Acquired Motor Speech Disorders: Past, Present, & Future

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Disclosures

- Author of book, *Motor Speech Disorders: Substrates, Differential Diagnosis and Management*
  - Receives royalties.

- Member of the Certification Board and Practice Guidelines committees for dysarthrias and apraxia of speech of the Academy of Neurologic Communication Disorders and Sciences (ANCDS)
  - Receives no compensation for role on these committees.
**Caveats**

- Multifaceted topic – can’t cover it all!
- Points emphasized (or not) may reflect biases & blind spots
- Will do my best to distinguish fact from opinion, but will be offering both
- Will rely on comments & questions to offset biases, omissions, & errors
Agenda

- **Preamble** – Why pay attention to MSDs?
- **Early Days** (1960-70s) – History is important!
  - The Darley, Aronson, & Brown paradigm (dysarthrias & AOS)
- **Trajectory of Progress** to the present
  - Understanding underpinnings
  - Clinical diagnosis
  - Management
- **The Future**
Motor Speech Disorders

Include:
- Dysarthrias
- Apraxia of speech (AOS)

May be:
- Congenital or acquired
- Static, improving, worsening
- Associated with lesions in variety of CNS & PNS structures
- Caused by numerous diseases/conditions
Why Attend To Motor Speech Disorders?

They occur frequently, particularly dysarthrias

- ~ 90% of people with Parkinson’s disease (Müller et al., 2001)
- ~ 50% of people with multiple sclerosis (Sandik, 1995)
- ~ 50% of people with TBI in rehab settings (Yorkston et al., 1989)
- ~ 30% of people with hemiparetic stroke (Melo et al., 1992)
- One of 1st symptoms in ~ 25% of people with ALS (Traynor et al., 2000)
- 30-90% with cerebral palsy (Yorkston, Beukelman, Strand, & Bell, 1999)
- Some suggest it’s the most common acquired speech disorder (Enderby, 1983)
Acquired Neurologic Communication Disorders
(N=10,436)

- Aphasia: 26%
- Dysarthria: 53%
- Apraxia of speech: 5%
- Other cog-lang disorders: 15%
- Other neuro speech disorders: 1%
Why Attend To Motor Speech Disorders?

- They occur frequently
- Prevalence may/will increase
- They may announce neurologic disease
- Aid localization & diagnosis of neurologic disease
- Contribute to understanding organization of speech planning, control, & execution
- They can affect daily life, sometimes profoundly
- They can be treated/managed
Past To Present

Early experiments in transportation
“Dysarthria” before ~ 1970

- The term represented inconsequentially heterogeneous neurological speech disturbances.
  - Viewed as a singular disorder, without precisely defined clinical manifestations or neurologic correlates.

- Distinctions made were between dysarthria & aphasia, not among types of dysarthria.

- Adjectival modifications were tied to neurologic diseases (e.g., “parkinsonian dysarthria,” “the dysarthria of M.S.”) or had no unitary basis (Brain ‘65; Froeschels ‘43; Grewel ’57; Luchsinger & Arnold ’65)
Then along came DAB!


Transition from Pre-Paradigm Periods

- Without a paradigm, all facts seem equally relevant.

- Acquisition of a paradigm is a sign of maturity in a scientific field.

- A paradigm can guide a group’s research, & allow it to be focused, effective, & efficient.

Kuhn (1970)
The DAB Approach to Classification

- What are its basic tenets?
- What research underpins it?
- What are its classification categories?
- Has it been a useful paradigm?
- What are some of its shortcomings?
- Has it been misinterpreted or misapplied?
- How universally is it accepted & used?
- How can it be refined or strengthened?
- Will alternative paradigms replace or complement it?
The DAB System - Basic Tenets

- Dysarthria is recognized by how it sounds.
- It is distinguishable from normal speech & non-neurologic speech disorders.
- Not all dysarthrias sound alike.
  - Differences go beyond those of severity.
- Some dysarthrias do sound alike.
  - Similarities go beyond those of severity.
Basic Tenets (cont.)

- Similarities logically reflect common site(s) of nervous system lesion & presumably, pathophysiology.
- Perceptually similar patterns are distinguishable from patterns associated with different lesion loci & pathophysiology.
- Recognizing distinctions can:
  - aid localization & diagnosis of disease
  - contribute to hypothesis formulation about the underlying problem
  - Sometimes influence decisions about clinical management
Research Underpinnings
-- The 1969 studies --

N = 212 patients with dysarthria (at least 30 in each group)

(1) Bulbar palsy  ➔  Flaccid
(2) pseudobulbar palsy  ➔  Spastic
(3) cerebellar lesions  ➔  Ataxic
(4) parkinsonism  ➔  Hypokineti
(5) dystonia  ➔  Hyperkinetic
(6) choreoathetosis  ➔  Hyperkinetic
(7) ALS  ➔  Mixed (F-S)
DAB - The 1969 studies

- 38 speech characteristics related to pitch, loudness, voice, resonance, respiration, prosody, & articulation rated on 7-point scale.

- Good intrajudge & interjudge reliability.
The most distinctive deviant speech characteristics within each group were identified & compared among groups.

8 "Clusters" - representing tendency for certain deviant speech dimensions to co-occur.

Analysis permitted inferences about neuromuscular bases for individual deviant speech characteristics & unique pattern of clusters within groups.

FOR EXAMPLE.....
Features
Low pitch, harsh voice, strained-strangled, pitch breaks, voice stoppages, slow rate, short phrases, excess loud. var.

