Childhood apraxia of speech in preschool and school-age children - Part I: Assessment, Treatment Planning, and Motor Learning

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Disclosures

Some of the research presented here was supported by a grant from Apraxia Kids (www.apraxia-kids.org) as well as NIH grants R03DC012152 and R15DC016426 (J. Preston, PI)

The presenters received an honorarium for this presentation

No other relevant financial or nonfinancial conflicts of interest to report

Agenda

Part I

8:30:-10:00	Assessment of Speech Sound Disorders, Features of CAS
10:00	BREAK
10:15-11:45	Treatment planning, principles of acquisition and motor learning

Evidence-Based Practice

PowerPoint slides are not "evidence" that a particular evaluation procedure or treatment approach is most effective

I will distill information from several studies, but the information represents my take on the research

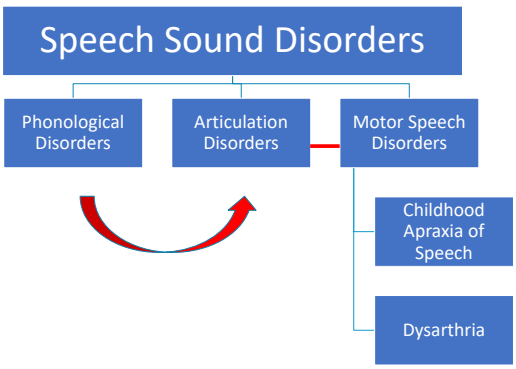
I am happy to point you toward the primary research and have provided several references for your review

Am I the Bearer of Bad News?

To diagnose CAS or other types of speech sound disorders, children must be regularly *attempting verbal output* and should be capable of verbal imitation.
- Language therapy may be a necessary precursor to speech therapy

There isn't one test that always reliably diagnoses CAS across all ages.
- But here are (relatively) agreed-upon features of CAS that can be identified with formal or informal tests

To treat speech in children with CAS, current evidence-based approaches require some form of drill. You can mix in play to keep kids engaged, but children must **practice a lot of speaking**.
- No clearly evidence-based solutions for children 0-3, or for children with CAS + severe ASD
- We'll focus on the approaches that have evidence, but which require structured practice



cf. Shriberg et al., 2017

Childhood Apraxia of Speech

A neurological childhood (pediatric) speech sound disorder in which the precision and consistency of movements underlying speech are impaired.

The core impairment in planning and/or programming spatiotemporal parameters of movement sequences results in errors in speech sound production and prosody (ASHA, 2007).

CAS is not defined by…

An overall lack of words or being non-verbal

The presence of unusual speech errors such as initial consonant deletion, if such errors are produced predictably

Slow/minimal progress in therapy

…This leads to the underdiagnosis/overdiagnosis problem (!)

Who diagnoses CAS?

Position Statement

Childhood Apraxia of Speech

Ad Hoc Committee on Childhood Apraxia of Speech

It is the policy of ASHA that the diagnosis and treatment of CAS are the proper purview of certified speech-language pathologists with specialized knowledge in motor learning theory, skills in differential diagnosis of childhood motor speech disorders, and experience with a variety of intervention techniques that may include augmentative and alternative communication and assistive technology. It is the certified speech-language pathologist who is responsible for making the primary diagnosis of CAS, for designing and implementing the individualized and intensive speech-language treatment programs needed to make optimum improvement, and for closely monitoring progress. Children with developmental disabilities and disorders with high rates of comorbid conditions present a

http://www.asha.org/policy/PS2007-00277/

Three Core Features of CAS

Inappropriate prosody

Listen for stress errors on multisyllabic words and phrases

Token-to-token inconsistency

Listen for consistency during multiple repetitions of the same multisyllabic words

Lengthened and disrupted coarticulatory transitions between sounds and syllables

Listen for sounds that are out of order, assimilation across syllables, lengthened segments, and pauses/gaps between syllables

(ASHA, 2007)

