Intervention for Apraxia of Speech in Adults

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Dr. Wambaugh is receiving payment for this presentation.

Session Overview
AOS treatments – overview of treatment approaches
Sound Production Treatment (SPT)
Rate/rhythm control treatment
Combined Aphasia and Apraxia of Speech Treatment (CAAST)

AOS Treatment Guidelines & Reviews
Sponsored by ANCDS – part of larger project
Supported in part by ASHA’s SIG 2
Original guidelines published 2006
Systematic review – 2015 – updates the guidelines
Wambaugh – summary of research since 2013 – Aphasiology?

Guidelines References

Systematic Review (Wambaugh et al. 2006)
- English language reports published through 2003
- 59 published reports
  - there was measurement of effects of treatment on the impact of acquired apraxia of speech (AOS) at any or all levels of functioning
  - authors must have indicated their intention 1) to treat AOS; 2) to measure the impact of a treatment on AOS; or 3) to impact on the sequelae of AOS
  - report must have provided some form of data pertinent to the effects of treatment with at least one person with AOS

Participants
“n” = 146

Etiology: 93% CVA, 5% TBI, 2% other

Gender: 78% male, 22% female

Age: mean = 54 yrs, min-max = 21–82

TPO: mean = 31 months; median = 14 months; min-max: 2 weeks – 192 months
Quality of Studies: AAN Criteria

65% Class IV - uncontrolled studies, case series, case reports, or expert opinion
33% Class III - controlled trials (including well-defined natural history control subjects or patients serving as own control subjects) in a representative population where outcome assessment is independent of patient treatment
2% Class II - prospective matched group cohort study in a representative population with masked outcome assessment

Brief Description of the Evidence

• Relatively small “n” overall and in individual studies
• Few attempts to replicate findings
• Only a few systematic lines of research
• Synthesis of findings of studies with generally similar foci (e.g., AAC, rate/rhythm control)
• Consequently, treatment guidelines are more general than specific

Treatment Guidelines Organization

General approaches summarized
• rationales
• treatment techniques
• treatment targets
• outcomes
• participants
• candidacy issues
• quality of the evidence

Approaches to Treatment (Guidelines – 2006)

Articulatory-Kinematic – use of techniques to improve articulatory accuracy
Rate/Rhythm control – use of techniques to reduce rate, impose timing or rhythm
Intersystemic reorganization – use of relatively intact systems to facilitate speech production
AAC – use of alternative or augmentative means of communication
Other

Articulatory Kinematic Approaches

Therapies that “concentrate on the disordered articulation...(and) emphasize the regaining of adequate points of articulation and the sequencing of articulatory gestures” (Rosenbek et al., p. 463).

Articulatory-Kinematic Approaches

• Repeated practice
• Modeling
• Integral stimulation
• Articulatory placement cues
• Shaping

• Minimal contrast practice – practice of contrasts
• Visual biofeedback
• Verbal feedback
• PROMPT
• Nonspeech movement practice (e.g., tongue tip movements)
Rate Control or Timing Approaches

Metronomic pacing
Finger tapping – finger counting
Instructional feedback
Computerized pacing – oral reading
Pacing board
Indirect control (MIT, PROMPT)

Intersystemic Reorganization

Use of a relatively intact system to facilitate functioning of another system

Iconic Gestures – Amerind most frequently used to facilitate and/or supplement speech
Rhythmic Gestures – tapping, finger counting
Vibrotactile Stimulation – externally applied rhythmic stimulation
Singing – choral singing, sentence completion, phrase production

AAC

Gestures – Amerind most frequently used
Communication boards/notebooks
Spoken computer output
Multiple communication systems – writing, drawing, notebooks, gestures
Electrolarynx
Alternative strategies for unproductive behaviors

Other Approaches

Conversational practice
Training significant others (e.g., interviewing skills)
Head movement training
Biofeedback for tension reduction
Silent rehearsal

AOS Guidelines Summary (2006)

Treatment for AOS can be expected to result in improvements in speech production, particularly when treatment has an articulatory-kinematic focus
More than half of the evidence base was derived from A-K treatments
Across all studies, all participants had AOS plus aphasia
Evidence base was modest in terms of "n" and experimental control, but was improving

