulation method developed by Strand and used in the Strand and Debertine (2000) efficacy study was recently given the name Dynamic Temporal and Tactile Cueing (DTTC). Strand, Stoeckel, and Baas (2006) completed an efficacy study on DTTC. A single-subject, multiple-baseline (across behaviors) was used with four

males for whom assessment protocols showed evidence of severe CAS, two of whom also exhibited mild coexisting dysarthria. Progress was assessed through the scoring of perceptual segmental and suprasegmental accuracy of the target utterances. Baseline data was collected on the experimental stimulus phrases. For all of the participants, frequent probes were completed, and for three of the children, nontreated, control stimuli were also probed periodically. Three of the four participants showed rapid, positive change in the production of the target stimuli. The authors noted that the fourth child was resistant to practicing the target phrases. A high level of practice is integral to the established principles of motor learning which have come from studies of limb movement and which may be applicable to other motor movements such as those involved in speech. Therefore, the authors posit that the child's lack of progress was due to his low motivation to practice. Like the earlier efficacy study, the individual PML elements that make up the treatment protocol (e.g., blocked versus random practice, type and frequency of feedback, etc.) were not controlled, and therefore the individual effect size is not known.

A recent study by Maas and Farinella (2012) compares the effects of random vs. blocked practice through the use of DTTC in a single-subject alternating treatment design with multiple baselines across behaviors with four children diagnosed with CAS. Progress was assessed through the scoring of perceptual segmental and suprasegmental accuracy of the target utterances, using the method described by Strand et al. (2006). Two of the children showed greater improvements with blocked practice, and one showed greater improvements with random practice. The third child did not show improvements under either practice condition. Although this study shows a slight advantage to using

blocked practice, the authors caution that “given the small sample size, we cannot determine with any confidence which factors might predict the relative benefits of random or blocked practice for a given child” (Maas & Farinella, 2012, p. 573). More studies need to be done on integral stimulation and/or DTTC with more participants, but the current literature suggests that these intervention techniques can have a positive impact on children diagnosed with CAS.

Another protocol based on the principles of motor learning (PML) is presented by Iuzzini and Forrest (2010). These authors investigated an approach that combines two treatments to improve the speech consistency of four children suspected as having CAS. The first treatment used was the stimulability training protocol (STP) which is based on studies of motor control and suggests that increasing the range of stimuable movements through imitation helps an individual apply motor behavior “maps” to their motor system. The second treatment used was a modified version of core vocabulary treatment (mCVT) which trains children to produce a list of personally-relevant functional words and phrases. Consistent with PML, this treatment provides the child with a high number of opportunities to produce varied motor targets. The authors used a single-subject, multiple-baseline (across subjects) design. The results indicate that the combined treatment approach increased the speech consistency of three of the four participants. The authors note that this progress was markedly different from the progress shown in other studies using only STP or CVT, suggesting that there are positive cumulative effects to using them together. Like other treatment approaches for CAS, the effectiveness of this approach needs to be demonstrated with a larger group of participants.

Strand and Skinder (1999) suggest that many of the other treatment methods in the literature for CAS are based on integral stimulation including tactile, gestural, and prosodic approaches. Examples of such methods are Touch-Cue (Bashir, Grahamjones, & Bostwick, 1984), PROMPT (Chumpelik, 1984), and Melodic Intonation Therapy (Helfrich-Miller, 1984). There is not sufficient efficacy data on these methods to include them in a list of evidence-based practice (ASHA, 2007b; Morgan & Vogel, 2009). However, their continued presence in the CAS literature requires a brief description of each as well as the research purportedly supporting them.

The Touch-Cue Method (TCM) for working with children diagnosed with CAS as described by Bashir, Grahamjones, and Bostwick (1984) is an approach based on the hypothesis that a child with CAS has trouble forming and incorporating the voluntary motor movements needed for speech. Auditory, visual, and kinesthetic cues are presented by the clinician to teach the child appropriate sequences of sounds to form, in turn, syllables, words, and connected speech. Because of this, Bashir et al. describe TCM as “a speech sound-scquencing and not a speech sound-teaching program per se” (p. 128). To date, no efficacy studies have been published on the use of this method alone to treat CAS. However, a study on the effects of both TCM and melodic intonation therapy (Martikainen & Korpilahti, 2011) was recently completed and those results are presented later in this paper.

Melodic intonation therapy (MIT) was used with adults with acquired apraxia of speech for several years before Helfrich-Miller (1984) described its possible applicability to children diagnosed with CAS. MIT is described as “a technique that focuses on the formulation of propositional language through the use of intoned sequences... [and] is

based on three elements of spoken prosody: the melodic line, tempo and rhythm, and points of stress” (Helfrich-Miller, 1984, p. 119-120). With this treatment approach, the clinician guides the child through stages that incrementally increase the length and complexity of utterances and decrease the reliance on the clinician and intonation supports. A specific difference between the approach as used with adults and the approach as used with children is the use of signed English with the children rather than generic hand tapping. Helfrich-Miller (1984; 1994) notes that care must be taken when using MIT for several reasons. First, MIT is best used in conjunction with other therapy approaches and not alone. Next, the repetition required in this approach can be boring for children, and the author recommends establishing a reward system. Finally, based on anecdotal evidence, progress with this therapy approach is slow.

In 2011, Martikainen and Korpilahti conducted a single-subject ABACA design with multiple baselines to test the effectiveness of MIT and TCM on a child diagnosed with CAS. Melodic intonation therapy was implemented during the first treatment period and the touch-cue method was implemented during the second. The authors assessed progress based on transcriptions of productions on a picture-naming task that were then analyzed for percentage of vowels correct (PVC), percentage of consonants correct (PCC), and whole-word analysis through phonological mean length of utterance (PMLU) which reflects the length of words and the number of correct phonemes. Based on this study, few conclusions about the therapy techniques can be made. One reason for this is that the authors did not control for the cumulative effect of using two treatment approaches with the same child. This natural consequence of ABACA designs would have been mitigated had the authors waited for the child’s performance to return to

baseline levels in between treatment periods, but that was not the case. Another reason for the lack of convincing conclusions also acknowledged by the authors is that it is possible that the improvements seen in the child's speech may have been due solely to the intensive practice completed rather than either treatment approach. Finally, the authors recognize that even if it could be shown that one or both of these approaches were responsible for facilitating the speech of children with CAS, it is still not known which aspects of these therapy techniques (e.g., slowed rate, multimodal cueing and feedback, etc.) are thought to improve speech. Further study is needed to answer the questions raised by this one.

Chumpelik (1984) describes a treatment approach called Prompts for Restructuring Oral Muscular Phonetic Targets (PROMPT) which is designed to alleviate the difficulty of planning, sequencing, and/or executing motor movements needed for speech. In this approach, the clinician uses tactile and kinesthetic cues on the child's face to impose the target position or movement sequence required to produce an utterance. It is thought that by imposing positions and sequences, PROMPT relieves the child from having to organize or control movement independently or in response to a model. Chumpelik (1984) states that, "the main focus of the system is to provide feed-forward information to the child so that the preselected sequence is... guided toward correct target positions and appropriate transitions" (p. 144). This statement seems to be in line with the previously mentioned computational neural modeling studies looking at feed-forward control and CAS. However, as with the other treatment approaches mentioned, PROMPT lacks solid efficacy data to support its use with children with CAS. For example, a recent study completed on the effectiveness of PROMPT had only a single participant labeled as

having a speech disorder with no specific mention of CAS (Grigos, Hayden, & Eigen, 2010).

In contrast to the perceptually-based interventions delineated above, some researchers have examined instrumentally-based biofeedback approaches. One such study completed by Lundeborg and McAllister (2007) used a single-subject ABAC approach with multiple baselines to determine the efficacy of using intra-oral sensory stimulation and electropalatography with a child diagnosed with CAS. Two treatment approaches were alternated with withdrawal periods separating them. One treatment approach involved using an electric toothbrush on the tongue, lips, and alveolar ridge for 3-5 minutes each day. The other treatment approach was training with electropalatography. Electropalatography is a method of providing biofeedback on contact between the tongue and hard palate through the use of electrodes imbedded in a mold made to fit the user's hard palate. The authors found that the participant improved in percentage of consonants correct (PCC), percentage of phonemes correct (PPC), and percentage of words correct (PWC) from baseline to post-treatment data, however, the study design raises several concerns. First is the fact that all measures of PCC, PPC, and PWC taken throughout the study were completed by the first author of the study, which raises the question of researcher bias. Second, the design of the study means that there may have been cumulative effects of the two treatments and it is not possible to determine the effect of each or whether the order of implementation matters. Next, the authors of the study included only data from the baseline, from the end of the first treatment period, and from the end of the second treatment period. By not including the data from the withdrawal period, it is not clear whether the change was due to the treatment or whether it was due

to some other factor. A final point of concern is that while the authors provide a reasonable rationale for the use of electropalatography with children diagnosed with CAS, the rationale given for intra-oral stimulation is very weak. Future studies on biofeedback techniques such as electropalatography are needed to establish the efficacy of their use with children diagnosed with CAS. However, the intra-oral stimulation described in this article falls into a controversial class of treatments referred to as non-speech oral motor treatments (NSOMTs) or, as they will be referred in this paper, non-speech oral motor exercises (NSOMEs).

McCauley and Strand (2008b) refer to NSOMEs as “nonspeech activities that involve sensory stimulation or manipulation of oral structures intended to influence the physiological mechanisms to improve function of those structures” (p. 289). This definition includes not only exercises meant to strengthen musculature, but also other types of treatments such as tapping, blowing, massage, and application of heat or cold meant to increase range of motion (ROM), respiratory support, or otherwise stimulate the senses. In a systematic review of the current evidence for the use of NSOMEs, McCauley, Strand, Lof, Schooling, and Frymark (2009) concluded that “the existing literature provides insufficient evidence to support or refute the use of nonspeech oral motor exercises” (p. 353). Despite the neutral finding, McCauley et al. (2009) caution clinicians to carefully consider the rationales for using NSOMEs and whether or not the purpose of using the exercises is relevant to the population. For example, these authors note that it is highly questionable to use strengthening exercises with a population for whom weakness is not an underlying problem. As McCauley and Strand (2008b) state, “although children with CAS often exhibit motor immaturity, they are typically not weak

and do not exhibit either physiologically decreased ROM or decreased respiratory support” (p. 289). The authors propose that a child diagnosed with CAS who does show signs of weakness or an insufficient ROM would likely be diagnosed as having concomitant dysarthria. Despite the lack of evidence and rationale for their use with CAS, NSOMEs are reported to be used often with children diagnosed with CAS either as the sole treatment or as part of a larger treatment plan (Lof & Watson, 2008; McCauley & Strand, 2008b).

This summary of treatments for CAS is meant to be an overview and is by no means exhaustive. Additional approaches and research studies exist, some with very similar theoretical underpinnings as the ones detailed above, and some which deviate drastically. These approaches and studies are not listed here due to low-levels of evidence (e.g., single case studies) or other problems with methodology, or because more recent research exists (see Ballard, Robin, McCabe, & McDonald, 2010; Beathard & Krout, 2008; Bornman, Alant, & Meiring, 2001; Cumley & Swanson, 1999; Helfrich-Miller, 1994; Krauss & Galloway, 1982).

