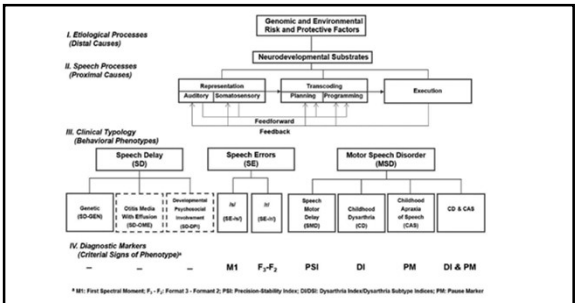
Differential Diagnosis of Childhood Apraxia of Speech



The Speech Disorders Classification System-used for research

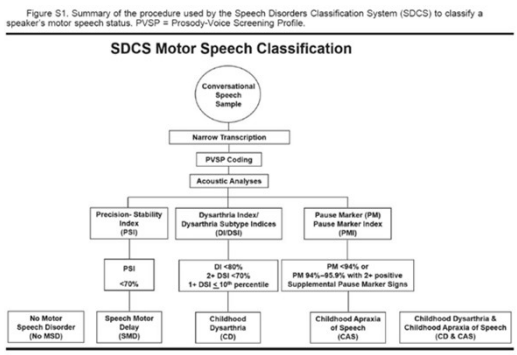
Shriberg, L., Kwiatkowski, J. & Mabie, H. (2019) Estimates of the prevalence of motor speech disorders in children with idiopathic speech delay, *Clinical Linguistics & Phonetics, 33:8*, 679-706, DOI: 10.1080/02699206.2019.1595731

Disclosure statement

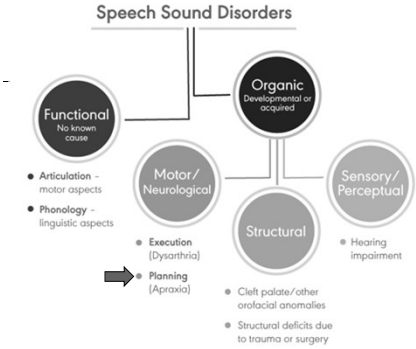
My name is Amy Skinder-Meredith. I am a Clinical Professor employed by Washington State University in Spokane, WA.

Disclosure:

- **Financial-** I provide workshops for ASHA, SpeechPathology.com, and Apraxia Kids, which I receive an honorarium for. I am also receiving an honorarium for this workshop.
- **Nonfinancia**l-I am on the Apraxia Kids advisory council.
- **Nonfinancia**l-I am a member of WSLHA and ASHA



Motor Speech Disorders in Idiopathic Speech Delay and in Complex Neurodevelopmental Disorders Using the Speech Disorders Classification System: Supplement (Shriberg et al., 2019)



https://www.asha.org/practice-portal/clinical-topics/articulation-and-phonology/

What are motor speech disorders?

- The term motor speech disorders is used to denote a collection of communication disorders involving the retrieval and activation of motor plans for speech, OR the execution of movements for speech production.
- The two major subcategories are ***apraxia*** and ***dysarthria*** of speech.
- Children may also have a **motor speech delay**.

CAS Definition (ASHA, 2007)

- 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).
  - *This does NOT mean it cannot co-exist with these issues, however.*
  - A child can have both CAS and CD and a craniofacial anomaly. (e.g., 22q11.2 deletion syndrome)

CAS can influence other areas.

The presence of CAS influences the development of phonology and other language processes.

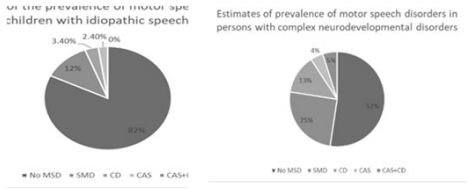
Thus, children with motor planning and programming deficits will also exhibit phonologic and perhaps other linguistic deficits.

Delays in speech development may occur because of concomitant delays or deviancies in *both* phonologic and motor processing.

(Caruso & E. Strand, 1999).

CAS Definition (ASHA, 2007)

- 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.



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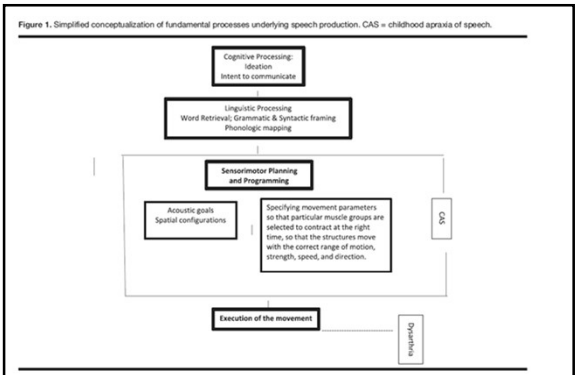


Strand, E. A., (2020). Dynamic temporal and tactile curing: A treatment strategy for Childhood Apraxia of Speech, American Journal of Speech Language Pathology, 29, 30-48.

