Part 2
Road Testing CAS Assessment and Treatment
Hands-on Practice Session

Finding Your Way: A Roadmap for Increasing Competence in CAS Assessment and Treatment

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Disclosures

- Ms. Caspari receives an honorarium as an invited speaker to this Speech Series
- Ms. Caspari is an advisory council member for the Apraxia Kids organization (formerly CASANA) and receives no compensation as a board member

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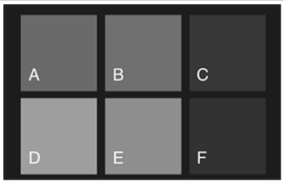
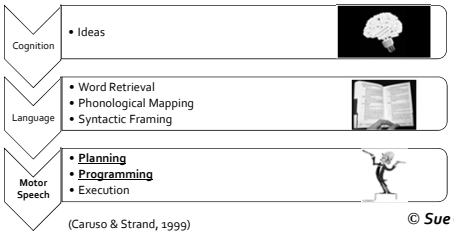


Once you log in – you should see the A, B, C, D, E, F choices.
Keep your phone/computer open to this page throughout today's talk.
The answer choices will refresh every time we do a new poll.

Overview of the day

- Review speech as a complex motor task
- Review CAS as a breakdown in speech motor skill
- Follow the case of 2 school aged children
  - 7 year old male
  - 15 year old female
- Practice identifying characteristics of CAS
- Practice making a diagnosis
- Practice making treatment decisions

Speech as a complex motor task



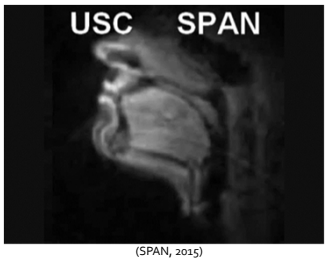
(Caruso & Strand, 1999)

Speech as a *complex* motor task

- What is involved in a speech motor task?
  - How many muscles and body parts are involved in speaking?
  - How fast do they move when we speak?
  - How precise must our speech be – pig vs big?

(Thelen, 1991; Caruso & Strand, 1999; Borden, 1984)

Speech as a *complex* motor task



(SPAN, 2015)

Speech as a *complex* motor task

- In speech, what are the units of movement (Smith, 2006)?
  - Sounds?
  - Syllables?
  - Words?
  - Phrases?
  - Sentence?
  - Utterances?
  - Other? _____

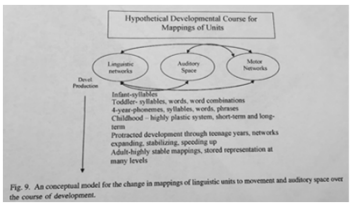
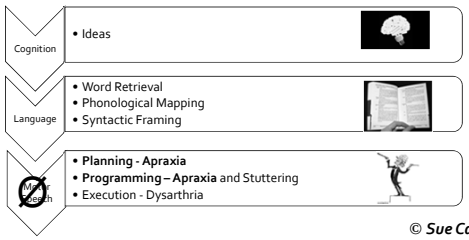


Fig. 9. An conceptual model for the change in mappings of linguistic units to movement and auditory space over the course of development.

Childhood apraxia of speech (CAS) as a breakdown in motor speech skill



Red flags for CAS

(ASHA, 2007a; Shriberg and Strand, 2014; Davis, Jacks, & Marquardt, 2005; Iuzzini-Seigel et al, 2015)

- Vowel error – substitution or distortion of target vowel
- Consonant distortion
- Difficulty w/initial artic configurations or transitionary movement gestures – initiation of utterance or initial speech sound is difficult and may sound lengthened or uncoordinated. Also, may have lengthened or disrupted coarticulatory gestures or movement transitions from one sound to the next within the utterance
- Lexical or phrasal stress errors – equal stress or inappropriate stress
- Syllable segregation or word segregation – brief or lengthy inappropriate pause
- Groping – prevocalic, silent, articulatory searching behavior
- Intrusive Schwa
- Voicing Errors – produced as the target's voicing cognate, or between voicing categories (blurred voicing boundaries)
- Slow speech rate (slowed part "tiiiiiiiiime" or the entire production "mmoommmmyy"
- Increased difficulty with multi-syllabic words (increased number of errors as the number of syllables increase)
- Inconsistent errors on repeated productions of same word

7 year old male

History 7 year old male

- Supraventricular tachycardia (SVT) in utero at 33 weeks
  - Digoxin until he was 1 year old
- Recurrent ear infections when younger
  - Myringotomy tubes
- Gross/fine motor delays

History 7 year old male

- Reynolds Intellectual Assessment Scales
  - WNL

	Standard score (Average = 85-100)	T-Score (Average = 40-60)	95% Confidence Interval	Percentile Rank
Nonverbal Intelligence Composite	92	45	86-99	30

Language 7 year old male

- Receptive and Expressive language impairment
  - PPVT-4

Raw Score	Standard Score (Average = 85 – 115)	Confidence Interval (95%)	Percentile Rank	Normal Curve Equivalent
59	75	69-82	5	15

  - CELF-4

Subtest	Raw Score	Scaled Score Average (7-13)	Standard Score	Percentile Rank
Concepts and Following Directions	Attempted 2x but unable to complete			
Word Classes-Receptive	13	7		
Sentence Structure	6	1		
Receptive Language Index	Unable to compute			

Language 7 year old male

- Receptive language impairments
  - Decreased vocabulary and semantic knowledge
  - Difficulty following single and multi-step directions, especially those containing linguistic concepts
- Expressive language impairments
  - Limited utterance length/syntactic structures
  - Decreased expressive vocabulary

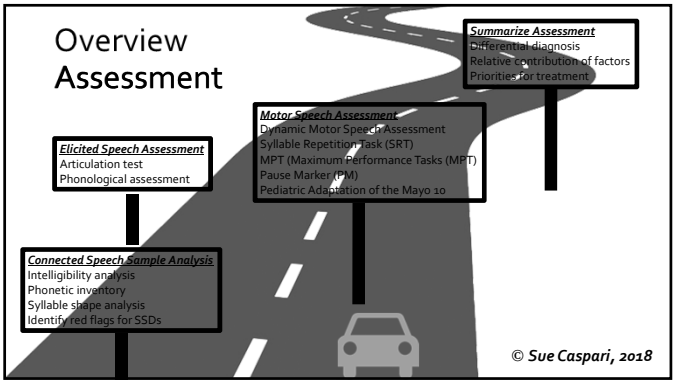
Auditory processing

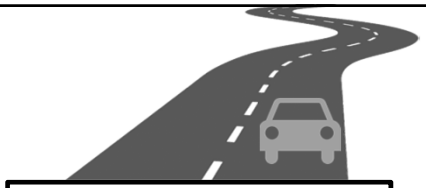
- Likely phonological awareness impairment for his age
  - CTOPP – Elision subtest – unable to score
    - only able to complete 3 items with maximum cues and support - after multiple attempts at teaching the task
  - CTOPP blending subtest – standard score of 9, percentile rank 37 – normal range for age.

Oral Mechanism Exam 7 year old male

- Structures and function WNL
- + Nonverbal oral apraxia

Overview Assessment





Connected Speech Sample Analysis
Intelligibility analysis
Phonetic inventory
Syllable shape analysis
Identify red flags for SSDs

7 year old male

- Collect speech sample - play with mom
- Transcribe 50 consecutive utterances

1. /kʊ.kɪŋ/
2. /pi.s̪ə/
3. /wʌ/ /dɪ/ /s̪ʌ/ **4/**
4. /ɪ/ /s̪aɪəs̪/
5. /ɪ/ /ʧeə/
6. /də/ /ʧeə/
7. /nʌənʊ/

Connected Speech Sample Analysis

- ***Intelligibility***
- Phonetic inventory
- Syllable shapes
- Red flags for SSDs

Connected speech sample 7 year old male

- Identify all unintelligible words

1. /kʊ.kɪŋ/
2. /pi.s̻ə/
3. /wʌ/ /dɪ/ /s̻ʌ/ /
4. /ɪ/ /s̻aɪəs̻/
5. /ɪ/ /ʧeə/
6. /də/ /ʧeə/
7. /nʌəno/

Connected speech sample 7 year old male

- Count up # of intelligible words
- Count up total # of words
- Calculate word-level intelligibility index (Flipsen, 2006)

  $\frac{\text{\# intelligible words}}{\text{total \# of words}}$
- 56/104 = **54%** intelligible at the word level

Alternate method for calculating intelligibility when speech is highly unintelligible

- Intelligibility Index (II) method, II-1.25 (Flipsen, 2006)
- 3:1 approximation rule
  - In a 5-syllable string, for which intelligibility is low enough to inhibit the perception of word boundaries, the first 3 syllables will constitute 3-monosyllabic words, and the 2 remaining syllables will compose 1-bisyllabic word
  - In sum, every 5 syllables will average out to be 4 words

Alternate method for calculating intelligibility when speech is highly unintelligible

[/wʌ/] [/dɪ/] [/sʌ/]
[/ɪ/ /saɪəs/]

3:1 approximation = 5 unintelligible syllables = 4 words

Original = 5 unintelligible words

In 7 year old speech sample

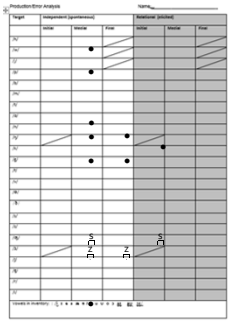
- 55 unintelligible syllables
- 3:1 approximation rule = 44 unintelligible words
- Calculate word-level intelligibility

  $\frac{\text{\# intelligible words}}{\text{total \# of words}}$
- 56/100 = 56% intelligible at the word level using 3:1 approximation (54% using original)

Connected Speech Sample Analysis

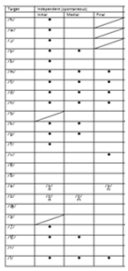
- Intelligibility
- ***Phonetic inventory – independent analysis***
- Syllable shapes
- Red flags for SSDs

1. /kʊ.kɪŋ/
2. /pi.s̪ə/
3. /wʌ/ /dɪ/ /s̪ʌ/
4. /ɪ/ /s̪aɪəs̪/
5. /ɪ/ /ʧeə/
6. /də/ /ʧeə/
7. /nʌəno/