Cluster
Phonatory Stenosis

Defect of movement or tone
Hypertonus biased toward adductors
Sustained or spasmodic in occurrence

Neurologic Defect
Dystonia or Spasticity

= Found in Spastic & Hyperkinetic Dysarthria
## Dysarthria Types

<table>
<thead>
<tr>
<th>Type</th>
<th>Locus</th>
<th>Distinctive Deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flaccid</td>
<td>Lower motor neurons</td>
<td>Weakness</td>
</tr>
<tr>
<td>Spastic</td>
<td>Upper motor neurons</td>
<td>Spasticity</td>
</tr>
<tr>
<td>Ataxic</td>
<td>Cerebellar control circuit</td>
<td>Incoordination</td>
</tr>
<tr>
<td>Hypokinetnic</td>
<td>Basal ganglia control circuit</td>
<td>Rigidity/↓ ROM</td>
</tr>
<tr>
<td>Hyperkinetic</td>
<td>Basal ganglia control circuit</td>
<td>Invol. movements</td>
</tr>
<tr>
<td>Unilateral UMN</td>
<td>Unilateral UMN</td>
<td>Weakness; incoord.; spasticity</td>
</tr>
<tr>
<td>Mixed</td>
<td>More than one</td>
<td>More than one</td>
</tr>
</tbody>
</table>
Q. Has it been a useful paradigm?

A. Yes

It permits inferences about localization of neurologic disease -- of particular value when

- MSD is first, only, or predominant sign of neurologic disease
- Neurologic diagnostic uncertainty
Q. “Comes here with a diagnosis of Parkinson’s disease but is this more than hypokinetic dysarthria?”

A. “Findings are consistent with a mixed hypokinetic-spastic-ataxic dysarthria. This combination of dysarthria types cannot be explained by a diagnosis of Parkinson’s disease alone…”
The two possibilities…are that we are dealing with motor neuron disease or…with a variant of multiple system atrophy. If …there is evidence of ataxia in his speech, then we may be dealing with MSA in which case it would be reasonable for the patient to undergo thermoregulatory sweat test and an autonomic reflex screen. However, if his speech is in keeping with motor neuron disease (ALS, ie flaccid or spastic dysarthria only) then I will have the patient undergo EMG… I think the diagnosis here will rest on the speech consultation.”
A. “The examination is consistent with a mixed spastic-flaccid dysarthria that is strongly suggestive of mixed bilateral upper & lower motor neuron involvement of the bulbar speech muscles. This pattern of speech difficulty is not incompatible with a diagnosis of ALS.”
CONSULTATION REQUEST

DATE 3 Sep 1987
Write future date above if future consult is desired rather than a same day consult.

Patient may be moved by
☐ Wheel Chair  ☐ Cart

Consultation Requested  Speech Pathology

Reason for Request  29 yo w/ abrupt onset multifocal CNS signs sx. Please dissect & analyze speech/laug.

CONSULTATIONS RECEIVED AFTER THE CUTOFF TIME LISTED IN SECTION 5 OF THE HOSPITAL PROCEDURE GUIDE WILL BE SEEN THE FOLLOWING DAY. EMERGENCY CONSULTATIONS ARE TO BE MADE BY PAGING THE APPROPRIATE SERVICE.

Requesting Service  Neuro B

Physician  M. Ferreira / R. Smith

MC 1376/R786
Has it been a useful paradigm? (cont.)

- Has improved understanding of salient speech characteristics associated with numerous diseases

- Permits inferences about whether or not features of a MSD are or are not compatible with a specific disease diagnosis or specific lesion locus
Today, we have an improved understanding of the abnormal speech patterns that can be or should not be associated with numerous neurological diseases (examples)

- ALS
- Parkinson’s disease
- Multiple sclerosis
- Wilson’s disease
- Olivopontocerebellar atrophy
- Progressive supranuclear palsy syndrome
- Corticobasal syndrome
- Shy-Drager syndrome
- Primary lateral sclerosis
- Paraneoplastic cerebellar degeneration
- Multiple system atrophy (MSA-C, MSA-P)
- Freidreich’s ataxia
- Spasmodic torticollis
- Meige syndrome
- Cerebral Palsy
- Spinocerebellar ataxia(s)
- Cerebellar mutism
- Essential voice tremor
- Spasmodic dysphonia
- Unilateral UMN lesions (stroke)
- Primary progressive AOS
Some are newly recognized or reclassified disorders - (examples only)

- Multiple system atrophy (MSA-P; MSA-C)
- Hereditary spinocerebellar atrophies (> 30 types)
- Paraneoplastic cerebellar degeneration
- Cerebellar mutism
- Primary progressive apraxia of speech (PPAOS)
Progressive Apraxia of Speech

- Can be the only or primary salient feature of neurodegenerative disease (PPAOS)
- It reflects L or L>R hemisphere abnormalities
  - frontal lobe (superior frontal, SMA)
- When predominant, it predicts eventual clinical diagnoses of
  - Corticobasal syndrome
  - Progressive supranuclear palsy syndrome (PSP)
  - Motor neuron disease/ALS (rare)
- Strong association with pathology (PSP,CBD) & biochemistry (tauopathy)

(Duffy, 2006; Josephs et al., 2006)
Has it been a useful paradigm? (cont.)

- Provides shorthand for communicating among ourselves & other health care professionals about MSDs & the people who have them.

- Provides a vocabulary for describing speech characteristics that can be used independent of DAB MSD type.
Some Shortcomings
(Inherent or subsequently identified)

In the 1969 studies...

- Some problems were under-represented
  - flaccid dysarthria (mostly VF paralysis)
  - hyperkinetic dysarthria (dystonia & chorea only)
  - mixed dysarthria (ALS only)

- Localization was predominantly clinical (pre CT & MRI).
Some Shortcomings (cont.)

Concerns frequently raised about reliability of perceptual ratings & diagnosis

- Zeplin & Kent, 1996
- Zyski & Weisiger, 1987
- Kearns & Simmons, 1988
- Sheard, Adams, & Davis, 1991
- cf., Bunton et al., 2007
- Fonville et al., 2008
- Van der Graff et al., 2009
**BUT... (largely opinion!)**

- Methods to examine reliability may bear weak relationship to “real” diagnostic process. For example,
  - Use of students
  - Inadequate speech samples (e.g., 2 sentences; 40 seconds)
  - Examine severity ratings of deviant characteristics when detection of presence/absence is more important to differential diagnosis
  - Use of an analytic process to derive reliability for what may be a synthetic one or one that relies on ID of only a few key features

- Uncertain definition of “experienced” when using “experienced” clinicians
BUT… (largely opinion!)