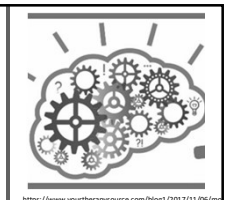
CAS Definition (ASHA, 2007)

The core impairment in planning and/or programming *spatiotemporal parameters* of movement sequences results in errors in speech sound production and prosody.

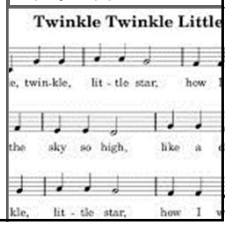
https://www.youtube.com/watch?v=uTOhDqhCKQs

What is the underlying deficit?

- A motor programming/planning deficit is responsible (Hall, Jordan & Robin, 1993; Rosenbek & Wertz, 1972).
- There is a breakdown in linguistic processes relating to a subtype of CAS where prosodic errors are a diagnostic marker. (Shriberg, Aram, & Kwiatkowski, 1997)

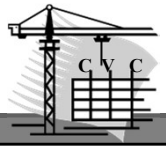


https://www.yourtherapysource.com/blog1/2017/11/06/motor-planning-cerebral-palsy/



Underlying Deficit Theories

- **Impaired ability to generate and utilize frames**, which would otherwise provide the mechanisms for analyzing, organizing, and utilizing information from their motor, sensory, and linguistic systems for the production of spoken language (Velleman & K. Strand, 1994).



Underlying Deficit Theories

- There is an interdependence of perception and production Groenen, Maassen, Crul, and Thoonen (1996; 2003). In other words, if the child doesn't hear the word correctly, he/she won't produce it correctly.
  - Children with CAS had difficulty discriminating consonants with subtle acoustic differences associated with place of articulation.
  - They also had difficulty with ID and discrimination of vowels.
- However, Zuk et al., 2018 found only children with CAS and language delay had poor speech perception.
  - Speech perception was measured by discrimination of /da/-/ga/ synthesized syllable continua that varied in frequency.

Underlying Deficit Theories

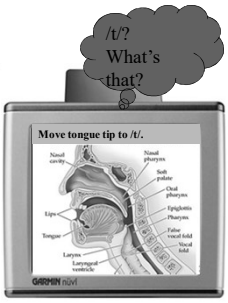
- The linguistic integrity of underlying phonological structures may be compromised.
  - dissolution of the neural substrates representing the phonologic framework of the child's speech motor programming performance (Marquardt, Sussman & Snow, 1998).

Underlying Deficit Theories

- Speech errors are due to impaired sensorimotor integration, due to missing rich sensory feedback and rhythmic coordination during the babbling period if the child is reported to have been a "quiet baby".
- There is an impairment of sensory processing and in particular proprioceptive input with an ensuing failure to program, organize, and carry out movements necessary for expressive speech. (Nelson, 1995)

Potential underlying deficit theories.

- "speech motor output would be severely handicapped as the **phonological targets** driving articulation **may be totally missing** or in various states of marginal operational integrity" (Marion et al., 1993).



Vocal tract image from: http://www.dukemagazine.duke.edu/issues/050608/images/050608-lg-figure1purves.jpg

Underlying Deficit -Clinal Implication

If children do not develop clear brain maps it affects development of speech, grammar and ultimately, reading.

- The ability to phonically decode for reading depends on the clarity of the brain maps.

Burnes, 2014 webinar on APD, dyslexia, & CAS

It's important to note that:

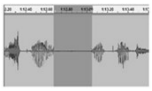
CAS may be (and often is) exhibited along with any number of other deficits and strengths for any child.

