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

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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.

- If there aren’t regular attempts to communicate verbally, language therapy is a necessary precursor to speech therapy

There isn’t a test to buy that has been proven to reliably diagnose CAS.

- But here are (relatively) agreed-upon features of CAS that can be identified with a variety of 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.

- Sadly, this means we currently have 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 (which most school-age children can handle)

Speech Sound Disorders

Phonological Disorders  Articulation Disorders  Motor Speech Disorders

Childhood Apraxia of Speech  Dysarthria

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

Who diagnoses CAS?


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


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 transitional 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

Speech Sound Disorders
- Phonological Disorders
- Articulation Disorders
- Motor Speech Disorders
  - Childhood Apraxia of Speech
  - Dysarthria
cf. Shriberg et al., 2017

A simple psycholinguistic model

Ideas, Syntax, Morphology, etc.
- Phonological categories, syllable structure
- Acoustic/Motor specifications of consonants and vowels
- Movement Planning (sequencing, timing); add prosody
  - Programming
  - Execute

A simple psycholinguistic model

LANGUAGE
- Phonological categories, syllable structure
- Acoustic/Motor specifications of consonants and vowels
- Movement Planning (sequencing, timing); add prosody
  - Programming
  - Execute

A simple psycholinguistic model

Ideas, Syntax, Morphology, etc.
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- Movement Planning (sequencing, timing); add prosody
  - Programming
  - Execute

Articulation disorders: what process are disrupted?

Ideas, Syntax, Morphology, etc.
- Phonological categories, syllable structure
- Acoustic/Motor specifications of consonants and vowels
- Movement Planning (sequencing, timing); add prosody
  - Programming
  - Execute

Movement goals may be inaccurate
- Lateral release of air for /s/
- Derhotized /r/

Acoustic specification may be inaccurate
- Speech perception
**A simple psycholinguistic model**

1. **Ideas, Syntax, Morphology, etc.**
2. **Phonological categories, syllable structure**
3. **Acoustic/Motor specifications of consonants and vowels**
4. **Movement Planning (sequencing, timing); add prosody**
   - Assembling the movement goals
   - Specifying order, timing, speed and force of movements
   - Transmitting message to muscles that will be used to achieve the plan
   - Translating movements to muscle contractions

**Operating:**
- **Programming**
- **Execute**

**Phonological Disorder**
- Articulation Disorder
- Childhood Apraxia of Speech
- Dysarthria

**Childhood apraxia of speech:**
what processes are disrupted?

1. **Ideas, Syntax, Morphology, etc.**
2. **Phonological categories, syllable structure**
3. **Acoustic/Motor specifications of consonants and vowels**
4. **Movement Planning (sequencing, timing); add prosody**
   - Precision and consistency of movements underlying speech
     - Sequencing
     - Timing
     - Prosody

**Operating:**
- **Programming**
- **Execute**

**Dysarthria:**
what processes are disrupted?

1. **Ideas, Syntax, Morphology, etc.**
2. **Phonological categories, syllable structure**
3. **Acoustic/Motor specifications of consonants and vowels**
4. **Movement Planning (sequencing, timing); add prosody**
   - Articulation precision
   - Articulatory precision
   - Limited range of motion
   - Production: articulation
   - Respiration
   - Phrasing
   - Vocal volume, quality
   - Articulatory precision
   - Limited range of motion
   - Poor build up of pressure

**Operating:**
- **Programming**
- **Execute**
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)

Assessment Tasks

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

Assessment Checklist for SSD

Contribute factors

- Case history/ interview
- Medical/ background
- Speech samples
- Standardized tests
- Additional speech sample (multisyllabic words, sentences, conversation)
- Consistency of words/phrases
- Hearing screen

Speech Samples

- Sounds in Error
- Deep Testing
- Stimulability
- Speech Perception

Oral Mechanism

- Structure
- Function (plos)

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)
Assessing sequencing and transitioning in CAS

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

Syllable segregation
“Noticeable gaps between syllables” when producing words of 3+ syllables.
Within-word pauses
Segregation on \( \geq 3\% \) of multisyllabic words is outside the range of typical

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

Syllable segregation examples
Envelope, Graffiti, Marshmallows, Police car, Potato, Wheelbarrow, Helicopter, Caterpillar, Octopus, Watermelon, Zipper, Teacher, Washcloth, Dentist, Splinter, Window, Thirsty, Television