Re classification of dysarthria type

- Two recent studies examined classification accuracy for neurologists & neurology trainees, or neurologists, neurology residents, & speech therapists (Fonville et al., 2008; Van der Graaf et al., 2009)
  - Correct classification ranged from about 35% to 40%.

- Conclusion = classification by perceptual judgment alone is not adequate; professionals should rely on other sources of information.

Agree -- and the other sources are……………!!!
**BUT...**

- An individual’s “experience” does not automatically suggest interrater reliability will be good.

- Studies of reliability of auditory-perceptual ratings of dysarthric speech have not made any formal attempt to “train” listener reliability or agreement.

- Future investigations are needed to examine the benefits of training on auditory-perceptual ratings of dysarthric speech.

Bunton, Kent, Rosenbek, Duffy, & Kent (2007)
Some Shortcomings (cont.)

- The DAB system has not been compared to other possible classification approaches (e.g., severity, disease type, acoustic analysis)
  - Investigation of alternate classification schemes may inform scientists about the relative homogeneity of participant groups defined in different ways.

(Kim, Kent & Weismer, 2011).
Some Shortcomings (cont.)

- The system does not capture all relevant information (a trait of any classification system). For example:
  - Childhood dysarthria (C.P.)
  - Disease course
  - Intelligibility
  - Severity
  - Activity/participation limitations

- No large scale study has addressed how well DAB system predicts anatomic localization or clinical neurologic findings!
  BUT…….
...many smaller studies provide confirmation on basis of disease diagnosis or imaging localization -- for example


25 adults with a speech path dx of progressive spastic dysarthria as the only (84%) or predominant (16%) speech disorder & only or predominant neurologic complaint seen between 2006-2012.
MRI/VBM Findings (N=7)

- **Bilateral** patterns of white matter volume loss
  - Underlying the motor cortex (BA 4), including the frontoparietal operculum (BA 43) reflecting involvement of corticofugal projection fibers.
- Brainstem white matter loss consistent with involvement of descending corticospinal & corticobulbar fibers
FDG-PET Findings

- When present, focal areas of hypometabolism were in premotor & motor cortices bilaterally.
- Findings consistent with DAB predicted site of lesion for “pseudobulbar palsy” (i.e., spastic dysarthria).
  - Damage to corticobulbar (UMN) pathways, bilaterally.
Misinterpretations?

Tendency to equate the research methods used by DAB to validate the classification system & the process actually used by clinicians to distinguish among dysarthria types.

PROBABLY NOT TRUE
“Probably, clinicians who employ the Mayo system do not rate a patient on each of the 38 dimensions. We suspect they listen for the presence or absence of specific dimensions to make their classification…”

(Wertz & Rosenbek, 1992, p. 43)

Only one or a small number of speech characteristics may be the real cues to diagnosis of a specific type of dysarthria.

- When these critical features are missing or subdued, judgments become less certain & less compatible with the assumed underlying neuropathology & dysarthria type.

(Kim, Kent, & Weismer, 2011)
Is it accepted & used?

- It seems to be the stated classification preference & is given homage in texts, reviews, papers, etc.

- But it may not be as widely used as implied
  - For example: *AJSLP & JSLHR, 1995-2001*)
    - ~50% did not describe dysarthria type
    - ~15% - no description of speech characteristics
    - ~30% - inadequate description of speech characteristics
The Dilemma

“The artificial preservation of the inert dampens the quest for the new. The risk of saving the moribund is the demise of the vital.”

Roger Cohen, NY Times op-ed piece, 12/18/08

“Old theories are old for good reason. They are robust, flexible. They have an uncanny correspondence to reality. They may even be True.”

Apraxia of Speech
Early Foundations
(Bouillaud ~1825)

Knowledge & use of words as symbols (language) is separable from the physical production of words (speech). Because they are not the same, problems with verbal expression resulting from brain injury could be due to an impairment of language OR an impairment of speech.
Early Foundations
(Bouillaud ~1825)

- Knowledge & use of words as symbols (language) is separable from the physical production of words (speech).

- Because they are not the same, problems with verbal expression resulting from brain injury could be due to an impairment of language OR an impairment of speech.
Broca (1861)

“There are cases in which all the muscles...are under voluntary control... and the general faculty of language remains unaffected, but in which ... a cerebral lesion abolishes articulate speech... this loss of speech is singular enough to warrant a special designation.”

= “Aphemia”

Localization = L hemisphere, foot of third frontal convolution
Early Foundations
(Broca & others ~ 1861)

- The left hemisphere plays a special role in speech.
- Speech can be impaired in the absence of paralysis, sensory loss, or general intelligence.
- It can be the only sign of brain injury.
Foundation Gaps?

The left hemisphere plays a special role in speech. But so does language! Speech can be impaired in the absence of paralysis, sensory loss, or general intelligence. It may be the only sign of brain injury.

But what is it?
Nonverbal Oral Apraxia
(buccofacial apraxia)

The volitional control of oral structures for nonspeech activities can be impaired in the absence of problems with strength, sensation, basic oromotor vegetative functions, or intelligence.
Liepman
*(1900, 1905, 1913)*

Limb Apraxia

- Ideational
- Ideomotor
- Limb kinetic

Foundation

- Limb movements can be affected under conditions similar to the orofacial disorder described by Jackson.

- Apraxia – at least in the limbs – seems to stem from problems with the planning or programming of movements.
Is AOS Logically Possible?

If the planning/programming of nonspeech oromotor & limb movements that do not involve language can be impaired (i.e., nonverbal oral & limb apraxia), what principle of neurologic organization can explain why a similar problem cannot affect speech movements?
Lacunae and Research Approaches to Them. IV.

In Brain Mechanisms Underlying Speech and Language, 1965.