Our goal -be as informed as possible regarding the nature of the motor planning deficit (in relation to any other deficits, such as cognitive, linguistic, and motor execution)

- Be able to answer, "**What is the relative contribution of the disorder to the child's overall communicative performance?**" (E. Strand, 1996)

Pause Marker-gap between words

- Shriberg et al. (2017) proposed the Pause Marker (PM) as a single sign to differentiate children with CAS from children with other SSDs.
- Defined as pauses between-words of 150 ms or more.
- To be counted, these pauses need to be:
  - In conversational speech
  - Linguistically inappropriate
  - Part of an intelligible utterance
- Inappropriate pauses may reflect two core features of CAS
  - Deficits in the auditory-perceptual and memory elements of presentational processes
  - Difficulty with planning and programming movements for speech



Core Characteristics (ASHA, 2007)

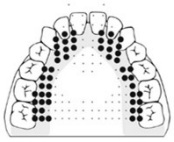
1. *Inconsistent errors* on consonants and vowels in repeated productions of syllables or words.
   - E.g., /efo/, /te-fo/, /te-e-o/ for 'telephone'
2. *Inappropriate prosody*, especially in the realization of lexical or phrasal stress.
   - Cho'ca'late'
3. *Lengthened and disrupted coarticulatory transitions* between sounds and syllables.
   - b(….) us

**A child may need to be at least 3 years old to demonstrate these characteristics.*

CAS-Articulatory Characteristics

Disturbance in temporal spatial relationship of the articulators

- Imprecise, nonspecific speech gestures
- *Palatometry* data suggest that children with apraxia do not develop the more finely tuned speech movements with any specificity or precision. (Gibbons, 2002)



https://completespeech.com/smartpalate/

Frequently used criteria in research Shriberg et al., 2017

Table 2. Pediatric adaptation of the Mayo Clinic System (MCS) to classify childhood apraxia of speech (CAS).

Ten Linguistic Domains Analytics		Motor Speech Disorder–Childhood Apraxia of Speech
Segmental	1. Vowels	1. Vowel distortions
	2. Consonants	2. Voicing errors
	3. Vowels and consonants	3. Distorted substitutions
		4. Difficulty achieving initial articulatory configurations or transitionary movement gestures
		5. Groping
		6. Intrusive schwa
		7. Increased difficulty with multisyllabic words
Suprasegmental		
Prosody	4. Phrasing	8. Syllable segregation
	5. Rate	9. Slow speech rate and/or slow diadochokinetic rates
	6. Stress	10. Equal stress or lexical stress errors
Voice	7. Loudness	
	8. Pitch	
	9. Laryngeal quality	
	10. Resonance	

Note. Signs are organized using the Ten Linguistic Domains Analytics (TLDA) in the Speech Disorders Classification System (Shriberg et al., 2010a). To be classified as positive for CAS using the MCS, a speaker is required to meet criteria for at least 4 of the 10 listed signs occurring in at least 3 of the 17 speech tasks in the Madison Speech Assessment Protocol (Shriberg et al., 2010a).

Language Implications

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

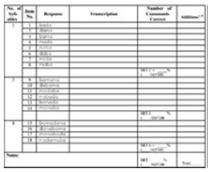
Language Implications

- **Expressive language**
  - Pronoun errors
  - Syntactic errors
  - Word omissions
  - (Ekelman & Aram, 1983)

Other deficits revealed with SRT task (Shriberg, Lohmeier, Strand & Jakielski, 2012)

Non-word repetition task-syllable repetition task(SRT)

- Children with CAS had significantly lower SRT competence, encoding, memory, and transcoding scores than controls (TD and other SSDs)
- *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)



http://www2.waisman.wisc.edu/phonology/techreports/TREP14.pdf

Metalinguistic and Literacy Characteristics of children with CAS (ASHA Technical Report, 2007; Caspari, 2007)

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

Neurological Implications

A high incidence of "subtle" or "soft" signs often (but not always) appear as an associated characteristic of CAS.

These include:

1. fine and gross motor incoordination
2. difficulties with gait
3. difficulties with alternating repetitive movement

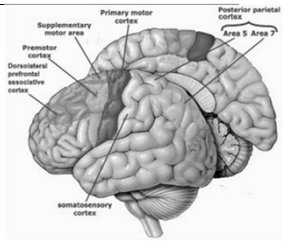
*49% of children with sCAS had possible DCD in a pilot study (Duchow et al., 2019)

CAS and Literacy

- Miller et al., 2019 investigated speech-language correlates of decoding disorders in children with sCAS and to ID predictors of poor reading skills.
- 7-18 y/o children with sCAS were compared to children with SSD and no CAS.
- 65% of children with sCAS and 24% of those with SSD only were classified as low-proficiency readers.
- Language and phonological awareness deficits of children with sCAS are related to their risks for reading failure.
- Motor speech deficits and speech sound production also increased risks for reading difficulties.

