Assessment and Diagnosis of Apraxia of Speech in Adults

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AOS: A Relatively New Disorder with an Evolving Knowledge Base

- Darley is typically credited with establishing AOS as a distinct clinical disorder ~ 1969
- Ongoing research over past 4 ½ decades:
  - Refinement of clinical characteristics & diagnostic criteria
  - Development of theories concerning the nature of AOS
  - Identification of brain biomarkers associated with the disorder & response to tx.
  - Development and testing of treatments


Disruption of motor planning/programming
- sound selection and ordering assumed to be intact
- neuromuscular system for realizing articulatory command assumed to be intact

Problem with the translation of correctly selected sounds to previously learned articulatory-kinematic parameters

Presenting Picture of AOS (Miller & Wambaugh, in press)

Characteristics depend upon severity
Range: complete inability to speak (muteness) to somewhat fluent speech with only occasional disruptions on challenging words or when speaker is under pressure
- Speech sound disruptions (distortions, dist. subst., substitutions)
- Slowed speech rate
- Dysfluent speech (audible and visible struggle)
- Inter and intraword and syllable pauses
- Disrupted prosody (tendency to syllabic speech, altered stress placement, over reliance on limited prosodic repertoire)
- Occasional disruptions of syllabic structure – e.g., schwa insertion

AOS Descriptors: Necessary for Diagnosis (McNeil et al., Wambaugh et al., 2006)

Slowed rate of speech production
- Increased interval time between words and syllables
- Increased time to produce individual sound segments and to transition between sounds

Sound Errors
- distortions (predominant type), perceived substitutions, omissions, additions (intrusive schwa)
- relatively consistent across repeated productions - location and type* - pure AOS differs from AOS + aphasia (severity?)

Prosodic Abnormalities
- Related to slow rate

Session Overview

• AOS definition and general characteristics
• Speech samples
• Considerations and criteria for differential diagnosis & speech samples
• Formal and informal diagnostic tools
• Assessment for treatment planning
AOS Descriptors: *Nondiscriminatory* for Diagnosis

- Articulatory groping
- Increasing errors with increasing word length or complexity
- Perseverative errors
- Speech initiation difficulties
- Awareness of errors (e.g., self-corrections)
- Automatic speech better than propositional speech
- Islands of error free speech

Characteristics that *Cannot be Used* to Diagnose AOS

- Anticipatory errors (pillow ≠ lillow)
- Transposition errors (spaghetti ≠ psghetti)
- Non speech oral apraxia
  - Have been used in the past
  - May co-occur
  - More likely to be attributable to other disorders (e.g., aphasia)

AOS Neuroanatomic Correlates??

- Left posterior inferior frontal gyrus (BA 44 & 45)
- Supplementary motor areas (BA 6)
- Insula
- Parietal lobe

Moderate AOS: Repeated Samples

- Butterfly
- Octopus
- Volcano
- Animal

AOS Samples Continued

- F, mild AOS, minimal aphasia
  - Mono-multisyllabic words
- M, mild-mod. AOS, mod.-severe aphasia
  - Monosyllabic
  - Mono-, multisyllabic
- M, moderate AOS, mod. Aphasia
  - ABA words of increasing length
  - Naming
  - 3X repetition
  - Picture description
Differentiating AOS from Phonemic Paraphasia (McNeil et al., 2009; Miller & Wambaugh, in press)

<table>
<thead>
<tr>
<th>AOS</th>
<th>PHONEMIC PARAPHASIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound errors – distortions, close to target</td>
<td>Sound errors – more displacement errors and far substitutions</td>
</tr>
<tr>
<td>AMRs /t-t-t/</td>
<td>AMRs – intact once target attained</td>
</tr>
<tr>
<td>SMRs – more likely to have perseveration errors</td>
<td>SMRs – sequence errors, distant substitutions</td>
</tr>
<tr>
<td>All word classes involved</td>
<td>Tends to be content words</td>
</tr>
<tr>
<td>Reading or repetition may be better than spontaneous</td>
<td>Reprod. Cond. repetition is significantly worse</td>
</tr>
<tr>
<td>Slow rate even in on-target utterances</td>
<td>(near) normal rate in on-target utterances</td>
</tr>
</tbody>
</table>

Differentiating AOS from Phonemic Paraphasia cont.