Other common features of CAS

The 3 core features of CAS aren't necessarily sufficient

The field still needs research on this

http://leader.pubs.asha.org/article.aspx?articleid=2608149

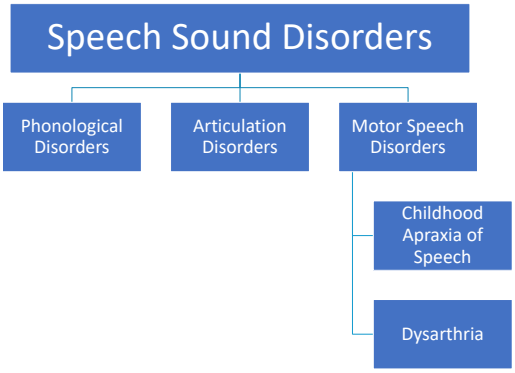
Dr. Edythe Strand article in the ASHA Leader about assessing apraxia

CAS Features – The Mayo Clinic System

- Vowel distortions
- Voicing errors
- Distorted substitutions
- Difficulty achieving initial articulatory configurations or transitionary movement gestures
- Articulatory "groping"
- Intrusive schwa
- Increased errors in multisyllabic words
- Slow speaking rate or slow DDK rate
- Syllable Segregation
- Equal stress or lexical stress errors

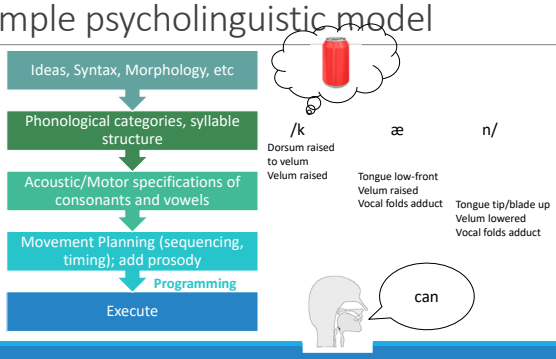
Shriberg, Potter, & Strand, 2011; Shriberg et al, 2017

Differential Diagnosis of Speech Sound Disorders



cf. Shriberg et al., 2017

A simple psycholinguistic model



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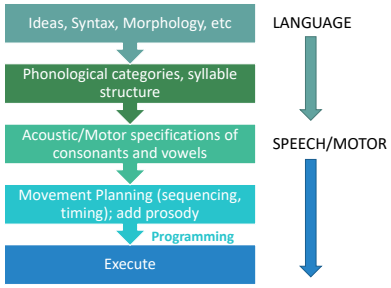

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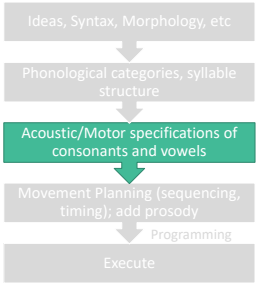
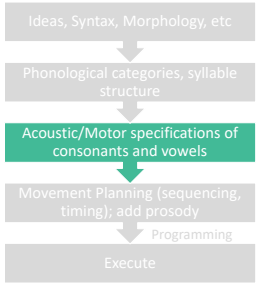


Movement goals associated with a phoneme
- Tongue position
- Lip movement
- Jaw height

Acoustic elements
- Voice onset time
- Spectral noise
- Formant structure

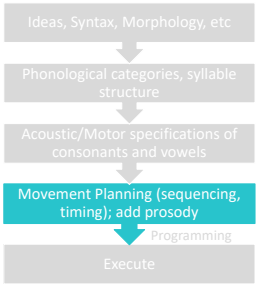
Articulation disorders: what process are disrupted?



Movement goals may be inaccurate
- -lateral release of air for /s/
- -derhoticized /r/

Acoustic specification may be inaccurate
- -speech perception

A simple psycholinguistic model



Assembling the movement goals

Specifying order, timing, speed and force of movements

Dorsum raised
to velum
Velum raised

Tongue low-front
Velum raised
Vocal folds adduct

Tongue tip/blade up
Velum lowered
Vocal folds adduct

A simple psycholinguistic model

Dorsum raised
to velum
Velum raised

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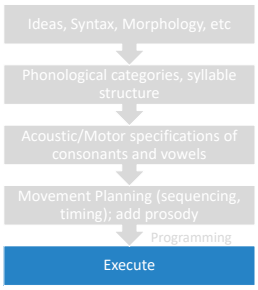
Tongue tip/blade up
Velum lowered
Vocal folds adduct

Selecting muscles

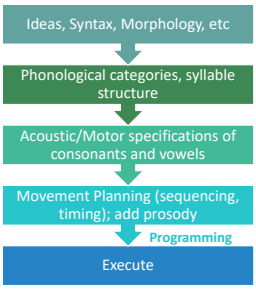
Transmitting message to muscles that will be used to achieve the plan

A simple psycholinguistic model



Activating muscles with appropriate force and range of motion to be easily understood.