Liégeois, Morgan, Connelly, and Vargha-Khadem (2011)

..Results indicated that "repetition in the affected members was severely impaired, and brain activation was significantly reduced in the **premotor, supplementary and primary motor cortices, as well as in the cerebellum and basal ganglia."(**p. 283)



http://thebrain.mcgill.ca/flash/a/a_06/a_06_cr/a_06_cr_mou/a_06_cr_mou_1a.jpg

Neural bases of childhood speech disorders

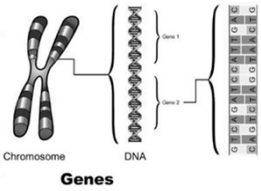
- "… long term and severe childhood speech disorders result predominantly from bilateral disruption of the neural networks involved in speech production" (Liegeois FJ, Morgan AT, 2012, p. 439)
  - No evidence of unilateral lesions has been found.
- MRI data that examined cortical thickness in areas of interest for children with and without CAS found "children with idiopathic apraxia had significantly thicker left posterior supramarginal gyrus than controls. (Kadis et al., 2014)

Genetic Studies

KE family-KE family researched by Vargha-Khadem et al. (1995) in England found a mutation of the FOXP2 (SPCH 1) gene

Research by Lewis, Shriberg, Petr and others have NOT found this mutation in children they have studied with CAS.

16p11.2 microdeletions (Raca, et al, 2012)

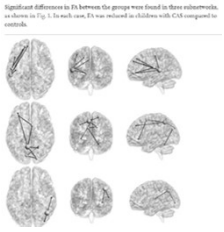


http://passel.unl.edu/Image/siteImages/ChromgendnaLG.jpg

DIFFERENTIAL DIAGNOSIS OF CHILDHOOD APRAXIA OF SPEECH
AMY SKINDER-MEREDITH, APRIL 10, 2021, ARSHA CONFERENCE

Neurological Findings using advanced diffusion imaging

- Fiori et al., (2016) examined structural connectivity using connectome analysis with advanced diffusion imaging analysis.
- Results showed kids with CAS had decreased activity in intra-hemispheric / interhemispheric subnetworks (SN)
  - SN 1 –altered connectivity centered on the L temporal regions
  - SN 2 included inter and intra-hemispheric connections of the L precunneus, R supplementary motor area, L cuneus and R cerebellum.
  - SN 3 included interhemispheric connections between the R angular gyrus, superior temporal gyrus, and inferior occipital gyrus



DIFFERENTIAL DIAGNOSIS OF CHILDHOOD APRAXIA OF SPEECH
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Genetic Studies

- **Galactosemia -**an inherited metabolic disorder that sometimes coincides with CAS (Weisbren et al., 2011)
- Several genes have implicated, but not all children with CAS have positive findings. (Laffin et al., 2012)
- Eighty percent of the children with CAS studied showed clinically reportable variants in one or two of 6 genes. (Worthey et al., 2013)
- 16p11.2 deletion (Fedorenko et al., 2016)-these kids have a variety of speech and language disorders, including CAS

DIFFERENTIAL DIAGNOSIS OF CHILDHOOD APRAXIA OF SPEECH
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Clinical Connections (Fiori et al., 2016)

Connectivity issues discovered correlate with deficits in:

- Feedback-based articulatory control
- Discrimination of phonemes
- Alteration in feed-forward mechanisms
- Motor planning
- Cognitive functioning
- Possible language functioning
- Conceptual planning during lexical search
- Action initiation
- Semantic processing

DIFFERENTIAL DIAGNOSIS OF CHILDHOOD APRAXIA OF SPEECH
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Genetic Studies

- Hillenbrand et al. (2020) Severe childhood speech disorder-Gene discovery highlights transcriptional dysregulation
  - Participants included 32 with CAS in isolation (n=13 -40.7%) or co-occurring with other SSDs of dysarthria (n=6-18.7%), phono delay or disorder (N=18-56.2%) or artic disorder (n=4 -12.5%)
  - found 9 novel genes for CAS
  - found to be a sporadic monogenic disorder
  - arising from a new mutation
  - genetically heterogenous
  - Data found CAS-implicated genes were highly co-expressed in the developing human brain

DIFFERENTIAL DIAGNOSIS OF CHILDHOOD APRAXIA OF SPEECH
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Assessment

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

How to differentiate CAS from other speech sound disorders

Dysarthria

- Weakness and/or discoordination of the muscles needed for speech-may include muscles for respiration, phonation, resonance, and articulation.
  - Errors are relatively 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

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'.*
  - *What are the most common errors in Portuguese?*
- *These errors are consistent*
- *Prosody is intact*
- *Vowels are intact*

Childhood Dysarthria

- Dysarthria subtypes are harder to discern in children than adults.
- When adult classification systems are used, the categorization is based more on symptoms than neurological differences.
- Difficulty is due to the functional differences between the developing and mature brains. *Why else might there be differences between childhood dysarthria and dysarthria acquired after brain maturation?*
- Structural changes can lead to symptomatic changes, such as growth of the vocal tract and changes in vocal fold tissue.
- Most commonly occurring types of dysarthria in children
  - Spastic
  - Ataxic
  - Hyperkinetic

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.