<table>
<thead>
<tr>
<th>AOS</th>
<th>PHONEMIC PARAPHASIA</th>
</tr>
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<tbody>
<tr>
<td>Prolonged movement transitions</td>
<td>Movement transitions w/in normal limits</td>
</tr>
<tr>
<td>Abnormally long vowels</td>
<td>Vowel duration w/in normal limits</td>
</tr>
<tr>
<td>Increased durations for individual sound segments</td>
<td>Individual sound durations w/in normal limits</td>
</tr>
<tr>
<td>Inability to increase rate while maintaining sound integrity</td>
<td>Variable ability to increase rate and maintain sound integrity</td>
</tr>
<tr>
<td>Schwa insertions common</td>
<td>Schwa insertions not common</td>
</tr>
</tbody>
</table>

Nature of AOS vs. Phonemic Paraphasia

**AOS:**
- phonetic-motoric speech disorder
- filled and accurate phonologic frame
- inefficiency in translating frame to previously learned movement parameters
- results in timing and spatial targeting problems

**Phonemic Paraphasia:**
- not a motoric disorder - problems with accurately filling the phonological frame

Phonemic Paraphasia Samples

- M, mod-severe PP, moderate Conduction aphasia
  - Monosyllabic words
  - Conversation

- M, moderate PP, moderate Conduction aphasia
  - Words
  - Conversation

- M, mild-moderate PP, moderate Conduction Aphasia
  - Word repetition
  - Conversation

Primary Progressive Apraxia of Speech (Duffy, Josephs and colleagues)

- Documented w/in the last several decades
- Distinct from Primary Progressive Aphasia
- Superior lateral premotor and supplementary motor cortices most often involved
- Most freq. dx. at autopsy is supranuclear palsy or cortico-basal degeneration (tau pathologies)

PPAOS

- AOS can be the only symptom (no aphasia or dysarthria) for an extended time (1.4-6 years)
- Characteristics similar to stroke-induced AOS
- Different profiles
  - predominately articulation difficulties
  - rate and syllable segregation problems
  - No predominance – both artic & rate/prosody
Assessment: Diagnosis

Acceptable for obtaining samples:
- ABA-2
- Duffy (2013)

For making differential diagnosis:
- ASRS 3.0
- Necessary criteria

ABA-2 (Dabul, 2000) (only use to obtain speech samples)
- DDK Rate
- Increasing Word Length
- Limb Apraxia and Oral Apraxia
- Latency Time and Utterance Time for Polysyllabic Words
- Repeated Trials
- Inventory of Articulation Characteristics of Apraxia

ABA – Inventory of Articulation Characteristics of AOS
Exhibits phonemic anticipatory errors (glen glass for green glass)
- NOT AN AOS SYMPTOM

Exhibits phonemic perseverative errors (pep for pet)
- NOT AN AOS SYMPTOM

Exhibits phonemic transposition errors (Arifca for Africa)
- NOT AN AOS SYMPTOM

ABA – Inventory of Articulation Characteristics of AOS
Exhibits phonemic voicing errors (ben for pen)
- Consistent with AOS & PP

Exhibits phonemic vowel errors (moan for man)
- Not common in AOS, but could be distortion

Exhibits visible/audible searching
- Consistent with AOS & PP

ABA – Inventory of Articulation Characteristics of AOS
Exhibits numerous and varied off-target attempts at the word
- "Numerous attempts" = consistent with AOS
- "Numerous, varied, off-target" = PP