AOS Guidelines Update: Systematic Review

New Guidelines Committee
- Kirrie Ballard – chair
- Joe Duffy
- Mick McNeil
- Julie Wambaugh
- Edwin Maas
- Shannon Mauszycki
- Claire Layfield

Guidelines Update (2015)

26 new articles (over 9 years – 2004 through 2012)

Sample sizes: n=1-44
  ◦ Median = 1
  ◦ n of 1-3 = 75% of studies
  ◦ ≥ n of 10 = 3 studies

107 participants in total
  ◦ 63-M 44-F
  ◦ MCA stroke – majority
  ◦ 6 nationalities represented

Articulatory Kinematic
  20 – SSED
  2 – group designs
  2 case studies

Rate/Rhythm Control
  2 – SSED
  1 - group

AAN Criteria Applied (Ballard et al., 2015)

19.2% Class IV - uncontrolled studies, case series, case reports, or expert opinion
80.8% Class III - controlled trials (including well-defined natural history control subjects or patients serving as own control subjects) in a representative population where outcome assessment is independent of patient treatment

New Advances....

Will discuss at end of session if time (slides are provided in final portion of presentation)

Which Treatment Approach to Select?

Articulatory Kinematic VS. Rate/Rhythm Control

• Much more evidence addressing A-K
• However, limited comparative data
  • Brendel and Ziegles; 2008
• No data concerning combined A-K plus Rate/Rhythm

Metrical Pacing Therapy (MPT; Brendel & Zeigler, 2008)

• Pacing tones reflect the natural, relative distances of syllables (taken from waveforms)
• Compared to non-pacing, control tx. – variety of A-K techniques
• 10 speakers with AOS
• Both txs. reduced # errors
• MPT reduced dysfluencies
Sound Production Treatment (SPT): An A-K Therapy

Developed to improve articulation of targeted (specifically selected) sounds in the context of words, phrases, sentences

Developed by Wambaugh and colleagues – 1st reports in 1996 & 1998

- AOS...is a non-linguistic sensorimotor disorder of articulation....Therefore, therapy should concentrate on the disordered articulation...(and) emphasize the regaining of adequate points of articulation and the sequencing of articulatory gestures" (Rosenbek et al., 1973)

Individualized for the AOS speaker
- Appropriate for a variety of AOS severities
- Minimum ability to repeat likely required

Uses therapeutic ingredients from earlier AOS research (e.g., Rosenbek et al.'s "8-step continuum"; 1973)

Techniques/Treatment Ingredients
- Verbal and visual modeling by clinician
- Orthographic cueing/written letter or word
- Integral stimulation – "watch me, listen to me, say it with me"
- Contrastive practice – target vs. typical error production
- Articulatory cueing
- Verbal feedback
- Repeated practice

SPT Hierarchy

Response – contingent hierarchy
- Steps only applied as needed (upon error)

Begins with minimum level of cueing – progresses to additional clinician support

Always starts at the 1st step (minimal step)

Not reversed

Latest version of hierarchy recommended

Original Hierarchy - Word Level

SPT Rationale

AOS – loss of access to motor programs or inadequacy of motor programs (speech sound target regions/maps)

- SPT provides instruction to reestablish sound targets or access to targets
- Repeated practice and contrastive practice focused on redeveloping and/or refining sound target regions

AOS may have difficulty in the utilization of proprioceptive and sensory feedback
- SPT provides augmented feedback

SPT Hierarchy: Step 1

1. Say target word and request repetition
- If correct, request additional repetitions (5 times) and go to next word.
- If incorrect, give feedback and say: "Now, let's try a different word – one that sounds like what you said" and present minimal pair word.
- If correct, give feedback and say: "Now, let's go back to the other word" & go to step 2 with the target word.
- If incorrect, give feedback, attempt with integral stimulation up to 3 times and go to 2 with target word.
SPT: Step 2

2. **Show printed letter** representing the target sound ("we’re going to try again and let’s pay attention to this sound"), say word, and request repetition
   - if correct, request additional repetitions (5 times) and go to the next item
   - if incorrect, go to Step 3

SPT: Step 3

3. **Integral stimulation** – “watch me, listen to me, and say it with me” up to 3 attempts to elicit a correct production
   - If correct, request additional repetitions (5 times) and go to next item
   - If incorrect, go to Step 4