As a final note on treatment, clinicians must be aware that as with other poorly-understood disorders, CAS has attracted individuals and companies looking to profit from marketing so-called “cures.” Examples include fish oil supplements, vitamins to improve speech, sound integration therapy/auditory integration therapy, and chiropractic adjustments. The companies selling these items under the pretense of curing CAS rely on personal testimony and unfounded theories as evidence of their effectiveness. As such, these treatments do not warrant further discussion.

Knowledge and Practice. Clearly, there are many outstanding questions regarding CAS, but there are many practitioners seeking definitive answers. Proof of this lies in the writing of the technical report on CAS by ASHA (2007b), which is stated to be in response to a large number of visitors to their website who are seeking information about CAS. Although increased dispersal of information is generally positive, “increased information on a disorder may both reflect and contribute to increased prevalence” (ASHA, 2007b, p. 6). Indeed, despite the above-mentioned controversies surrounding CAS, it seems that CAS diagnoses are rising (“Childhood Apraxia of Speech: Causes and Numbers,” n.d.). It is difficult to determine exactly how many children have CAS because of the lack of agreement concerning diagnostic features amongst professionals making these diagnoses. As Davis et al. (1998) note, it is currently not possible to determine how many of the children diagnosed with CAS actually have CAS and how many have some other severe speech disorder. Therefore, conclusions based on the increase in diagnoses of CAS must be made with caution. The fact that CAS diagnoses are increasing might actually be a sign that SLPs in the field do not realize how tenuous our current understanding of the disorder is.

For example, in a study completed by Davis, Jakielski, and Marquardt (1998), SLPs at conferences were presented with a list of eight characteristics that could suggest CAS, and were then asked to refer children whom they thought fit those descriptions for a proposed research study. Of the twenty-two children who were referred with a firm or tentative CAS diagnosis, only 4 were also identified by the researchers as having CAS. This shows a great mismatch between what some SLPs understand about the disorder versus what experts in the field understand about the disorder.

An additional example of this mismatch is found in a study completed by Forrest (2003). In this study, SLPs who attended a continuing education workshop on the assessment and treatment of CAS were asked to write down three characteristics necessary for a CAS diagnosis. The 75 participants produced 50 different diagnostic characteristics, some of which were contradictory. Although there were six characteristics that were listed by between 6.2% and 14.1% of participants, the other 44 characteristics were each listed by fewer than 4%. Forrest (2003) concludes that “this variation across individuals in the understanding of [CAS] may lead to errors in the diagnosis of the disorder” (p. 379). As diagnostic decisions naturally lead to treatment decisions, this misunderstanding of CAS has far-reaching implications for the field of speech-language pathology.

Although there is much controversy surrounding CAS and few definitive answers, there may be additional factors affecting the apparently common misdiagnosis of CAS among professionals working with this population. One potential factor is a gap between the available research literature and knowledge base. An official policy adopted by ASHA (2005) reads,

It is the position of the American Speech-Language-Hearing Association that audiologists and speech-language pathologists incorporate the principles of evidence-based practice in clinical decision making to provide high quality care. The term *evidence-based practice* refers to an approach in which current, high-quality research evidence is integrated with practitioner expertise and client preferences and values into the process of making clinical decisions. (p. 1)

However, a study completed by Zipoli and Kennedy (2005) in which SLPs were surveyed on their attitude toward and use of evidence-based practice (EBP) found that when making treatment decisions, most SLPs rely on their own observations of their clients, the opinions of their colleagues, and their training as students and during their clinical fellowship year (CFY) rather than on research literature. These results are concerning. As Dollaghan (2004) notes, although intuition, anecdotal evidence, and expert opinion have a place in EBP, research studies concerning clinical practice must constitute the bulk of the evidence for responsible decision-making.

Unfortunately, SLPs who do seek out research evidence to support their practice are not guaranteed to find reputable sources. If these SLPs spend what little time they have for locating and evaluating evidence on unworthy publications, their resulting knowledge base will be lacking (Dollaghan, 2004). The same problem can occur when SLPs seek out opportunities for continuing education units (CEUs) to maintain their ASHA certification. Lof and Watson (2008) posit that SLPs attending conferences might believe that ASHA authorization of CEUs for the event means that the content presented is also approved. However, the ASHA Continuing Education Board (CEB) manual states that, "ASHA CEB approval of continuing education provider status does not imply endorsement of course content, specific products, or clinical procedures" (ASHA, 2011a, p. 47). Thus, to better understand the potential for misdiagnosis of CAS, it is imperative know on what sources SLPs are basing their practice.

Because of the high potential for misdiagnosis of CAS and the difficulties in choosing evidence-based practices for treatment, the writers of the technical report published by ASHA (2007b) note that "speech-language pathologists who lack training

or experience with this disorder should refer such cases to others or carry out assessments and interventions under the supervision of a speech-language pathologist with the appropriate background” (p. 53). Without such oversight, it is highly likely that misdiagnoses of CAS will occur.

The consequences of high rates of misdiagnosis or over-diagnosis are not trivial. For one, misdiagnosis results in resources being spread too thinly (Mosheim, 2004). Additional consequences presented by Mitchell (2012), though targeting the psychiatric field, can be applied to any diagnosis with fluid, shifting, or poorly defined criteria, including CAS. First, he states that misdiagnosis or over-diagnosis can lead to overtreatment or inappropriate treatment, a professional concern highlighted by the ASHA code of ethics (2010). Additionally, there is a troubling circularity present in that uncertainty about diagnostic criteria can lead to misdiagnoses, and high rates of misdiagnoses, in turn, can lead to further uncertainty about and expansion of diagnostic criteria (Mitchell, 2012). Patten (2012), another researcher in the field of psychiatry, adds that this subsequent expansion of diagnostic criteria leads to degradation of the link between diagnosis and clinical intervention, as each facet may be addressed by a different intervention. A final consequence warned of by scholars across fields is that of the dire impact misdiagnoses can have on research, due to the varied means of selecting subjects (McCauley & Strand, 2008b; Mitchell, 2012; Patten, 2012; Shriberg, Potter, & Strand, 2011).

Research Questions

Although guidelines are available publicly on the ASHA website, it is not known how individual SLPs make decisions regarding the diagnosis and treatment of CAS nor is

it known from which sources SLPs are gaining the bulk of their knowledge about CAS. The alignment of best practice standards with the actual practice of those working in the field is imperative for the reputation of speech-language pathology in the public eye. Therefore, those involved in developing and researching assessment and treatment procedures for CAS as well as those responsible for the education and continuing education of SLPs need to understand the current knowledge and practice of working SLPs. Specifically, (a) How do SLPs diagnose CAS? (b) How do SLPs treat CAS? And (c) How do SLPs learn about CAS?

II. METHODS

When the number of diagnoses of a disorder rises, it is important to find an explanation. Whether it is due to a true increase in the number of children diagnosed or whether it is due to an increase in false positives is an important distinction. If the disorder in question has a tenuous and contested list of diagnostic features, such as in the case of CAS, then a purported rise in diagnosis rates becomes particularly curious. The purpose of this study is twofold. The first purpose is to investigate SLPs' protocols for diagnosing CAS and making treatment decisions for those diagnosed. Understanding the current practices of SLPs is important to those who oversee education at the undergraduate, graduate, and continuing education levels because it enables them to tailor their offerings to the needs of the target audiences. The second is to investigate the sources from which SLPs gain knowledge about CAS. In a field that espouses the use of evidence-based practice like speech-language pathology, it is important to gauge the application of research evidence outside of academic circles.

Participants

The population surveyed included speech-language pathologists working in public school districts and charter schools in Wisconsin. The project was approved by the Institutional Review Board at the University of Wisconsin-Eau Claire before any participants were contacted. Participants were recruited from 393 of the 443 school districts and charter schools in Wisconsin. Contact information for the SLPs employed in these districts was available on the district or charter school website, with the exception of the Milwaukee Public School District (MPS). In order to contact the SLPs working within MPS, permission was obtained from the district's Office of Research and

Evaluation. Once permission was granted, the speech and language program coordinator sent the introductory email including the link to the survey to all of the SLPs on the district's list serve. This extra measure was taken with this district because it is the largest in the state and its inclusion was important for the sample to be representative of the population. The 50 districts and charter schools not included were omitted because the contact information for the SLPs employed there was not available on their websites. Extra measures were not taken to include these districts and charter schools because they were small in population and geographically distant from one another. In this way, each geographic area of the state was sampled even though not every district and charter school was included. A total of 1,617 SLPs were contacted to participate.

This population was chosen because the SLPs were likely to have experience diagnosing and/or treating a child with a diagnosis of CAS or suspected CAS. Medical and private practice SLPs were not included in this study because complete listings of these individuals and their contact information were unavailable. Various means of sampling SLPs working primarily in settings other than schools would have involved either a loss of control of the sample who had access to the survey (e.g., via internet forums) or a prohibitive cost (i.e., mailing paper surveys). Additional research targeting these other populations would be beneficial to a complete understanding of how CAS is diagnosed and treated, and how SLPs gain their knowledge about this disorder.

Materials

An electronic survey was used as an effective and efficient means to assess the current knowledge and practice of SLPs regarding CAS. As Fowler (2009) explains, quantitative survey research is a method of finding "statistical descriptions of people by

asking questions” (p. 1). The electronic survey was distributed through email as this is a cost-effective and timely method of surveying populations for whom email is readily accessible (Fowler, 2009). Emails containing a link to the survey were distributed to the participants on September 26, 2012. A follow-up email to this group was sent on October 3, 2012. The speech and language program coordinator for the Milwaukee Public School District sent an email to the MPS SLP list serve on November 28, 2012. A follow-up email was sent by the coordinator on December 5, 2012. This delay in surveying the MPS SLPs was due to the need for the district’s Office of Research and Evaluation to meet to approve the project before any action could be taken.

The survey was created using Qualtrics Survey Research Suite (Qualtrics Labs, Inc., 2012), an online survey software available to University of Wisconsin-Eau Claire students and faculty. A cover letter was included in the email that was sent to each participant which also contained the link to the survey. Appendix A contains a copy of the cover letter which informed the participants of the topic of the survey as well as participation criteria. The participants were aware of the voluntary nature of their participation and the ability to withdraw at any time. The participants confirmed their informed consent when they elected to complete the survey by following the link provided.

Validity

Validity in survey design refers to “the extent to which a survey question measures the property it is supposed to measure” (Thayer-Hart, 2010). To avoid confusion and unreliable responses, each question on the survey was carefully worded so as to avoid complex language, technical terms, and ambiguous phrasing. The questions

were then approved by three university professors who hold doctoral degrees. These steps increased the likelihood that participants would correctly interpret the intent of the question and provide responses that accurately reflect their opinions and experiences (Fowler, 2009).

Efforts were also made to reduce the social desirability bias that is a threat to the validity of survey research. Social desirability bias occurs when the participants answer questions in a way that they feel the researcher or society as a whole would want them to answer instead of giving their true answer (Fowler, 2009). One step taken to reduce this bias was to use a self-administered survey rather than phone or in-person interview. Another important step was to give participants anonymity (Fowler, 2009). The email survey contained no questions that required identifying information nor did it track any identifying information from internet protocol (IP) addresses or email addresses. This assurance of anonymity was given in the introductory email as well as at the beginning of the survey. A final step taken to reduce social desirability bias involved the non-judgmental wording of questions. For example, treatment methods for CAS were listed alphabetically to avoid any implied comments about their usefulness. In addition, whenever applicable, an open “other” response was allowed so that respondents did not feel pressured to select a given response that did not match their true opinion or experience (Thayer-Hart, 2010). This has the added advantage of discovering unanticipated answers.