Diadochokinetic tasks

<table>
<thead>
<tr>
<th>Task</th>
<th>CAS</th>
<th>Dysarthria</th>
</tr>
</thead>
<tbody>
<tr>
<td>/papapapa/</td>
<td>Normal or slow</td>
<td>Slow</td>
</tr>
<tr>
<td>/tatatatata/</td>
<td>Rhythm disrupted</td>
<td>Imprecise, weak</td>
</tr>
<tr>
<td>/kakakaka/</td>
<td></td>
<td>Frequent breaths</td>
</tr>
<tr>
<td>/puh-tuh-kuh/</td>
<td>Slow?</td>
<td>Slow</td>
</tr>
<tr>
<td></td>
<td>Rhythm disrupted</td>
<td>Imprecise, weak</td>
</tr>
<tr>
<td></td>
<td>Segregated syllables</td>
<td>Frequent breaths</td>
</tr>
<tr>
<td></td>
<td>Sequencing errors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Deleted sounds/syllables</td>
<td></td>
</tr>
<tr>
<td>/a – m – u /</td>
<td>Groping, false starts</td>
<td></td>
</tr>
</tbody>
</table>

Shriberg et al. 2017
Maximum Performance Tasks

Evaluate speech motor functioning with DDK and sustained fricatives an vowels

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

Tutorial for administration and scoring found here:

Maximum Performance Tasks

Maximum phonation duration (MPD)
/[a]/, repeated productions of /mama/ 

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

Max repetition rate – monosyllabic (MRRmono)
Alternating motion rates
Repetitions of /pa/, /ta/, /ka/ 

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

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

Case example: Difficulty with sequencing and transitioning

P32 Maximum Performance Tasks

P32 Sentence Repetition

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

Goal: Produce appropriate lexical stress in multisyllabic words

<table>
<thead>
<tr>
<th>English (Lexical Stress)</th>
<th>Chinese (Lexical Stress)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasshopper</td>
<td>蟋蟀 (sāng jiè)</td>
</tr>
<tr>
<td>Valentine</td>
<td>情人节 (qīng rén jié)</td>
</tr>
<tr>
<td>Chicken</td>
<td>鸡 (jī)</td>
</tr>
<tr>
<td>Banana</td>
<td>香蕉 (xiāng jiāo)</td>
</tr>
<tr>
<td>Pajamas</td>
<td>睡衣 (shuì yī)</td>
</tr>
<tr>
<td>Octopus</td>
<td>章鱼 (zhāng yú)</td>
</tr>
<tr>
<td>Jumping</td>
<td>跳跃 (tiào yuè)</td>
</tr>
</tbody>
</table>

What features do you hear?

<table>
<thead>
<tr>
<th>English (Features)</th>
<th>Chinese (Features)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dinosaur</td>
<td>恐龙 (kěng lóng)</td>
</tr>
<tr>
<td>Measuring cup</td>
<td>测量杯 (cè liàng bēi)</td>
</tr>
<tr>
<td>Xylophone</td>
<td>木鱼 (mù yú)</td>
</tr>
<tr>
<td>Shovel</td>
<td>铁锹 (tiě qiāo)</td>
</tr>
<tr>
<td>Hippopotamus</td>
<td>海牛 (hǎi niú)</td>
</tr>
<tr>
<td>Grasshopper</td>
<td>蟋蟀 (sāng jiè)</td>
</tr>
<tr>
<td>Basket</td>
<td>篮子 (lán zi)</td>
</tr>
<tr>
<td>Ice cream</td>
<td>冰淇淋 (bīng qílín)</td>
</tr>
<tr>
<td>Toothbrush</td>
<td>牙刷 (yá shuā)</td>
</tr>
<tr>
<td>Mailbox</td>
<td>邮箱 (yóu xiāng)</td>
</tr>
<tr>
<td>Jump rope</td>
<td>跳绳 (tiào shéng)</td>
</tr>
<tr>
<td>Blanket</td>
<td>被子 (bèi zi)</td>
</tr>
<tr>
<td>Spider</td>
<td>蜘蛛 (zhī zhū)</td>
</tr>
<tr>
<td>Swimming pool</td>
<td>游泳池 (yóu yǒng chí)</td>
</tr>
<tr>
<td>Washcloth</td>
<td>洗衣巾 (xiǎng yī jīn)</td>
</tr>
</tbody>
</table>

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
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)

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

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

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 Contributions?
Plan treatment based on speech features, not the label

Planning Treatment from Assessment Data

Independent analyses may help you describe inventory

<table>
<thead>
<tr>
<th>Bilabials</th>
<th>Labio-dental</th>
<th>Inter-dental</th>
<th>Alveolar</th>
<th>Palatal</th>
<th>Velar</th>
<th>Glottal</th>
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<table>
<thead>
<tr>
<th>Nasals</th>
<th>Stops</th>
<th>Fricatives</th>
<th>Affricates</th>
<th>Liquids</th>
<th>Glides</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>b</td>
<td>v</td>
<td>θ</td>
<td>l</td>
<td>w</td>
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<td>n</td>
<td>p</td>
<td>f</td>
<td>ð</td>
<td>j</td>
<td>j</td>
</tr>
</tbody>
</table>

