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Current Best Practices in the Evaluation & Management of CAS: A Multidimensional Approach

Guest Editor: Kimberly Farinella, PhD, CCC-SLP

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Part 1: Evaluation of Childhood Apraxia of Speech

Amy Skinder-Meredith, PhD, CCC-SLP

Moderated by:
Amy Hansen, MA, CCC-SLP, Managing Editor, SpeechPathology.com

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Evaluation of Childhood Apraxia of Speech

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ASHA Disclosure statement

- My name is Amy Skinder-Meredith. I am a Clinical Professor employed by Washington State University in Spokane, WA.
- Disclosure:
  - **Financial-** I provide workshops for CASANA, Speech Pathology.com, and PESI and receive an honorarium for these workshops.
  - I am receiving an honorarium for this seminar.
  - **Nonfinancia**l-I am on the CASANA advisory board.
  - **Nonfinancia**l-I am a member of WSLHA and ASHA

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Webinar Objectives

1. List three key characteristics of CAS.
2. Describe how to differentially diagnose apraxia of speech from phonologic delay, dysarthria, and other communication disorders that can result in speech delay.
3. Explain how to determine where to start treatment, based on assessment results.

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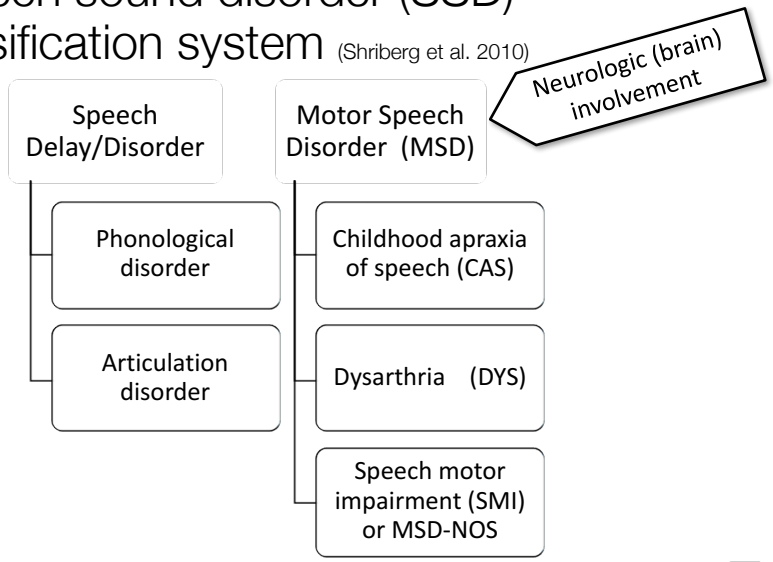
What do we know about CAS?

Speech sound disorder (SSD) classification system (Shriberg et al. 2010)



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How do we define CAS?

- ***Childhood apraxia of speech*** 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).
- CAS may occur as a result of known neurological impairment, in association with complex neurobehavioral disorders of **known or unknown origin**, or as an idiopathic neurogenic speech sound disorder.
- The core impairment in planning and/or programming spatiotemporal parameters of **movement sequences results in errors in speech sound production and prosody** (ASHA, 2007, p. 3-4).

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Core Characteristics of CAS (ASHA, 2007)

1. *Inconsistent errors* on consonants and vowels in repeated productions of syllables or words.
   - *Kindergarten: kigergarden, dingergaren, dindergargen*
2. *Lengthened and disrupted coarticulatory transitions* between sounds and syllables.
   - Want- to- p-lay?
3. *Inappropriate prosody*, especially in the realization of lexical or phrasal stress.
   - HE IS GO-ING vs. HE is GOing.