SPT: Step 4

4. give **Articulatory Placement Cues** that are specific to the error, attempt word again after cueing using integral stimulation (e.g., “when we say this word, we need to have our tongue slightly behind the upper front teeth and make a hissing sound – while demonstrating, Now, let’s try it again – watch me, listen to me, and say it with me”)  
   - If correct, request additional repetitions (5 times)
   - If incorrect, go to next item

SPT - Demo

**Severe AOS and aphasia – “trial SPT”**

- Word-initial /l/  
- Word-initial /s/  
- Word-initial /b/

**Mild-moderate AOS and aphasia – demo.**

SPT Evidence Base (Bailey, Eatchel, & Wambaugh, 2015)

Meta analyses of SPT studies
- 24 speakers with AOS & aphasia – across 10 investigations
- Aggregation of effect sizes across all participants

Established “benchmarks” for magnitude of tx. change
- Consistent improvements for treated items
- Consistent, but somewhat less improvements for untreated items

More studies in progress


SPT Acquisition Effects

Positive for all participants
Positive for vast majority of targeted sounds for all participants
- Treatment provided for 3 to 9 sound targets (in words/phrases/sentences) for each participant

Performance criterion not always reached, but gains were always evident
SPT Response Generalization Effects: Untrained Exemplars

Response generalization has always been positive

Improvements in untrained exemplars typically follow learning curves for trained exemplars
- Only exception has been for multisyllabic words and in few cases where acquisition has not been strong

Training 8-10 exemplars of a sound target should be sufficient to result in generalization to untrained exemplars
- Caveat – trained exemplars should reflect a variety of vowel contexts

SPT Response Generalization Effects: Untrained Items (Not Exemplars)

Only should be expected if...
- Cognate of trained items (e.g., p → b)
- Related in error type (e.g., t → p)
- Related in production (e.g., sh → ch)

Otherwise, is likely to be minimal

SPT Stimulus Generalization Effects

Have not been measured as systematically as with acquisition and response generalization effects

Measured to...
- Longer utterances (words → phrases)
- Different elicitation contexts (repetition → sentence completion)

Varied across and within participants
May be associated with level/strength of acquisition effects

Maintenance Effects & Overgeneralization

Maintenance typically good - measured up to 6 & 8 weeks; chronic patients

Overgeneralization is a possibility
- Use of trained sound beyond appropriate contexts
- Can interfere with previously learned sounds
- May require maintenance treatment
- May indicate lack of stimulus discrimination
- Multiple sound training may be warranted

SPT Outcomes Summary

- Can expect improvement of trained sounds in words/phrases/sentences
- Can expect improvement of trained sounds in untrained words/phrases/sentences (to untrained exemplars)
- Improvement of untrained sounds may be minimal
- Generalization to other contexts may occur, but cannot assume this will be positive
Outcomes: Probe Data vs. Treatment Data

Only one study designed to address this issue
Treatment performance may be better than probe performance – i.e., probes are a more stringent test of learning
So...conduct probes periodically or before making a decision to discontinue treatment

SPT Hierarchy (summary)

**Step 1** – Clinician model with pt. repetition
- Contrastive practice upon error (monosyllabic words only)

**Step 2** – Printed orthographic cue, Clinician model with pt. repetition

**Step 3** – Integral stimulation

**Step 4** – Articulatory cueing

**Step 5** – next word

SPT Hierarchy: Application Specifics

**Minimal contrast**
- used ONLY with monosyllabic word targets (single words or words in phrases)
- e.g., sun – ton
- Big sun – Big ton
- Contrastive practice – should NOT be considered negative practice
- target sound contrasted with typical replacing sound

**Orthographic cueing**
- may use cards with individual target sound or preprinted word/phrase/sentence – underline problem sound

**Integral stimulation**
- may need to use hand gestures or other instruction to elicit simultaneous production
- 3 integral stimulation productions not required – move to 5 repetitions upon correct production

**Articulatory placement cueing**
- will be individualized – experiment with best cues

Five repeated productions – always after correct response
- May use integral stimulation as needed to maintain accuracy
- Feedback – may need to use 100% initially, but suggest fading

Treatment Application

- hierarchy applied to each target word
- response contingent
- not reversed

Can target up to 3 different sound targets simultaneously with 8-10 words per target
All target items presented in random order = 1 trial attempt to complete at least 6-7 trials per session
session – 45 min to 1 hour
research application – 3X/week (typical*)
Organization of Trials

1st trial: blocked presentation

- if target sounds are correct in <6/8 words (for any of the sounds), next trial is blocked
- if target sounds are correct in 6/8+ words for all 3 sounds, next trial is randomized

If 6/8 criteria is met (on 1st or any subsequent trials), alternate between blocked and randomized for the rest of the session but, continue with blocked until criteria is met.