Autism

Study results are mixed on whether children with ASD have CAS or a different speech sound disorder, such as a motor speech delay. Overlapping symptoms include:

- Language communication impairment
- May have delayed articulation
- Typical and atypical phonological patterns
- Limited consonant inventory
- Disordered prosody

(Wolk, 2019)

- 14.3% of 42 children with ASD and an SSD fell into the motor speech delay category and % in CAS (Shriberg et al., 2019)

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

"I wanwatevision"

and/or omission of word endings

"Turn the televisoff"

https://www.asha.org/practice-portal/clinical-topics/fluency-disorders/

Speech Motor Delay

- Used to be called MSD-NOS
- Imprecise and/or unstable speech,
- prosody,
- and/or voice
- that does not meet the criteria for childhood dysarthria or CAS

Shriberg et al., 2019

Selective Mutism

Anxiety disorder-fear of communication

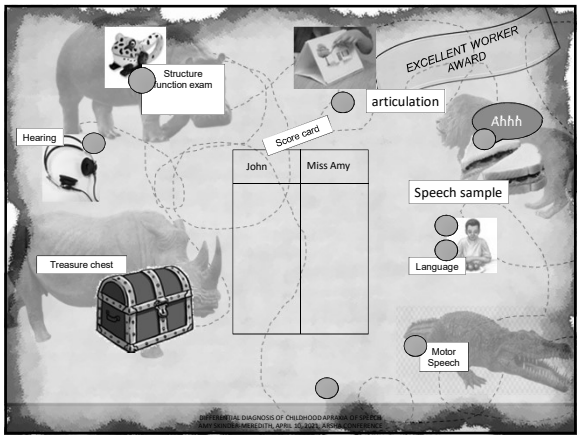
Can co-occur with and without a speech sound disorders

If sudden onset, child may have been exposed to trauma

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

Elements of Assessment for a Child with sCAS+

- *Hearing Evaluation*
- *Developmental History*
- *Neuromuscular condition*
- *Structural-Function-Praxis Exam*
- *Examination of Physiological Parameters*
- *Motor Speech Examination*
- *Articulation Testing and Phonologic Analysis of Speech Errors*
- *Receptive and Expressive Language*
- *Phonologic awareness and literacy skills*
- *Cognitive/Intelligence*



Screen for ASD with 16 early signs by 16 months

9. More interested in objects than people
10. Unusual ways of moving their fingers, hands, or body
11. Repeats unusual movements with objects
12. Develops rituals and may get upset over change
13. Excessive interest in particular objects or activities
14. Very focused on or attached to unusual objects
15. Unusual reaction to sounds, sights, or textures
16. Strong interest in unusual sensory experiences

En Española https://autismnavigator.com/16-signos-tempranos-de-autismo-a-los-16-meses-de-edad/#fb0=3

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)

Developmental History

Higher Receptive than Expressive Language Skills-

- Often typical for kids with CAS
- Can vary for kids with dysarthria
- Always test receptive skills. Parents frequently report that the child "understands everything", but language testing may show more subtle deficits.

Screen for ASD with 16 early signs by 16 months

1. Hard to get baby to look at you
2. Rarely shares enjoyment with you
3. Rarely shares their interests with you
4. Rarely responds to their name or other bids (e.g., come here, bye-bye)
5. Limited use of gestures such as show and point
6. Hard to look at you and use a gesture and sound
7. Little or no imitation of others or pretending
8. They may use your hand as a tool, while not looking at you

https://www.readingrockets.org/article/16-early-signs-autism-16-months

Examination of 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?

EXAMINATION OF NEUROMUSCULAR CONDITION

Are there any *involuntary movements*?

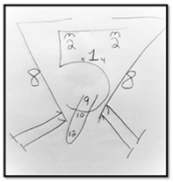
Fasciculations, spasms, myoclonus, tremors, chorea, dystonia, spasmodic torticollis

If so, this would be indicative of damage to the cerebellar control circuit or the basal control circuit, as in the case of ataxic, and athetoid movement disorders (e.g., Cerebral Palsy).