10 characteristics of CAS (Shriberg et al., 2017a)

Segmental Errors

1. Vowel errors
2. Voicing errors
3. Distorted substitutions
4. Difficulty achieving articulatory configurations or transitory movement gestures
5. Groping
6. Intrusive schwa (gəreen/green; manə)
7. Increased difficulty with multisyllabic words

Suprasegmental Errors

1. Syllable segregation
2. Slow rate/slow diadochokinetic rates (slow DDK)
3. Equal stress or lexical stress errors

Language Characteristics

- **Receptive language >expressive language**
  - HOWEVER performance may vary according to the task (e.g., receptive one-word vocabulary may be age appropriate while comprehension of complex sentences is impaired.)
  - Crary (1993) states AT LEAST three areas of comprehension be assessed
    - semantic comprehension
    - syntactic comprehension
    - influence of increased length of input

Language Characteristics

- **Expressive language**
  - Pronoun errors
  - Syntactic errors
  - Word omissions

(Ekelman & Aram, 1983)

Metalinguistic and Literacy Characteristics of children with CAS (ASHA Technical Report, 2007; Bird et al., 1995; Lewis et al., 2004)

- At risk for phonological awareness deficits (important for literacy development)
- Deficits in:
  - rhyming (producing rhymes)
  - word attack, word identification, and spelling
  - phonological perception
  - phonological discrimination
  - phonological memory

Other deficits revealed with Syllable Repetition Task (SRT) (Shriberg, Lohmeier, Strand & Jakielski, 2012)

- Task requires child to repeat 2-syllable, 3-syllable and 4-syllable non sense words with early developing sounds (e.g., bada, bamana, bamadana)
  - Children with CAS had significantly lower SRT competence, encoding, memory, and transcoding scores than controls (typical and other SSDs)
  - Hence, there are *speech processing deficits* in:
    1. **Encoding**-requires short-term representations of the non-word stimuli, adequate peripheral hearing, accurate auditory-perceptual encoding of the salient features of speech sounds
    2. **Memory**-STM, difficulty remembering longer sequences of sounds
    3. **Transcoding**-had more sound additions(e.g., banda for bada)

Pause Marker (PM) (Shriberg et al., 2017a, 2017b, 2017c, 2017d)

- "The PM defines a between-words pause as any between-words period of at least 150 ms in which there is no speech." (Shriberg, et al., 2017a, p. S1108)
- "A PM score is the percentage of occurrence of four types of inappropriate between-words pauses in a continuous speech sample. A PM score is calculated by dividing the number of such pauses in a continuous speech sample by the number of between/word pause opportunities." (Shriberg et al., 2017d, p. S1154)
- PM scores below 94% meets the criterion for CAS.
- PM Scores of 94-95.9% plus two of three supplemental pause marker signs (slow artic rate, inappropriate sentential stress, & transcoding errors) = marginally positive for CAS

How to differentiate CAS from other speech sound disorders

Articulation delay/disorder:

- Difficulty in coordinating the articulators in production of a **limited** set of sounds; difficulty with the motoric aspects of speech production (Small, 1998).
  - *The most common articulation errors in English include 'r', 's', and 'l'.*
  - *These errors are fairly consistent*
  - *Prosody is intact*
  - *Vowels are intact*

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Phonologic Delay/Disorder

- Difficulty in speech sound production resulting in multiple speech sound errors ultimately involving the sound system of a language (Small, 1998).
  - Consistent patterns of phonological processes will become evident when doing a careful phonologic analysis
  - Prosody is intact
  - Vowels are intact

Phonological process	example
Deletion of Final Consonants:	'do' for 'dog'
Syllable Reduction:	'pupu' for 'purple'
Stopping:	'*d*ip' for '*z*ip'
Cluster Simplification:	'*t*ee' for '*tr*ee'
Liquid Simplification:	'*w*un' for '*r*un'
Velar Fronting:	'*t*ate' for 'c*k*ake'
Palatal Fronting:	's*h*ip' for 's*h*ip'
Deaffrication:	's*h*oe' for 'c*h*ew'
Initial Voicing:	'*d*o' for '*t*wo'
Final Devoicing:	'fu*ss*' for 'fu*zz*'