Type of Presentation

<table>
<thead>
<tr>
<th>Blocked</th>
<th>Randomized</th>
</tr>
</thead>
<tbody>
<tr>
<td>pie, pot, ping, pea, pay, pope, pen, pert</td>
<td>sis, pope, ping, low, late, sigh, pert, loose, soap, say, pen, luck, pot, sock, lamb, etc.</td>
</tr>
<tr>
<td>say, sis, seal, sigh, sue, sock, sank, soap</td>
<td>loose, luck, lamb, lark, lie, low, lip, late</td>
</tr>
</tbody>
</table>

Wambaugh et al. (2017, JSLHR)

n = 20 (includes 10 participants from 2015; 2014)
Each participant received BOTH treatments in a crossover design
Each participant’s performance was evaluated continually in probes
Blocked and Random practice conditions were compared...
- Effect sizes
- % change over highest baseline point

Results

All participants improved with both random and with blocked practice
Effect sizes were NOT statistically significantly different for condition
% change above baseline WAS statistically significantly greater for RANDOM for TREATED items
No differences between conditions for untreated items

% Change Over HIGHEST Baseline

<table>
<thead>
<tr>
<th>Condition</th>
<th>Comparison</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random</td>
<td>BL vs Tx</td>
<td>65.5%</td>
</tr>
<tr>
<td></td>
<td>BL vs 2 wk FU</td>
<td>58.5%</td>
</tr>
<tr>
<td></td>
<td>BL vs 10 wk FU</td>
<td>46.25%</td>
</tr>
<tr>
<td>Blocked</td>
<td>BL vs Tx</td>
<td>51%</td>
</tr>
<tr>
<td></td>
<td>BL vs 2 wk FU</td>
<td>45.8%</td>
</tr>
<tr>
<td></td>
<td>BL vs 10 wk FU</td>
<td>38.0%</td>
</tr>
</tbody>
</table>

Examples of SPT Administration
Assessment of Sound Production: What Should be Targeted in Treatment?

- Identify problematic sounds
- Determine appropriate level/complexity of production
- Prioritize sounds to be treated
- Group sounds to be treated

Selection of Treatment Targets

- Level of success
- Impact on intelligibility
  - % in error
  - homonymy
  - frequency of occurrence in language
- Trial therapy - stimulability

Developing Treatment Stimuli

Suggest selecting 1-3 sounds to be treated at one time
8-10 items needed for each sound (if only one word position)
- "Items" = monosyllabic words, multisyllabic words, words in phrases/sentences
- Real words preferred

matching minimal contrast words for each
- may need to approximate error

vary phonetic contexts!!! (variety of vowels)
- vary syllable shape if appropriate

Example of Responses

/r/ = 30% accuracy
- ray → way
- rip → whip
/sh/ = 0% accuracy
- shy → sigh
- she → see
/k/ = 10% accuracy
- key → dee
- car → dar

Treatment Stimuli: /r/

- ray...way (CV...æ)
- rip...whip (CVC...ɪ)
- rock...wok (CVC...o)
- rue...woo (CV...u)
- right...white (CVC...æ)
- reed...weed (CVC...i)
- row...woe (CV...o)
- rut...what (CVC...æ)

Treatment Stimuli: /ʃ/

- shave...save (CVC...e)
- ship...sip (CVC...ɪ)
- shock...sock (CVC...o)
- shoe...Sue (CV...u)
- shy...sigh (CV...æ)
- she...see (CV...i)
- show...sew (CV...o)
- shun...sun (CVC...ʌ)
Treatment Stimuli: /k/
Kay...day (CV...e)
kill...dill (CVC...ɪ)
cot...dot (CVC...o)
coo...do (CV...u)
cab...dab (CVC...æ)
keep...deep (CVC...i)
comb...dome (CVC...o)
Ken...den (CVC...ɛ)