A simple psycholinguistic model



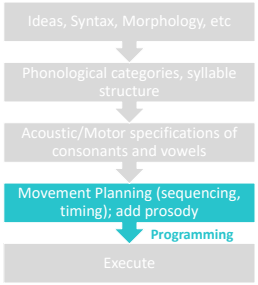
Phonological Disorder

Articulation Disorder

Childhood Apraxia of Speech

Dysarthria

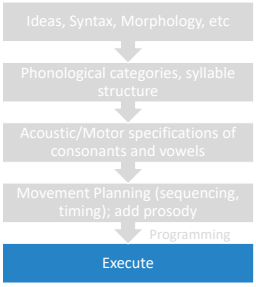
Childhood apraxia of speech: what processes are disrupted?



Precision and consistency of movements underlying speech

- Sequencing
- Timing
- Prosody

Dysarthria: what processes are disrupted?



Respiration
- phrasing

Phonation
- vocal volume, quality

Resonance
- slow or weak closure of VP port

Articulatory precision
- limited range of motion
- Distortions/imprecision
- Poor build up of pressure

Dysarthria

A neurological childhood (pediatric) speech sound disorder in which the neuromuscular execution of speech is impaired.

Often associated with organic disorders, but doesn't necessarily have to be (e.g., CP, Down Syndrome)

Features differ based on type of dysarthria (e.g., spastic, flaccid)

Dysarthria

Imprecise speech production
- Slurring
- Distortions
- Monotone/Monoloud or highly variable (type-dependent)

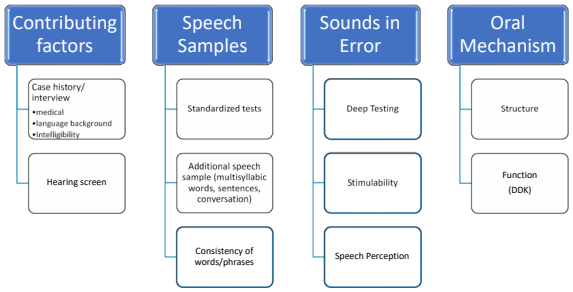
Involuntary/Vegetative motor control often impaired
- Chewing
- Swallowing

Errors generally more consistent than CAS

Feature	CAS	Dysarthria
Breath Support	Adequate breath support	Poor breath support (e.g., short utterance length)
Groping, False Starts	May be present	Unlikely to occur
Automatic Speech	More accurate than spontaneous	Equally affected
Vegetative functions	Unlikely to be affected (unless oral apraxia)	Likely to be affected
Speech sound errors	Substitutions, omissions, distortions, additions	Mostly distortions
Resonance	Normal or intermittent problems with resonance	More pervasive problems (e.g., hypernasality)
Prosody	Excess equal stress, stress shifts, syllable segregation	Reduced equal stress (monolound/monopitch) depending on type
Speech rate	Slow rate?	Slow rate

Assessment Tasks

Assessment Checklist for SSD



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- Listen for sounds that are out of order, assimilation across syllables, lengthened segments, and pauses/gaps between syllables

(ASHA, 2007)

Assessing sequencing and transitioning in CAS

PAUSE MARKER
SYLLABLE SEGREGATIONS
DIADOCHOKINETIC TASKS/MAXIMUM PERFORMANCE TASKS

Shriberg's Pause Marker

Between-word pauses of at least 150 msec. Identified acoustically. 4 primary types.