FREDERIC L. DARLEY
Mayo Clinic
Rochester, Minnesota

Asked to reflect as a speech pathologist on the impact of this Conference, I would like to respond with comments in three areas. First, I believe we need to solve some evident problems concerned with the identification of language phenomena and with terminology. It seems to me there are some problems here in several areas we have been talking about. For example, let us talk about aphasia.

Not everything called aphasia by someone is, indeed, aphasia. The question has arisen: Is aphasia caused by a lesion of subcortical structures? We have heard Dr. Myers point out that lesions or stimulation of the thalamus lead to confusion or dementia. This might overwhelm or obscure any language deficit, if it were present; or this confusion man⁴ in 1955 and again in a revised statement in 1960.⁵ The gropings of the motor aphasic patient for correct positioning of his articulators, his clumsiness in finding the correct pattern of movement to produce a polysyllabic word, his near misses phonemically, and his retrials are predominant. And in the kind of patient I am talking about, they are coupled, as Broca pointed out, with no reduction in auditory comprehension and no disability in expressing himself fluently in writing. In other words, his performance represents no cross-modality impairment in the use of language symbols but a specific modality-bound deficit, better labeled an apraxia, to be exact, an oral verbal apraxia.

Now, Bay does not call this apraxia; he calls it cortical dysarthria,⁶ emphasizing
Characteristics of Acquired AOS

- Groping for correct positioning of articulators
- Clumsiness in finding correct patterns of movement for polysyllabic words
- Near misses phonemically
- Retrials
- Without reduction in auditory comprehension
- Without disability in written expression
The problem “represents no cross-modality impairment in the use of language symbols but a specific modality-bound deficit, better labeled an apraxia, to be exact, an oral verbal apraxia.”

(Darley, 1967, p.236)

Let’s call this apraxia of speech.
Darley’s Definition of AOS

“impairment...of the capacity to program the positioning of speech musculature and the sequencing of muscle movements for the volitional production of phonemes.”

(Darley, 1969, p.1)
MSDs
Then What Happened?

“His writings were not intended to be scriptural. They were meant to be tested.”


- DAB (’69, p.462) -- “These conclusions may serve as hypotheses for more accurate physiologic and neurophysiologic measurements to further delineate the problems of dysarthria.”
Medline Search (dysarthria + AOS) (1960-9/2014)

Dysarthria = 93% of total citations
Medline #s

- Dysarthria
- AOS
It’s not clear whether an “increase in numbers” is directly related to an ‘increase of actionable knowledge,’ for reducing needs, extending our knowledge about nature in some lasting way, or some other “higher purposes.”

(Bornmann, 2012, 2013)
The 1970s-1980s

- Accumulating laboratory & clinical data base
- Books & book chapters began to influence training, research, & practice. Examples:
  - Darley, Aronson, & Brown (1975) – *Motor speech disorders*
  - Netsell, (1984) – *A neurobiologic view of the dysarthrias*
  - Perkins (1983) – *Dysarthria and apraxia: current therapy of communication disorders*
  - Rosenbek & LaPointe (1985) - *The dysarthrias: description, diagnosis ,and treatment*
  - Wertz, LaPointe, & Rosenbek (1984) - *Apraxia of speech in adults: the disorder and its management*
  - Yorkston, Beukelman, and Bell (1988) - *Clinical management of dysarthric speakers*

- 1982 -- Yorkston, Beukelman, & Berry spearheaded the Clinical Dysarthria Conference, held every other year since (now called Conference on Motor Speech), with subsequent publications stemming from it.
The 1970s-1980s (cont.)

Interest in MSDs fueled by many factors – for example

- growth in disciplines of speech science & speech-language pathology
- good government funding for research & training
- population growth, increased life span, & improved neuro dz survival
- technologic advances permitting acoustic & physiologic study of speech motor control & MSDs.

- Research carried out in relatively few institutions.

- **Today** -- Contributions from institutions worldwide
1970s-1980s & Beyond
Physiologic Research


- EMG, cineradiographic, kinematic, & aerodynamic measures - increasingly sophisticated in recent years (e.g., electropalatography, EMA).
  - Help ascertain function of individual components of speech production
  - Used to detect/infer pathophysiologic features (e.g., weakness, rigidity, slowness, incoordination).

- By mid-1980s these efforts had considerably improved understanding of physiologic underpinnings of dysarthrias (e.g., Abbs, Hunker, & Barlow, 1983; Hunker & Abbs, 1984)

- Studies identified gaps in understanding of relationships between auditory-perceptual features & movements that produce them, suggesting they are much more complex than initially thought.

1970s-1980s & Beyond
Improved Understanding of Motor System Function &
Mechanisms of Disease Effects – e.g., Basal Ganglia & PD

From: Sapir: Multiple factors are involved in the dysarthria associated with parkinson’s disease: a review with implications for clinical practice and research. JSLHR, 2014.
1980s & Beyond
Physiologic & Computational Model Research

In last 2 decades +

- Sophisticated neuroimaging techniques (e.g., PET, fMRI, & TMS).
- Significant refinements in neurologically plausible psycholinguistic & computational models of the motor, biomechanical, & sensory processes involved in speech production.
  - DIVA & GODIVA models (e.g., Bohland, Bullock, & Guenther, 2009; Peeva et al., 2010)
  - State feedback control models (Hickok, 2012)
  - Non-linear probabilistic phonetic code model (Ziegler, 2009)
- Can be validated with neuroimaging, psychophysical, physiologic, anatomic, acoustic & perceptual data. Combined, they have…
  - Improved our understanding of speech motor control (e.g., motor equivalence, & coarticulation)
  - Implications for understanding MSDs.
The GODIVA model suggests that inaccurate articulation associated with AOS could reflect
- Damage to motor programs
- Defective selection of motor programs
  - Each alternative localized differently in model’s neural architecture (Bohland, Bullock, & Guenther, 2009).