But, what about...?
Distortions errors
More than one replacing sound
Cluster errors
Perseveration

Treatment Stimuli: /p/
pie...die (CV...aɪ)
pot...dot (CVC...o)
ping...ding (CVC...ɪ)
pea...thee (CV...ɪ)
pay...they (CV...eɪ)
pope...dope (CVC...o)
pen...then (CVC...ɛ)
pert...dirt (CVC...ɛ)

Outcome Measures: Acquisition
Probes vs. treatment data

Acquisition measure: is the person learning what he/she has been working on in therapy?
Can the target behaviors be produced when not in the context of therapy? (under similar conditions, but without treatment occurring)

/st/ → /t/
star...tar
stop...top
sty...tie
stew...two
store...tore
stack...tack
Stan...tan
stow...toe
Outcome Measures: Response Generalization 1

**Response Generalization Measure** – to untrained exemplars of trained behaviors
Production of items that are very similar to the trained items
- same target sound
- same syllable structure
- same elicitation procedure

Outcome Measures: Response Generalization 2

**Response Generalization Measure** – to untrained behaviors
production of behaviors that are related to, but not the same as, the trained behaviors
- different, but related sound
- voiced cognate
- similar in manner or place
- behavior that MIGHT respond to the treatment of the trained behavior

Outcome Measures: Stimulus Generalization

**Stimulus Generalization Measures** – to untrained contexts
production of the behavior in contexts that vary from the training context
- complexity
- phonetic environment
- method of elicitation
- how
- where
- who

Examples of Outcome Measures

**Response Generalization** – untrained, related sounds
- /p/ by, bee, bed, bit, bay
- /s/ zoo, zip, Zane, zeal, zing
- /l/ ??

**Stimulus Generalization**
- different word position
- phrases
- bisyllabic words
- different elicitation mode (e.g., story completion)
- etc.

Examples of Outcome Measures Cont.

Pre and Post SPT samples

Severe AOS & Mod. Aphasia

Other examples
Clinical Application:
Rate/Rhythm
Control Treatment

WAMBAUGH & MARTINEZ, 2000
MAUSZYCKI & WAMBAUGH, 2008
WAMBAUGH ET AL., 2012

Examples of Multisyllabic Words

Benefit

Spaghetti

Represent

Level 1
Metronome Training – Multisyllabic Words
Level 1
Schematic and tapping review

↓ ___ ___

Metronome set at reduced rate (increase word durations about 50%)
◦ CM – one production
◦ Patient taps along while clinician models (4-5X)
◦ Unison production and tapping (3X)
◦ Patient production (1X)
Feedback = about tapping accuracy, # syllables, production to the beat (not about sound production)
Target items presented in random order (n=20; ?X)

Level 2

Faded clinician model & repeated patient productions

Schematic & tapping review
Reduced metronome setting
◦ Clinician model (1X)
◦ PPT (3X)
◦ If errors (tapping to beat or # syllables) then CM (1X) + unison production and tapping
◦ If correct – next word
Feedback – same
Scoring: +/- for 1st production of PPT

Level 3

No clinician model & repeated patient productions

Schematic & tapping review
Metronome set to reduced rate
◦ Clinician produces word with normal rate & prosody (not to the beat and with no tapping)
◦ PPT (3X)
◦ If errors (tapping to beat or # syllables) then CM (1X) + PPT (3X)
◦ If errors remain, then CM (2X) + UPT (3X)
◦ If correct – next word
Feedback – same
Scoring: +/- for 1st production of PPT

Level 4

Increased rate of production

Schematic & tapping review
Metronome setting increased from previous levels
◦ Clinician produces word with normal rate & prosody (not to the beat and with no tapping)
◦ PPT (3X)
◦ If errors (tapping to beat or # syllables) then CM (1X) + PPT (3X)
◦ If errors remain, then CM (2X) + UPT (3X)
◦ If correct – next word
Feedback – same
Scoring: +/- for 1st production of PPT
Level 5

Syncopation

Clinician explains concept of syncopation
- Target word produced in 2 beats
  - 1st syllable on first beat
  - 2nd syllable & 3rd syllable on second beat
Schematic, tapping review
Metronome set at Level 4 rate
Apply syncopation to Levels 1-4