Phonetic inventory – independent analysis – 7 year old male

- Initial word position
  - /h, w, j, p, b, m, t, d, n, k, g, f, ʃ, ʧ, l/
- Medial word position
  - /p, m, t, d, n, k, g, ʧ, l/
- Final word position
  - /m, t, d, n, v, l/



Connected Speech Sample Analysis

- Intelligibility
- Phonetic inventory
- ***Syllable shapes***
- Red flags for SSDs

Syllable shapes

1. /kʊ.kɪŋ/
2. /pi.ðə/
3. /wʌ/ /ðɪ/ /θʌ/
4. /ɪ/ /θaɪəs/
5. /ɪ/ /tʃeə/
6. /də/ /tʃeə/
7. /nʌəno/

- V - //
- CV - ~~////~~ /
- CVC - /
- CVCV - //
- CVCVC - /

Syllable shapes – 7 year old male

- 60% simple syllable shapes of:
  - CV - 36.5%
  - CVC – 23.6%
- VC – 9%
- V – 5%
- Remaining syllable shapes less than 4% each
  - VV, CCV, CVV, VCV, VCVC, CVCV, CVVCV, VVCV, CVCVC, VCVVCV, CVCCV, CVCVCC

7 YEAR OLD MALE SYLLABLE SHAPE ANALYSIS

V - 5
VV - 1
CV - 34
CCV - 3
CVV - 4
VC - 8
VCV - 2
CVC - 22
VCVC - 1
CVCV - 3
CVVCV - 1
VVCV - 1
CVCVC - 4
VCVVCV - 1
CVCCV - 1
CVCVCC - 2

By age 5, children are expected to be producing all word shapes, including 3+ syllable word shapes (Shriberg 1993)

Syllable shapes – 7 year old male

- Average syllables/word – 1.26
  (3 year, 2 mo old equivalent, Flipsen, 2006a)

7 YEAR OLD MALE SYLLABLE SHAPE ANALYSIS

V - 5
VV - 1
CV - 34
CCV - 3
CVV - 4
VC - 8
VCV - 2
CVC - 22
VCVC - 1
CVCV - 3
CVVCV - 1
VVCV - 1
CVCVC - 4
VCVVCV - 1
CVCCV - 1
CVCVCC - 2

Connected Speech Sample Analysis

- Intelligibility
- Phonetic inventory
- Syllable shapes
- ***Red flags for SSDs***

Summary connected speech sample

- Aticulation/phono errors
  - Interdental /s/
  - /θ, ð/ substitutions
  - Cluster reduction
  - w/r gliding
  - vocalization

Summary connected speech sample

- Red flags for CAS
  - Vowel errors
  - Consonant distortions
  - Difficulty w/initial artic configurations or transitionary movement gestures
  - Lexical or phrasal stress errors
  - Syllable segregation or word segregation
  - Groping
  - Intrusive Schwa
  - Voicing Errors
  - Slow speech rate and/or slow DDK
  - Increased difficulty with multi-syllabic words
  - Inconsistent errors on repeated productions of same word

Elicited Speech Assessment
Articulation test
Phonological assessment

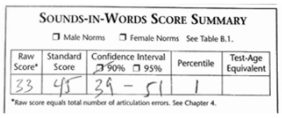
Elicited Speech Assessment

- ***Articulation/phonological assessment***

Goldman Fristoe Test of Articulation 7 year old male

- Goldman Fristoe Test of Articulation administered and analyzed for articulation errors and phonological patterns

GFTA – 7 year old male

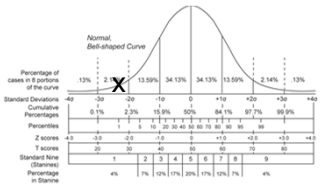


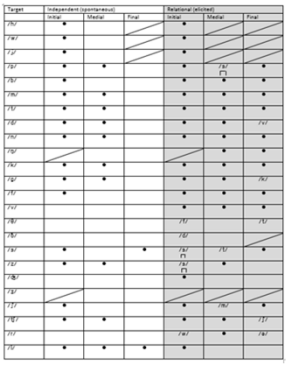
SOUNDS-IN-WORDS SCORE SUMMARY

❒ Male Norms ❒ Female Norms See Table B.1.

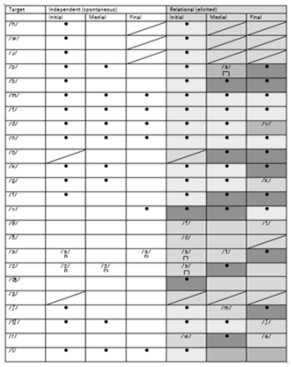
Raw Score*	Standard Score	Confidence Interval ❒ 90% ❒ 95%	Percentile	Test-Age Equivalent
33	45	39 – 51	1	

*Raw score equals total number of articulation errors. See Chapter 4.





- Relational Analysis – Elicited speech sample on GFTA



- Compare spontaneous to elicited

Independent inventory

Relational inventory

Both inventories

Phonetic inventory

Solid in his inventory

- Initial word position
  - /h,w,j,p,b,m,t,d,n,k, g,f,ʃ,tʃ,l/
- Medial word position
  - /m,t,d,n,k,g,tʃ/
- Final word position
  - /m,t,n,v/

Exist in one context at least

- Initial word position
  - /v,ɹ/
- Medial word position
  - /b,ŋ,f,v,z,r/
  - /p,l/
- Final word position
  - /p,b,ŋ,k,f,s,ʃ/
  - /d,l/

Independent inventory

Relational inventory

Both inventories

Phonetic inventory

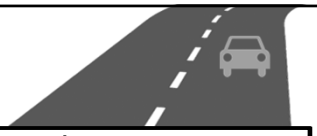
- Not yet in his inventory
  - Initial word position
    - /s,z,r,θ,ð/
  - Medial word position
    - /s,θ,ð,ɹ,ʃ/
  - Final word position
    - /g,z,θ,ɹ,tʃ,r/

Summary – Artic/Phono 7 year old male

- GFTA Articulation/phonological errors
  - Interdental /s, z/ (/sɪz̪ə/ for scissors)
  - Sound class errors - /θ,ð,r/
    - Substitutions for /θ,ð/
      - /f/ for initial /θ/: /fʌm/ for 'thumb'
      - stopping: /bæt/ for 'bath', /də/ for 'this'
    - Vocalization (/fɛ.ə/ for feather)
    - Gliding w/r (/wæbət/for rabbit)
  - Cluster reduction (/faɪə/ for flower)

Summary – Artic/Phono 7 year old male

- Red flags for CAS
  - Vowel errors
  - Consonant distortions
  - Difficulty w/initial artic configurations or transitionary movement gestures
  - Lexical or phrasal stress errors
  - Syllable segregation or word segregation
  - Groping
  - Intrusive Schwa
  - Voicing Errors
  - Slow speech rate and/or slow DDK
  - Increased difficulty with multi-syllabic words
  - Inconsistent errors on repeated productions of same word



Motor Speech Assessment

Dynamic Motor Speech Assessment
Syllable Repetition Task (SRT)
Maximum Performance Tasks (MPT)
Pause Marker (PM)
Pediatric Adaptation of the Mayo 10

Motor Speech Assessment

- ***Dynamic Motor Speech Assessment***
- Syllable Repetition Task (SRT)
- Maximum Performance Tasks (MPT)
- Pause Marker (PM)
- Pediatric Adaptation of the Mayo 10

Dynamic motor speech assessment

- Make your own
- List of syllables and syllable sequences at increasing levels of length and complexity
- Taylor to the child's level
  - Simpler syllable shapes for more impaired child
  - Longer syllable shapes for less impaired child

Dynamic motor speech assessment

- Consideration for length and complexity
- Index of Phonetic Complexity (IPC) (Jakielski, 1998)
  - 1 point each for:
    - Dorsal place /k, g, ŋ/
    - Fricative, affricate, liquid manner /f, v, s, z, h, θ, ð, ʃ, ʒ, tʃ, dʒ, l, ɹ/
    - Rhotic vowel (vowel plus /r/)
    - Syllable shapes ending with consonant (VC, CVC, etc.)
    - 3+ syllable lengths
    - Time consecutive singleton consonants that vary by place (coat)
    - Consonant clusters (step)
    - Heterorganic clusters – consonants vary by place in cluster (play)

Length and complexity?

Me

Shop

Length and complexity?

Me
- IPC = 0

Shop
- IPC = 3
  - Fricative – 1
  - Ends in a C – 1
  - Time consecutive singletons that vary by place - 1

Length and complexity?

Hippopotamus

Phantasmagoric

Length and complexity?

Hippopotamus

IPC = 8

Fricative = 2

3+ Syllable = 1

Time consec C vary by place = 4

Ends with a C = 1

Phantasmagoric

IPC = 12

Dorsal = 2

Fricative, Affricate, Liquid = 2

Rhotic = 1

Ends with C = 1

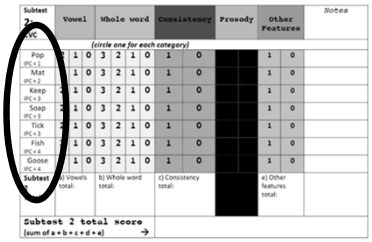
3+ syllable = 1

Time consec C vary by place = 2

Consonant clusters = 2

Heterorganic clusters = 1

Motor speech assessment example organized by IPC



Subtest 2: CVC	Vowel	Whole word	Consistency	Prosody	Other Features	Notes
	(circle one for each category)					
Pop IPC = 1	2 1 0	3 2 1 0	1 0		1 0	
Mat IPC = 2	2 1 0	3 2 1 0	1 0		1 0	
Keep IPC = 3	2 1 0	3 2 1 0	1 0		1 0	
Soap IPC = 3	2 1 0	3 2 1 0	1 0		1 0	
Tick IPC = 3	2 1 0	3 2 1 0	1 0		1 0	
Fish IPC = 4	2 1 0	3 2 1 0	1 0		1 0	
Goose IPC = 4	2 1 0	3 2 1 0	1 0		1 0	
Subtest	a) Vowels total:	b) Whole word total:	c) Consistency total:		e) Other features total:	
Subtest 2 total score (sum of a + b + c + d + e) →						

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Motor speech assessment example