Survey Design

The survey consisted of twenty-two questions. The questions were designed to elicit information about the SLP's knowledge, knowledge source, and practices regarding CAS. Appendix B contains a copy of the questions included in the survey.

Both closed and open questions were used. Closed questions provide the participant with a list of acceptable answers. This question type has several advantages. First, it allows for more reliable responses, as all participants are guided to understand the question in a similar way (Fowler, 2009). It also allows the participants to answer questions more quickly, thereby increasing the likelihood that participants will complete the survey. In contrast, open questions do not provide a list of acceptable answers. While closed questions are thought to be better suited to compiling data, there are advantages to using some open questions. Open questions allow participants to answer in their own words and give answers that the researcher did not expect, thereby more closely describing their true perspective on the issue (Fowler, 2009). To take advantage of this feature of open questions, the primarily-closed questions also included an open option, allowing the participants to choose "other" and provide additional information when none of the given options applied. The inclusion of this open option in otherwise closed questions can increase the reliability of the responses as participants are not forced to choose an answer that does not describe them or their perspective (Fowler, 2009).

Likert scales were also used in the survey. This type of question requires the participants to use a continuum to best describe his/her opinion or perspective. For example, participants were asked to rate their familiarity with several CAS treatment methods (i.e., "Very Familiar," "Somewhat Familiar," "Minimally Familiar," and

“Unfamiliar”). As Fowler (2009) explains, this type of scale is useful for making comparative statements; however, when the distinction between scaled options is too fine for the participant to discriminate, the answers will be less reliable. In this survey, four response options were given for each Likert scale question. Three response options would have lacked the level of detail necessary to describe the participants’ possible responses. Five response options would have included a “neutral” or “unsure” option. Since the Likert questions ask participants to describe their knowledge level and likelihood of action rather than to describe their feelings or opinions, it was felt that including a “neutral” or “unsure” option would be unnecessary.

The survey was designed to decrease nonresponse rates to the extent possible. This is an important consideration because a survey with a low sample response rate cannot be considered an accurate representation of the population (Thayer-Hart, 2010). By using the Panels feature in Qualtrics, the emails were sent out on a schedule through the Qualtrics software, but appeared in the recipients’ inboxes as if they were sent from the researcher’s university email account. This ensured that the emails were not flagged by spam filters. The Panels feature also allows researchers to customize the introductory letter so that each email is addressed to the recipient personally. Studies have shown that this type of personalization can increase participation (Thayer-Hart, 2010). The use of a majority of close-ended questions is also thought to help decrease nonresponse and partial response rates. This type of question decreases the cognitive demands placed on the participants and also the amount of time that they must devote to completing all questions, both of which may encourage survey completion (Fowler, 2009). An additional method of reducing the amount of time participants needed to spend on the

survey was the use of Skip Logic in Qualtrics. This feature allows questions to be linked in a way that they are only given to those participants to whom the question applies. For example, the question asking what methods an SLP used to diagnose a child with CAS was only revealed if the SLP indicated in a previous question that he or she had, in fact, diagnosed a child with CAS.

The questions in the survey were grouped into four sections. The first group of questions was meant to gain non-identifying demographic information from the participants. The remaining three sections were each concerned with one of the three research questions: how do SLPs diagnose CAS, how do SLPs treat CAS, and how do SLPs learn about CAS?

Data Analysis

The descriptive data gleaned from this survey were analyzed in two ways. First, simple statistics were completed using the built-in features of Qualtrics Survey Research Suite including averages, percentages, and groupings. Second, responses to the entirely open question were coded by the researcher and cross-checked by a graduate student not otherwise involved in the project. This question asked participants to list what they believed to be the necessary characteristics for diagnosing a child with CAS. Each response was given a numerical code that corresponded to the characteristic that best encapsulated the response (e.g., 204= decreased intelligibility, 205= inconsistent errors, 206= atypical errors, etc.). This same process was also completed independently by another graduate student who was trained in the coding process, but was given neither the numerical codes nor the characteristics used by the researcher. Each response was then discussed and consensus was reached as to the appropriate code to assign. The resulting

characteristics were ranked according to the frequency with which they were listed by participants.

III. RESULTS

Although the number of children diagnosed with CAS appears to be on the rise, it is not clear why this is occurring (“Childhood Apraxia of Speech: Causes and Numbers,” n.d.). Because of the lack of agreement on diagnostic criteria and no standardized protocol for evaluating children suspected of having CAS, a diagnosis of CAS can look vastly different from one child to another (Davis et al., 1998; Shriberg et al., 1997a; 1997b; 1997c). The information gained from this survey helps to answer the following research questions and the data are organized accordingly: (a) How do SLPs diagnose CAS? (b) How do SLPs treat CAS? And (c) How do SLPs learn about CAS?

Participants

A total of 1,617 SLPs working in public schools in Wisconsin were contacted to participate and 574 chose to do so. This yields a response rate of 35.5%. The survey was designed to allow participants to skip questions if they so desired, so 470 of the surveys that were started were completed entirely. This yields a completed response rate of 29.0%.

Participants provided information about the size of the school district in which they work in terms of the total number of students attending public school in that district by selecting one of four ranges. Of the 524 SLPs who responded to this question, 67 reported that their district had fewer than 600 students, 154 had between 600 and 2,000 students, 153 had between 2,001 and 7,000 students, and 150 had more than 7,000 students (see Table 1). Participants also indicated the setting or settings in which they work. Many participants appear to work in more than one setting. Of the 537 SLPs who responded to this question, most indicated that they spent all or some time working in

Table 1

Workplace characteristics of participants.

<i>Demographic</i>	<i>Percentage^a</i>
District size by number of students	
Fewer than 600	13%
600-2,000	29%
2,001-7,000	29%
More than 7,000	29%
Employment settings	
Early intervention	30%
Preschool	85%
Elementary school	95%
Middle School	67%
High School	59%
Medical	32%
Private practice	12%
Other	9%

^a Percentages are rounded

elementary schools (95%) and preschools (85%), although other settings were also represented (see Table 1).

The participants were asked to indicate the years in which their degree or degrees were earned. The majority of participants indicated that the highest degree earned was a master's degree with graduation years ranging from 1975 to 2012, while two participants earned PhDs in 2010, and one earned an EdD in 1998 (see Table 2). Of the 528 participants who reported the number of years spent working with children with speech sound disorders, many (47%) indicated more than fifteen years' experience (see Table 2).

Table 2.

Education and experience of participants.

<i>Demographic</i>	<i>Percentage^a</i>
When master's degree was earned	
2000 to present	37%
1990s	26%
1980s	29%
1970s	10%
Experience with childhood speech sound disorders	
Less than 1 year	2%
1-5 years	17%
6-10 years	18%
11-15 years	17%
More than 15 years	47%

^a Percentages are rounded**Diagnosing CAS**

A total of 495 SLPs responded to a question asking whether they had ever diagnosed a child with CAS and 51.3% responded “yes” while 48.7% responded “no.” The SLPs who responded “yes” were asked a follow-up question which asked them about assessment measures used to make that diagnosis and 251 of those SLPs responded to it. The participants were asked to select all assessment measures used from a list containing the components used at Mayo Clinic in Rochester to make a diagnosis of CAS (R. Stoeckel, personal communication, May 13, 2012) with the additions of “published checklist” and “other” (see Table 3). The “other” option was open which allowed participants to elaborate on any other measures or techniques used. Responses to this

Table 3

Assessment techniques/measures used to diagnose CAS.

Assessment	Frequency	Percentage ^a
Formal test of articulation	225	89.6%
Oral mechanism examination	196	78.1%
Parent/caregiver interview	193	76.9%
Language sample	182	72.5%
Motor speech examination	182	72.5%
Speech sound inventory	152	60.6%
Formal test of phonology	146	58.2%
Formal test of language	112	44.6%
Formal test of motor speech	89	35.5%
Published checklist	60	23.9%
Other	50	19.9%

^a Percentages are rounded

open option included: Kaufman's speech praxis test, PROMPT evaluation, therapy data over time, diadochokinetic rates, and observations among others.

The SLPs who responded that they had diagnosed a child with CAS were asked an additional follow-up question to approximate the number of children that they had diagnosed with CAS. Participants were instructed to select one of four ranges given. Of the 249 participants, 59.4% had diagnosed between one and five children, 24.0% had diagnosed between six and ten children, 7.2% had diagnosed between 11 and 15 children, and 9.24% had diagnosed more than 15 children.

All participants were asked to list the characteristic or characteristics that he/she felt necessary for a diagnosis of CAS and 391 participants responded. This question was

in an open-response format and participants were asked to separate characteristics with commas. The number of characteristics listed by the participants ranged from one to twenty-two with a mean of 4.24 and a mode of three.

The researcher and a graduate student independently coded all responses according to the process described in the data analysis section of chapter two of this document. The researcher grouped responses into 194 characteristics while the graduate student grouped responses into 133 characteristics. One reason for the disparity was due to participants' use or lack of use of commas. For example, one participant may have listed within their response "inconsistent errors, atypical errors" while another may have listed "inconsistent atypical errors." These responses were coded as three separate characteristics by the researcher (inconsistent errors, atypical errors, and inconsistent atypical errors), but as two characteristics by the graduate student. It was decided that the more stringent way of coding by the researcher assumed a level of semantic specificity that was likely not intended by the participants. Therefore, responses like the example above that contained two descriptors without a separating comma were coded according to the first descriptor mentioned for consistency. The number of different characteristics listed by the participants after consensus was 141. The most frequently-cited characteristics are shown in Table 4, with ties ordered alphabetically.

The 51% of participants who reported diagnosing at least one child with CAS used a variety of measures including tests of articulation, oral mechanism exams, parent interviews, and language samples. The characteristic felt to be necessary to diagnose a child with CAS that was listed the most often was "inconsistent productions/errors."

Table 4

Characteristics felt to be necessary to diagnose CAS.

Characteristic	Frequency	Percentage ^a
Inconsistent productions or errors	217	55.5%
Groping	103	26.3%
Decreased intelligibility	99	25.3%
Accuracy decreases as length or complexity increases	75	19.2%
Difficulty imitating speech	63	16.1%
Motor planning/programming problems	58	14.8%
Difficulty sequencing	57	14.6%
Vowel errors/substitutions	55	14.1%
Prosodic abnormalities	51	13.0%
Limited/slow progress in therapy	41	10.5%
Limited phonemic repertoire	32	8.2%
Better receptive than expressive language skills	31	7.9%
Speech sound errors/articulation errors	31	7.9%
Oral motor problems	26	6.6%
Difficulty with multisyllabic words	25	6.4%
Distorted vowels	25	6.4%
Degrading performance with repetition	23	5.9%
Difficulty coordinating speech movements	23	5.9%
Lack of muscle weakness	23	5.9%

^a Percentages are rounded

Treating CAS

All participants were asked to rate their levels of familiarity with a list of treatments for CAS found in scholarly journal articles. NSOMEs were included because previous research indicated that CAS is one of the top disorders for which SLPs use NSOMEs (Lof & Watson, 2008). From the 470 responses, the only treatment category a majority of participants indicated they were somewhat or very familiar with was nonspeech oral motor exercises (NSOMEs) at more than 80%. The next highest level of familiarity was for melodic intonation therapy with only about 40% of participants indicating that they were somewhat or very familiar with it (see Figure 1).