- Such hypotheses beginning to influence efforts to examine speech planning & preparation in AOS using online reaction time methods (e.g., Maas & Mailend, 2012).
- These model-to-clinical relationships are bi-directional because clinical analysis of AOS breakdowns may help test & improve model validity.
Acoustic Analysis
- Practical Facts in the Present -

- State-of-the-art instrumentation for acoustic analysis has become affordable, accessible, efficient/automated, & user-friendly for clinical practice.

- Capacity to make speech signal visible & quantifiable can provide:
  - Tangible/quantifiable baseline data
  - Index of stability, improvement or deterioration over time
  - A source of visual feedback during therapy.
1970s-1980s & Beyond
Acoustic Analysis Contributions

- Substantial contributions to description & understanding of MSDs.

- Has provided quantitative, confirmatory, & refined support for many perceptual judgments of key features of MSDs

  - e.g., rate; voice quality & steadiness; pitch & loudness variability; articulatory precision

  - Spectrographic displays enhance reliability of auditory perceptual judgments of certain features (e.g., breathiness, strain) (Jan et al., 2007)
1970s-1980s & Beyond

Acoustic Analysis Contributions

- Have made important contributions to theoretical constructs for MSDs
  - e.g., along with physiologic measures have provided data supportive of phonetic, motor planning/programming basis of AOS
    
    (McNeil, Robin & Schmidt, 2009; Weismer, 2007)

- Some acoustic measures appear to differentiate people with AOS plus aphasia from those with aphasia & no AOS
  - syllable durations within sentences (Haley et al., 2012)
  - pairwise variability index (PVI) of vowel durations (lexical stress in multisyllabic words (Courson et al., 2012, Ballard et al., under review),
  - median pause duration & and variability of pause duration in connected speech (McKechnie et al., 2008; Ballard et al., under review).
Acoustic Analysis Contributions
(identification of commonalities)

“There are probably a constrained number of ways in which performance of the speech mechanism can deteriorate when affected by neurological disease.”

- “A common set of acoustic characteristics is exhibited in multiple types of dysarthria.
- “The presence of acoustic commonalities is not surprising because many of the perceptual dimensions in the DAB studies are shared across dysarthria types.”

Kim, Kent & Weismer, 2011
Acoustic Analysis Contributions

Acoustic variables predict speech intelligibility (Kim, Kent, & Weismer, 2011)

- **Measures related to prosody** - articulation rate and F0 range

- **Measures related to segmental articulation** – e.g., vowel space, F2 slope, & voiceless interval duration

- F2 slope seems to reflect dysarthria severity - as indexed by intelligibility scores - independent of dysarthria type & etiology.

(Kent et al., 1989; Weismer et al., 1992; Weismer, 1991).
Examined best predictor of group membership (DAB type, intelligibility, disease) by acoustic measures.

Findings suggested - variation in speech severity within a dysarthria type may explain as much variance in physiological, acoustic, &/or perceptual data as variation across dysarthria type. If so, classification according to speech severity might be as accurate as classification by dysarthria type, when properly selected acoustic measures are used as input variables.

“…a requirement that dysarthria type be reported even when disease type is known, may not provide additional insight to interpretation of speech production or perception data obtained from speakers with dysarthria.”

Kim, Kent & Weismer, 2011

Double digital portraits, part of 2000 photos merged into one image in center
Acoustic Measure Contributions
Predicting dysarthria type & disease severity

Liss, LeGendre & Lotto, 2010; Liss et al., 2009

- **Rhythm metrics** - based on acoustic measures of vocalic and consonant segment durations
- **Envelope modulation spectra** - quantifies rhythmicity of speech within specified frequency bands
  - 84-100% classification accuracy for group membership (normal, ataxic, hypokinetic, hyperkinetic, mixed spastic-flaccid)

Bayestehtashk et al., 2014

- From group of 168 PD Ss, extracted 1582 acoustic features using standard speech processing algorithms.
- Predicted UPDRS motor scale severity score (61% of variance)
  - reading task superior to vowel prolongation & DDK tasks
Apraxia of Speech (AOS)
1970s to Present

Clinical conception has evolved from:

- AOS as an articulatory disorder (Darley, 1969)
- AOS is a articulatory disorder with secondary prosodic compensations (DAB, 1975)
  - or primary or secondary prosodic abnormalities (Wertz, LaPointe, & Rosenbek, 1984)

To:

- Both articulatory & prosodic abnormalities are primary features.
  
  (McNeil, Robin & Schmidt, 1997)
Wait a minute!

At least some of these articulatory characteristics can also be explained on phonologic (linguistic) grounds!
Comment on A. D. Martin’s “Some Objections to the Term Apraxia of Speech”

In a paper in the February 1974 issue of JSHD (pp. 53-64), A. Damien Martin offered “Some Objections to the Term Apraxia of Speech” and suggested an alternative expression, “aphasic phonological impairment.” We wish to take exception to his arguments in several respects.

Selectivity of Impairment. Martin objects to the term apraxia of speech primarily because it implies “that the observed phonological impairment is a motor impairment, separate and distinct from other language systems” (p. 53). He believes that this particular phonological impairment is part of “the disruption of an entire system” (p. 61) involved in linguistic behavior. To support his concept, he uses Jakobson and Halle’s model (1956), which points out two operations—selection and combination—in all linguistic events. Martin states:

The production of speech entails the selection of particular desired phonemes and the concatenation of these selected phonemes. The selection and concatenation of these phonemes must conform to the phonological rules of the language. ... The operation of this mechanism depends on some impairment of the internalized rule structure that should display it with regard to phoneme selection and combination. But the simple fact known to everyone who works with a spectrum of patients with cerebral damage, is that not all aphasic patients display phonologic impairment. Only some of them do. And some patients display phonologic impairment in pure culture with no associated problems in the use of letter or syntax.