Stimulus items written here can be changed to suit the child's sound repertoire

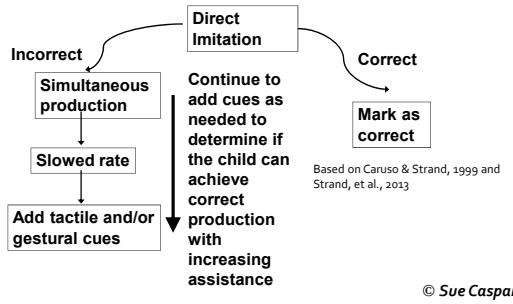
Utterance Type	Overall articulator accuracy (0-4)	Vowel accuracy (0-2)	Prosodic accuracy (0-1)	Consistency (0-1)
CV				
1. Me				
2. Hi				
3. Boy				
4. Do				
5. No				
6. My				
7. Go				
8. Pay				

Adaptation by Amy Meredith & Ruth Stoeckel

Dynamic motor speech assessment

- Ask the child to imitate each word
- Score for:
  - Vowel accuracy
  - Prosody – note sound additions, stress errors, sound/syllable segmentation
- If errored, cue up to 5 times to try to obtain a correct production
- After cueing, score for
  - Overall accuracy
  - Consistency – note if any inconsistencies across trials

Dynamic Motor Speech Assessment



Based on Caruso & Strand, 1999 and Strand, et al., 2013

Dynamic motor speech assessment

- Vowel accuracy – scored on first attempt
  - 2 = immediate correct repetition of the vowel
  - 1 = mild distortion
  - 0 = frank distortion

Strand, et al., 2013, p. 508, Table 2

Dynamic motor speech assessment

- Prosodic accuracy – scored on first attempt (2= syllable words)
  - 1 = correct
  - 0 = incorrect

Strand, et al., 2013, p. 508, Table 2

Dynamic motor speech assessment

- Overall articulatory accuracy – scored after all cued attempts
  - 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
  - 1= correct after two or three additional cued attempts
  - 0 = not correct after all cued attempts

Strand, et al., 2013, p. 508, Table 2

Dynamic motor speech assessment

- Consistency – scored after all cued attempts
  - 1 = consistent across all trials
  - 0 = inconsistent across any 2 or more trials

Strand, et al., 2013, p. 508, Table 2

Practice scoring a motor speech assessment – 7 year old male

- Practice – large group (video)
  VIDEO – CV
  - Have child say target
  - Score vowel
  - Dynamic cueing up to 5 more trials (any cues allowed)
  - Score consistency and accuracy after all trials

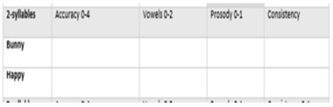
Utterance Type	Overall articulatory accuracy 4 = Immediate correct repetition. 3 = Immediate; accurate rate and movement but consistent error. 2= correct after first cued attempt 1 = Needs cuing (multiple cues) 0 = No correct response. R=Refusal; inattention; no attempt.	Vowel accuracy 2 = Immediate correct repetition of the vowel 1 = Mild distortion 0 = Frank distortion *On first attempt*	Prosodic accuracy 1 = Correct 0 = Incorrect *On first attempt*	Consistency 1= Consistent 0 = Inconsistent *On any 2 or more trials*
CV	Accuracy 0-4	Vowels 0-2	Prosody 0-1	Consistency 0-1
1. me				
2. hi				
3. toy				
4. day				
5. show				

Summary Dynamic Motor Speech Assessment – 7 year old male

- Red flags for CAS
  - Vowel errors
  - Consonant distortions
  - Difficulty w/initial artic configurations or transitionary movement gestures
  - Lexical or phrasal stress errors
  - Syllable segregation or word segregation
  - Groping
  - Intrusive Schwa
  - Voicing Errors
  - Slow speech rate and/or slow DDK
  - Increased difficulty with multi-syllabic words
  - Inconsistent errors on repeated productions of same word

Practice scoring a motor speech assessment – 7 year old male

- Practice – large group (video)
  VIDEO – 2-syllable
  - Have child say target
  - Score vowel
  - Dynamic cueing up to 5 more trials (any cues allowed)
  - Score consistency and accuracy after all trials



2-syllables	Accuracy 0-4	Vowels 0-2	Prosody 0-1	Consistency
Bunny				
Happy				

Summary Dynamic Motor Speech Assessment – 7 year old male

- Red flags for CAS
  - Vowel errors
  - Consonant distortions
  - Difficulty w/initial artic configurations or transitionary movement gestures
  - Lexical or phrasal stress errors
  - Syllable segregation or word segregation
  - Groping
  - Intrusive Schwa
  - Voicing Errors
  - Slow speech rate and/or slow DDK
  - Increased difficulty with multi-syllabic words
  - Inconsistent errors on repeated productions of same word

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Practice scoring a motor speech assessment – 7 year old male

- Practice – large group (video)
  VIDEO – 3-syllable
  - Have child say target
  - Score vowel
  - Dynamic cueing up to 5 more trials (any cues allowed)
  - Score consistency and accuracy after all trials

3-syllables	Accuracy 0-4	Vowels 0-2	Prosody 0-1	Consistency 0-1
Banana				
Potato				
Video				

Summary Dynamic Motor Speech Assessment – 7 year old male

- Red flags for CAS
  - Vowel errors
  - Consonant distortions
  - Difficulty w/initial artic configurations or transitionary movement gestures
  - Lexical or phrasal stress errors
  - Syllable segregation or word segregation
  - Groping
  - Intrusive Schwa
  - Voicing Errors
  - Slow speech rate and/or slow DDK
  - Increased difficulty with multi-syllabic words
  - Inconsistent errors on repeated productions of same word

Motor Speech Assessment

- Dynamic Motor Speech Assessment
- ***Syllable Repetition Task (SRT)***
- Maximum Performance Tasks (MPT)
- Pause Marker (PM)
- Pediatric Adaptation of the Mayo 10

Syllable Repetition Task (SRT)

- Syllable Repetition Task (Shriberg et al., 2012)
  - 3+ years
  - Repeat nonsense syllables /n, b, d, m/ plus schwa
  - 1-4 syllables
  - Count sound additions = transcoding score
  - Cutoff - <80% likely CAS
  - Diagnostic Accuracy – 78.4% (Shriberg, et al, 2012)

Syllable Repetition Task (SRT)

No. of Syllables	Item No.	Response	Transcription	Number of Consonants Correct	Additions*
2	1	bada			
	2	dama			
	3	bama			
	4	mada			
	5	naba			
	6	daba			
	7	naca			
	8	maba			
				SRT=2 = ____% /16*100	
3	9	bamana			
	10	dabama			
	11	madaba			
	12	nabada			
	13	banada			
	14	manaba			
				SRT=3 = ____% /18*100	
4	15	bamadana			
	16	banabama			
	17	manabada			
	18	nadamaba			
				SRT=4 = ____% /16*100	
Notes:				SRT = ____% /50*100	Total

Syllable Repetition Task (SRT)

"nada" = "n**a**m**d**a" "mada" = "m**a**n**d**a" "dabama" = "d**a**m**a**n**d**a" "madaba" = "**n**a**d**a**d**an**d**a"

Additions

Motor Speech Assessment

- Dynamic Motor Speech Assessment
- Syllable Repetition Task (SRT)
- ***Maximum Performance Tasks (MPT)***
- Pause Marker (PM)
- Pediatric Adaptation of the Mayo 10

Maximum Performance Tasks (MPT)

- Maximum Performance Tasks (Rvachew et al., 2005; Thoonen et al., 1996, 1999)
  - 6+ years
  - Maximum vowel and fricative durations
  - DDK – AMR & SMR
  - Criteria for Dysarthria vs. Apraxia
  - Diagnostic accuracy – 95.2%

Maximum Performance Tasks (MPT)

- MPD (maximum phonation duration)
  - Average longest production of /a/ and /mama/

	TRIAL 1	TRIAL 2	TRIAL 3
[a]	1.76	2.44	2.49
[mama]	1.34	not valid	2.67
MPD Score:	**3.18**		

Maximum Performance Tasks (MPT)

- MFD (maximum fricative duration)
  - Average longest production of [f], [s] and [z]

	TRIAL 1	TRIAL 2	TRIAL 3
[f]	1.15	1.38	1.79
[s]	2.34	2.69	1.64
[z]	1.79	2.22	2.03
MFD Score:	**2.32**		

Maximum Performance Tasks (MPT)

- MRRmono
  - Average fastest (syllables per second) of the fastest [pa…], [ta…], and [ka…]

	TRIAL 1	TRIAL 2	TRIAL 3
[pa] /pʌ/	3.85	3.80	3.30
[ta] /tʌ/	3.62	3.80	3.85
[ka] /kʌ/	3.30	3.05	3.08
MRRmono Score:	**3.66**		

Maximum Performance Tasks (MPT)

- MRRtri Score
  - Average fastest (syllables per second) /pataka/ (all three syllables must be sequenced accurately 5X within the trial)
- Sequence Score
  - Score 1 if at least one correct repetition of /pataka/; Score 0 if no correct repetition of /pataka/
- Attempts Score
  - Count the number of additional attempts (beyond the first three) that are required for the child to achieve a correct repetition of /pataka/.

	TRIAL 1	TRIAL 2	TRIAL 3
[pataka] /pʌtʌkʌ/	patata	pukaka	papapa
Additional trials	pakaka	pakaka	papata
MRRtri Score: unable	Sequence: (0= none correct): 0	Additional Attempts: 3	

Summary MPT
7 year old male

Dysarthria Score	Dyspraxia (CAS) Score
0 MRRmono > 3.5	0 MRRtri ≥ 4.4
1 MRRmono 3.0 < > 3.5 & MPD > 7.5	1 MRRtri 3.4 < > 4.4 & MFD > 11 sec & Attempts < 3
2 MRR mono < 3.0 or MRRmono 3.0 < > 3.5 & MPD ≤ 7.5	2 MRRtri ≤ 3.4 or Sequence = 0 or Criteria for 0 or 1 not met

Motor Speech Assessment

- Dynamic Motor Speech Assessment
- Syllable Repetition Task (SRT)
- Maximum Performance Tasks (MPT)
- ***Pause Marker (PM)***
- Pediatric Adaptation of the Mayo 10

Pause Marker (PM)

- Pause Marker (PM) (Shriberg & Strand, 2014, Shriberg et al., 2017a, 2017b)
  - 3+ years
  - The Type I "Pause Marker" provides a "single sign marker that likely can be used cross-linguistically to discriminate CAS from speech delay, and to scale the severity of CAS"
  - Type I = atypical pause - *abrupt, alone, change, grope*
  - NOT Type II = more typical addition, repetition/revision. long, breath

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

- Between-Word Pause = Any between-words period of at least 150 ms (.15 sec) in which there is no speech.
- Inappropriate pause - "a between-words pause that occurs either at an inappropriate linguistic place in continuous speech and/or has one or more inappropriate articulatory, prosodic, or vocalic features within the pause or in a sound segment preceding or following the pause."