These are NOT typically associated with apraxia, but with *dysarthria*.

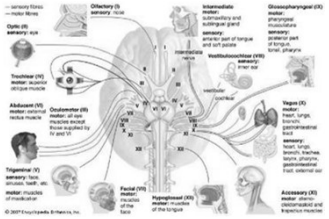
CN IX-Glossopharyngeal & CN X-Vagus

- 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



Cranial Nerve Exam

https://www.britannica.com/science/cranial-nerve



CN XII-Hypoglossal nerve

- Provides motor for the tongue
- Tasks
  - Move tongue side to side, elevate, depress
  - Move against resistance laterally and protruded
  - Children with MSD were found to have weaker tongues when compared to TD and children with speech delay (Potter, Nievergelt, & VanDam (2019)
  - Strength can be tested objectively with the Iowa Oral Performance Instrument
    - https://iopimedical.com/
  - Test subjectively with a tongue depressor or something flavored for more fun.

Testing cranial nerves for speech- part of the SFA

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

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

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.

Laryngeal function

- Cough-is there good adduction?
- Voice quality during sustained phonation
- Ability to vary pitch and loudness
- Is the child able to achieve adequate volume for speech?
- Is vocal quality breathy, harsh, or strained-strangled?
- Is there instability in the phonation?
- Are there voice breaks?
- Is there any stridor?

Examination of Physiologic Parameters of the Speech Subsystems

Respiratory function

- Sustained phonation
- DYS/CAS vs. CAS/PHONO
- 5 cmH2O for 5 seconds rule
- What else could you look at?
- 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

VP Function and Resonance

- Does the velopharyngeal port close off the nasal cavity for all sounds except for m, n, and ng?
- Use listening tube while comparing oral phrases to nasal phrases
  - E.g., *seis, tchau papai* versus *minhae mamãe*
- Have child repeat oral and nasal syllables if unable to repeat phrases.
  - Mama, nana, papa, si si si
- Does the child sound hypernasal, hyponasal, or mixed?
- Is it consistent, inconsistent, or sound specific?
- Pinching and releasing nares during 'pa'-is there a difference?

TABLE 3. Mean (*M*) and standard deviation (*SD*) of rate and duration measures for each age group and for the entire sample.

	/pʌ/		/tʌ/		/kʌ/		/pəɾəkə/		*patticake*		*Max phon time*	
Age group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
2:6–2:11	3.70	0.86	3.70	0.76	3.65	0.49	1.00	0.27	1.26	0.11	5.55	1.87
3:0–3:5	4.66	0.80	4.56	1.02	3.82	1.45	1.06	0.29	1.36	0.32	5.51	1.49
3:6–3:11	4.81	1.20	4.78	1.13	4.83	0.57	1.76	0.90	1.75	0.83	7.79	2.37
4:0–4:5	4.89	1.12	4.77	1.05	4.58	1.08	1.37	0.28	1.56	0.25	8.01	2.11
4:6–4:11	4.64	0.82	4.46	0.62	4.29	0.57	1.34	0.27	1.33	0.10	9.22	2.19
5:0–5:5	4.76	0.84	4.82	0.85	4.56	0.94	1.40	0.43	1.58	0.28	8.06	1.97
5:6–5:11	5.09	0.44	5.22	0.45	4.91	0.25	1.58	0.19	1.65	0.21	9.42	1.65
6:0–6:5	5.36	0.64	5.32	0.48	4.94	0.28	1.45	0.25	1.61	0.23	10.99	3.06
6:6–6:11	5.51	0.43	5.37	0.72	4.85	0.71	1.72	0.19	1.64	0.26	11.47	3.02
Total sample	4.85	0.92	4.80	0.91	4.51	0.88	1.43	0.44	1.54	0.38	8.51	2.91

Diadochokinesis Tasks (DDK)

- Alternating motion rate (AMR) of individual syllables: pa, ta, ka
- Sequential motion rate (SMR) Repetition of alternating syllables, such as, pataka
- 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).

Acoustic software to assess pitch range, MPD, amplitude range, and periodicity

Pitch range, shimmer and jitter measures can be obtained with PRAAT (https://praat.en.softonic.com/)

WASP
https://www.speechandhearing.net/laboratory/wasp/

Audacity
https://www.audacityteam.org/

Motor Speech Evaluation

Examine ability to produce phonetic sequences while varying the temporal relationship between stimulus and response. Try in the following order: (if one level doesn't work, got to the next level)

1. direct imitation
2. direct imitation with child looking at you and decreasing rate
3. simultaneous
4. simultaneous with tactile cuing

**Keep in mind that this is just a tool to help in diagnosis, treatment planning, and treatment.*

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.
- Note if sensory normal or impaired.