One's theory of language and the model selected to explicate it should accord with the facts. It was the observation of the clinical facts of patient behavior that led Brolle (1964) to conclude that the communicative difficulty of some patients involved no impairment of the “general facility of language,” but rather impairment of a specific “facility of articulated language.” In our own ray (1966) in a study of what he called “unselected aphasic patients” reported a distinct subtype: “a well-defined and frequent group of speech disorders is marked by a distinct apraxia of the articulatory muscles and impaired tongue movements. ... These patients show practically no receptive disorders but a uniform disturbance of the expressive speech performance.” He has repeatedly stated that “it is a motor disorder independent of language and we most distinguish this motor disorder from the linguistic disorder which we call aphasia” (p. 239). Similarly Weisman et al.

Reply to Atten, Darley, Deal, and Johns

The comments by Atten, Darley, Deal, and Johns raise many interesting points. I shall attempt to divide my response according to the headings they have used even though the points are often closely interrelated.

Selectivity of Impairment. Simple facts known to everyone can be deceptive in that they are often not simple, are not known to everyone, and are not factual. The writers state, “One’s theory of language and the model selected to explicate it should accord with...”
Some Early Studies
(and some seeds for dispute!)

1970 - *Phonemic* variability (Johns & Darley)

1972 - Situational and linguistic influences on *phonemic* accuracy
       (Deal & Darley)

1975 - *Phonemic* characteristics (LaPointe & Johns)

1984 - “A neurogenic *phonological* disorder” reflecting
       “impairment of the capacity to select, program, and/or execute
       …the positioning of the speech musculature.”

       Wertz, LaPointe, & Rosenbek
Evolving Concepts:  
Distinguishing Expressive Language & Motor Speech Planning/Programming

- AOS has an “untidy” history confounded by under-developed concepts or faulty assumptions about nature of phonological errors versus AOS features. These assumptions led to:
  - Uncertainty about results of studies that mixed or failed to distinguish the two disorders.

(McNeil, Robin & Schmidt, 1997)
Evolving Concepts: Distinguishing Expressive Language & Motor Speech Planning/Programming

The Basics:
- Phonological encoding (aphasia)
- Motor planning/programming (apraxia)
Phonologic Encoding

- Metrical frame generation
  - # of syllables, stress pattern
    - “strategiery” / strategic
- Slot construction
  - # of phonemes, phoneme order
    - “clan” / can
- Segment selection & filling
  - Specific phoneme selection, specific phoneme order
    - “top” / cop
Motor Planning

preprogramming, central programs, generalized motor programs

- Specifies motor goals.
- Identifies steps necessary to reach goals, but not details.
- Plans not formulated anew each time speech takes place. Efficient motor plans are stored in sensorimotor memory as *engrams*. Syllable units?
  - Stored plans accessed & sequenced during subsequent planning in mature speakers.
Motor Programming

- Depends on a plan to guide it.

- Controls spatial & temporal details of movement.
  - Movement parameterization to muscles/muscle groups - details about muscle tone, direction, force, range, & rate.

- Movement commands may be modified based on feedback.
The Bottom Line?

“…AOS is by definition, a motor planning/programming disorder.

The issue is not one of defining ‘apraxia.’ That has been done.

The issue is one of specifying to whom the term AOS applies.”

McNeil, Robin, & Schmidt, 1997, p. 328
Proposed a set (cluster) of perceptual characteristics that differentiate AOS from phonemic paraphasias

- Sound distortions (including distorted sound substitutions)
- Extended segment durations (slow speech with lengthened consonants and vowels)
- Extended intersegment durations (sound, syllable and word segregation)
- Prosodic deficits
Clinical Characteristics – **Nondiscrimininitive**
(i.e., they can occur in aphasia & AOS)

(major influence by McNeil, Robin, & Schmidt, 1997)

- Articulatory groping
- Perseverative errors (e.g., popato/potato)
- Increased errors with increasing length
- Speech initiation difficulties
- Awareness of errors (e.g., self corrections)
- Automatic speech better than propositional speech
- Islands of error free speech
Characteristics that should not be used to diagnose AOS

(major influence by McNeil, Robin, & Schmidt, 1997)

- Nondistorted anticipatory errors (e.g., “kick”/pick)
- Nondistorted transposition errors (e.g., “Dofter Ducky!”)
- Limb or nonverbal oral apraxia
- Expressive-receptive speech/language gap
AOS – Current Definition

A phonetic-motor disorder of speech production resulting from brain injury reflecting an impaired capacity to accurately or efficiently translate intended phonemes & phoneme sequences into neural commands that generate movements within & among muscles & structures that lead to accurate articulation & prosodically normal speech.

Duffy, 2013
But not all is settled
(is it ever?)

- New thinking about relationship of abstract (phonologic) representations of word forms to their phonetic counterparts.

- Recent articulatory phonology models propose an interactive interface between phonological & phonetic encoding processes in which “abstract” phonemes have physical properties (gestural scores) associated with speech movement patterns (Goldrick & Blumstein, 2006; Ziegler, 2009).

- The frequent perceptual challenge of distinguishing AOS from phonological errors may partly reflect complexities of “an integrated… system whose higher order components have emerged from and are rooted in the physical conditions of speaking”
  
Localization
Speech Planning/Programming Circuitry

Attempts to localize motor speech programming & AOS
- Have migrated away from classical search for a single responsible structure
- Current general consensus that speech is product of actions within a distributed interactional network of cortical & subcortical structures & pathways
  - left premotor cortex
  - posterior inferior frontal lobe
  - supplementary motor area
  - sensorimotor cortex
  - auditory cortex
  - parietal-frontal dorsal pathway
  - insula
  - basal ganglia
  - thalamus
  - cerebellum

(Bohland, Bullock, & Guenther, 2009; Ghosh, Tourville, & Guenther, 2008; Poeppel, Emmorey, Hickok, & Pylkkänen, 2012; van der Merwe, 2009).
Assessment & Intelligibility Measures

Dysarthria

- **Frenchay Dysarthria Assessment** (FDA, Enderby, 1983a, 2008)
- **Assessment of Intelligibility in Dysarthric Speakers** (AIDS; Yorkston & Beukelman, 1981)
- **The Sentence Intelligibility Test** (SIT; Yorkston & Beukelman, 1996)
- **Word Intelligibility Test** (Kent, Weismer, Kent, & Rosenbek, 1989)
- **Munich Intelligibility Profile (MVP)** (Ziegler & Zierdt, 2008)
- + less formal rating scales of intelligibility (Duffy, 2013; Yorkston et al., 1993)

AOS

- **Apraxia Battery for Adults** (ABA-2; Dabul, 2000)
- **Apraxia of Speech Rating Scale** (ASRS; Strand, Duffy, Clark, & Josephs, 2014)
Assessment Measures
Scales for Functional Communication & Psychosocial Impact


- *Dysarthria Impact Profile* (Walshe, Peach & Miller, 2008) – scale completed by speaker; assess psychosocial impact, acceptance of disorder, perception of others’ reactions, etc.