- Occurs at an inappropriate linguistic place in continuous speech
- Abrupt, sudden onset or offset of energy
- May be immediately preceded or followed by a phoneme or word that includes significant change in amplitude, frequency or rate
- May include groping - pause that includes lip or tongue gesture or inappropriate voicing

Shriberg et al. 2017

Shriberg's Pause Marker

And 'bout by nine o'clock they shoot them, uhum,

They don't make pizza

Get new toy maybe

He has blond hair

Tilkens, C. M., Karlsson, H. B., Fourakis, M., Hall, S. D., Mabie, H. L., McSweeny, J. L., Wilson, D., & Shriberg, L. D. [2017]. *A diagnostic marker to Discriminate Childhood Apraxia of Speech (CAS) from Speech Delay (SD): The Pause Marker* [Tech. Rep. No. 22]

Syllable segregation

"*Noticeable gaps between syllables*" when producing words of 3+ syllables.

Within-word pauses

Segregation on ≥3% of multisyllabic words is outside the range of typical

(Murray, McCabe, Heard, & Ballard, 2015)

Syllable segregation examples

Binoculars	Helicopter	Teacher
Photographer	Caterpillar	Washcloth
Propeller	Octopus	Dentist
Trampoline	Watermelon	Splinter
Wheelbarrow	Zipper	Window
		Thirsty
		Television

Diadochokinetic tasks

Task	CAS	Dysarthria
/papapapa/ /tatatata/ /kakakaka/	• Normal or slow • Rhythm disrupted?	• Slow • Imprecise, weak • Frequent breaths
/puh-tuh-kuh/	• Slow? • Rhythm disrupted • Segregated syllables • Sequencing errors • Deleted sounds/syllables • Groping, false starts	• Slow • Imprecise, weak • Frequent breaths
/a – m – u /		

Maximum Performance Tasks

Evaluate speech motor functioning with DDK and sustained fricatives an vowels
(Thoonen, et al, 1996, 1999)

Can aid in the differential diagnosis of CAS and dysarthria
(Rvachew, Hodge, & Ohberg, 2005)

Tutorial for administration and scoring found here:
http://tocs.plus.ualberta.ca/pdf/Dec_jslpa_2005_MPT.pdf

Maximum Performance Tasks

Maximum phonation duration (MPD)
/ɑ/, repeated productions of /mɑmɑ/

Maximum fricative duration (MFD)
Measure sustained /f/, /s/, and /z/

Max repetition rate – monosyllabic (MRRmono)
Alternating motion rates
Repetitions of /pʌ/, /tʌ/, /kʌ/

Max repetition rate – trisyllabic (MRRtri)
Sequential Motion Rates
Repetitions of /pʌtʌkʌ/

Slow, imprecise single syllables is the primary diagnostic marker for dysarthria

Slow, inaccurate trisyllables (or inability to generate 5 consec sequences) is the primary diagnostic marker for CAS

Maximum Performance Tasks

Maximum phonation duration (MPD)
/ɑ/, repeated productions of /mɑmɑ/

Maximum fricative duration (MFD)
Measure sustained /f/, /s/, and /z/

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Max repetition rate – trisyllabic (MRRtri)
Sequential Motion Rates
Repetitions of /pʌtʌkʌ/

16 y/o

10 y/o

Case example: Difficulty with sequencing and transitioning

P32 Maximum Performance Tasks

P32 Sentence Repetition

Goal: Appropriate sequencing/transitioning across syllables in multisyllabic words and phrases

Assessing prosody

LEXICAL STRESS OF MULTISYLLABIC WORDS

Assessing lexical stress

Produce multisyllabic words of various lengths and stress patterns

Listen for articulatory accuracy AND appropriateness of stress
- Stressed syllables are HIGHER in pitch, LOUDER in intensity, and LONGER in duration
- Errors may include
  - Equal stress
  - Stress shifts
  - **Segregation may or may not be present as well

Common lexical stress patterns

Strong-Weak (Sw)
- table, money

Weak-Strong (wS)
- balloon, remote

Strong-Weak-Weak (Sww)
- calendar, elephant

Weak-Strong-Weak (wSw)
- banana, potato

Lexical stress errors: examples

Is the expected stressed syllable…
- HIGHER in pitch
- LOUDER in intensity
- LONGER in duration

Grasshopper
Valentine
Chicken
Banana
Pajamas
Octopus
Jumping

Goal: Produce appropriate lexical stress in multisyllabic words

What features do you hear?