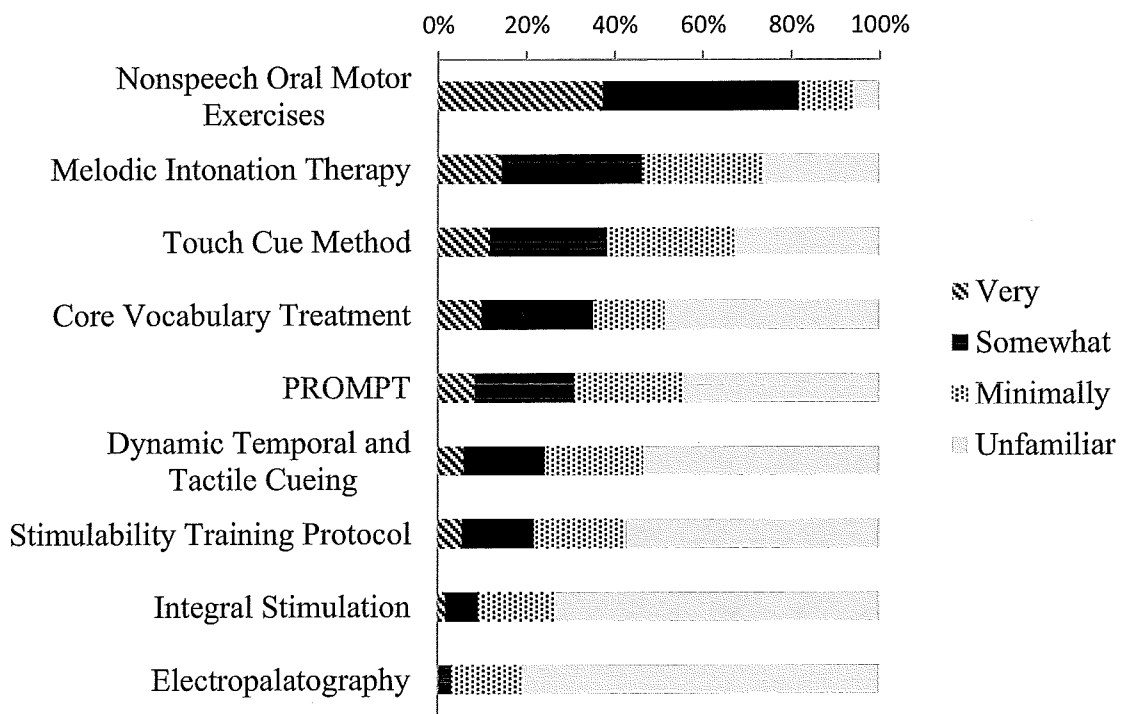


Figure 1. Level of familiarity with treatments for CAS.

A follow-up question asked participants to rate their level of familiarity with research evidence for each treatment for which they had indicated at least minimal familiarity. NSOMEs was the only treatment category with which at least half of

participants at least minimally familiar with it also indicated they were somewhat or very familiar with available efficacy research (see Figure 2).

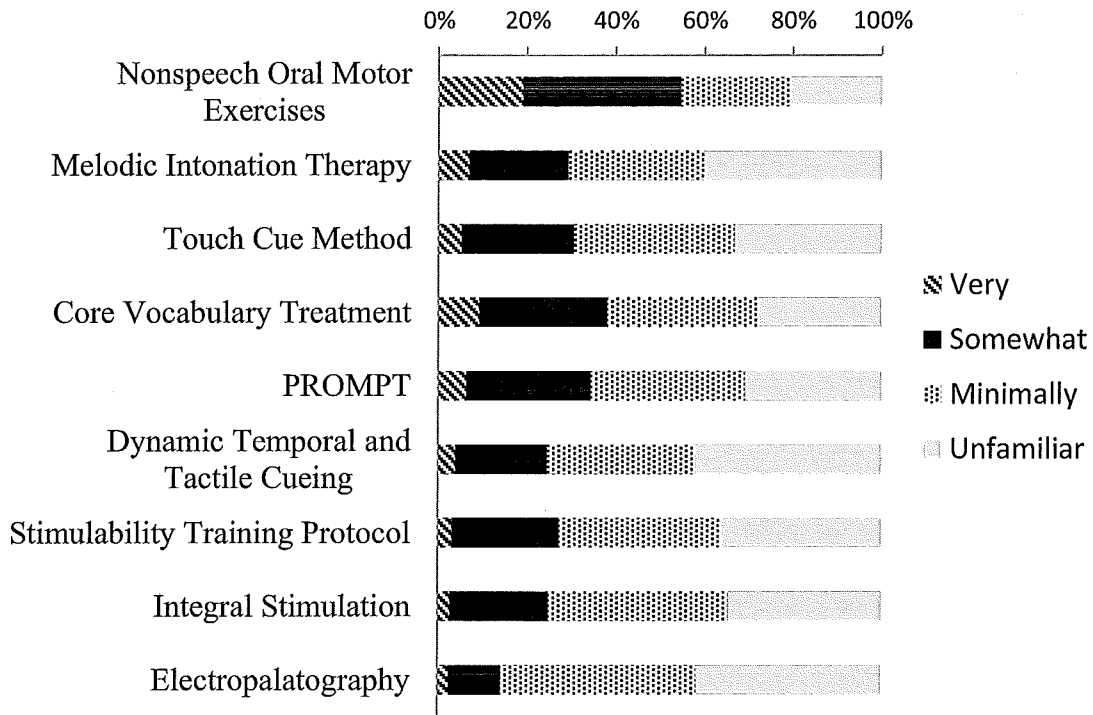


Figure 2. Level of familiarity with efficacy research on treatments for CAS.

A total of 495 SLPs responded to a question asking whether they had ever treated a child with CAS. Most SLPs indicated that they had (93.1%). Those who responded that they had treated a child with CAS were asked some follow-up questions.

First, this group was asked to approximate the number of children with CAS that they had treated. The participants were given four ranges to choose from. Of the 454 who responded, 56.4% had treated between one and five children, 21.6% had treated between six and ten children, 10.4% had treated between 11 and 15 children, and 11.7% had treated more than 15 children.

Next, they were asked which treatment method(s) they had used with those children with CAS and 468 responded. The same list of treatment methods used for the

earlier question regarding familiarity with research was used for this question and participants were instructed to select all that applied (see Table 5). The most common Table 5.

Methods used to treat children with CAS.

Treatment	Frequency	Percentage ^a
Other	330	73.2%
NSOMEs	195	43.2%
Touch Cue Method	163	36.1%
Core Vocabulary Treatment	129	28.6%
Melodic Intonation Therapy	108	24.0%
PROMPT	92	20.4%
Dynamic Temporal and Tactile Cueing	89	19.7%
Stimulability Training Protocol	56	12.4%
Integral Stimulation	14	3.1%
Electropalatography	0	0.0%

^a Percentages are rounded

response was “other” (73.2%) which was open for elaboration. Examples of responses listed in this open option include: Kaufman Apraxia Program, Hodson’s Cycles, Easy Does It Apraxia, Just for Kids Apraxia, Marshalla’s Apraxia Uncovered and other resources from Marshalla, Riley system, Moving Across Syllables, iPad applications, general phonological approaches, general articulation approaches, multisensory cues, high repetition practice, and breathing/yoga. The next most common methods reported to be used for treatment were NSOMEs (43%) and the same four that they had indicated some familiarity with in the previous question. The use of these other four methods ranged from about 20% to 35%. It is interesting to note that many participants reported

using treatment methods for which they indicated unfamiliarity with efficacy research data in an earlier question. For example, 40.2% of respondents who indicated that they were unfamiliar with efficacy research for NSOMEs report using this method with children diagnosed with CAS. For the other four most commonly used methods, the use of methods by participants who reported being unfamiliar with efficacy research for them ranged from 19.5% to 37.5%.

Learning about CAS

A total of 446 SLPs responded to a question asking from which sources they had learned new information about CAS. Participants were instructed to select all that applied. The top three responses were continuing education (71.5%), colleagues (68.7%), and websites (59.9%) (see Table 6).

Table 6.

Sources which provided information about CAS.

Sources	Frequency	Percentage ^a
Continuing education	333	71.5%
Colleagues	320	68.7%
Websites	279	59.9%
Scholarly articles	177	38.0%
University courses	163	35.0%
CFY mentor	85	18.2%
Message boards	58	12.5%
Other	38	8.2%
No external sources	13	2.8%

^a Percentages are rounded

The participants who indicated that they had learned about CAS through university courses were asked a follow-up question to determine whether this learning was done at the undergraduate or graduate level and the amount of course time devoted to the topic. It appears to be more common for students to be exposed to CAS at the graduate level than at the undergraduate level (see Figure 3). At both levels it is most common for the topic to be discussed for less than half of a course.

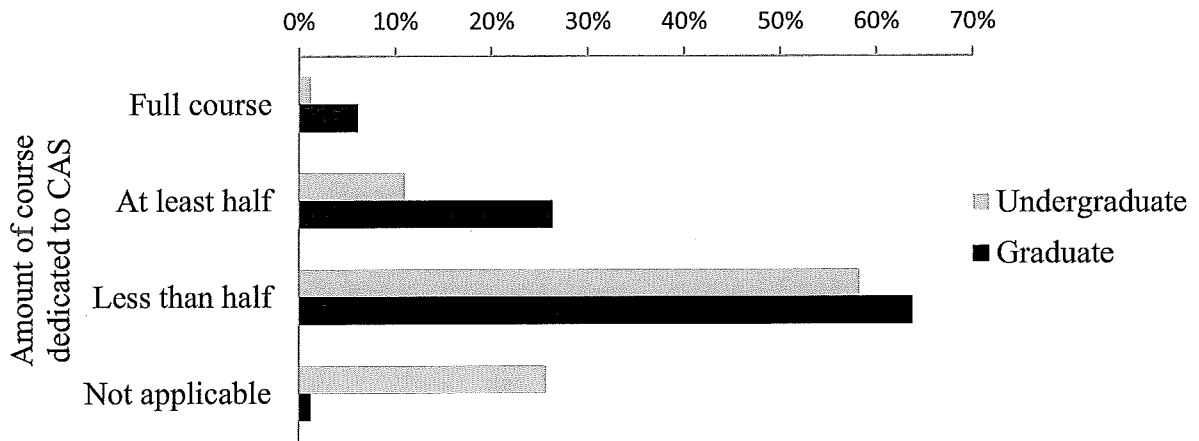


Figure 3. Level and amount of university course(s) which discussed CAS.

The SLPs who responded that they had learned about CAS through continuing education were asked two follow-up questions about the nature and amount of continuing education. The first follow-up questions asked for the sponsoring organization of the continuing education opportunity or opportunities and 322 participants responded. Nearly half of these participants responded that the continuing education was sponsored by ASHA or the Wisconsin Speech-Language Pathology and Audiology Association (WSHA) (see Table 7). About 13% of participants indicated “other” for sponsoring organization, and were instructed to elaborate. Common answers included the Department of Public Instruction (DPI) and workshops sponsored by a Cooperative

Table 7

Sponsoring organizations of continuing education about CAS.

Sponsoring organization	Frequency	%
ASHA or WSHA	156	48.5%
Private company	126	39.1%
Unsure	80	24.8%
University	77	23.9%
Other	42	13.0%
CAS Association of North America	18	5.6%

Educational Service Agency (CESA). The second follow-up question asked for the approximate number of hours of continuing education regarding CAS and 328 SLPs responded. More than a third of participants indicated that they had received between 5 and 8 hours of training (see Table 8).