- *Living with Dysarthria* (Hartelius, 2008) – self assessment measure about speech, limitations imposed by dysarthria, effects of speech on other factors (e.g., fatigue), and coping strategies
Scales for Functional Communication & Psychosocial Impact (skipping ahead to the near future re management)

Are relevant to movement toward:

- Value-Based Practice (component of ACA)
  - Emphasis on client-centered care & intervention results
  - Perceived value by clients & their families, & relative cost.
- Patient Reported Outcomes (PROs)

They point to the need to ask clients about value of our interventions.

- Self-report measures used in minority of dysarthria studies.
- Researchers should consider adding them to outcome measures in intervention studies.

(Yorkston & Beukelman, Perspectives update of systematic reviews, 2013)
Management  
1970s-1980s & Beyond

- Little attention to management of dysarthrias until Rosenbek & LaPointe (1985) provided comprehensive overview of treatment philosophy, goals, approaches, & techniques. They observed that:
  - efforts at description & explanation of had “created a basis for an expanding treatment literature.”
  - much about treatment was without support of data

- Subsequent research & clinical efforts provided sufficient new information to lead to publication of books largely devoted to management of dysarthria or MSDs in general. e.g.,
  - Yorkston, Beukelman, & Bell, 1988
  - Caruso & Strand, 1999
  - Yorkston, Beukelman, Strand, & Bell, 1999.
1980s & Beyond
Primary Directions of Management

- Restore lost function - *reduce impairment*
- Promote use of residual function - *compensate*
- Reduce need or adapt to lost function – *adjust*
1980s & Beyond
Approaches to Management
--Dysarthrias--

- Medical
  - Surgical
  - Pharmacologic
- Prosthetic
- Behavioral

None are mutually exclusive!
1980s & Beyond
Medical/Surgical (examples)

- Medialization laryngoplasty (vocal fold paralysis, hypofunction)
- Injectable substances (e.g.)
  - autologous fat, gelfoam, hyaluronic acid - laryngeal or velopharyngeal incompetence
  - Botox - laryngeal dystonia (SD); tremor; mandibular dystonia
- Deep brain stimulation (DBS) - PD, E.T., dystonia
  - MSD a known possible side effect
  - Pre-DBS MSD sometimes improves
Prosthetic Management
Temporary or permanent mechanical & electronic devices designed to improve speech or assist communication

Vocal Tract Modifiers – structural/postural
- Palatal lift prostheses
- Nose clip/nasal obturator
- Neck brace or cervical collar (posture)
- Adjustable beds/wheelchairs

Acoustic signal modifications – electronic
- Voice amplifiers
- Vocal intensity feedback devices
Prosthetic/Behavioral Management

Speech modifiers
- Delayed auditory feedback (DAF)
- Pacing board
- Alphabet supplementation
Prosthetic & Behavioral Management
Augmentative & Alternative Communication (AAC)

Has grown over years into an subspecialty area of practice
- SIG Division 12
- No-tech to low-tech augmentative & alternative approaches
- Dramatic development & refinement over years re AAC devices, with speech generating capacity (SGDs), & support for their acquisition
  - Wide array of dedicated electronic & computerized devices
  - Apps for non-dedicated, very portable devices (e.g., smart phones, iPad)

Most dramatically effective for people with MSDs & relatively preserved/adequate cognitive/language abilities
Behavioral Management

Speaker-Oriented Approaches
- Reduce or compensate for impairment
- Improve intelligibility, comprehensibility, efficiency; reduce maladaptive behaviors

Communication-Oriented Approaches
- Improve communication even if speech does not improve
- Managed by speaker or listener
- Sometimes ignored that these also require practice & must be learned
1970s-1980s & Beyond
Behavioral Management

Speaker-Oriented Treatment

- Hundreds of clinical behavioral techniques identified that appear to facilitate speech. Many/most are not new!
  - Respiratory – controlled exhalation; inspiratory checking; optimal breath group
  - Phonatory – Intense, high level phonatory effort (LSVT); effort closure techniques; high lung volumes; breathy onset
  - Resonance - exaggerate jaw movement; increase loudness; general consensus that nonspeech VP strengthening & passive stimulation exercise not helpful; CPAP?
  - Articulation – phonetic placement; sensory tricks; “clear speech”
**Lee Silverman Voice Treatment (LSVT)**  
-- A Model for establishing behavioral tx efficacy? --

- Strong theoretical & clinical rationale
- Well-specified, replicable treatment program for a specific disorder.
- Programmatic approach to research into its efficacy (multiple data-based refereed publications since early 1990s)
  - Pre-post case studies
  - Group outcomes (pre vs post tx)
  - Group comparisons (e.g., LSVT vs respiration tx)
- Documented short- & long-term benefits.
- Tx effects documented in multiple ways (e.g., perceptual, aerodynamic, laryngostroboscopic, acoustic, social validity, neuroimaging)
“Maybe the most powerful behaviorally modifiable variable for improving intelligibility” (Yorkston et al ‘92)

Prosthetic & Behavioral Approaches

- Metronome
- DAF
- Pacing board
- Alphabet supplementation
- Hand/finger tapping
- Computer feedback/pacing
- “Clear speech”
Prosody & Naturalness (+ influence on speech subsystems)

- Modify breath group duration (increase or learn to chunk)
- Reduce or increase frequency of inhalation
- Contrastive stress tasks
- Referential tasks
Behavioral Management
1970s-1980s & Beyond

Communication-Oriented Treatment

Speaker Strategies

- Alerting signals
- Convey how communication will take place
- Set context
- Modify content & length
- Monitor comprehension
- Alphabet board supplementation
Behavioral Management
1970s-1980s & Beyond

Communication-Oriented Treatment

Listener Strategies
- Modify physical environment
- Maximize listener hearing & visual acuity
- Learn “active” listening (practice listening?)
  - confirm comprehension

Interaction Strategies
- Maintain eye contact
- Establish methods of feedback
- Establish what works best when
Many listener & interaction strategies used for dysarthrias have been applied to managing AOS.