Errors are highly inconsistent
- NOT AN AOS SYMPTOM

Errors increase as phonemic sequence increases
- Consistent with AOS & PP

ABA – Inventory of Articulation Characteristics of AOS
Exhibits fewer errors in automatic speech than in volitional speech
- Consistent with AOS & PP

Exhibits marked difficulty initiating speech
- Consistent with AOS & PP

Intrudes a schwa sound between syllables or in consonant clusters
- Consistent with AOS
ABA – Inventory of Articulation Characteristics of AOS

- Exhibits abnormal prosodic features
  - Consistent with AOS
- Exhibits awareness of errors and inability to correct them
  - Consistent with AOS & PP
- Exhibits a receptive-expressive gap
  - Consistent with AOS & PP

Duffy (2013) AOS Screen

- Sound repetition
- AMRs & SMRs
- Monosyllabic words – inventory of consonants in (i) and (f) positions: fife, pipe
- Polysyllabic words
- Increasing length
- Repeated productions
- Sentence repetition
- Counting
- Days of the week
- Singing familiar tunes
- Conversational & narrative speech
- Reading aloud

AOS Descriptors – Current:

**Necessary for Diagnosis**

- Slowed rate of speech production
  - Increased interval time between word and syllables
  - Increased time to produce individual sound segments and to transition between sounds
- Sound Errors
  - distortions (predominant type), perceived substitutions, omissions, additions (intrusive schwa)
  - relatively consistent across repeated productions - location and type

Prosodic Abnormalities

ASRS Version 3.0: Under Development

- Reduced number of items (n = 13)
- Clarified rating scale
- Reorganized
  - Articulatory features
  - Prosodic features
  - Other: AMRs, SMRs, reduced word/breath group, groping

Utianski et al. (2018) Brain & Language

The Apraxia of Speech Rating Scale

**(ASRS; Strand, Duffy, Clark & Josephs, 2014)**

Uses a 5-point scale – presence/absence, prominence, severity of particular characteristic; 16 characteristics

- 0 = not present
- 1 = observed, but infrequently
- 2 = observed fairly frequently, but not on all tasks
- 3 = pervasive, nearly always evident but not severe (intelligibility not much impacted)
- 4 = noted on almost all tasks, targets difficult to recognize

*Used verbal language tasks from WAB, conversation, word fluency tasks, AMRs, SMRs; scored during and after*

ASRS V3.0 Rating Scale (2016)

|  |  |  |  |  |
|---|---|---|---|
| 2 | 3 | 4 | 5 |
| Not observed in any task | Infrequent | Frequent but not pervasive | Nearly always evident but not marked in severity |
| More than one occurrence | Noted more than once but less than about 20% | Noted more than once but less than about 50% of all utterances, but not on most tasks or utterances |
| Noted on many utterances on most tasks but not enough to decrease overall intelligibility | Noted on most utterances on most tasks and severe enough to impact intelligibility |
| Noted on all tasks and severe enough to impact intelligibility |
| Score no higher than “2” if present only during repetition |

Score no higher than “2” if present only during repetition
### ASRS V3.0 – 13 Characteristics

**Rated**

1. **Articulatory Features**
   - 1. Sound distortions (excluding distorted substitutions or additions)
   - 2. Distorted sound additions
   - 3. Distortion sound additions including intrusive schwa
   - 4. Increased sound distortions or distorted sound substitutions with increased utterance length or increased syllable/word articulatory complexity

**Cont.**

2. **Prosodic Features**
   - 5. Syllable segmentation within words > 1 syllable (brief silent interval between syllables and/or inappropriate equalized stress across syllables)
   - 6. Syllable segmentation across words in phrases/sentences (increased inter-word intervals and/or inappropriate equalized stress across words)
   - 7. Overall slow rate
   - 8. Lengthened vowel and/or consonant segments

**3. Other**
   - 9. AMRs
   - 10. SMRs
   - 11. Consistently reduced words per breath group or reduced # of AMRs repetitions per breath group
   - 12. Visible or silent articulatory groping
   - 13. Audible false starts

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### ASRS V3.0 – Characteristics Cont.