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Dysarthria

- Weakness and/or discoordination of the muscles needed for speech-may include muscles for respiration, phonation, resonance, and articulation.
  - Errors are fairly consistent
  - Articulation is imprecise and distorted in general
    - Ataxic and hyperkinetic dysarthria has other characteristics
  - Speech will improve when there is an increase in drive or muscular effort, as in the case of yelling
  - Prosody will most likely be affected
    - May have difficulty controlling pitch and loudness variation

Intellectual Development Disorder-IDD)

- DSM V classifies as a neurodevelopmental disorder of brain development.
- Their speech is delayed, but may also be at the same level as their receptive language skills.
  - *Expectations* of motor speech skills need to be in line with other delays the child has.

Cluttering

- In cluttering, the breakdowns in clarity that accompany a perceived rapid and/or irregular speech rate are often characterized by deletion and/or collapsing of syllables (e.g., "I wanwatevision") and/or omission of word endings (e.g., "Turn the televisoff"). (http://www.asha.org/PRPSpecificTopic.aspx?folderid=8589935336&section=Overview#Cluttering)

Selective Mutism

- Anxiety disorder-fear of communication
- Can co-occur with and without a speech sound disorders

(good resource: Kotrba, Aimee (2015). *Selective Mutism: An Assessment and Intervention Guide for Therapists, Educators & Parents*)

Overview of Assessing CAS

What should the assessment accomplish?

- SLP should be able to determine the nature of the motor planning deficit in relation to any other deficits, such as intelligence, linguistic, and motor execution, so that he or she can may make reasonable decisions as to the **relative contribution of the disorder to the child's overall communicative performance**.
- CAS may be (and often is) exhibited along with any number of other deficits and strengths for any particular child.

(Caruso & Strand, 1999)

Basic conceptualization of the processes involved in speech production (Strand, 1996)

Ideation	Communicative Intent	**Cognitive**
Symbolization	Word Retrieval Phonologic Mapping Syntactical Framing Stress assignment	**Linguistic**
Motor Planning & Motor Programming	Specify Movement Parameters * range of motion * strength * speed * direction * degree of muscle contraction	**Motor**
Acoustic Output	Move Muscles Involved * respiration * phonation * resonance * articulation	**Motor**

The assessment should look at the whole child

- *Developmental History*
- *Neuromuscular condition*
- *Structural-Functional (Oral-Peripheral) Examination*
- *Examination of Physiological Parameters*
- *Motor Speech Examination*
- *Articulation Testing and Phonologic Analysis of Speech Errors*
- *Receptive and Expressive Language*
- *Phonologic awareness and literacy skills*
- *Hearing Evaluation*
- *Cognitive/Intelligence*

Developmental History

- Children with CAS are often described as having the following characteristics:
  - Quiet baby, little babbling
  - Limited sound repertoire and vocal output
  - Limited intonation patterns
  - Delayed first words
  - Difficulty putting a C-V together-limited word shapes
  - Reduced syllable shapes
  - Possible groping or uncoordinated feeding

(Davis & Velleman, 2000 & Overby & Caspari, 2015)

Neuromuscular Condition

- Observe *tone*
  - Normal, hypotonic (floppy) or hypertonic (rigid)?
- *Reflexes*-are there reflexes that shouldn't be there any more or are there reflexes that should be there but aren't?
- *Strength*-is there weakness?
- *Symmetry*-do both sides look the same?
  - Atrophy-muscle shrinkage
  - Hypertrophy- muscle or tissue looks bigger than expected
- *Gait*-how does the child walk?
  - Is it broad based, as if having difficulty with balance?
  - Is the movement clumsy?
  - Does one side look weaker than the other?

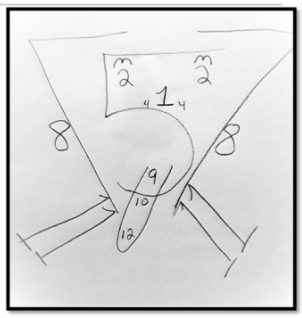
Structural-Functional Examination

- Is there a *dysarthric* component to the child's communication impairment?
  - *Dysarthria*: group of speech disorders caused by disturbances in the strength or coordination of the muscles of the speech mechanism as a result of damage to the brain or nerves.
  - Observations about the muscles needed for speech and nerves that innervate them should be stated.