Table 6. Auditory-perceptual and acoustic descriptions for eight subtypes of inappropriate between-words pauses.

Type	Subtype	Locus of inappropriate behavior: Within pause	Locus of inappropriate behavior: Within adjacent sound(s)	Descriptions of eight types of inappropriate pauses
Type I	Abrupt		X	A pause immediately preceded or followed by a phoneme that includes a sudden strong onset of energy or sudden offset of energy. Steep-amplitude rise/fall time is the best current visual and acoustic correlate of the percept of an abrupt phoneme.
	Alone	–	–	A pause that occurs at a linguistically incorrect position in an utterance, is not one of the other seven subtypes of inappropriate pauses, and does not have any identifiable auditory or acoustic feature.
	Change		X	A pause immediately preceded or followed by a phoneme or word that includes a significant change in amplitude, frequency, or rate.
	Grope	X		A pause that includes visible acoustic energy in the spectrogram consistent with a lip or tongue gesture or inappropriate voicing. The gestures may include formant traces of sounds or traces of incompletely realized stop bursts.
Type II	Long	X		A pause that has a lengthened duration that is unusual for the linguistic context (usually > 750 ms).
	Breath	X		A pause that includes audible inhalation not associated with excessive length of the utterance or emotional excitement.
	Repetitions/ revisions		X	A pause immediately preceded or followed by a dysfluent word or syllable repetition or revision.
	Additions		X	A pause immediately preceded or followed by an added speech sound.

Note. See text for rationale for dividing the subtypes into two classes termed Type I and Type II. The four subtypes of inappropriate pauses within Type I and within Type II are each listed in decreasing frequency of occurrence in the present sample of participants with childhood apraxia of speech.

Shriberg, et al, 2017a

Pause Marker (PM) (Tilkens, et al, 2017)

OVERVIEW OF STEPS

1. Obtain a conversational speech sample (page 3).
2. Complete transcription and prosody-voice coding to yield 24 usable utterances (page 5).
3. Complete acoustic analyses to identify occurrences of Type I (abrupt, alone, change, grope) and Type II (addition, repetition/revision, long, breath) between-words pauses in each utterance (page 13).
4. Calculate the Pause Marker Index (PMI) (page 17).
5. Classify CAS Status (page 18).

WARNING:
The PM is a complex assessment that requires a fair amount of auditory-perceptual training and audio-processing skill. This manual is not intended as a substitute for the acquisition of these skills, but as a helpful reference once those skills have been established. We recommend that you read through this manual, first, and then read through the entries listed in the **References** section below. Read through this manual once more, before administering the assessment.

Thank you to my students:
Phil Mahoney and
Alyssa Treiber

Pause Marker (PM) (Tilkens, et al, 2017)

- Determine Severity (Tilkens, et al, 2017)
  - "Mild" CAS = PM percentages 90.0% to 93.9%
  - "Mild-Moderate" CAS = PM percentages 85.0% and 89.9%
  - "Moderate-Severe" CAS = PM percentages 80.0%-84.9%
  - "Severe" CAS = PM percentages below 80.0%

Motor Speech Assessment

- Dynamic Motor Speech Assessment
- Syllable Repetition Task (SRT)
- Maximum Performance Tasks (MPT)
- Pause Marker Method (PM)
- ***Pediatric Adaptation of the Mayo 10***

Pediatric Adaptation of the Mayo Clinic System

- Gold Standard: CAS Classification using a Pediatric Adaptation of the Mayo Clinic System (Shriberg & Strand, 2014)
  - Vowel errors
  - Consonant distortions
  - Difficulty achieving initial articulatory configurations or transitionary movement gestures
  - Lexical or phrasal stress errors
  - Syllable or word segregation
  - Groping
  - Intrusive schwa
  - Voicing errors
  - Slow speech rate and/or slow DDK rates
  - Increased difficulty with multi-syllabic words
- ≥ 4 signs over ≥ 3 speech tasks = CAS

Adapted Mayo 10 Clinical Signs for Childhood Apraxia of Speech across Several Speech Tasks

≥4 signs in ≥3 Speech Tasks = CAS **Instructions:** **If a 'sign' (below) is seen at least two times within a 'task' (on right), put check in the corresponding box**	Repeat 1-Syllable Words	Repeat 2-Syllable Words	Repeat 3+ Syllable Words	Artic Test	Phono Test	Connected Speech Sample	DDK	Other	**TOTAL SIGNS: If a row has at least one check mark, put + sign in corresponding box in this column.**
Vowel distortions									
Distorted substitutions									
Difficulty w/initial artic configurations or transitionary movement gestures									
Lexical or phrasal stress errors									
Syllable segregation or word segregation									
Groping									
Intrusive Schwa									
Voicing Errors									
Slow speech rate and/or slow DDK									
Increased difficulty with multi-syllabic words									
Inconsistent errors on repeated productions of same word									
TOTAL SPEAKING TASKS: If a column has at least one check mark put + sign in corresponding box in this row. Adapted from: Shriberg & Strand, 2014)									**TOTAL SIGNS = ___ (total +'s in column)** **TOTAL TASKS = ___ (total +'s in row)**

Adapted Mayo 10 Clinical Signs for Childhood Apraxia of Speech across Several Speech Tasks

≥4 signs in ≥3 Speech Tasks = CAS **Instructions:** **If a 'sign' (below) is seen at least two times within a 'task' (on right), put check in the corresponding box**	Repeat 1-Syllable Words	Repeat 2-Syllable Words	Repeat 3+ Syllable Words	Artic Test	Phono Test	Connected Speech Sample	DDK	Other	**TOTAL SIGNS: If a row has at least one check mark, put + sign in corresponding box in this column.**
Vowel distortions	✓	✓	✓	✓					+
Distorted substitutions									
Difficulty w/initial artic configurations or transitionary movement gestures			✓	✓					
Lexical or phrasal stress errors						✓			+
Syllable segregation or word segregation		✓		✓		✓			+
Groping			✓						+
Intrusive Schwa									
Voicing Errors			✓	✓					+
Slow speech rate and/or slow DDK									
Increased difficulty with multi-syllabic words			✓	✓					+
Inconsistent errors on repeated productions of same word		✓	✓	✓		✓			+
TOTAL SPEAKING TASKS: If a column has at least one check mark put + sign in corresponding box in this row. Adapted from: Shriberg & Strand, 2014)	+	+	+	+		+			**TOTAL SIGNS = 8 (total +'s in column)** **TOTAL TASKS = 5 (total +'s in row)**

8 signs in 5 tasks +CAS

Summarize Assessment
Differential diagnosis
Relative contribution of factors
Priorities for treatment

Summarize Assessment

- ***Differential diagnosis***
- Relative contribution of factors
- Priorities for treatment

Differential diagnosis

- + CAS
  - Vowel distortions
  - Difficulty achieving initial articulatory configurations or transitionary movement gestures
  - Lexical or phrasal stress errors
  - Syllable or word segregation
  - Groping
  - Voicing errors
  - Increased difficulty with multi-syllabic words
  - Inconsistencies

Differential diagnosis

- + Articulation/phonological errors
  - Interdental /s, z/ (/sɪzə/ for scissors)
  - Sound class errors - /θ,ð,r/
    - Substitutions for /θ,ð/ - /f/ for initial /θ/, and stopping (/fʌm/ for 'thumb', /bæt/ for 'bath', /də/ for 'this')
    - Vocalization (/fɛ.ə/ for feather)
    - Gliding w/r (/wæbət/for rabbit)
  - Cluster reduction (/faɪə// for flower)

Differential diagnosis

- No dysarthria
  - Oral mechanism exam within normal limits
  - MPT dysarthria score = 0
  - No concerns for respiration or phonation/voice

Summarize Assessment

- Differential diagnosis
- ***Relative contribution of factors***
- Priorities for treatment

Relative contribution

- Cognition
  - WNL
- Linguistics
  - Expressive and receptive language impairment
- Speech skill
  - CAS
  - Articulation placement errors (interdental /s, z/)
  - Sound class errors / ɾ , θ , ð/ - gliding w/r, vocalization of /ɝ/, f/initial θ, stopping d/initial ð and t/final θ

Largest contributors to reduced intelligibility

- CAS errors
  - Vowel distortions (sh**i**vel/sh**o**vel)
  - Unusual substitutions (**t**imen for **p**ajamas)
  - Stress errors (difficult to identify word boundaries)
  - Syllable Segmentation (difficult to identify word boundaries)
  - Voicing contrast errors (**f**ideego/**v**ideo)
- Cluster reduction (sound omissions)
  - /**F**O81/ for flower
- Stopping
  - Ba**t**/ba**th**, **d**e/**th**e

Lesser contributors to reduced intelligibility

- Expressive language errors
  - Reduced morphological structure – "Let do again"
- Sound substitutions
  - Vocalization (chai**e**/chai**r**)
  - Gliding w/r
- Sound placement errors
  - Interdental /s, z/

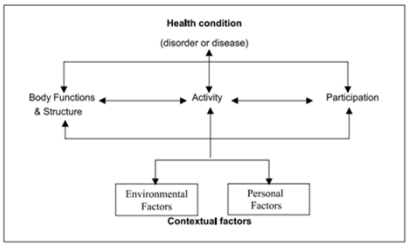
Other factors to consider

- Reduced phonological awareness skills – negative impact on literacy skills

Summarize Assessment

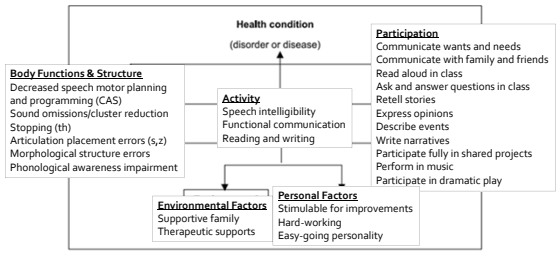
- Differential diagnosis
- Relative contribution of factors
- ***Priorities for treatment***