Dinosaur
Measuring cup
Xylophone
Shovel
Hippopotamus
Grasshopper
Basket
Ice cream

Toothbrush
Mailbox
Jump rope
Blanket
Spider
Swimming pool
Washcloth

I have 15 minutes to make a CAS diagnosis…here's what I'd do…

Multisyllabic word tasks

Production of multisyllabic words
- Percent consonants correct
- Syllable segregation
- Lexical stress accuracy

DDK ("puh-tuh-kuh")
- Can they generate accurate repeated sequences?

These 4 variables achieved 91% correct classification for CAS (compared to "expert" judgment)

Murray et al., 2015

Assessing consistency

PRODUCING THE SAME WORDS MULTIPLE TIMES

Standardized assessments which measure consistency

Diagnostic Evaluation of Articulation and Phonology

- Ages 3-8 years
- 25-item list consisting of words 1 – 4 syllables in length
  - Most (11) are single-syllable words
- Administer 25 items in list three times
- Distractor task between administrations
- May be appropriate for preschoolers and those with moderate/severe impairment (the items aren't too difficult)

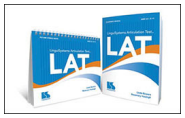
Dodd, Hua, Crosbie, Holm, Ozanne, 2006

deap
Diagnostic Evaluation of Articulation and Phonology

Standardized assessments which measure consistency

Linguisystems Articulation Test

- 12 multisyllabic words, assessed 3 times
  - Most (10) are 3-syllable words
- Consecutive administration
  - "Say *eyelashes* three times"
- May be better for older children or those with more mild characteristics (the items are more challenging)



Bowers & Huisingh, 2010

Assessing consistency

Can also generate an informal assessment with multisyllabic words (e.g., refrigerator, hospital), or short phrases (e.g., "Buy Bobby a Puppy")

- For preschoolers, pick "complex" words that are in their expressive vocabulary (e.g., computer, pajamas, elephant)

Inconsistency on repeated attempts may indicate problems with motor programming

Iuzzini-Seigel, Hogan, & Green (2017)

Assessing consistency examples

Assessment of the **same words** produced multiple times

- 4 yr old (table, fish)
- 6 yr old (Buy Bobby a puppy)
- 12 year old (rapid, repeated picture naming)

Goal: Improve consistency

Word	Articulation Disorder	Phonological Disorder	CAS	?
Sneaker	[ˈsˌnikə] [ˈsˌnikə] [ˈsˌnikə]	[ˈnitə] [ˈnitə] [ˈnitə]	[ˈdetə] [ˈniˈnʌ] [ˈsˌiˈkʌ]	[ˈikə] [ˈikə] [ˈikə]
Stove	[sˌtov] [sˌtov] [sˌtov]	[tob] [tob] [tob]	[sˌtob] [suv] [vov]	[ob] [ob] [ob]
Kissing	[ˈkɪsˌɪŋ] [ˈkɪsˌɪŋ] [ˈkɪsˌɪŋ]	[ˈtɪtɪn] [ˈtɪtɪn] [ˈtɪtɪn]	[ˈdɪbən] [ˈkɪˈkʌŋ] [ˈkɪsˌnɪd]	[ˈ ɪdɪŋ] [ˈ ɪdɪŋ] [ˈ ɪdɪŋ]
Geese	[gisˌ] [gisˌ] [gisˌ]	[dit] [dit] [dit]	[fis] [gɪd] [dit]	[it] [it] [it]

Phonological errors and inconsistency

Different phonological processes may affect a single phoneme in a number of ways

- which may make the phoneme *seem* inconsistent
- Look across sound classes for consistency

Inconsistency may be observed across productions of a particular PHONEME because of phonological processes:

- Example: inconsistently produced /s/?
- /s/ may be deleted in clusters [Ø]
- /s/ may be stopped and voiced in onset singleton [d]
- /s/ may be stopped (and voiceless) in coda [t]

The presence of initial consonant deletion, backing, atypical cluster reduction, etc. don't necessarily mean CAS is present

….but…

…they are not mutually exclusive either.