Testing cranial nerves for speech

- *CN V-Trigeminal nerve*
  - Provides motor for the jaw and sensory for the face and teeth
  - Tasks
    - Move lower jaw side to side
    - Close and open jaw with resistance
- *CN VII-Facial nerve*
  - Provides motor to the face and sensory to the anterior 2/3rds of the tongue
  - Tasks
    - Smile-pucker
    - Hold lips together while resisting opening at the four corners

Cranial nerves for speech



- *CN IX-Glossopharyngeal & CN X-Vagus*
  - Provides motor to the larynx and pharynx
  - Important for swallowing and voice
  - Tasks
    - Swallow
    - Raise and lower pitch
    - Sustain 'ah'-listen to voice quality and resonance
    - Say ah-ah-ah in a staccato fashion-look for efficient timing of velar raising
- *CN XII-hypoglossal nerve*
  - Provides motor for the tongue
  - Tasks
    - Move tongue side to side, elevate, depress
    - Move against resistance laterally and protruded

Structural-Functional Examination

- Look for the following during movement and at rest:
  - Symmetry
  - Adventitious movement (i.e., involuntary movement, such as tremors, myoclonic jerks)
  - Strength
  - Tone (state of muscle at rest)
  - Range of motion
  - Coordination
  - Ability to vary tension

Examination of Physiological Parameters

- *Respiration*: Is there enough breath support for speech?
  - Sustain 5cm for 5sec
  - Max voluntary phonation duration (MVPD)
    - Kids aged 2:6-2:11 can sustain for an average of 5.55 seconds.
    - As the child ages, the length increases.
    - Children 6:6-6:11 can sustain phonation for an average of 11.47 seconds

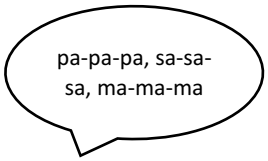
    (Norms can be found at Robbins & Klee, 1987 http://jshd.pubs.asha.org/article.aspx?articleid=1775347)

5 cm

Examination of Physiological Parameters

- *Phonation*:
  - Ability to change pitch and loudness
  - Voice quality
  - Sustain phonation
  - Cough
  - Glottal coup
  - Pitch range, shimmer and jitter measures can be obtained with PRAAT (https://praat.en.softonic.com/)

Examination of Physiological Parameters



- *Articulation*-Is articulatory movement sufficient for speech?
- *Resonance*-
  - Can the velopharyngeal port close off the nasal cavity for all sounds except for m, n, and ng?
  - Have child repeat oral and nasal syllables if unable to repeat phrases.
  - Does the child sound hypernasal, hyponasal, or mixed?
  - Is it consistent, inconsistent, or sound specific?

Summarizing motor execution

- The evaluation should indicate that structure, function, and physiology were assessed.
- Summary statement may state that:
  - All structures for speech are *within normal limits* (WNL) or *within functional limits* (WFL)
  - OR note weakness, decreased speed, decreased range of motion, or decreased coordination of specific structures needed for speech.
  - Note the physiological support needed for speech is WNL, WFL, or impaired.

Motor Speech Evaluation

- Determines motor planning ability for speech
- Examine ability to sequence sounds in various contexts.
  - CV; VC; CVC (using various vowels)
  - monosyllabic word repetition with same consonants (mom)
  - Monosyllabic with different consonants (e.g., mop)
  - Bisyllabic word repetition (mama, mommy, patty)
  - multisyllabic word repetition
  - Repetition of words of increasing length (e.g., zip, zipper, zippering)
  - phrase repetition of increasing length
- Comparison of automatic speech (e.g., counting, days of the week) to novel utterances.