Dynamic Evaluation of Motor Speech Skill (Strand & McCauley, 2019)

DEMSS-Assessment for younger children

Meredith (2020) modified and expanded it for school-age kids

- Words and phrases of increasing length with varying temporal and tactile parameters
- Consistency of errors
- Vowel errors
- Lexical stress errors

MOTOR SPEECH EXAMINATION

Examine ability to sequence phonetic segments in various contexts.

1. V, CV; VC; CVC (using all vowels)
2. monosyllabic word repetition
3. multisyllabic word repetition
4. phrase repetition
5. repetition of sentences of increasing length

Compare automatic speech (e.g., counting) to novel utterances.

DEMSS scoring (Strand &McCauley, 2019)

Overall articulatory accuracy: 5-point multidimensional scoring
4 = correct on first attempt
3 = consistent developmental substitution error (e.g., /t/ for /k/; /w/ for /r/) without slowness or distortion of movement gestures
2 = correct after first cued attempt or after immediate self-correction
1= correct in direct imitation after additional cued trials
0 = incorrect in direct uncued elicitation after all cued attempts
X= refusal, inattention, or no attempt

DEMSS scoring (Strand &McCauley, 2019)

Vowel accuracy: 3-point multidimensional scoring
2 = correct
1 = mild distortion
0= frank distortion
X=refusal or no attempt
Prosodic accuracy: Binary scoring
1 = correct 0 = incorrect
Consistency: Binary scoring
1= consistent across all trials
0 = inconsistent across any 2 or more trials
X = refusal or no attempt

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.
  - *DEMSS* (Strand & McCauley, 2019)

DEMSS-additional observations

Note/Tally

Inconsistent voicing errors ___

Groping ___

Intrusive schwa ___

Slow rate ___

Trial and error ___

Vowel or consonant distortion __

Lexical stress errors ___

Segmentation ___

Difficulty with multisyllabic words ___

Awkward movement transitions ___

Consistency of Articulation Errors

-Percent consistency of productions

Number of productions of
the most frequent production x 100 = % consistency
Number of total productions of production

Example:

target	productions	ratio
primavera	pemava 3x pamama 2x	3/5
princess	ces 2x prinsa 2x pasasa 1x	2/5
dinosaur	dino 3x dinosasa 2x	3/5
wagon	wagon 5x	5/5
telephone	telepo 2x te-e-po 1x tepo 1x fone 1x	2/5

total = 15/25 = .6 x 100 = 60%

Additional Observations of Prosodic Error Types

Just check for later reference

Segmented ____

Equal stress ____

Incorrect stress ____

Weak syllable deletion ____

Added syllable ____

Apraxia Exams on the Market that Include a Motor Speech Exam

Verbal Motor Production Assessment for Children (VMPAC) (Hayden & Square, 1999)-
- Assesses for any motor impairment (dysarthria and apraxia)
- provides normative data for comparison

Screening test for Developmental apraxia of Speech-2 (Blakely, 2000)

The Apraxia Profile/Checklist (Hickman, 1997)

The Kaufman Speech Praxis Test for Children (1995)

Dynamic Evaluation of Motor Speech Skill DEMSS) (Strand & McCauley, 2019)

Connected Speech Sample

Park Play: A picture description task (Patel & Connaghan, 2014)

- What can the connected speech sample get you that the other assessments can't?

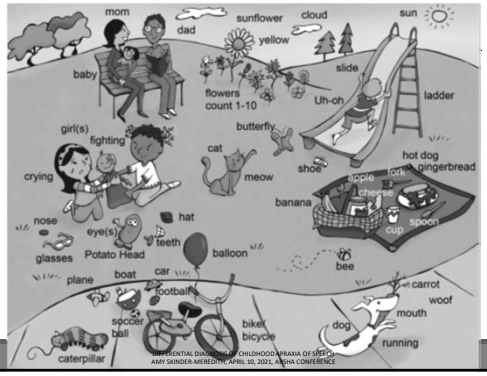
Assessment of Articulation Skills- What to look for

Assess all sounds in all word positions at the single word level.