Relative Contributions

Many children have characteristics of multiple types of SSD

- Articulation errors
- Consistent phonological processes
- Prosodic disturbances, sequencing errors, etc.

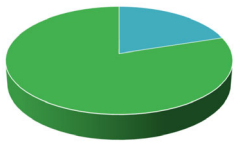
What is the comparative impact of the characteristics of each disorder?

Select a treatment option that is appropriate for the areas of greatest need.

Relative Contribution

HIGH IMPACT: RESIDUAL ARTIC

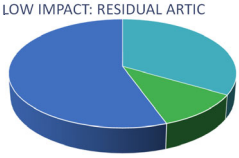
LOW IMPACT: CAS



HIGH IMPACT: DYSARTHRIA

MODERATE IMPACT: CAS

LOW IMPACT: RESIDUAL ARTIC



Relative Contribution?

Residual Speech Errors (Artic) **Childhood Apraxia of Speech**

Suzie wore a simple red dress to lunch

The cops arrest a robber at the drug store

The eager squirrel travels far to get nuts

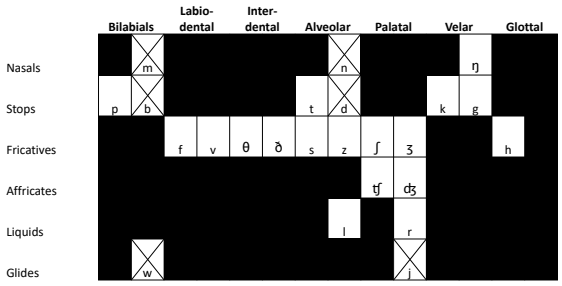
The silly dog barks and wants to chase the ice-cream man

Relative Contributions?

Plan treatment based on speech features, not the label

Using Assessment Data for Target Selection

Independent analyses may help you describe inventory



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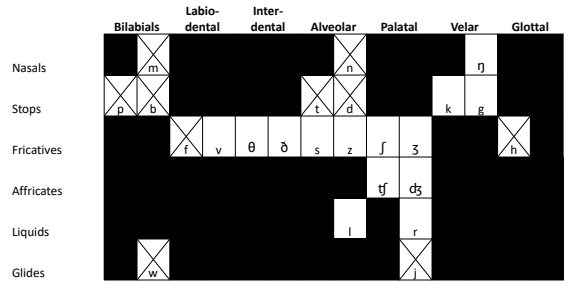

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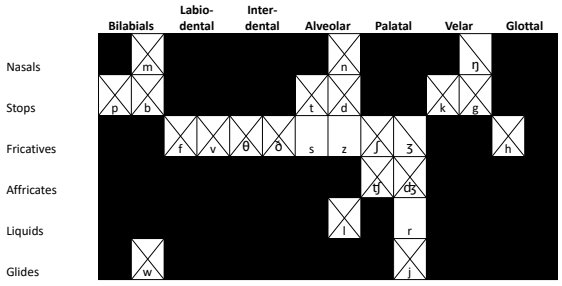

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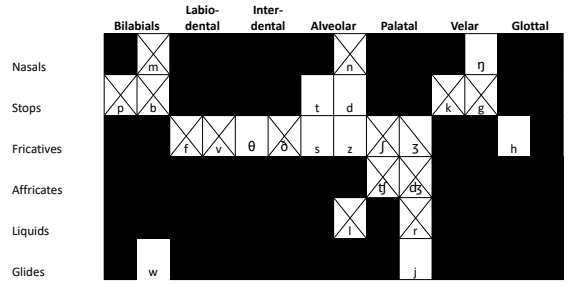


Dynamic Evaluation of Motor Speech Skills (DEMSS)

Imitate words of varied difficulty

CV (e.g., do)

VC (e.g., eat)

Reduplicated CVCV (e.g., papa)

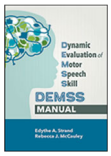
CVC1 (e.g., mom)

CVC2 (e.g., home)

Bisyllabic (one C, Two Vs) (e.g., puppy)