Motor Speech Evaluation

- Be ***dynamic*** in the assessment to determine what level of cuing is needed for success
  - Assess the ability to produce particular sound sequences while varying the temporal relationship between stimulus and response
    1. *Immediate Repetition-the* child repeats it right after the examiner (if incorrect, try simultaneous)
    2. *Simultaneous*-the child and examiner says the utterance together

    (if incorrect, add tactile cues)

Dynamic Evaluation of Motor Speech Skill (DEMSS) (Strand, et al., 2013)

- *DEMSS*-Designed to assess CAS in young children with CAS:
  - Words and phrases of increasing length with varying temporal and tactile parameters
  - Consistency of errors
  - Vowel errors
  - Lexical stress errors

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Example protocol derived from Strand et al., 2013 framework

- Use early developing sounds
- Stimuli also includes
  - C_1VC_1 (mom)
  - C_1VC_2 (mad)
  - $C_1V_1C_1V_2$ (mommy)
  - $C_1V_1C_2V_2$ (bunny)
  - multi-syllabic words
  - phrases of increasing length

Utterance Type	Overall articulatory accuracy 0 = Immediate correct repetition. 1 = Immediate, accurate rate and movement but consistent error. 2= correct after first cued attempt 3 = Needs cuing (multiple cues) 4 = No correct response. X=Refusal/inattention/no	Vowel accuracy 0 = Immediate correct repetition of the vowel 1 = Mild distortion 2 = Frank distortion *On first attempt*	Prosodic accuracy 0 = Correct 1 = Incorrect *On first attempt*	Consistency 0 = Consistent 1 = Inconsistent *On any 2 or more trials*
CV				
1. me	0 1 2 3 4 X	**0 1 2**		**0 1**
2. hi	0 1 2 3 4 X	0 1 2		**0 1**
3. boy	0 1 2 3 4 X	0 1 2		**0 1**
4. do	0 1 2 3 4 X	0 1 2		**0 1**
5. no	0 1 2 3 4 X	0 1 2		**0 1**
6. may	0 1 2 3 4 X	0 1 2		**0 1**
7. pie	0 1 2 3 4 X	0 1 2		**0 1**
Subtotal of each #				
VC syllables				
1. eat	0 1 2 3 4 X	0 1 2		0 1
2. on	0 1 2 3 4 X	0 1 2		0 1
3. in	0 1 2 3 4 X	0 1 2		0 1
4. up	0 1 2 3 4 X	0 1 2		0 1
5. off	0 1 2 3 4 X	0 1 2		0 1
6. eight	0 1 2 3 4 X	0 1 2		0 1
7. I'm	0 1 2 3 4 X	0 1 2		0 1
Subtotal of each #				
Re-duplicated syllables				
1. mama	0 1 2 3 4 X		**0 1**	
2. booboo	0 1 2 3 4 X		**0 1**	
3. bye bye	0 1 2 3 4 X		**0 1**	
4. papa	0 1 2 3 4 X		**0 1**	
Subtotal of each #				

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Non-verbal oral apraxia

- Test for ability to volitionally sequence non-speech oral movement
  - Pucker
  - Pucker-smile
  - Pucker-smile-blow
- Need to be able to differentiate dysarthria from non-verbal oral apraxia
- *Not necessary to treat the oral apraxia, but it will need to be taken into consideration when treating the verbal apraxia.*

Other measures to assist with motor speech assessment

- Spontaneous speech sample
  - The SLP will be able to make observations about:
    - Expressive language skills (if they can understand the child well enough)
    - Articulation skills
    - Prosody – the melody of speech including pitch, loudness, phrasing, pauses
    - Resonance- is it hypernasal, hyponasal, mixed, normal?
    - Breath support- how many syllables can the child say in one breath group?
    - Fluency
    - Any noticeable groping?