Priorities for treatment



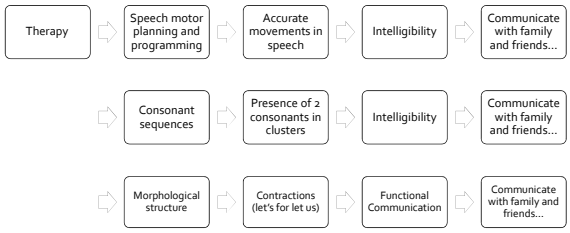
World Health Organization, 2002

Priorities for treatment



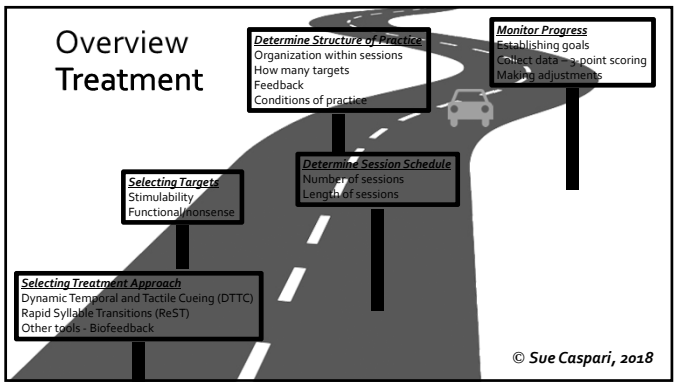
World Health Organization, 2002

Priorities for treatment



Murray, Iunizzi-Seigel, 2017

Overview Treatment



Overall goal of treatment for CAS

- CAS – goal is to improve *movement gestures* in speech
  - Want the child to be able to produce the fluent, coordinated speech movements needed for increasingly longer and more motorically/phonotactically complex syllable shapes
  - MOVEMENT-BASED goal, not SOUND-based

Overall goal of treatment for CAS

Overall goal of treatment for CAS

Flute lesson
- Using a few target songs
- Carefully selected in terms of difficulty
- With the GOAL of being able to help the child become more adept at coordinating the movements of respiration, finger /lip/tongue movements required to produce fluent music

CAS Speech lesson
- Using a few target utterances
- Carefully selected in terms of difficulty
- With the GOAL of being able to help the child become more adept at coordinating the movements of respiration, phonation and articulation required to produce fluent speech

Overall goal of treatment for CAS

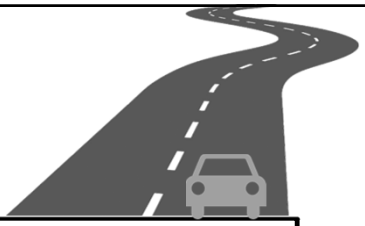
- Goal is to demonstrate accurate MOVEMENT GESTURES across the *entire* utterance - in increasingly longer utterances over time
  - Includes accurate consonants within the utterance - but also includes so much more.....
- Goal is NOT just to produce accurate consonants
  - Consonants are part of the determination of accurate movements, but even IF consonants are correct, can still have inaccurate movement between sounds and syllables

Overview motor-based treatment – Review from Part 1

- Be conscious of frequency and intensity of practice
- Think about range of difficulty in stimuli -- challenge can facilitate motor learning
- Adjust the level of cuing carefully
- Emphasis is on *movement* versus sounds

Overview motor-based treatment – Review from Part 1

- The child should be able to produce the target with some level of cuing
  - Success can lead to increased motivation/effort
  - If the child is not stimulable, the result may be frustration and distrust
- Think about the needs of the "whole child"
  - Build vocabulary and language as well as speech accuracy
  - Give the child ways to interact with others and with their environment



Selecting Treatment Approach

Dynamic Temporal and Tactile Cueing (DTTC)
Rapid Syllable Transitions (ReST)
Other tools - Biofeedback

Selecting Treatment Approach

- ***Dynamic Temporal and Tactile Cueing (DTTC)***
- Rapid Syllable Transitions (ReST)
- Other tools - Biofeedback

DTTC (Strand, Stoeckel & Baas, 2006; Yorkston et al, 2010; Maas, et al, 2014)

- Imitation – repetitive intensive drill - of increasingly longer real words and phrases (functional vocabulary used as targets)
- Incorporates principles of motor learning – all acquisition and motor learning strategies
- Targeted to young, severely impaired children with CAS
- Has strongest evidence base for use with children with CAS
  - 6 studies
  - 3 independent labs
- Across DTTC treatment studies, the greatest gains occurred when:
  - Targets were functional
  - Treatment was frequent
  - Production frequency was highest
  - Motivation was highest

DTTC (Strand, Stoeckel & Baas, 2006; Yorkston et al, 2010)

- Integral stimulation type speech therapy – involves imitation ("watch me, listen, and do what I do")

- This means:
  - Direct type of therapy (not indirect)
  - Child understands what is being asked and why
    - They need to know they are working on "*movements*" vs. sounds

DTTC (Strand, Stoeckel & Baas, 2006; Yorkston et al, 2010)

- Target utterances are real words/phrases that are functional and meaningful to the individual child

I DO IT **Tony**

She went

- This means
  - Ask teachers and parents to generate laundry list of motivating, functional words and phrases
    - Motivation is increased
    - Spoken communication becomes quickly functional
    - Can target specific syntactical forms

DTTC (Strand, Stoeckel & Baas, 2006; Yorkston et al, 2010)

- Targets utterances are carefully selected to meet criteria for optimum challenge level in terms of sounds, syllable length and phonotactic structure

"Tony"
4 movements/sounds
Simple syllable structure
Cvcv
IPC = 0

"invitation"
9 movements/sounds
More complex syllables structure
VCCVCVCVC
IPC = 6

- This means:
  - Select from the laundry list, targets that meet parameters for optimum challenge level
    - Phonetic inventory
      - Sounds the child already can produce
      - Sounds the child is stimulable for
      - Sounds that are early developing and highly visible – see handout
    - Syllable shape
    - Phonotactic complexity – IPC
    - Consider place, manner and voicing features

DTTC (Strand, Stoeckel & Baas, 2006; Yorkston et al, 2010)

- Repetitive intensive drill of functional vocabulary is a key aspect and is intended to increase generalization of motor patterns to functional communicative settings
  - "Tony"
  - "Tony"
  - "Tony"
  - "Tony"
  - "Tony"
- This means:
  - Relatively small set of targets at any one time so you can get more practice trials of each one
    - 4-6 targets early in treatment or for severe disorders
    - 10-15 targets later in treatment or for more mild disorders
  - Activities in therapy session have to allow for lots of practice, and reinforcers should be quick

DTTC (Strand, Stoeckel & Baas, 2006; Yorkston et al, 2010)

- The child is encouraged to **watch the clinician's mouth** when she model's a target , especially when first working on a target, to facilitate attention and focus to the speech movement gestures

DTTC (Strand, Stoeckel & Baas, 2006; Yorkston et al, 2010)

- Importance of mirror neurons in motor learning(Rizzolatti et al,1996)
  - Neuron X fired every time the monkey grabbed for a peanut
  - Neuron X = motor planning neuron essential to motion
  - Human grabbed the peanut while the monkey was watching
  - Neuron X fired IN THE MONKEY but the monkey was not moving – just watching
  - Motor neurons essential for movement fire when just watching a motor movement
  - Similar mirror neuron system found in humans

This means: Watching is just like doing it yourself

DTTC (Strand, Stoeckel & Baas, 2006; Yorkston et al, 2010)

- The child is encouraged to imitate a slower speech rate at first and as motor planning improves, the rate is slowly increased to conversational rates

- This means:
  - Clinician's model is slow, but not too slow at first
    - Try to maintain coarticulation/fluency of entire movement gesture – do not break into parts or segment

DTTC (Strand, Stoeckel & Baas, 2006; Yorkston et al, 2010)

- Practice schedule, and variability are adjusted throughout progression of each target in order to facilitate motor learning

Sammy		Sammy
Sammy		Hi mom
Sammy	VS.	I do it
Sammy		Hi mom
Hi mom		I do it
Hi mom		Sammy
Hi mom		Sammy

- This means:
  - Blocked, constant practice at beginning of treatment, or for severe disorders
  - Random, varied practice as targets become mastered later in treatment, or for milder disorders

DTTC (Strand, Stoeckel & Baas, 2006; Yorkston et al, 2010)

- Accurate movement gestures during speech are shaped through multimodal cueing techniques (visual, verbal, tactile cues)
- The cues change from trial to trial based on the errors the child makes
- Feedback is systematically altered to facilitate motor learning (knowledge of performance vs knowledge of results)

- This means:
  - Listen to child's attempt
  - Identify error
  - Provide cue based on error
    - At first be specific – consider movement-based words for verbal cues
    - Later be more general
  - Increase amount or intensity of cues as needed to achieve accurate movement (verbal, gestural, tactile) – do not want to practice incorrect movement gestures

DTTC (Strand, Stoeckel & Baas, 2006; Yorkston et al, 2010)

- Cues are gradually faded and the time from presentation of the model to the child's response is lengthened as the child progresses to support independence

  Therapist: Say 'Hi mom'

  ---- PAUSE ----

  Child: "Hi mom"

- This means:
  - Fade cues systematically to enable the child to hold onto accurate productions
    - Frequency of cues/feedback
    - Timing of feedback

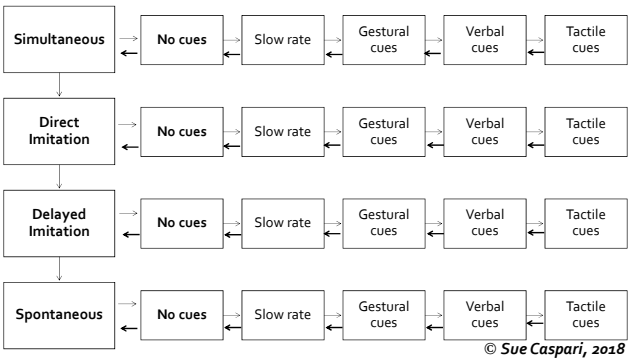
DTTC (Strand, Stoeckel & Baas, 2006; Yorkston et al, 2010)