Results – Metronome Treatment

<table>
<thead>
<tr>
<th>Target</th>
<th>Pre-Post</th>
<th>% words</th>
<th>%Cs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 – Tx. (1st syllable)</td>
<td>9 - 72</td>
<td>64 – 94</td>
<td></td>
</tr>
<tr>
<td>Group 1 – Untx.</td>
<td>5 - 60</td>
<td>75 – 85</td>
<td></td>
</tr>
<tr>
<td>Group 3 – Tx. (3rd syllable)</td>
<td>20 - 90</td>
<td>67 – 91</td>
<td></td>
</tr>
<tr>
<td>Group 2 – Untx. (2nd syllable)</td>
<td>29 - 48</td>
<td>79 – 95</td>
<td></td>
</tr>
<tr>
<td>Group 4 – Untx. (4 syllables)</td>
<td>16 - 35</td>
<td>70 – 86</td>
<td></td>
</tr>
<tr>
<td>Group 5 – Untx. (blends)</td>
<td>28 - 60</td>
<td>81 – 90</td>
<td></td>
</tr>
</tbody>
</table>

Metronome Rate/Rhythm Control

Consider combining with a-k
Select rate for practice
Select tx. items
Select generalization items

Metronome Apps (all free)

 TempoPerfect : PC/MAC/iphone/ipad/Android
 Metrotimer: iphone/ipad
 Steinway Metronome: iphone/ipad
 Metronome beats: Android
 B’metronome: Android

Treatment Protocol

Hand-tapping – hand/location
Amount of therapist instruction/modeling – fading of participation
Type of metronome control – Visible? Audible?
Criteria for changing timing
Type/amount/timing of feedback
Outcome measures

Combined Aphasia and Apraxia of Speech Treatment (CAAST)
CAAST Publications


RET was designed to increase production of content and length of utterance (Kearns, 1985)

Robust literature supporting effects

Modified-RET

For use with persons with aphasia & AOS

- Similar language outcomes to RET
- No measurement of impact on speech
- Increased productivity, but speech production difficulties are not addressed

CAAST

Sentence frame introduced (1X)

M-RET

Picture stimuli used to elicit any utterance (models, repetition, integral used as needed)

Utterance is reinforced, written in frame and then elaborated

Elaborated utterance is presented for repetition

Sound errors are targeted using SPT

SPT

Designed to improve articulation of preselected problematic sounds produced in the context of words/phrases/sentences

Response contingent hierarchy

- Modeling/repetition
- Orthographic cuing
- Integral stimulation
- Articulatory cuing

Consistently results in improved production of targets in treated items with generalized production to untrained items

CAAST Steps – see handout

<table>
<thead>
<tr>
<th>Doer</th>
<th>Action</th>
<th>Theme</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAN</td>
<td>SHAVE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Outcome Measures

CIUs (Correct Information Units; Nicholas & Brookshire, 1993)
- With experimental stimuli (trained & untrained pictures)
- With N & B stimuli

Percent Consonants Correct – sentence repetition
- With printed sentences
- Without printed sentences

Word Intelligibility

Initial CAAST Findings (Wambaugh et al., JSLHR, 2014)
All 4 participants (chronic AOS+aphasia): CIUs for 2 applications of CAAST

Positive generalization to untrained sets

Gains were seen for 2/4 Ps on the Nicholas & Brookshire (1993) task

↑ in speech intelligibility for 1/4 Ps

↑ in accuracy of articulation in sentence repetition for 2/4 Ps
Modifications for 2nd CAAST study (Wambaugh et al., 2017, IJSLP)

- 8 pictures instead of 10
- SPT completed one additional time with each elaborated utterance
- Generalization practice (one picture per session)

"We're going to practice talking about the picture like we do in our probes. We want you to be able to put words together in longer phrases or sentences.

"That's great! There are likely many more sentences you could make about this picture. It is fine to practice them now. Of course, when we practice, we will be saying as much as you can using individual words. But, we also know that helps you put the words together in phrases.

Summary of CAAST-2 Findings

- 3/4 participants: CIU production with experimental stimuli (trained pictures, untrained pictures)
- 4/4 participants: CIU productions in Nicholas & Brookshire task
- 4/4 participants: PCC in sentence repetition at 2 weeks – larger increases with written stimuli; but 3/4 maintained at 6 weeks
- 3/4 participants: Intelligibility