Consistency of errors

- Does the child make consistent errors or do they vary?
  - E.g., says telephone as t-e-fo once and then le-te-po the next time
  - The SLP may have the child repeat a set of words multiple times to determine consistency of errors.
  - Assessments that look at consistency of errors
    - Dodd, author of ***Diagnostic Evaluation of Articulation and Phonology (DEAP)***, classifies speech productions that are 40% inconsistent or more as being inconsistent.
    - LAT (Linguisystems Articulation Test) built in CAS screener – 12 target words said 3 times each plus "Tell-A-Story" for intelligibility rating
    - DEMSS (Strand & McCauley, in press)

Diadochokinesis Tasks (DDK)

- Sequential motion rate (SMR) of individual syllables: pa, ta, ka
- Alternating motion rate (AMR) Repetition of alternating syllables, such as, pataka (or patticake or buttercup)
- The SLP may note:
  - Rate of speech – compared to normative data
  - Voicing errors-e.g., does pa turn into ba?
  - Ability to sequence the syllables
- Polysyllabic production accuracy and DDK, as part of the oral motor exam, may be sufficient to reliably diagnose CAS and rule out dysarthria (Murray, et al., 2015).

Published Assessments & Screeners for CAS/MSD

- *Verbal Motor Production Assessment for Children (VMPAC)* (Hayden & Square, 1999)-
  - Assesses for any motor impairment (dysarthria and apraxia)
  - provides normative data for comparison
- *The Apraxia Profile/Checklist* (Hickman, 1997)
- *The Kaufman Speech Praxis Test for Children* (1995)
- *Dynamic Evaluation of Motor Speech Skill DEMSS)* (Strand & McCauley, in press)
- LinguiSystems Articulation Test (Bowers & Huisingh, 2011)
- *Screening test for Developmental apraxia of Speech-2* (Blakely, 2000)

Assessment of Articulation Skills

(Eisenberg & Hitchcock, 2010; Macrae, 2017)

- Typically assess all sounds in all word positions at the single word level.
- *Norm-referenced Tests that assess vowels*
  - *Arizona Articulation Proficiency Scale-3 (AAPS-3)*
  - *Diagnostic Evaluation of Articulation and Phonology (DEAP)*
  - *Hodson Assessment of Phonological Patterns-3rd edition (HAPP-3)*
  - *Photo-articulation test-3rd edition (PAT-3)*
- Norm-referenced tests that go beyond the one word level.
  - Clinical Assessment of Articulation and Phonology- 2nd ed. (CAAP-2)
  - DEAP
  - Goldman Fristoe Test of Articulation-3rd ed. (GFTA-3)
  - Structured Photographic Articulation Test II (SPAT-DII)

Assessment of Phonological Processes or Patterns

- Phonological processes analysis
  - Looks for *patterns* in the child's speech errors
  - Examples of tests include:
    - *HAAP-3*
    - *CAAP-2*
    - *Kahn-Lewis Phonological Analysis-3* to be used with the *GFTA-3*
    - *DEAP*
- Results can help differentiate between a phonological delay, apraxia, or a combination of both.

CONTINUED

Language Assessments

- Receptive Language Skills
  - *Semantics* (word meaning/vocabulary)
  - *Morphology* (this includes sentence structure and the understanding of plurals, prepositions, verb tense, etc.)
  - Sentences of increasing length and complexity
  - Following directions
  - Reading for school-age children

CONTINUED

Language Assessments

- Expressive Language Skills
  - Vocabulary
  - Morphology
  - Syntax
  - Word finding
  - Writing for school-age children
  - Pragmatics & Social Language

Phonological and Phonemic Awareness Skills

- Examples of phonemic and phonologic awareness skills:
  - Rhyming
  - Segmentation (divide sentences into constituent words; divide words into syllables; and divide words into phonemes
  - Isolation (identify the initial, final, and medial sounds in words)
  - Deletion (what's 'coat' without the 'c'?)
  - Substitution (what's 'coat' if you take away 'c' and put in 'm')
  - Blending (what does c-a-t say?)
  - Graphemes (what sound does this letter make?)
  - Decoding (what word do these letters make?)

  *Sound-letter awareness, segmenting, and blending are crucial for learning to read and write.