- Distribute practice over time, environments, and contexts

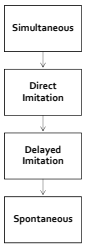
- This means:
  - Frequent (3-5X/wk) short (30 min) sessions to allow for mass and distributed practice of targets over time within sessions
  - Target utterances are sent home and into the classroom for practice as they achieve mastery within speech sessions

DTTC – Key differences from traditional articulation and phonological therapy

	DTTC	Articulation	Phonological
Number of stimuli	Fewer	Many	Many
Stimuli parameters	Length and phonotactic complexity of utterance (using sounds that are already mastered)	Sounds in error	Phonological patterns in error
Goal	Produce entire utterance correctly (eg produce movement gestures in CVC words accurately so there are no errors in sounds (C&V), sequencing, coarticulation or prosody)	Produce target sound correctly (eg /s/ produced accurately in initial, medial and final word position)	Demonstrate knowledge of the rule (eg final consonants added in words that should have final consonants)

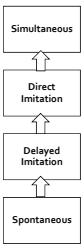


DTTC



- Move ahead in the levels once the child has
  - No articulatory errors
  - Normal rate
  - Good prosody

DTTC



- Move back a level anytime if needed
  - Goal is to get as many "correct" practice trials as possible
  - Perfect practice makes perfect
  - Do not want to practice the "incorrect" movement gesture – negative learning

Selecting Treatment Approach

- Dynamic Temporal and Tactile Cueing (DTTC)
- ***Rapid Syllable Transitions (ReST)***
- Other tools - Biofeedback

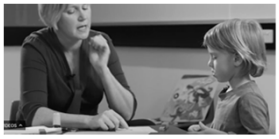
ReST (Murray, McCabe & Ballard, 2015)

- Rapid Syllable Transition (ReST)
  - Repeated productions of multi-syllabic non-words – surrogate for novel vocabulary
  - Focuses on principles of motor learning that facilitate retention (but also includes pre-practice which focuses on "performance")
    - Large practice amount
    - Random practice schedule
    - Variable practice
    - Reduced feedback frequency
  - May be best for older CAS children with mild-moderate impairment
  - Relatively strong evidence base for CAS treatment (Maas, et al, 2014)
    - Has fewer studies than integral stimulation, but one study is RCT – higher level of evidence
    - All studies done by one research group
    - N=3 children ages 7;8 – 10;10

ReST

(Murray, McCabe & Ballard, 2015)

- Rapid Syllable Transition (ReST)
  - Addresses
    - (a) segmental (sound) consistency through improving accuracy (SOUNDS)
    - (b) rapid and fluent transitions from one segment and syllable to the next (SMOOTHNESS)
    - (c) accurate production of lexical stress, and demands accuracy on all three aspects simultaneously (BEATS)



ReST

(Murray, McCabe & Ballard, 2015)

- Practice schedule
  - 10-12 1-hour sessions across 3 weeks
  - Spread 10-12 hours over 6 weeks

ReST

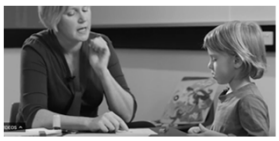
(Murray, McCabe & Ballard, 2015)

- 20, 2-syllable or 3-syllable non-words (start at level just above client's abilities on assessment)
- Advance from 2-syll, to 3-syll, to 3-syll as final noun within a carrier phrase (e.g., "Can I have a ba**gu**ti?")
- 10 have WS; 10 have SW

ReST

(Murray, McCabe & Ballard, 2015)

- Use of pseudowords – reduces the linguistic load



ReST

(Murray, McCabe & Ballard, 2015)

- "All pseudowords had a high phonotactic probability and were orthographically biased to facilitate selection of the targeted stress pattern in reading aloud by the literate children or by the clinician for modeling for preliterate children"

ReST

(Murray, McCabe & Ballard, 2015)

- Consonants and vowels in pseudowords are individualized for each child

ReST

(Murray, McCabe & Ballard, 2015)

- Training/Prepractice
  - "*minimal internal reference of correctness*" -- This means that they need to understand what is required of them but they do not need a high degree of success in this phase initially.
  - Clinician model for student and provide specific KP feedback after every production
    - SOUNDS - phonetic placement cues
    - BEATS – prosodic cues - tapping out the stress pattern (e.g. for the prosodic pattern: "Great soft then strong beat, well done" or "you said all strong beats."); visual cues (long tall block for stressed, short small block for unstressed
    - SMOOTHNESS - visual cues for fluency (no segmenting)
  - Fade cues until student can produce 5 correct pseudowords of any of the nonsense words in a row without a model
    - Once any 5 pseudowords are produced correctly the session moves to the practice phase

ReST – Pre-practice

(Murray, McCabe & Ballard, 2015)

- Clinician: Tell the child they need to exactly match how you say the words
- Explain
  - Sounds
  - Beats
  - Smoothness

ReST – Pre-practice

(Murray, McCabe & Ballard, 2015)

- Clinician: Show the child the card

keeda

- Say the word: "/kidə/"
- Child: Say the word with the stress on the correct syllable and the sounds all correct but with a pause between syllables "/ki.də/"

ReST – Pre-practice

(Murray, McCabe & Ballard, 2015)

- Clinician: Show the cue card for

smoothness

- Provide any/all specific cues to blend the syllables together without segmenting
- Child: Respond to the cues with a correct production: "/kidə/"

ReST – Pre-practice

(Murray, McCabe & Ballard, 2015)

- Clinician: Fade cues until student can produce 5 correct pseudowords in a row without a model

keeda
deba
fadee

feka
bade

ReST – Practice

(Murray, McCabe & Ballard, 2015)

- Practice
  - Pseudowords are presented "orthographically" (written on cards)
    - With clinician model!
  - 20 pseudowords – one trial each of each psuedoword, in random order
    - If no correct responses in 2 consecutive blocks, insert an additional block of training
    - After each block, there is a 2 min break to play a game
  - KR (or "right" "wrong") feedback provided after 3-5 second delay between response and feedback for all
    - at first on 9/10 trials and at end only 1/10 trials – average 5/10 trials
  - Go through the 20 pseudowords 4 more times (5 blocks total)
  - Goal is 80% accurate with no cues across 100 trials (20 treated items, 5X/each) over 2 consecutive sessions (then advance to next level)

ReST – Practice

(Murray, McCabe & Ballard, 2015)

- Clinician: Show and say word "/kidə/" keeda
- Pause while you transcribe child's response
- Provide right/wrong feedback only verbally "That's right/wrong" on 16 of 20 words
- Go on to next word (20 words total) "/dəbɔ/" deba

- Child: Repeat each word once

Selecting Treatment Approach

- Dynamic Temporal and Tactile Cueing (DTTC)
- Rapid Syllable Transitions (ReST)
- ***Other tools - Biofeedback***

Biofeedback

- Biofeedback treatment for CAS (Maas, et al, 2014)
  - Uses visual feedback of speech movements
    - Electropalatography – tongue to palate movements
    - Ultrasound – tongue movements
  - May be best for older children
  - No studies yet on "acoustic spectral" biofeedback
    - Spectral biofeedback
    - Linear predictive coding (LPC) spectrum

Biofeedback

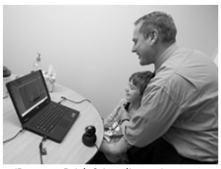
- Electropalatography
  - Customized retainer with different electrodes in different locations on the palate
  - Data sent through microprocessor to a computer
  - Software shows tongue-to-palate contact on computer screen

(Lundeborg, McCallister, 2007)

Courtesy of E. Hitchcocke, Montclair State University

Biofeedback

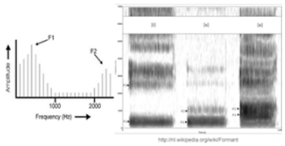
- Ultrasound
  - Ultrasound transducer is connected to a laptop
  - Transducer then placed under the child's chin with gel – child can hold it or lean on it on a stand
  - Child is oriented to image
  - Slow speech rate used
  - Visual display provides real-time feedback about tongue movements



(Preston, Brick & Landi, 2013)

Biofeedback

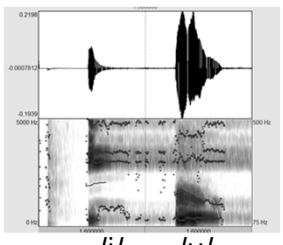
- Spectral biofeedback (non-CAS)
  - Use spectrograph like Praat
  - Use external mic
  - Clinician models target
  - Image of formants displayed on spectogram
  - Child is oriented to image
  - Child tries to match their own production to the model formants – but ***not real-time***



(Shuster, Ruscello, Toth, 1995)

Biofeedback

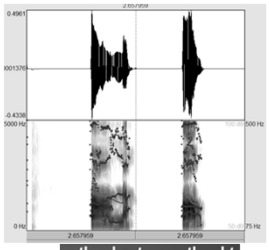
- Praat use for children with CAS - vowels



/i/ /ʊ/

Biofeedback

- Praat use for children with CAS – added schwa



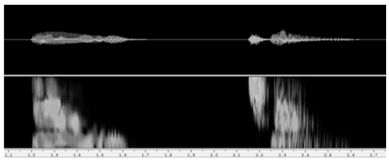
/balə/ vs. /bal/

Biofeedback

- Praat does provide real-time visual aspects of speech – can help with added sounds/schwa

Biofeedback

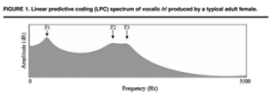
- Wavesurfer – real-time visual image of speech signal
  - Voicing contrasts



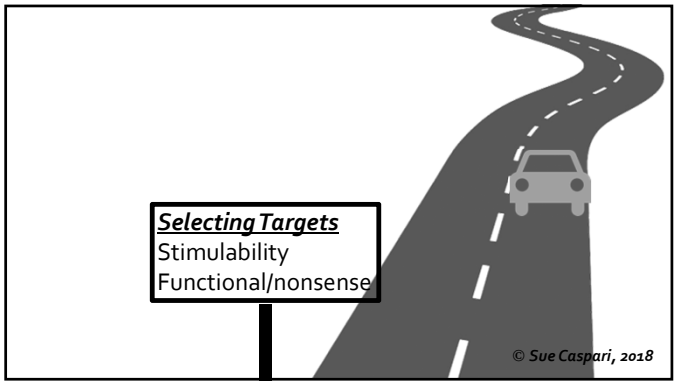
/du/ /tu/

Biofeedback

- Linear predictive coding (LPC) spectrum (non-CAS)
  - Visual representation of the acoustic signal of speech
  - F1 and F2
  - Shown as vertical peaks in a waveform (instead of horizontal bars)
  - Clinician produces model and freezes waveform
  - Save clinician model as template
  - Template outline stays on screen as child produces target and tries to match template
  - Also pre-set targets for different ages, sex, size