Table 8.

Approximate number of continuing education hours about CAS.

Hours	Frequency	%
5-8 hours	127	38.7%
Less than 4 hours	104	31.7%
9-13 hours	57	17.4%
More than 14 hours	40	12.2%

Finally, all participants were asked to rate the likelihood of seeking new information from a list of potential sources and 458 responded. The top three responses were colleagues, websites, and continuing education (see Figure 4).

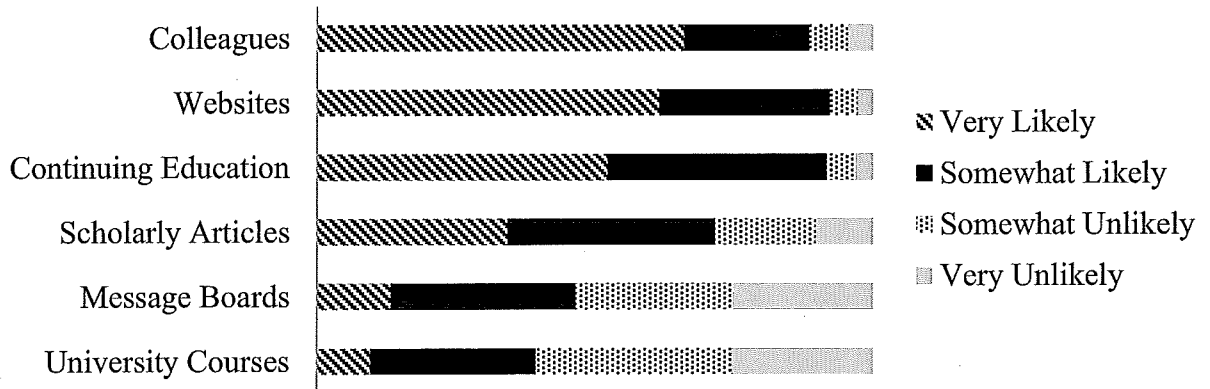


Figure 4. Likelihood of seeking new information about CAS from listed sources.

IV. DISCUSSION

Validity

Although it is agreed that in survey research, higher response rates allow for more useful generalizations of the results to the larger population, there is no agreed-upon minimum response rate for valid conclusions (Fowler, 2009). Nevertheless, electronic surveys are generally expected to yield response rates between 30% and 40% (Thayer-Hart, 2010). This survey had a completed response rate of 29.0%. Including the participants who answered at least one question but skipped some questions or exited the survey before completing it brings the response rate to 35.5%. Therefore, this survey is considered representative of the views and opinions of SLPs working in Wisconsin public and charter schools. This study sought to answer three research questions: (a) How do SLPs diagnose CAS? (b) How do SLPs treat CAS? and (c) How do SLPs learn about CAS? These questions are answered according to the information gained from the survey. A post-hoc question is also discussed: (d) How do inconsistencies in terminology affect discussions about CAS?

Diagnosing CAS

Prevalence. Prevalence estimates for CAS range from 0.125% (Shriberg, Aram, & Kwiatkowski, 1997a) to 1.3% (Morley, 1972). About 50% of participants reported having diagnosed one or more children with CAS. Of those, about 60% had diagnosed between 1 and 5 children with CAS and the remaining 40% had diagnosed 6 or more children with CAS. Because the question asked for total number of children diagnosed rather than a percentage of the SLPs' caseload, it's is not possible to use statistics to compare these rates to the prevalence rates cited above.

Nevertheless, the number of SLPs who have given the diagnosis of CAS appears higher than what would be considered prudent by experts in the field. For example, the technical report published by ASHA (2007b) recommends caution in diagnosing and suggests that clinicians use language such as “*CAS cannot be ruled out, signs are consistent with CAS, or suspected to have CAS*” (p. 54). This difficulty in ever being “sure” of a diagnosis of CAS is echoed even by those actively seeking definitive diagnostic markers (Shriberg, et al., 1997c) and diagnostic protocols (Strand & McCauley, 2008). It is important to note that caution is advised even when using the more liberal label of suspected CAS. Shriberg, Aram, & Kwiatkowski (1997c) suggest the use of that term with the caveat that it be used only when assessment results clearly document praxis deficits and not as a catch-all for children displaying one or more of the other characteristics commonly thought to be associated with CAS (e.g., late onset of speech, reduced phonemic inventories, low intelligibility, inconsistent errors, and atypical errors). In the present study, the survey question regarding diagnostic characteristics yielded 141 different characteristics (see Table 4). When the percentage of SLPs who have diagnosed CAS is considered within that context, it becomes apparent that appropriate caution may not be being taken by these SLPs when making diagnostic decisions about CAS.

Sources of diagnoses. Although 50% of participants indicated that they had diagnosed one or more children with CAS, nearly every participant indicated that they had treated one or more children with CAS. The possible explanations for this are important to consider. One possibility is that many diagnoses of CAS are made by SLPs outside of the school setting, including those working exclusively in Birth-to-Three,

private practice, or medical settings. Another possibility is that diagnoses of CAS are being made by professionals who are not SLPs, such as medical doctors. In the open response options available in the questions pertaining to diagnosing CAS, more than one participant remarked that they deferred to medical doctors for this diagnosis. In both cases, it would be interesting to learn the criteria and methods used to make the diagnosis. It would be particularly interesting to investigate medical doctors' extent and sources of knowledge regarding CAS.

Diagnostic methods. The response options for the question asking participants to check all assessment measures used to diagnose a child with CAS were taken from the protocol used by clinicians at Mayo Clinic in Rochester, MN with the additions of "published checklist" and an open "other" response.

A thorough examination of a child suspected on having CAS would include all of the assessment techniques used by clinicians at Mayo Clinic in Rochester, MN. According to Dr. Stoeckel (personal communication, May 13, 2012), the most critical component of the assessment is the motor speech examination and the only components that could be given "short shrift" would be the standardized tests of language and articulation. As Dr. Stoeckel notes, language and speech sounds must be a part of the assessment, but a spontaneous speech sample yields much of the information covered by these two measures. In looking at the responses of the school SLPs, however, a formal test of articulation was the most commonly-selected response (89.6%). Perhaps even more concerning is that 27.5% of participants did not select "motor speech examination" as one of their assessment measures. This information suggests that at least some SLPs working in schools have a poor understanding of the nature of CAS, relying more heavily

on measures of speech sound accuracy than on measures of speech praxis. Even the frequent use of an oral mechanism examination does not ameliorate this situation, as this measure would not readily distinguish a child with an oral or facial apraxia from one with apraxia of speech or with apraxia of speech with a co-existing oral or facial apraxia.

Of the choices of methods used to assess for CAS, “other” was the least-selected option, followed by “published checklist.” Published checklists have been condemned for having strong levels of sensitivity (low false negatives) but unacceptable levels of specificity (high false positives) and for presenting hierarchical characteristics as linear and autonomous (Shriberg, Campbell, et al., 2003). That this method was the least-frequently selected of the given options may be a sign that the majority of SLPs are aware of its ineffectiveness. However, nearly one-quarter of respondents did indicate using this method, suggesting that any diagnoses made based on this information, even in conjunction with other assessments, may have been a false positive.

Standardized assessments. When participants were asked to elaborate on the response of “other” for assessment methods, many listed the Kaufman Speech Praxis Test for Children (KSPT), a standardized assessment which is published as a tool to assist with the diagnosis of CAS. As McCauley and Strand (2008) found in their review of six available assessments for diagnosing CAS, no test in its current form, including the KSPT, is adequately developed due to insufficient normative data, behavioral standards, reliability, and/or validity. As these authors note, until a gold standard of diagnosis is found for CAS, all standardized tests will fall short in these psychometric characteristics. That one such test is reportedly used by practicing SLPs to make diagnostic decisions

raises concerns about the accuracy of those diagnoses as well as these SLPs' understanding of valid and reliable testing measures.

Diagnostic characteristics. Although the technical report on CAS published by ASHA (2007b) lists three features that have enjoyed relative acceptance in the literature as being indicative of CAS, the authors caution that these features are neither necessary nor sufficient to make a diagnosis. In addition to these three features, there are lists of additional characteristics of CAS elsewhere on the ASHA website, on other websites, in journal articles, and in other publications. Many of these include “corollary characteristics” which, while they may frequently co-occur with praxis deficits, are not themselves indicative of praxis deficits (Davis & Velleman, 2000; Shriberg et al., 1997c). This lack of clarity means that the most salient characteristics are in the eye of the diagnostician, resulting in the CAS diagnosis being applied to widely different profiles.

The open question asking participants to list the characteristics necessary to diagnose a child with CAS yielded interesting results. These responses can be compared to the three characteristics listed in the technical report on CAS published by the national organization for speech-language pathologists (ASHA, 2007b): “(a) inconsistent errors on consonants and vowels in repeated productions of syllables or words, (b) lengthened and disrupted coarticulatory transitions between sounds and syllables, and (c) inappropriate prosody, especially in the realization of lexical or phrasal stress” (p. 4). These characteristics are reiterated in the position statement on CAS also published by ASHA (2007a). In the present study, “inconsistent errors/productions” was the characteristic most frequently listed at 55.5% of participants. “Prosodic abnormalities” was listed by

13.0% of participants while “disrupted and lengthened coarticulatory transitions” was listed by just 2.8% of participants.

Because ASHA credentials speech-language pathologists, it is considered by many to be the final authority on issues related to the field. However, this study shows that the vast majority of SLPs do not consider two of the three characteristics of CAS listed by this organization as necessary for diagnosis. Even “inconsistent productions,” which was the most commonly cited characteristic, was still not considered necessary by 44.5% of participants. One possible explanation for this is that many SLPs working in schools have not read the position statement or technical report on CAS published by ASHA (2007a; 2007b). This could be due to time constraints or a lack of awareness of the existence of these documents. Another possible explanation is that although SLPs are aware of the importance of these characteristics in the literature, they are not confident in their ability to isolate and assess these characteristics. Therefore, they are more likely to rely on characteristics that, while less widely accepted as diagnostic criteria, are more visible.

These two explanations highlight two areas of need for SLPs. First, there is a need for better training in universities and continuing education opportunities for assessment of this disorder so that the most salient features presented in the literature can be used effectively in diagnosing CAS. Second, there is a need for continued research of the diagnostic criteria for CAS so that there is stronger agreement on the distinguishing features of this disorder. This would allow for better assessment methods, including standardized assessments, which would assist SLPs in making this diagnosis.

Although it is positive that “inconsistent errors” was the most commonly-cited characteristic of CAS and this characteristic is echoed by publications from ASHA, there is some recent research that suggests this characteristic may be too broad to effectively diagnose CAS. Iuzzini and Forrest (2012) explain that there are two types of speech inconsistency: token-to-token inconsistency, which is the inconsistency of a word across multiple productions (e.g., “elephant” as /ɛpədʌn/, /ɛdæn/, /ʌpfæn/), and phonemic inconsistency which is the inconsistency of a phoneme across multiple productions, words, and word positions (e.g., /s/ as /s, t, d, ʃ, dz/). In a recent study, these authors found that only one measure of phonemic inconsistency (the Inconsistency Severity Percentage) could reliably differentiate the two groups. This study indicates that merely observing inconsistencies in a child’s speech production is not specific enough to diagnose him/her with CAS. Rather, the type and frequency of inconsistencies must be documented and compared to the scores of typically-developing children and children with PD. Therefore, the results of the present study which show that SLPs consider “inconsistent productions/errors” to be the top characteristic of CAS suggest yet another area in which increased education and training may be warranted.