Phonological Awareness and Language & Literacy Assessments

- Comprehensive Test of Phonological Processing-2nd edition (CTOPP-2)
  - Assesses phonological awareness, phonological memory, and rapid naming
  - Ages 4-24
- Test of Integrated Language and Literacy Skills (TILLS)
  - assesses speech perception and production, decoding and spelling, comprehension, and story recall
  - Ages 6-18

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Summary of language skills

- Children with CAS tend to have a receptive-expressive language gap.
  - Test scores should show this, in addition to parent report.
- Deficits may also be seen in phonological processing, reading and writing in school-age children.

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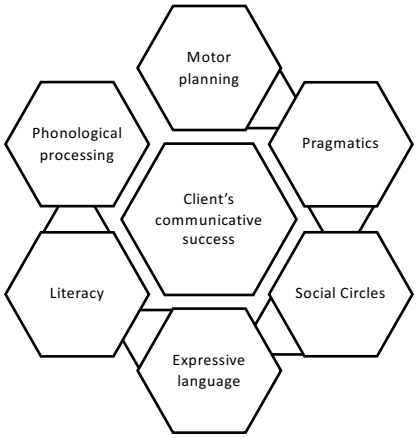
Putting the pieces together and where to go from here…..



Is there a case for CAS?

- What's your evidence?
- What symptoms does this child present that allow the SLP to differentiate from other disorders?
  - Consistency of errors?
  - Presence of vowel errors?
  - Disordered prosody?
  - Increased errors on increasing length of utterance?
  - Inappropriate pauses?
  - Difficulty sequencing sounds and syllables?

What if there is more than just CAS?

- Which symptoms suggest a dysarthric component vs. apraxic or phonologic vs. apraxic?
- Are there phonologic processing concerns?
- Are there any other symptoms that may suggest difficulties with word finding, memory, expressive language delay, etc.

CONTINUED

VERY IMPORTANT

- A child is rarely ever JUST APRAXIC!
- Don't let the diagnosis of apraxia be the only diagnosis when there's more going on.
- Don't assume that because the child has apraxia their other symptoms are part of the CAS diagnosis, (e.g., poor phonological awareness, poor reading and writing skills, challenging behaviors, etc.)
- The SLP should be very clear about ALL of the factors contributing to the child's communication disorder, as well as the child's success.

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Recommendations

- Recommendations need to reflect **all** areas requiring intervention
- In the case of motor planning, the motor speech assessment results will lead to the specific recommendations to improve speech intelligibility
- Look at what the child was able to accomplish with and without cuing:
  - phonemic repertoire (independent repertoire and what was stimulable
  - syllable shapes (CV, VC, CVC, CCVC, CVCC)
  - word length (how many syllables)
  - phrase length

Determine targets for treatment

- For phrases to be functional, talk with parents.
  - Use the *Functional Communication Parent Questionnaire* (Wilson & Gildersleeve-Neumann) (https://www.pdx.edu/sphr/sites/www.pdx.edu.sphr/files/Parent%20Questionnaire.pdf)
- Probe potential targets and facilitators for correct production

1. direct imitation only
2. direct imitation with miming
3. simultaneous
4. simultaneous with tactile cue

NC = Never correct

target	Level of cuing	PCC	PVC	PPC
Hi mom				
Me too!				
Help me				
I do				
Wanna play?				

Find what will facilitate correct articulatory movement and sequencing

- Simultaneous production with tactile cues
- Graphemic cues
- Sentences with picture symbols
- Say and Do (Perkins Faulk & Priddy, 2005)
- Video modeling
- Tasty tactile cues

Pictured sentence strip created with PictureIt software

To Summarize

- Assessment needs to look at the whole child.
- The motor speech assessment should be ***dynamic*** to allow the clinician to know what level to work on and what cues are most helpful.
- Keep in mind functional phrases that will serve the greatest need when determining targets.
- Note all areas of concern in the report and prioritize treatment in a way that reflects the relative contribution of the child's needs for successful communication and academics.

Questions?

Thank You!

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