HIGH IMPACT: RESIDUAL ARTIC
LOW IMPACT: CAS
MODERATE IMPACT: CAS
LOW IMPACT: RESIDUAL ARTIC
DYSARTHRIA

HIGH IMPACT: DYSARTHRIA
LOW IMPACT: RESIDUAL ARTIC
CAS

Independent analyses may help you describe inventory
Independent analyses may help you describe inventory

Bilabials  Labiodental  Interdental  Alveolar  Palatal  Velar  Glottal

Nasals
Stops
Fricatives
Affricates
Nasals m n ŋ
Stops p b t d k g
Fricatives f v θ ð sz ʃʒ h
Affricates ʧʤ
Liquids l r
Glides w j

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)

From diagnosis to therapy

Ideas, Syntax, Morphology, etc
Phonological categories, syllable structure
Acoustic/Motor specifications of consonants and vowels
Movement Planning (sequencing, timing); add prosody
Execute

<<Language Therapy>>

Contrast approaches, Phonological awareness
Perception training, sound-specific motor-based treatment
Coordinate syllables and prosody in increasingly complex utterances
ROM, precision, force of movements

What process is disrupted?

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

Write goals to address those areas

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
Frequent Phonological Processes → suppress phonological processes
Limited Consonant Inventory → add sounds to inventory
Inconsistent Production of Multisyllabic Words Beginning with Weak syllables →
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)

Retention or generalization of learned behavior
- Relatively permanent changes

See Maas et al., 2008

What is Motor Learning

SESSION PERFORMANCE DATA
Assesses acquisition of motor pattern
Performance within session on treated targets

PROGRESS MONITORING DATA
Assesses motor learning (retention and generalization)
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

**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

**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

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**Motor Learning Principles**

<table>
<thead>
<tr>
<th>Child &quot;up&quot;</th>
<th>Clinician</th>
<th>Knowledge of Performance or Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;uh&quot; [A]</td>
<td>Bring those lips together. Watch me. Up.</td>
<td>KP</td>
</tr>
<tr>
<td>&quot;up&quot; [A]</td>
<td>Yay! Those lips closed. Up!</td>
<td>KP</td>
</tr>
<tr>
<td>&quot;uh&quot; [A]</td>
<td>Lips didn't close.</td>
<td>KP</td>
</tr>
<tr>
<td>&quot;up&quot; [A]</td>
<td>You got 'em closed! One more time</td>
<td>KP</td>
</tr>
<tr>
<td>&quot;uh&quot; [A]</td>
<td>Great! Let's do it again!</td>
<td>KR</td>
</tr>
<tr>
<td>&quot;up&quot; [A]</td>
<td>Remember to close 'em at the end.</td>
<td>KP</td>
</tr>
<tr>
<td>&quot;up&quot; [A]</td>
<td>Way to close those lips!</td>
<td>KP</td>
</tr>
</tbody>
</table>

**Motor Learning Principles**

<table>
<thead>
<tr>
<th>Child &quot;sit down&quot;</th>
<th>Clinician</th>
<th>Knowledge of Performance or Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Go- uh</td>
<td>Remember to close those lips for &quot;up,&quot; Go up</td>
<td>KP</td>
</tr>
<tr>
<td>Go up</td>
<td>Great</td>
<td>(KP)</td>
</tr>
<tr>
<td>Go-uh</td>
<td>Not quite</td>
<td>KR</td>
</tr>
<tr>
<td>Go up</td>
<td>(smile and nod)</td>
<td>KR</td>
</tr>
<tr>
<td>Go up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Go up</td>
<td>(pause…) You got it!</td>
<td>KR</td>
</tr>
</tbody>
</table>

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Motor Learning Principles

Practice amount
- High frequency (many responses) probably aids both motor performance and motor learning
- Aim for a high response rate
- Structure sessions with quick motivators

Adapted from Maas et al., 2008
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

<table>
<thead>
<tr>
<th>Session 1: Blocked</th>
<th>Session 9: Random</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hi mom x20</td>
<td>Hi mom</td>
</tr>
<tr>
<td>Go home x20</td>
<td>Go home</td>
</tr>
<tr>
<td>Wake up x20</td>
<td>Wake up</td>
</tr>
<tr>
<td>Hi mom x20</td>
<td>Wake up</td>
</tr>
<tr>
<td>Go home x20</td>
<td>Go home</td>
</tr>
<tr>
<td>Wake up x20</td>
<td>Go home</td>
</tr>
<tr>
<td>Hi mom</td>
<td>Wake up</td>
</tr>
<tr>
<td>Wake up</td>
<td>Hi mom</td>
</tr>
<tr>
<td>Hi mom</td>
<td>Go home</td>
</tr>
</tbody>
</table>

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

Video U002

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