Look for tests that assess vowels

Norm-referenced tests that go beyond the one-word level

Park Play Response sheet



Assessment of Articulation Skills

Articulation Skills

- There are **many** standardized tests available.
- Typically assess all sounds in all word positions at the single word level.
- The following are examples of articulation exams that go beyond the one-word level.
  - *Goldman Fristoe Test of Articulation-3 (GFTA-3)*
  - *Diagnostic Evaluation of Articulation and Phonology (DEAP)*

**Most articulation tests do not assess vowels, so the therapist may need to supplement his or her testing materials.*

Additional observations from connected speech samples

- Speech Characteristics Rating form
  - Vowel distortions
  - *Resonance (hyper/hyponasality, mixed)*
  - *Voice quality (including vocal fry)*
  - *Rate*
  - *Fluency*
  - *Loudness and pitch*

Assessment of Phonological Processes or Patterns

Phonological processes analysis

- Looks for *patterns* in the child's speech errors (see next slide)
- Examples of tests include:
  - *Hodson Assessment of Phonological Patterns*
  - *Kahn-Lewis Phonological Analysis-2* to be used with the *GFTA-2*
  - *Diagnostic Evaluation of Articulation and Phonology (DEAP)*

These results can help differentiate between a phonological delay, apraxia, or a combination of both.

Terms for phonological processes (patterns)

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

7-point intelligibility scale

Intelligibility: 7-point rating scale (from UW)

1. No noticeable differences from normal.
2. Intelligible though some differences occasionally noticeable.
3. Intelligible although noticeable different.
4. Intelligible with careful listening although some words unintelligible.
5. Speech is difficult to understand with many words unintelligible.
6. Usually is unintelligible.
7. Unintelligible

Additional Measures

Prosody

- Observe prosody in conversational speech, as well as the ability to imitate prosodic contours of phrases.
- Does the child stress the appropriate words and syllables?
- Can the child use contrastive stress (e.g., **I** want to go home vs. I want to go **home**.)?
- Can the child imitate the prosodic contour of sentences?

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

Intelligibility Measures

- Intelligibility: "the degree to which the acoustic signal is understood by the listener" (Yorkston, Strand, & Kennedy, 1996)
- Intelligibility in Context Scale http://www.csu.edu.au/research/multilingual-speech/ics

Expressive Language Skills

- Vocabulary
- Morphology
- Syntax
- Word finding
- Writing for school-age children
  - Spelling
  - Sentences
  - Narratives
- 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.

Writing the Report

Is the following statement good enough?

"The child is three years old and isn't speaking yet. The child primarily communicates by saying 'ah' and pointing to what he wants. Due to lack of movement of his tongue he is most likely has apraxia and dysarthria."

Summary of language skills

Children with CAS tend to have a receptive-expressive language gap.

Test scores may show this, in addition to parent report.

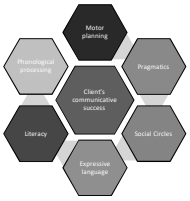
Deficits may also be seen in phonological processing, reading and writing in school-age children.

What's the relative contribution?

1st, What are the factors contributing to the child's communication disorder?

- Phonologic?
- Apraxic?
- Dysarthric?
- Cognitive?
- Expressive and/or receptive language?
- Articulation delay?
- Hearing Impairment?

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



Building a case for CAS vs. Dysarthria vs. Phono

What's your evidence?

What symptoms does this child present that allow you to differentiate from other disorders?

Consistency of errors?	Presence of vowel errors?	Disordered prosody?	Increased errors on increasing length of utterance?	Groping?	Difficulty sequencing sounds and syllables?

What if there is more than just CAS

Note which symptoms suggest a dysarthric component vs. apraxic or phonologic vs. apraxic.

Note level of phonologic awareness skills (if they're old enough to assess this.)

Note any symptoms that may suggest difficulties with word finding, memory, APD, etc.

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	Co-articulation	prosody
all done						
me too						
help me						
I do it						
my turn?						

A child is rarely ever JUST APRAXIC

What did the Murray et al. article reveal about kids with CAS?

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, PDD behaviors, etc.)

Be very clear with parents about ALL of the factors contributing to the child's communication disorder.

Provide recommendations for ALL deficits observed in the assessment.

Take Age into Consideration

If a 2;6-year-old child is nonverbal, does it mean they're apraxic?

- Young children may not be able to present enough evidence for the dx.
- Allow time for dynamic assessment and treatment before making a dx.

Recommendations

Reflect
- Recommendations need to reflect all areas requiring intervention

Lead
- In the case of motor planning, the motor speech assessment results will lead to the specific recommendations to improve speech intelligibility

Look
- 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

Caregiver Input

No evaluative report is complete without the caregivers' input!

Caregivers typically know their child best.

Make sure the report includes the child's strengths.

Every child has strengths!

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.

Gracias! Thank You!