This open question regarding the characteristics necessary to diagnose a child with CAS was a repetition of the question Forrest (2003) asked of a group of SLPs at a lecture about CAS, and it is interesting to compare the results. As in that study, the present study found a very high number of unique response categories. The 75 SLPs in Forrest’s study produced 50 different characteristics while in this study the 391 school SLPs produced 141. In the previous study, the top response, inconsistent productions, was listed by 14.1% of participants. In the present study, the top response, also

inconsistent productions, was listed by 55.5% of participants. This suggests that SLPs are moving toward closer agreement on at least this feature of CAS, although as described previously, this characteristic is only useful when carefully measured. In both studies, there were a significant number of characteristics that were listed just one time and could not be grouped with any other listed characteristic. In Forrest's (2003) study, 40.0% of responses were listed only one time and in this study, 36.2% of responses were listed only once.

In both studies, many of the stand-alone characteristics are not among those listed in any peer-reviewed articles and there are many that contradict one another. This raises questions about why these SLPs felt that these characteristics were helpful in diagnosing children with CAS. A possible explanation is that when answering this question, some SLPs listed all characteristics of the specific children with CAS they had diagnosed or treated, rather than listing those characteristics that are indicative of the disorder. This method of attempting to describe any disorder would lead to errors as it does not consider which characteristics fit the disorder, which are due to co-occurring disorders, and which are idiosyncratic to that individual. If this is true of these SLPs, it is not clear whether the main problem is the lack of understanding of CAS or whether it is indicative of a larger problem with the understanding of diagnostic theory and practice. Whatever the reason, the lengthy list of characteristics of CAS generated by these SLPs has the same shortcomings as the diagnostic checklists disparaged by experts. If too many characteristics are thought to be indicative of a disorder, then there will likely be a high rate of false positives (Shriberg, Campbell, et al., 2003). This observation coupled with the long list of characteristics found in this study suggests that there is a high rate of false

positives among those children diagnosed with CAS. Therefore, misdiagnosis could be at least a partial explanation to the apparent increase in prevalence of CAS.

Summary. The lack of agreement among researchers regarding the nature and characteristics of CAS appears to be magnified in the larger population of practicing clinicians. This study shows that although many SLPs are diagnosing children with CAS, they are using vastly different methods and criteria. This lack of agreement among practicing clinicians can lead to mismanagement of care, both for children misidentified as having CAS and for those misidentified as not having CAS. Furthermore, it appears that large numbers of SLPs who are diagnosing CAS are not using the available research evidence to do so. It is true that there is no gold standard for diagnosing this disorder. However, there has been considerable research done to find diagnostic criteria for CAS and although there are no repeated, randomized, controlled-trial studies to date, there is strong agreement on at least three characteristics. In this study, those three characteristics were not listed at the high rates that would be expected. This suggests that SLPs are not using the principles of evidence-based practice when diagnosing CAS. Evidence-based practice requires the use of the best *available* evidence, and it is the responsibility of each SLP to seek that information and apply it as appropriate.

Treating CAS

As previously mentioned, 93.1% of participants indicated that they had treated a child with CAS. The other questions regarding treatment attempted to gather information about the types of treatments being used and the awareness of research evidence available. This study shows that SLPs are as disparate in their treatment decisions as they are with their diagnostic criteria.

Familiarity with treatments and efficacy research. A list of treatments from efficacy studies for CAS was presented to participants who were asked to indicate their level of familiarity with each one with a Likert scale. Nonspeech oral motor exercises (NSOMEs) had the highest ratings of familiarity by far (37.2% were “very familiar” and 44.5% were “somewhat familiar”). Only 6.2% of participants indicated that they were “unfamiliar” with NSOMEs as a treatment for CAS. In contrast, the other listed treatments were unfamiliar to 26.7% – 81.0% of participants. Ethical treatment decisions must be informed decisions, and this study shows that SLPs may be making treatment decisions without full knowledge of the available options. The low familiarity (24.3% were very or somewhat familiar) that participants had with Dynamic Temporal and Tactile Cueing is particularly telling as it is the treatment with the highest level of research evidence to support it and one of the only treatment methods listed designed specifically to treat CAS. Since the treatment choices given in the survey are listed within the technical report on CAS published by ASHA (2007b), these results support the earlier statement that this document is not widely read by SLPs.

The participants were next asked to rank their level of familiarity with available efficacy research for each treatment method for which they had indicated at least minimal familiarity. Once again, the NSOMEs received the highest ratings of familiarity with available research, although the ratings were not as uniformly robust as when asked to rate general familiarity. For most of the other treatments, however, those participants who indicated that they were at least minimally familiar with a treatment seem to have higher ratings of familiarity with research. These data are perhaps a reflection of the level of exposure that each of the listed treatment methods has in the field of speech-language

pathology. NSOMEs, a hot topic in a variety of academic and non-academic forums, are familiar to SLPs even though many of them haven't been exposed to the relevant research which, notably, does not support their use with CAS. On the other hand, the other treatments listed are less often discussed; therefore, the SLPs who are familiar with them have likely sought out information on their own which may have given them a deeper understanding, including the available efficacy research.

Treatments used. In this study, about 93% of participants reported having treated a child with CAS and when presented with a list of treatment methods that they may have used, about 73% of those chose "other," making it the most common response. This result was not expected when the question was written, but it is fitting given the low levels of familiarity with these treatment methods found from the earlier question. The responses provided in the open section when "other" was selected suggest some troubling trends in treatment decisions. First, many of the responses were treatment methods for other disorders, such as articulation or phonological disorders. This suggests that for some SLPs, the diagnostic label of CAS does not change the treatment approach taken with a child. This may be indicative of SLPs' poor understanding of treatment options or poor understanding of the nature of CAS and how it differs from other speech sound disorders. Another possibility is that this is the result of the widely different diagnostic criteria used to diagnose. If SLPs are treating children who have the label of CAS but who do not display characteristics indicative of a praxis deficit, then the SLPs may be justified in choosing these other approaches.

Another disconcerting trend noticed in the responses to this open option is that many of them are treatment *materials* (e.g., Easy Does It Apraxia, Just For Kids Apraxia,

Apraxia Uncovered, Moving Across Syllables, and iPad applications) and not *methods*. A treatment method includes, along with instructions for implementation, the theoretical underpinnings that its creator(s) cite as justification for its effectiveness. Treatment materials are often slick, ready-to-use sets that, while possibly being based on solid theory, do not require the SLP to understand or even be aware of that theory in order to use them. Additionally, these treatment materials may present a one-size-fits-all approach to a disorder that may have varying presentations across time and contexts (Shriberg et al., 1997a; Strand & McCauley, 2008).

The second most common treatment reportedly being used with children with CAS was nonspeech oral motor exercises. This finding reflects Lof and Watson's (2008) finding that CAS was the second most-common disorder for which SLPs use NSOMEs. The ramifications of this finding are troubling. To begin, there is a lack of supporting evidence for the use of NSOMEs with any population, meaning that responsible clinicians must use caution before using them to treat any disorder (McCauley et al., 2009). Some might argue that along with research studies, evidence-based practice includes other sources of information such as intuition, anecdotal evidence, and expert opinion (Dollaghan, 2004). However, even with this concession, there is still not adequate support for the use of NSOMEs as the main course of treatment for CAS. As the name implies, children with CAS have adequate strength and movement for nonspeech tasks and it is only in speaking that the deficits are present; therefore, NSOMEs target a domain that is within normal limits for these children and which have not been proven to carry over into speech tasks (Davis & Velleman, 2000; Lof, 2003; Lof & Watson, 2008; McCauley et al., 2009; McCauley & Strand, 2008b).

Other findings in the present study seem to suggest that SLPs do not effectively use evidence-based practice in regards to CAS, but the finding related to NSOMEs is particularly concerning. A full 40% of SLPs who indicated that they were unfamiliar with efficacy research for NSOMEs use them to treat CAS. This suggests that many SLPs do not consider efficacy data when making treatment decisions. Additionally, 30% of SLPs who indicated that they were very familiar with efficacy research for NSOMEs use them to treat CAS. As previously mentioned, the available efficacy research does not support the use of NSOMEs for any disorder, with particular arguments against their use with CAS. This group of SLPs, then, are either disregarding the available evidence, or are misunderstanding the conclusions.

Summary. The problems SLPs face in diagnosing children with CAS continue into the treatment of these children. The results of this study show that many SLPs are unaware of treatment methods proposed in the literature and therefore these methods are reported to be used infrequently by participants (about 3% to 19%). This leads these SLPs to turn to other methods and materials that are not present in research literature. Some of these methods are unfounded, some of the materials are meant for other disorders, and other materials may mask the complexity of treating a nosologically precarious disorder such as CAS. It is true that there are no repeated, randomized, controlled-trial studies done on any of the treatment methods listed here (Morgan & Vogel, 2008). However, as mentioned in the discussion of diagnostic criteria, evidence-based practice requires the utilization of the best *available* evidence. To date, that distinction belongs to Dynamic Temporal and Tactile Cueing, which is not being implemented by the majority of SLPs in this study. The need for further research into

appropriate treatment methods is not negligible, but even more pressing is the need for SLPs to recognize the importance of turning to the research literature for treatment decisions. The use of evidence-based practice must be emphasized by universities, but the responsibility of its implementation within the day-to-day practice belongs to the individual.

Learning about CAS

This study also investigated how SLPs have learned about CAS and the likelihood of using various sources of information to continue to learn about CAS in the future. It is not possible to make direct correlations between the sources and amount of education on CAS and the reported practices of diagnosing and treating CAS from this study. However, in light of the responses to the questions regarding the diagnosis and treatment of CAS, this information does lead to some important questions about the future direction of SLP training.

Sources of information. The vast majority of participants (97.2%) indicated that they had received information about CAS from some outside source (e.g., college course, website, colleague, etc.). The types of sources varied, but the top response was continuing education (71.5%) followed by colleagues (68.7%), websites (59.9%), scholarly articles (38.0%), and university courses (35.0%). The study suggests that the ways SLPs diagnose and treat CAS are highly varied and often not based on available research evidence, but it would seem that this apparent lack of knowledge is not due to a lack of *exposure* to the topic. Rather, it appears that there is a problem either in the quality of information presented or in the ability of the SLPs to understand and apply the information.

These findings suggest that there is a problem in how SLPs learn, not only about CAS specifically, but also more generally about finding and evaluating any new information that will inform practice decisions. University training should provide the foundation for knowledge of speech disorders, but also the skills needed to discriminate high- from low-quality information that future SLPs may come across throughout their careers. This study shows that only 35% of participants received information about CAS through coursework. This means that the remaining SLPs needed to learn information without the guidance of a knowledgeable professor. At the continuing education stage of a career, the certified SLPs are responsible for using the Code of Ethics of ASHA to provide best practice assessments and treatments. For disorders like CAS, continuing education is particularly important as the field is constantly changing as new theories and research findings are being published. It is the responsibility of SLPs to discriminate good sources from poor to stay abreast of the latest information.