McAllister Byun & Hitchcock, 2012



Selecting Targets

- ***Stimulability***
- Functional/nonsense

Stimulability
7 year old male

- Looking for the optimum challenge level (not too hard, not too easy) – length and complexity
  - What are the predominate syllable shapes he is using in connected speech?
    - CV - 36.5%
    - CVC – 23.6%
  - Where does he begin to have errors?
    - Dynamic motor speech assessment – mild errors at 2-syllable level, moderate errors at 3-syllable level
  - At what length and complexity is he stimulable for making accurate productions
    - 2- and 3-syllable words with IPC of 1-5
    - Range of difficulty in stimuli -- challenge can facilitate motor learning

Stimulability
7 year old male

- Looking for the optimum challenge level (not too hard, not too easy) – current phonetic inventory
  - Initial word position
    - /h,w,j,p,b,m,t,d,n,k,g,f,ʃ,ʧ,l,v,ð/
  - Medial word position
    - /m,t,d,n,k,g,ʧ,b,ŋ,f,v,z,r,p,l/
  - Final word position
    - /m,t,n,v,p,b,ŋ,k,f,s,ʃ,d,l/

Independent inventory

Relational inventory

Both inventories

Stimulability
7 year old male

- Looking for the optimum challenge level (not too hard, not too easy) – sounds he is stimulable for
  - /θ, s/

Selecting Targets

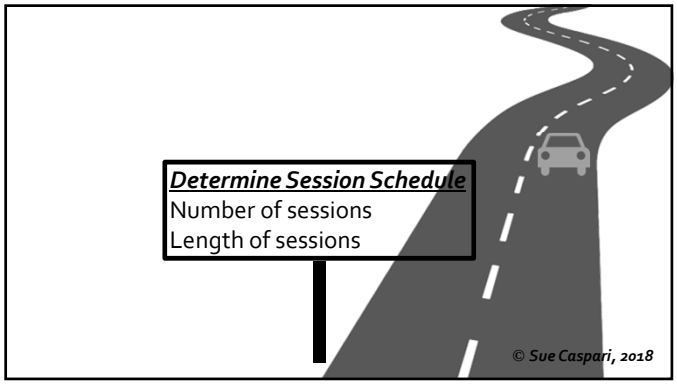
- Stimulability
- ***Functional/nonsense***

Functional/nonsense 7 year old male

- DTTC utilizes ***functional***, customized, motivating targets at optimum challenge level from laundry list provided by family and teachers
- Consider language needs
  - Vocabulary
  - Morphology/grammar
  - Social interaction purposes

Functional/nonsense 7 year old male

- Initial targets (IPC)
  - Simple open syllable shape to work on clusters (CCV) (sounds in inventory) including verbs. Include facilitating /s/ cluster.
    - Fly (4)
    - Snack (4)
  - New syllable shapes - 2-syllable with simple IPC (sounds in inventory)
    - CVCVC - Why not? (1)
  - New syllable shape - 3-syllable targets with higher IPC (sounds in inventory) and with consideration for function of "greeting" and "requesting"
    - CVCVCVC – Hi Joey (3)
    - CVCVCV – Can I go? (5)
  - New consonant in initial position in 1-syllable, stable syllable shape (CVC)
    - Thing (2)
  - Challenge targets. One with new morphological form and both with facilitating placement context for /s/
    - CVCCCV - Let's go (5)
    - CVCCVCV – Castaway (4)

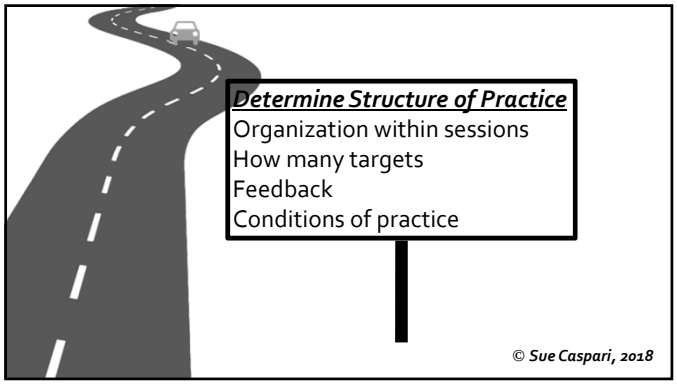


Number and length of sessions 7 year old male

- Three to five, half-hour sessions recommended for children with severe CAS in effort to best facilitate motor learning (ASHA. 2007a, b)
- Factors to consider
  - This child had severe CAS
  - Child was able to participate – eager to practice
  - Strong family/educational support
  - Child had OT and PT and reading tutor – so other therapies to attend

Number and length of sessions 7 year old male

- Recommended for this child
  - Three, 30-minute sessions/week
    - Allows for maximum practice trials
    - Allows for mass and distributed practice of targets over time and within sessions
    - Allows time for other therapies
  - Strong home program
    - Targets sent home for home practice once close to mastery within sessions to promote practice of accurate movement gestures
    - Parents asked to practice targets 60X each across at least 3 different contexts, every other day to distribute practice across communication partners and environments



Determine Structure of Practice

- ***Organization within sessions***
- How many targets
- Feedback
- Conditions of practice

Organization within sessions - Review from Part 1

Principle	Acquisition	Retention
Practice Distribution	Mass	Distributed
Practice Variability	Consistent context. Consistent prosody, pitch, rate.	Varied context. Varied prosody, pitch, rate.
Practice Schedule	Blocked, predictable order.	Random, unpredictable order

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Organization within sessions
7 year old male

FOCUS ON AQUISITION	FOCUS ON RETENTION
• When targets are difficult	• When targets are simpler
• When just starting to work on a target	• When targets are approaching mastery
Castaway	Why not?
Fly	Thing
Can I go	Hi Joey

Organization

- **Mass, consistent, blocked**
- Distributed, varied, random

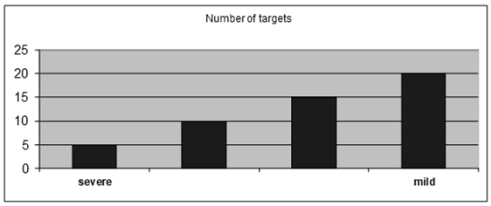
DAY 1
Castaway X 10
Why **not**? X 3
Fly X 10
Thing X 3
Can I go? X 10
Hi Jo**ey** X 4
Castaway X 10
Hi Joey X 3
Fly X 10
Why not? X 4
Can I go? X 10
Thing**?** X 2
Castaway X 10
Why not**!** X 3
Fly X 10
Etc…

Determine Structure of Practice

- Organization within sessions
- ***How many targets***
- Feedback
- Conditions of practice

How many targets – review from Part 1

- Depends on severity



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Determine Structure of Practice

- Organization within sessions
- How many targets
- ***Feedback***
- Conditions of practice

Feedback – Review from Part 1

Principle	Acquisition	Retention
Feedback Type	Knowledge of performance	Knowledge of results
Feedback Frequency	Often, immediate	Inconsistent, delayed

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Feedback
7 year old male

FOCUS ON AQUISITION
- When targets are difficult
- When just starting to work on a target

SPECIFIC MOVEMENT BASED

"Put your tongue between your teeth and blow air"

FOCUS ON RETENTION
- When targets are simpler
- When targets are approaching mastery

GENERAL OUTCOME ORIENTED

"That sounded right"

Determine Structure of Practice

- Organization within sessions
- How many targets
- Feedback
- ***Conditions of practice***

Conditions of practice – Review from Part 1

- Need focused attention, even if brief
- Develop the habit of child looking at clinician's face
- Emphasize improving *movement* rather than sounds
- Challenge, but don't frustrate
- Use activities that generate many opportunities for repetition
- We want *good quality* practice; shaping to accuracy

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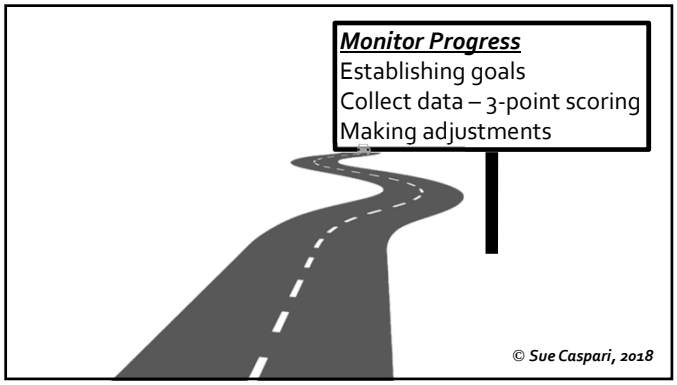


Monitor Progress

- ***Establishing goals***
- Collect data – 3-point scoring
- Making adjustments

Establishing goals
7 year old male

- Child will produce accurate movement gestures of a functional core vocabulary that are 1-3 syllables in length and with an IPC of 0-5, in delayed imitation with no cues with 75% cumulative accuracy (score of 9 out of 12) for each item. An item is counted as accurate if it contains correct consonants, vowels, sequencing of sounds, and prosody.
  - a) accuracy in 1 syllable contexts: CVC, CCV, CCVC (thing, fly, snack)
  - b) accuracy in 2-3 syllable sequences: CVCVC, CVCVCV, CVCCCV (Why not, Hi Joey, Can I go, Let's go)
  - c) accuracy in 3 syllable contexts: CVCCVCV (Castaway)

Monitor Progress

- Establishing goals
- ***Collect data – 3-point scoring***
- Making adjustments

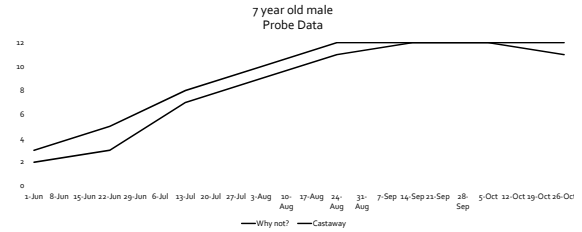
Collect data – 3 point scoring 7 year old male