**Cont.**

3. **Other**
   - 9 – AMRs
   - 10 – SMRs
   - 11 – Consistently reduced words per breath group or reduced # of AMRs repetitions per breath group
   - 12 – Visible or silent articulatory groping
   - 13 – Audible false starts

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### ASRS – Psychometric Properties

Overall intra and interjudge reliability acceptable
- But refinement needed for some items (<70% agreement for presence/absence for a few items)
- Reliability for less experienced clinicians???

Validity: Strong correlation with independent clinical judgment

Sensitivity (proportion of individuals with the disorder who are diagnosed with the disorder by the test):
- 90.5% with a cut-off of “10” and 96% with a cut-off of “8”

Specificity (proportion of individuals w/o disorder who are shown to NOT have the disorder):
- 100% with cut-off of “8”

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### Ballard et al. (2016)

- Assess predictor variables for diagnosing the presence of AOS (stroke induced)
- Relatively large “n” (72)
- Expert judgment and candidate predictors (behavioral measures of linguistic, cognitive, nonspeech oral motor, and speech)
- Predictive modeling
- 2 measures distinguished AOS+aphasia from aphasia alone

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### Ballard et al. cont.

72 participants with L-hemisphere CVA; Suspected of having AOS

2 expert judges (JD, MM) rated 20 minute samples
- Presence/severity of AOS on a 7 point scale (provided estimate of confidence of rating)
- Presence/absence of 9 features of AOS
- Slow rate*, distorted phonemes*, syllable segregation*, silent groping, audible groping, errors on words of increasing length*, inconsistent errors over repeated productions, consistent errors over repeated productions and SMRs poorer than AMRs
- * highest reliability between raters (>80%)
Ballard et al. cont.

Dx: 35 = AOS+aph. (37= aphasia only)
◦ 33 = speech sound distortions
◦ 30 = errors with increasing word length
◦ 27 = slow rate
◦ 20 = syllable segregation

15 test variables examined for ability to predict expert dx of AOS

Statistical modeling identified 2 variables

Ballard et al. Predictive Variables

Speech errors with words of increasing length
◦ Adapted from ABA-2 (adjusted scoring)
◦ [Col. 1 x Col. 3]+1/Col. 1+ 1

Relative vowel duration in 3 syllable words with weak-strong stress pattern (banana, potato)
◦ Pair-wise variability index (measure of difference in syllable durations divided by average syllable duration)

These features are most closely associated with AOS (but not aphasia)

Other features are informative & can help support dx.

Assessment: Severity Determination

ASRS 3.0 – total score
◦ Higher = more severe
◦ Interpretation not yet determined
◦ Does not take into consideration all factors
◦ Correlates well with intelligibility

Severity – factors to consider

Sound Errors
◦ Percentage of errors
◦ Level of breakdown
Intelligibility
Rate/durational measures
◦ Segments
◦ Syllabic/word durations
◦ ISIs
Measures of prosody
◦ Ratings of naturalness
Functional measures
◦ Non discriminatory behaviors
◦ Etc.

Assessing for Tx. Planning & for Documenting Change

AOS
◦ Sound error analysis
◦ Intelligibility assessment
◦ Durational analysis
◦ Quantification of accompanying behaviors
◦ Patient Reported Outcomes
◦ Participation

OTHER
◦ Aphasia
◦ Oral, nonverbal apraxia
◦ Dysarthria
◦ Cognition

Sound Error Analysis: Sampling Conditions

Sounds in isolation *
◦ Single monosyllabic words/syllables (all word positions)
◦ Multisyllabic words
◦ Words of increasing length
◦ Phrases
◦ Sentences
◦ Discourse
### Sound Error Analysis: Elicitation Methods
- Repetition
- Oral reading
- Sentence completion
- Self generation