Continuing education. When asked to indicate the sponsoring organization of any continuing education about CAS, the top responses were ASHA or WSHA (48.5%), private company (39.1%), and unsure (24.8%). State and national organizations like ASHA and WSHA are generally good sources of unbiased information, so it seems promising that many SLPs are seeking knowledge from them (see the later limitations section for methodological concerns that may affect the validity of this response). If this information is accurate, then this finding may indicate that these organizations must do a better job presenting the information in a way that allows SLPs to understand the information and how it relates to practice so that they can apply it to their decision-

making. The bulk of the responsibility may lie with the individual presenters to consider theories of learning and apply best practice to their lectures and other materials.

The second and third most common sponsoring organizations of continuing education about CAS, private companies and “unsure,” raise some concerns about the quality of the information received. While there certainly can be valuable information presented at conferences and webinars sponsored by private companies, there is also the possibility of financial conflict of interest. A discerning consumer would be wary of one-sided arguments, poor methodology in research studies, and unfounded claims. That 24.1% of participants were unsure of what organization sponsored their continuing education suggests that many SLPs are not as discerning as would be hoped. As Siegel (1993) states, “clinicians need to have enough familiarity with research to judge whether the claims are reasonable and to determine just how closely the proposed clinical procedures adhere to the research methods and underlying theory” (p.36). That statement can be extended to any information clinicians receive about their practice including expert opinion, clinical observations, and personal testimony. Put simply by Schiavetti, Metz, and Orlikoff (2011), “critical thinking is the foundation of effective professional practice” (p. 1). Therefore, if the problems with diagnosing and treating CAS as found in the study are due to SLPs using poor sources to learn about this disorder, then the solution is that they must become more discerning consumers of information. The accredited teaching institutions are responsible for preparing their students to carefully evaluate what they read and hear before applying it to their practice. After that preparation, the onus is on individual clinicians to think critically about what is presented to them before accepting it as fact.

Summary. This study shows that significant changes must be made to how SLPs gain the knowledge that informs their practice. It appears that many SLPs are not using research-based information to make diagnostic and treatment decisions regarding CAS. These SLPs may not have been taught this information in university courses (only 35% reported some university exposure to CAS) and/or they may not have stayed current in their understanding of this disorder. In a dynamic field such as speech-language pathology, some areas of university training will naturally become obsolete over time. Therefore, all professionals must be competent at continually seeking out high-quality information to inform their practice. Although this finding places significant responsibility on the individual clinicians to seek out and evaluate research evidence, there are larger groups that are also responsible for supporting the standard of evidence-based practice for SLPs, such as organizations that sponsor continuing education opportunities and university programs that train students to be SLPs. This study did not evaluate university training on the use of evidence-based practice provided to students. Nevertheless, this study shows that these organizations must consider how much emphasis this area is given, how this skill is taught, and the extent to which learner outcomes are met in order to assure that the future clinicians they train are prepared to uphold the ethical obligation to use the highest available research to inform their practices.

Terminology for CAS

An additional observation made from this study is that terminology problems interfere with SLPs' ability to effectively communicate about CAS. Terminology issues have serious consequences for the profession of speech-language pathology. One

problem is the tendency for the field of speech-language pathology, among others such as psychology, to group behavioral symptoms and give them a label as a disorder. As Walsh (2005) states, “the ‘disorder’ label implies an etiology or cause where none is actually established” (p. 68). This is precisely the case with CAS, but there are other issues to consider as well: Walsh (2005) cites the propensity to use terms with multiple meanings and the existence of multiple terms that share one meaning. These terminology issues affect the communications from one professional to another as well as the communication between the profession, the general public, and policy-makers.

Semantics. Several examples of terminology problems in this study can be found in the responses to the question asking SLPs to list the characteristics necessary for diagnosing a child with CAS. First, there was liberal use of terms and phrases such as *spontaneous*, *imitated*, and *on command*. SLPs use these terms to attempt to describe the context of tasks used to diagnose CAS. However, the meaning of these terms becomes murky in responses such as “inability to imitate jaw/facial movements on command” and “unable to imitate facial motor movements spontaneously.” Besides presenting opposite behaviors as indicative of CAS, these examples also show that there may be some confusion as to what *imitation* entails. Semantically, the use of the term *imitate* negates the need for the phrase *on command* and is in direct opposition to the term *spontaneously*.

Severity. Another example found in the responses to this question is how some participants quantified behaviors by using the phrase *inability to*. It is likely that those who used “inability to” meant that the child had an inability to *accurately* perform the task that followed this phrase such as imitate movements, produce sounds and words, and control articulators, thus that was how these responses were coded. However, as written,

these responses are either nonsensical (a complete inability to imitate would be difficult to differentiate from a complete unwillingness to imitate) or would imply a total absence of these behaviors, which would lead to a different diagnosis (e.g., in the observation of a complete inability to produce sounds) or unique cases, indeed (e.g., in the observation of a complete inability to control articulators).

Direction. Another, more subtle, terminology issue was seen in the responses to this open question. There were several participants who listed behaviors or characteristics, but did not specify the direction of these behaviors. For example, “motoric speed” was listed as a characteristic of CAS without the specification of whether this is observed as fast or slow. Similar examples include, “intelligibility,” “prosody,” “oral motor planning,” “muscle tone,” “cognitive functioning,” “motor timing,” “motor coordination,” and others. Perhaps these participants felt that the direction, accuracy, or presence of these behaviors was obvious. This assumption, when communicating with other SLPs, parents of children with CAS, or policy makers, will lead to misunderstandings and frustrations. This lack of clarification is perhaps partially responsible for the presence of characteristics that were directly opposing among the responses.

Classifications. Terminology was also a problem in the open responses to the “other” option presented with the lists of given responses to several questions. For the question asking which methods or techniques were used to diagnose a child with CAS, the open responses often fell under one of the given responses. It is possible that some participants overlooked these choices, but it is also possible that they have different understandings of the terms listed than the author. For example, one open response read

“speech production tasks looking at increasing length/complexity, etc.” A true motor speech examination would include tasks such as this, but this response was not checked. Another example is the frequent open response of the Kaufman Speech Praxis Test (KSPT). This test is just one of several that attempts to assess a child’s speech motor abilities (the reader is referred back to the literature review for more information on these assessments). Therefore, the given choice to encompass such tests was “Formal test of motor speech.” It is possible that the SLP simply wished to be more specific in his/her response, but it is also possible that the lack of agreement between the questions’ intent and the participant’s response was compounded by the SLPs’ lack of understanding of the nature of CAS, the purpose of the KSPT, or both.

Summary. Difficulty with terminology is not a new problem to the field of speech-language pathology nor to discussions about CAS specifically. This study does provide examples of the inconsistencies of terminology and the tendency to make assumptions about a listener’s perspective on a topic. This is challenging when SLPs communicate with each other, but can be even more problematic when SLPs communicate with other disciplines or members of the general public. It is critical that SLPs use language that is clear, concise, and specific to avoid misunderstandings and to maintain, as much as possible, the scientific discipline of the field.

Limitations

Limitations to the present study are acknowledged. First, because this study sampled SLPs working in public school districts and charter schools, it is not known if the data can be validly extrapolated to SLPs working in other settings.

A second concern is with questions that asked participants to list or check multiple responses without asking them to rank the relative importance or saliency of these responses. For example, the open question that asked SLPs to list the characteristics necessary to diagnose a child with CAS did not ask them to rank those characteristics. Therefore, the results show the listed characteristics in order of frequency, but not necessarily in order of importance. A similar limitation applies to the question asking participants to check the assessment methods used to diagnose a child with CAS.

Another limitation is that although each question was carefully constructed, they did not all elicit the intended responses from all participants. An example is the question that asked participants to list characteristics felt to be necessary to diagnose a child with CAS. Sixty-three of the responses to this question were not included in the final results section due to this issue. These excluded responses include personal characteristics of the diagnosing SLP (e.g., “experience and competence”), knowledge of the diagnosing SLP (e.g., “knowledge of ‘typical’ child development”), and diagnostic techniques (e.g., “speech sample, case history, hearing evaluation”).

A final concern is with the validity of the responses to the question asking which organization sponsored continuing education opportunities from which the participants learned about CAS. The concern relates to the issue of how continuing education units (CEUs) are earned. ASHA will approve CEUs from continuing education courses and seminars even when the content taught there does not align with the general views and opinions of ASHA as an organization. Although the question asked for the sponsoring organization, not just whether ASHA CEUs were earned, it is possible that some respondents interpreted it as the latter.

Conclusions

Due to the controversy that has surrounded childhood apraxia of speech for over fifty years, there are perhaps more questions than answers about the diagnosis and treatment of this disorder. This study sought to uncover how SLPs working in the field balance this lack of definitive answers with the ethical requirement to use best practice with all clients. The results suggest that finding this balance is a problem for most SLPs.

The participants provided an extremely wide range of characteristics used to diagnose CAS, most of which are not supported by research findings and many of which contradicted each other. This calls into question the validity of the number of children diagnosed with CAS. Perhaps the extreme variety within the profiles of the children diagnosed with CAS is part of the reason that there is extreme variety in how these children are treated. Of the given treatment options, the participants chose “other” as the most commonly used. Although there are no universally-accepted methods to diagnose and treat CAS, there are some methods with stronger evidence than others, which should be given higher consideration according to evidence-based practice guidelines. Unfortunately, these “best available” practices appear underutilized by most SLPs.

By looking at how SLPs learn about CAS, it would seem that the problem lies not in a lack of exposure as nearly all participants reported receiving information about CAS from an external source. Therefore, the accessibility of that information must be considered as well as the quality of the information to which these SLPs are exposed. Those responsible for training future and practicing SLPs must take measures to ensure that the information is presented in a way that the learners can understand it and apply it to their practices. Additionally, individual SLPs must take responsibility for considering

the sources of all information that informs their practice and evaluate it for bias, methodological flaws, and faulty logic before accepting it as true. Universities can help in this measure by guiding students to becoming critical readers and thinkers.

A final implication of this study is the real need for continued research. It was found that the disagreements among the experts regarding diagnosing and treating CAS are amplified among the practicing SLPs. It has been established from a nosological standpoint that there is a need for a standardized assessment protocol and diagnostic criteria for CAS that have sensitivity and specificity (ASHA, 2007b). There is currently research being done to validate a standardized assessment for CAS, which may ameliorate some of the noted diagnostic problems (Strand, et al., in press). Until there is a gold standard for diagnosis, research on CAS will continue to be plagued by methodological concerns regarding subject selection (McCauley & Strand, 2008; Shriberg, Potter, & Strand, 2011). However, it is imperative to note that unless SLPs are prepared to continually seek out information about the disorders that they treat, research findings will not have an impact on the general practice.

As the field of speech-pathology continues to push for the standard of evidence-based practice, it will become increasingly vital that practice be informed by knowledge. When a disorder has a growing body of research, such as CAS, clinicians must seek out the best available evidence and be willing to shift their approaches accordingly. Without this individual accountability, the field as a whole suffers because poor practice habits can lead to a negative public identity and decreased public confidence. Keeping abreast of the current knowledge and practice of SLPs is the first step in ensuring that ethical standards are upheld. It is by maintaining these high standards that SLPs will continue to

make progress toward the ASHA (n.d.) vision of “making effective communication, a human right, accessible and achievable for all” well into the future.