Bisyllabic (varied) (e.g., bunny)

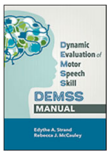
Multisyllabic (e.g. peekaboo)



Dynamic Evaluation of Motor Speech Skills (DEMSS)

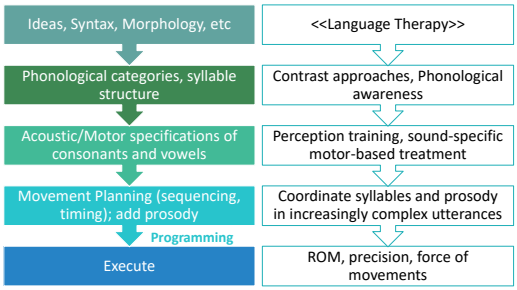
Identify accuracy, consistency AND level of support needed

- e.g., correct on first attempt, correct after cueing, never correct



For children with severe SSD and suspected CAS, this may help you determine relative strengths, areas of need, and facilitative strategies to help with treatment planning

From diagnosis to therapy



What process is disrupted?

Use assessment data (and present level of performance) to identify main impact or largest *relative contributions*

Write goals to address those areas

- Frequent Phonological Processes → suppress phonological processes
- Limited Consonant Inventory → add sounds to inventory
- Poor Respiration → increase length of phrase per breath group
- Poor Lexical Stress → produce appropriate lexical stress
- Frequent Syllable Segregation → produce accurate transitions/ connections between syllables
- Inconsistent Production of Multisyllabic Words Beginning with Weak syllables →

Principles of Motor Learning

Principles of Motor Learning

For Articulation Disorders, Dysarthria, and CAS, the problems are (primarily) in the motoric aspects of speech production

Similar *principles* are likely warranted in treatment

Over the last decade, Principles of Motor Learning have been increasingly applied to treatments of both Articulation Disorders and CAS

Motor Learning Principles

Acquisition

- Performance during practice (during therapy)

Motor Learning

- Retention or generalization of learned behavior
- Relatively permanent changes

See Maas et al., 2008

What is Motor Learning

SESSION PERFORMANCE DATA	PROGRESS MONITORING DATA
Assesses *acquisition* of motor pattern	Assesses *motor learning* (retention and generalization)
Performance within session on treated targets	Performance on untrained targets measured periodically

Sample Goals to address Learning

Prosody:

Sam will produce appropriate lexical stress in untrained 2- 3 syllable words without feedback or cues

Sounds:

Sam will produce /t/ and /d/ onsets in untrained 2- 3 syllable words in sentences without feedback or cues

Consistency/Transitioning:

Sam will produce untrained 2, 3, and 4 syllable words with properly sequenced phonemes and smooth transitions between sounds and syllables without feedback or cues

Motor Learning Principles

What affects acquisition and motor learning?

Feedback

- Feedback type: Knowledge of Performance vs. Knowledge of Results
- Feedback frequency: High frequency vs. Low frequency
- Feedback timing: immediate vs. delayed

Practice Conditions

- Practice amount: few vs. many trials
- Practice schedules: blocked vs. random (within a session)
- Practice variability: constant practice vs. variable practice
- Target complexity: simple vs. complex

Adapted from Maas et al., 2008

Motor Learning Principles

Feedback Type

Knowledge of Performance

- Giving feedback on aspects of movement
  - "I saw your lips close when you made that /m/ sound."
  - "The back of your tongue didn't go up when you made the /k/ sound."
- Should enhance motor performance/acquisition

Knowledge of Results

- Giving feedback on accuracy of the motor movement
  - "That's right"
  - "Not quite."
- Should enhance motor learning/generalization

Adapted from Maas et al., 2008

Motor Learning Principles

Feedback Frequency

High frequency

- Giving feedback on 90 – 100% of trials should aid performance/acquisition

Low frequency

- Giving feedback on 50 – 60% of trials should aid motor learning/generalization

Feedback frequency may depend on whether the child is ready to transition from a focus on acquisition to a focus on learning (Maas, Butella, & Farinella, 2012)