### Sound Production Analysis
- Patterns: e.g., voicing control, initial C’s, initial Vs, final sounds, clusters, starters/anchors
- Level of breakdown - context & elicitation
- Generative analysis
  - % of errors

### Intelligibility Assessment
Haley et al. (2011) – only intelligibility test specific to AOS
- Customized software
- 50 monosyllabic words elicited via computer (similar results to live presentation of stimuli)
- Eliminates problem of recording the presenter’s production
- Strong test-retest reliability
May also use assessments designed for dysarthria (ASSIDS, Yorkston & Beukelman)
- Should not use primary clinician as “listener”
- Be consistent in use of listener

### Accompanying Behaviors
- False starts
- Silent or audible groping
- Starters
- Fillers
- Overall communication efficiency
  - (e.g., CIU’s/time)
- Perceived effort
- # of verbal initiations

### Correct Information Units (Nicholas & Brookshire, 1993)
- Content measure in discourse
- Narrative & procedural discourse elicited systematically
- Measures
  - Total # words
  - Total # CIUs
  - Efficiency measure
- Normative data

[https://www.med.unc.edu/ahs/sphy/card/resources/chapel-hill-multilingual-intelligibility-test-chmit/](https://www.med.unc.edu/ahs/sphy/card/resources/chapel-hill-multilingual-intelligibility-test-chmit/)
CIU Elicitation

4 single pictures (cookie thief, picnic scene, cat up
tree, dog & birthday cake)
2 sequences of pictures
2 response to requests for personal information
  • Do on Sundays?
  • Where live? Describe.
2 procedural descriptions
  • Doing dishes
  • Write & send a letter

CIU Example

TREE:
Ah how say that...cat cat da ah dog ahm
man bird girl ah bike bike ahm how say that two
men ahm how say that um ah bike back truck
truck
Words: 22
CIUs: 9

CIU Reference

for quantifying the informativeness and efficiency
of the connected speech of adults with aphasia.
JSNR, 36, 338-350.

Rate/Durational Measures

Most applicable if working on rate control or
prosody
Syllables or words per second
Efficiency measure (e.g., CIUs per minute)
Segmental measures – acoustic analyses

Dysarthria Impact Profile

impact profile: development of a scale
to measure psychosocial effects. Int. Journal
of Language and Communication Disorders, 44(50),
893-715.

DIP: Sections

Effect of dysarthria (AOS – speech difficulty) on me as a
person
Accepting my dysarthria (AOS)
How I feel others react to my speech
How dysarthria (AOS) affects my communication with
others
10-14 questions per section
Negatively and positively worded
Examples of DIP Questions

- I am as confident now as I was before I had a speech problem.
- I am not happy with my speech as it is now
- I don’t care what people think of my speech
- The difficulties I have with my speech restrict my social life

Communicative Participation Item Bank (CPIB, Baylor et al.)

Items ask to what extent the respondent’s condition interferes with participation in a variety of communication situations (Yorkston, 2019)

Examples:
- “Talking with people you know.”
- “Asking questions in conversation.”
- “Talking with a clerk in a store…”

46 items
10 item short form
Calibration samples: people with PD, MS, head & neck cancer, ALS, aphasia

LIV Cards (Life Interests and Values; Haley et al., 2010)

121 cards – to “facilitate self-determination and autonomy” in the process of management of communication disorders

95 cards depicting activities of interest to adults – corresponding composite cards

- Home/community activities
- Relaxing & creative activities
- Physical activities
- Social activities

Sorting process used to prioritize interests


Summary of Assessment

Sample of Speech Across Production Contexts – ASRS v3.0

Sound error analysis
Intelligibility assessment
Durational analysis -optional
Accompanying behaviors quantification - optional
PRO Participation

Principles of Treatment

Efficacy

Acquisition
Response generalization
Stimulus generalization
Maintenance
Social Validity

Intro: TREATMENT