- Cold probes of all targets X5 productions every 3 weeks on Monday morning **–** in delayed imitation with no cues

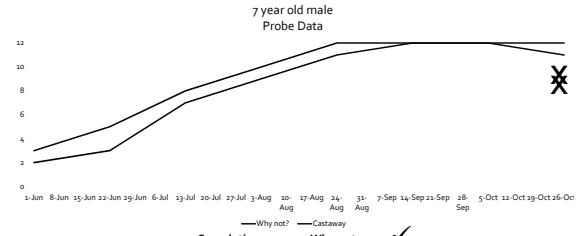
Date	Syllable/Phrase	Responses in delayed imitation no cues					Total Points
6/1	Why not?	0	1	1	1	0	3
	Castaway	1	0	0	1	0	2
6/22	Why not?	1	1	1	1	1	5
	Castaway	1	1	1	0	0	3
7/13	Why not?	2	1	2	2	1	8
	Castaway	2	1	1	1	2	7

Scoring (adapted from Strand, Stoeckel & Baas, 2006 and Baas, et al., 2008)
2 = accurate production
1 = mostly accurate with error of place, manner or voicing on one consonant or mild vowel distortion
0 = frank vowel distortion and/or prosody error and/or more than one error on consonant production

Collect data – 3 point scoring 7 year old male



Cumulative accuracy (X)
7 year old male



Cumulative accuracy Why not – 9.24✓
Cumulative accuracy Castaway – 8.4

Monitor Progress

- Establishing goals
- Collect data – 3-point scoring
- ***Making adjustments***

Making adjustments
7 year old male

Date	Syllable/Phrase	Responses in delayed imitation no cues					Total Points
6/1	Fly	0	1	1	1	0	3
6/22	Fly	0	0	1	1	1	4
7/13	Fly	1	1	0	0	0	2

15 year old female

History

- History of delayed speech development
  - No babbling
  - Late onset of first words
- Speech services since age 2 years
  - Inconsistent service due to family difficulties
- Parents and client concerned that others only understand her speech about 50% of the time
- Recent language testing revealed average receptive language skills in the context of an expressive language delay
  - Simple sentence structures
  - Reduced variation in word choice

Connected speech – 15 year old female

- Intelligibility
  - 82% at the word level
  - 40% at the utterance level
- Phonetic inventory
  - All consonants except /r/ (gliding and vocalization)
  - All vowels – but with frequent distortions
- Syllable shapes
  - Predominantly simple syllable shapes (70%)
    - CVC – 24.7%
    - CV – 23%
    - VC – 12.5%
    - VCV – 11.9%

Connected speech – 15 year old female

- Concerns for CAS in her connected speech
  - Vowel errors - sixteen → /sɪteɪn/; fifteen → /fɪftɪn/; and → /ɛnd/
  - Syllable segmentation – choppy speech
  - Prosody errors - fifteen /fɪftɪn/ (equal stress)
  - Inconsistencies - volleyball → /vʌwɛbɔ/ /vəwɪbɑl/

Summary connected speech assessment – 15 year old female

- Red flags for CAS?
  - Vowel errors
  - Consonant distortions
  - Difficulty w/initial artic configurations or transitionary movement gestures
  - Lexical or phrasal stress errors
  - Syllable segregation or word segregation
  - Groping
  - Intrusive Schwa
  - Voicing Errors
  - Slow speech rate and/or slow DDK
  - Increased difficulty with multi-syllabic words
  - Inconsistent errors on repeated productions of same word

Articulation assessment

- DEAP – no standardized score as client above age ceiling
  - Sound class error for /r/
    - Gliding
    - Vocalization
  - Red flags for CAS
    - Vowel errors
    - Stress errors
    - Segmented syllables
    - Inconsistencies on repeated trials of the same word

Summary articulation assessment – 15 year old female

- Red flags for CAS?
  - Vowel errors
  - Consonant distortions
  - Difficulty w/initial artic configurations or transitionary movement gestures
  - Lexical or phrasal stress errors
  - Syllable segregation or word segregation
  - Groping
  - Intrusive Schwa
  - Voicing Errors
  - Slow speech rate and/or slow DDK
  - Increased difficulty with multi-syllabic words
  - Inconsistent errors on repeated productions of same word

Practice scoring a motor speech assessment – 15 year old female

- Practice – large group
  AUDIO – CV
  - Have child say target
  - Score vowel
  - Dynamic cueing up to 5 more trials (any cues allowed)
  - Score consistency and accuracy after all trials

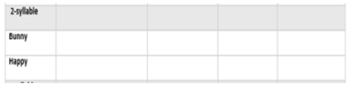
Utterance Type	Overall articulatory accuracy 4 = immediate correct repetition. 3 = immediate, accurate rate and movement but consistent error. 2= correct after first cued attempt 1 = heads cuing (multiple cues) 0 = No correct response. Verbal: Inattention: no attempt.	Vowel accuracy 2 = immediate correct repetition of the vowel 1 = Mild distortion 0 = Frank distortion On first attempt	Prosodic accuracy 1 = Correct 0 = Incorrect On first attempt	Consistency 1= Consistent 0 = Inconsistent On any 2 or more trials
CV	Accuracy 0-4	Vowels 0-2	Prosody 0-1	Consistency 0-1
Me				
Hi				
Toy				
Day				
Show				

Summary Dynamic Motor Speech Assessment – 15 year old female

- Red flags for CAS
  - Vowel errors
  - Consonant distortions ? (sh)
  - Difficulty w/initial artic configurations or transitionary movement gestures
  - Lexical or phrasal stress errors
  - Syllable segregation or word segregation
  - Groping
  - Intrusive Schwa
  - Voicing Errors
  - Slow speech rate and/or slow DDK
  - Increased difficulty with multi-syllabic words
  - Inconsistent errors on repeated productions of same word

Practice scoring a motor speech assessment – 15 year old female

- Practice – large group
  AUDIO – 2-syllable
  - Have child say target
  - Score vowel
  - Dynamic cueing up to 5 more trials (any cues allowed)
  - Score consistency and accuracy after all trials

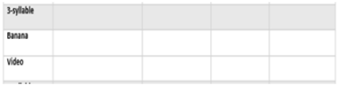


Summary Dynamic Motor Speech Assessment – 15 year old female

- Red flags for CAS
  - Vowel errors
  - Consonant distortions
  - Difficulty w/initial artic configurations or transitionary movement gestures
  - Lexical or phrasal stress errors
  - Syllable segregation or word segregation
  - Groping
  - Intrusive Schwa
  - Voicing Errors
  - Slow speech rate and/or slow DDK
  - Increased difficulty with multi-syllabic words
  - Inconsistent errors on repeated productions of same word

Practice scoring a motor speech assessment – 15 year old female

- Practice – large group
  AUDIO – 3-syllable
  - Have child say target
  - Score vowel
  - Dynamic cueing up to 5 more trials (any cues allowed)
  - Score consistency and accuracy after all trials
  - Banana
  - Video

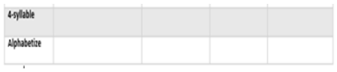


Summary Dynamic Motor Speech Assessment – 15 year old female

- Red flags for CAS
  - Vowel errors
  - Consonant distortions
  - Difficulty w/initial artic configurations or transitionary movement gestures
  - Lexical or phrasal stress errors
  - Syllable segregation or word segregation
  - Groping
  - Intrusive Schwa
  - Voicing Errors
  - Slow speech rate and/or slow DDK
  - Increased difficulty with multi-syllabic words
  - Inconsistent errors on repeated productions of same word

Practice scoring a motor speech assessment – 15 year old female

- Practice – large group
  AUDIO – 4-6-syllable
  - Have child say target
  - Score vowel
  - Dynamic cueing up to 5 more trials (any cues allowed)
  - Score consistency and accuracy after all trials
  - Alphabetize



Summary Dynamic Motor Speech Assessment – 15 year old female

- Red flags for CAS
  - Vowel errors
  - Consonant distortions
  - Difficulty w/initial artic configurations or transitionary movement gestures
  - Lexical or phrasal stress errors
  - Syllable segregation or word segregation
  - Groping
  - Intrusive Schwa
  - Voicing Errors
  - Slow speech rate and/or slow DDK
  - Increased difficulty with multi-syllabic words
  - Inconsistent errors on repeated productions of same word

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Summary motor speech assessment – 15 year old female

- Prosody errors - 75%
  - segmentation of syllables
  - incorrect lexical stress
  - equal stress
- Inconsistencies - 38.1%
- Vowel errors – 20%

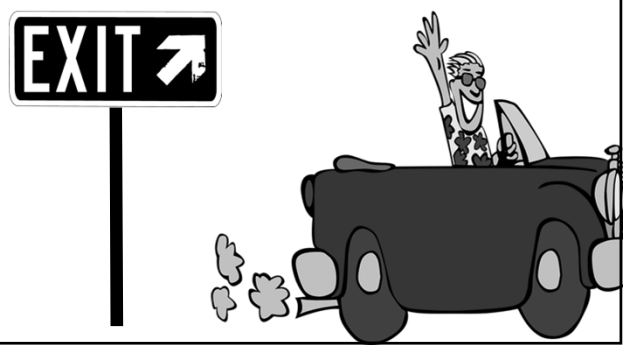
Summary Dynamic Motor Speech Assessment – 15 year old female

- Red flags for CAS
  - Vowel errors
  - Consonant distortions
  - Difficulty w/initial artic configurations or transitionary movement gestures
  - Lexical or phrasal stress errors
  - Syllable segregation or word segregation
  - Groping
  - Intrusive Schwa
  - Voicing Errors
  - Slow speech rate and/or slow DDK
  - Increased difficulty with multi-syllabic words
  - Inconsistent errors on repeated productions of same word

Determine other assessments and recommendations for therapy

Can speech therapy help a child with CAS learn to speak?

- Children with CAS can learn to speak, given appropriate intervention ✓
- Outcomes vary (Jakielski, 2017)
  - Co-occurring symptoms: language, cognition, oral/limb apraxias
  - Severity
  - Initial progress in therapy
  - Motivation, cooperation and attention
  - Intensity and appropriateness of therapy, and continued progress
  - Accessibility to services and support at home
  - Age that services begin



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