Adapted from Maas et al., 2008

Motor Learning Principles

Child "up"	Clinician	Knowledge of Performance or Results?
"uh" [ʌ]	Bring those lips together. Watch me. Up.	KP
"up" [ʌp]	Yay! Those lips closed. Up!	KP
"uh" [ʌ]	Lips didn't close.	KP
"up" [ʌp]	You got 'em closed! One more time	KP
"up" [ʌp]	Great! Let's do it again!	KR
"uh" [ʌ]	Remember to close 'em at the end.	KP
"up" [ʌp]	Way to close those lips!	KP

Motor Learning Principles

Child "go up"	Clinician	Knowledge of Performance or Results?
Go- uh	Remember to close those lips for "up," Go up	KP
Go up	Great	KR
Go-uh	Not quite	KR
Go up	(smile and nod)	KR
Go up		
Go up		
Go up	(pause…) You got it!	KR

Motor Learning Principles

Feedback Timing

Immediate feedback
- Should aid performance/acquisition

Delayed feedback (wait 2 – 3 seconds)
- Should aid motor learning/generalization

Adapted from Maas et al., 2008

Motor Learning Principles

Practice amount
- High frequency (many responses) probably aids both motor performance and motor learning

Clinically?
- Aim for a high response rate
- Structure sessions with quick motivators

Motor Learning Principles

Practice Schedules

Blocked practice
- Should result in better acquisition/performance
- Working on target A for 15 trials before moving to target B

Random Practice
- Should aid motor learning/generalization
- The order of the stimuli are mixed up throughout the session

Consider whether the child is ready to transition from a focus on acquisition to a focus on learning (Maas, Butella, & Farinella, 2012)

Adapted from Maas et al., 2008

Motor Learning Principles
Blocked vs. Random

Session 1: Blocked	Session 9: Random
Hi mom x20	Hi mom
Go home x20	Go home
Wake up x20	Hi mom
Hi mom x20	Wake up
Go home x20	Go home
Wake up x20	Go home
	Wake up
	Hi mom
	Wake up
	Hi mom
	Go home

Motor Learning Principles

Practice variability
- **Constant practice**
  - Same target sound in same word position
  - Just a few items (4-5 syllables or words)
  - Spoken the same way
  - Should help with performance/acquisition
- **Variable practice**
  - Target sound in different word positions, stress patterns
  - Large stimulus set (e.g., 20 items)
  - Varied rate, intonation, loudness, pragmatic functions
  - Should help with learning/generalization

Motor Learning Principles
Homework Example

Try making your best low sounds in these words. Practice each word 5 times in these different "voices". Be sure to listen for your best low - how does it sound in each "voice"?

	SLOW	RISING	FALLING	LOUD	QUIET	FAST
Yellow						
Alone						
Loading						

Motor Learning Principles

Complexity of response

Simple responses
- e.g., syllables, monosyllabic words
- may result in better performance/acquisition

Complex responses
- e.g., multisyllabic targets, phrases, sentences
- may help with learning/generalization

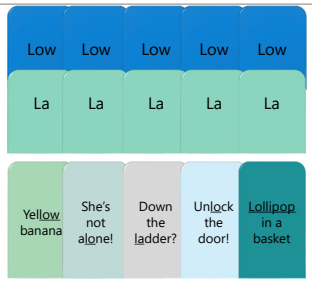
Clinically?
- Try to build up to a few complex targets ***quickly***

Motor Learning Principles

Acquisition
- Constant practice
- Few, simple stimuli
- *Blocked* practice

Vs

Learning
- Many, complex stimuli
- Random practice
- Variability



Motor Learning Principles Summary

TO **ACQUIRE** A SKILL
(MOTOR PERFORMANCE)
- Knowledge of performance
- High frequency of feedback
- Immediate feedback
- Many trials per session
- Blocked practice
- Constant practice
- Small stimulus set
- Simple targets

TO **RETAIN** A SKILL
(MOTOR LEARNING)
- Knowledge of results
- Lower frequency of feedback
- Delayed feedback
- Many trials per session
- Random practice
- Variable practice
- Large stimulus set
- Complex targets

Ear Training

Do you hear evidence of…
- Impaired transitioning between sounds and syllables
- Impaired prosody
- Inconsistency