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Appendix A: Cover Letter

Dear [first name] [last name],

My name is Anne Kulinski and I am a graduate student in the Department of Communication Sciences and Disorders at the University of Wisconsin- Eau Claire. I am conducting a survey to describe the knowledge and practices of Wisconsin SLPs regarding childhood apraxia of speech (CAS) as a part of my Master's thesis. You have been chosen as part of a statewide sample of practicing SLPs to participate in this study. As an SLP, you are in a position to provide valuable information for administrators of university programs and continuing education opportunities as well as for other professionals in the field working with children with CAS or suspected CAS. I ask your help in this research by completing the electronic survey linked at the bottom of this e-mail.

The questionnaire should take about ten minutes to complete. Your participation in this project is completely voluntary. Informed consent is implied upon completion and submission of the survey. Your responses are completely anonymous and cannot be linked in any way to your email address, internet protocol (IP) address, or any other identifying information. There are no foreseen risks to participation. In approximately one week, everyone involved in this study will receive a follow-up e-mail as a reminder to complete the survey and as a thank you for participation in the study.

I hope that you will choose to participate in this study. A high return rate is needed to assure that the data are representative. The results of this study will be presented at the 2012 ASHA Convention. If you have any questions about this project or the results please contact the faculty advisor, Dr. Marie Stadler, Department of Communications Sciences and Disorders, University of Wisconsin-Eau Claire, 54702-40004, (715) 836-4861.

The distribution of the survey has been approved by the University of Wisconsin-Eau Claire Institutional Review Board for the Protection of Human Subjects. If you have any questions or concerns about your treatment as a participant in this study, please contact Dr. Don Bredle, Chair, Institutional Review Board for Protection of Human Subjects, Schofield 17, University of Wisconsin-Eau Claire, WI, 54702-4004, (715) 836-2373. Thank you for your time and cooperation.

Sincerely,

Anne Kulinski
Graduate Student Researcher
Department of Communications Sciences and Disorders
University of Wisconsin- Eau Claire
wrasae@uwec.edu

[Click Here to Access Survey](#)

Appendix B: Survey Questions

Your answers to the following questions are anonymous. Thank you for participating!

Q1

Please indicate in what year you earned your degree at the following levels.
(enter the year in the space provided; leave black if it does not apply)

Bachelors	<input type="text"/>
Masters	<input type="text"/>
PhD	<input type="text"/>
EdD	<input type="text"/>

Q2

Please indicate in what setting(s) you currently work as a speech-language pathologist. (check all that apply)

- Early Intervention (Birth to 3)
- Preschool
- Elementary school
- Middle School
- High School
- Medical
- Private Practice
- Other (please specify)

Display This Question:

If Please indicate in what setting(s) you currently work as ... **Preschool Is Selected** Edit

Or Please indicate in what setting(s) you currently work as ... **Elementary school Is Selected** Edit


Or Please indicate in what setting(s) you currently work as ... **Middle School Is Selected** Edit

Or Please indicate in what setting(s) you currently work as ... **High School Is Selected** Edit

Q3

Please indicate the approximate size of the school district in which you work.

- Less than 600 students
- 600-2,000 students
- 2,001-7,000 students
- More than 7,000 students

 **Display This Question:**
 If Please indicate in what setting(s) you currently work as ... Early Intervention (Birth to 3) Is Selected Edit

Q4



Please indicate the approximate population of the county in which you provide Birth-to-Three services.

- Less than 20,000 residents
- 20,000-50,000 residents
- 50,001-100,000
- More than 100,000 residents


Q5



Please indicate the approximate percentage of time you work at each of these settings. The total must equal 100% of your work time.

- » Early Intervention (Birth to 3)
- » Preschool
- » Elementary school
- » Middle School
- » High School
- » Medical
- » Private Practice
- » Other (please specify)

• Total
<input type="text"/>

 Carry Forward Selected Choices from "Please indicate in what setting(s) you currentl..." Edit

Q6



Please indicate approximately how many years you have worked with children with speech sound problems as part of your caseload in your professional career.

- 0
- 1-5
- 6-10
- 11-15
- More than 15

Q7



Please check all of the settings in which you have worked as a speech-language pathologist, including where you are currently providing services.

- Early Intervention (Birth to 3)
- Preschool
- Elementary School
- Middle School
- High School
- Medical
- Private Practice
- Other (please specify)

Q8



Please list the characteristic/s that you believe is/are necessary to result in a diagnosis of childhood apraxia of speech (CAS) or suspected childhood apraxia of speech (sCAS). If listing multiple characteristics, please separate with commas.

Q9



Have you ever diagnosed a child with childhood apraxia of speech (CAS), suspected childhood apraxia of speech (sCAS), or any variation of those (e.g., developmental apraxia of speech or developmental verbal apraxia)?

- Yes
- No

Display This Question:
 If Have you ever diagnosed a child with childhood apraxia of... Yes Is Selected Edit

Q10



Please check which assessment techniques/measures you have used to give the diagnosis of childhood apraxia of speech (CAS), suspected childhood apraxia of speech (sCAS), or any variation of those (e.g., developmental apraxia of speech, developmental verbal apraxia). (check all that apply)

- Formal test of articulation
- Formal test of language
- Formal test of motor speech
- Formal test of phonology
- Language sample
- Motor speech examination
- Oral mechanism examination
- Parent/caregiver questionnaire/interview
- Published checklist
- Speech sound inventory
- Other (please specify)

**Display This Question:**

If Have you ever diagnosed a child with childhood apraxia of... Yes Is Selected Edit

Q11



Please indicate approximately how many children you have diagnosed with childhood apraxia of speech (CAS), suspected childhood apraxia of speech (sCAS), or any variation of those (e.g., developmental apraxia of speech or developmental verbal apraxia)?


- 1-5
- 6-10
- 11-15
- More than 15

Q12



Have you ever treated any children with a diagnosis of childhood apraxia of speech (CAS), suspected childhood apraxia of speech, or any variation of those (e.g., developmental apraxia of speech or developmental verbal apraxia)?

- Yes
- No

 **Display This Question:**
 If Have you ever treated any children with a diagnosis of ch... Yes Is Selected Edit

Q13



Please indicate approximately how many children you have treated with childhood apraxia of speech (CAS), suspected childhood apraxia of speech, or any variation of those (e.g., developmental apraxia of speech or developmental verbal apraxia).

- 1-5
- 6-10
- 11-15
- More than 15

Q14



Please indicate your familiarity these treatment methods for childhood apraxia of speech (CAS).

	Very Familiar	Somewhat Familiar	Minimally Familiar	Unfamiliar
Core Vocabulary Treatment (CVT)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Continuous Integration Therapy (CIT)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Dynamic Temporal and Tactile Cueing (DTTC)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Electropalatography	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Integral Stimulation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Melodic Intonation Therapy (MIT)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Nonspeech Oral Motor Exercises or Treatments	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prompts for Restructuring Oral Muscular Phonetic Targets (PROMPT)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stimulability Training Protocol (STP)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Touch Cue Method (TCM)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

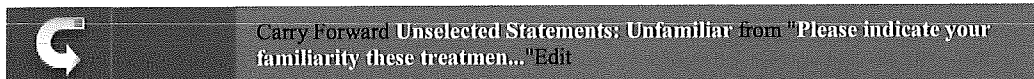
Q15

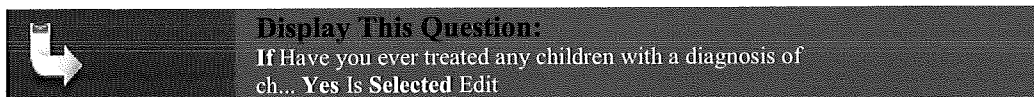


Please indicate your familiarity with *available research* that has examined the effectiveness of the following treatment methods for childhood apraxia of speech (CAS).

	Very Familiar	Somewhat Familiar	Minimally familiar	Unfamiliar
	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Very Familiar	Somewhat Familiar	Minimally familiar	Unfamiliar
» Core Vocabulary Treatment (CVT)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
» Continuous Integration Therapy (CIT)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
» Dynamic Temporal and Tactile Cueing (DTTC)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
» Electropalatography	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
» Integral Stimulation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
» Melodic Intonation Therapy (MIT)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
» Nonspeech Oral Motor Exercises or Treatments	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
» Prompts for Restructuring Oral Muscular Phonetic Targets (PROMPT)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
» Stimulability Training Protocol (STP)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
» Touch Cue Method (TCM)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>





Q16




Please indicate which treatment methods you have used with a child diagnosed with childhood apraxia of speech (CAS), suspected childhood apraxia of speech (sCAS), or any variation of those (e.g., developmental apraxia of speech, developmental verbal apraxia). (check all that apply)

- Other treatment methods
- » Core Vocabulary Treatment (CVT)
- » Continuous Integration Therapy (CIT)
- » Dynamic Temporal and Tactile Cueing (DTTC)
- » Electropalatography

- » Integral Stimulation
- » Melodic Intonation Therapy (MIT)
- » Nonspeech Oral Motor Exercises or Treatments
- » Prompts for Restructuring Oral Muscular Phonetic Targets (PROMPT)
- » Stimulability Training Protocol (STP)
- » Touch Cue Method (TCM)

 Carry Forward Unselected Statements: Unfamiliar from "Please indicate your familiarity these treatmentmen..."Edit

 Display This Question:
If Please indicate which treatment methods you have used wit... Other treatment methods is SelectedEdit

Q17



Please list or describe any other treatment methods that you have used with children diagnosed with childhood apraxia of speech (CAS), suspected childhood apraxia of speech (sCAS), or any variation of those (e.g., developmental apraxia of speech, developmental verbal apraxia). If listing multiple treatment methods, please separate by commas.


Q18



Please indicate which of the following sources have provided you with information regarding childhood apraxia of speech (CAS). (check all that apply)

- Clinical Fellowship Year (CFY) mentor
- Colleagues
- Continuing Education (workshops, lectures, etc.)
- Message Boards
- Scholarly Articles
- University Courses
- Websites
- I have not received external information
- Other (please explain)




 **Display This Question:**
 If Please indicate which of the following sources have provi... **University Courses Is Selected Edit**

Q19



From what type and how much of a university course did you receive information regarding CAS?

	Full course dedicated to CAS	At least half of a course dedicated to CAS	Less than half of a course dedicated to CAS	Not applicable
Undergraduate Courses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Graduate Courses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>


 **Display This Question:**
 If Please indicate which of the following sources have provi... **Continuing Education (workshops, lectures, etc.) Is Selected Edit**

Q20



Please indicate any types of continuing education that you have participated in regarding childhood apraxia of speech (CAS)? (check all that apply)

- Workshop or lecture sponsored by ASHA or WSHA
- Workshop or lecture sponsored by the Childhood Apraxia of Speech Association of North America (CASANA)
- Workshop or lecture sponsored by a private company
- Workshop or lecture sponsored by a university
- Unsure of who sponsored the workshop or lecture
- Other (please specify)

 **Display This Question:**
 If Please indicate which of the following sources have provi... **Continuing Education (workshops, lectures, etc.) Is Selected Edit**

Q21



Please indicate the number of hours of continuing education you have earned regarding childhood apraxia of speech (CAS).

- Less than 4 hours
- 5-8 hours
- 9-13 hours
- More than 14 hours

Q22



Please indicate the likelihood that you will seek new information about childhood apraxia of speech (CAS) from the following sources:

	Very Likely	Somewhat Likely	Somewhat Unlikely	Very Unlikely
Colleagues	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Continuing Education (workshops, lectures, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Message Boards	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Scholarly Articles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
University Courses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Websites	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>