Most unique AOS treatments are speaker-oriented & behavioral

**Imitation** integral part of most tx programs

Most employ concepts of intersystemic & intrasystemic reorganization *(Rosenbek ‘85; Wertz, LaPointe & Rosenbek ‘84)*

- **Intrasystemic** - emphasizes more primitive or higher level of control within speech system
- **Intersystemic** - use of nonspeech activity to support speech
AOS Management
1970s-1980s & Beyond

Broad categories of behavioral AOS treatment approaches

- Articulatory-kinematic (prime examples)
  - Eight-step continuum (Rosenbek, 1973)
  - Sound Production Treatment (SPT) (Wambaugh & colleagues, early 2000s)

- Rate-rhythm control (prime examples)
  - Metronome, pacing board & related pacing techniques (e.g., Dworkin ‘96; Wambaugh & Martinez, 2000)
  - Metrical Pacing Therapy (MPT) (Brendel & Ziegler, 2008)
AOS Management
1970s-1980s & Beyond

Many additional Techniques at Sound, Syllable, & Word Level

- Key word techniques
- Script training
- Phonetic derivation & placement techniques
- Work on sounds or meaningless syllables
- Cueing strategies--sentence completion; first sound of target word; printed target word; description of function; associated words; prolongation of sounds; rehearsal before responding; immediate responding
Some recent approaches reflect advances in technology.

- Jury still out re efficacy or general clinical applicability…
  - Electromagnetic articulography (EMA) (Katz et al., 2010; McNeil et al., 2010)
  - Self-administered computerized therapy (Cowell et al., 2010; Whiteside et al., 2012)
  - Transcranial direct current stimulation (tDCS) (Marangolo et al., 2011)
Increasing # of tx studies employ principles of motor learning, most often related to:

- Feedback frequency (immediate vs summary: 100% or less)
- Timing of feedback (immediate vs delayed)
- random vs blocked practice
- high vs low complexity
- high intensity practice

(Ballard et al., under review)
Principles of Motor Learning
Some relevant assumptions & practices derived from them

- Efforts to improve strength should follow rules of strength training - for example:
  - Overload muscle
  - Repetition

- # of people for whom nonspeech strengthening exercise is appropriate – for purpose of improving speech - is probably small.
*Phases of Motor Learning*

- **Early (fast)** – improvement in a single session
- **Later (slow)** – further gains across sessions
- **Consolidation** – Spontaneous gains following a latent period (6 h) w/o practice
- **Automatic** – minimal cognitive resources needed & resistant to interference
- **Retention** – easy execution without further practice

* Doyon & Benali (2005)
Staging Management
Doing the right things at the right times

Tx may be unnecessary/inappropriate at a point in time but…

- prescheduled or as-needed reassessment at regular intervals to update recommendations & provide brief intervals of tx as needed
- Changes during staging often anticipate increasing needs for compensation & adoption of augmentative or alternative means of communication (AAC)
- Adaptations should be in place & used with skill BEFORE they are actually needed!
- Dysarthria in ALS = prime example

Staging should be considered in non-degenerative circumstances as well (e.g., acute care)!
Evidence Based Practice
(relatively new to our lexicon!)

- “Guidelines are needed that specify which treatments are most effective for the various dysarthrias.” (Yorkston, 1996, p. S53).

- “Efficacy data for most of these approaches [for AOS] are rare or nonexistent, although some treatment outcomes have been described” (Wambaugh, Kalinyakfliszar, West, & Doyle, 1998).

- Limited research effort on treatment outcomes & efficacy trials (Kent, 2000)
Evidence Based Practice
The Last Decade or so

Academy of Neurologic Communication Disorders & Sciences (ANCDS), with ASHA support, initiated efforts to develop practice guidelines & systematic reviews for neurologic communication disorders

- MSDs were first major area to receive attention.

- Several systematic reviews relevant to MSDs published since 2001.

- Studies demonstrating efficacy are increasing in quality & #
Published Practice Guidelines or Systematic Reviews (2001-2007)


Managing MSDs
The Current Bottom Line

Dysarthria
“There is both scientific & clinical evidence that individuals with dysarthria benefit from the services of speech-language pathologists. This evidence is documented in experimental research, program evaluation data, & case studies.”

Yorkston, 1996

AOS
“…an ever-increasing literature supports the efficacy of treatment…”

McNeil, Robin & Schmidt, 2009

- The weight of evidence supports a strong effect for both articulatory-kinematic and rate/rhythm approaches to AOS treatment.

Ballard et al., under review
The Future
The Future

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>FORECAST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stone is Wet</td>
<td>Rain</td>
</tr>
<tr>
<td>Stone is Dry</td>
<td>Not Raining</td>
</tr>
<tr>
<td>Shadow on Ground</td>
<td>Sunny</td>
</tr>
<tr>
<td>While on Top</td>
<td>Snowing</td>
</tr>
<tr>
<td>Can’t See Stone</td>
<td>Foggy</td>
</tr>
<tr>
<td>Swinging Stone</td>
<td>Windy</td>
</tr>
<tr>
<td>Hole Jumping Up &amp; Down</td>
<td>Earthquake</td>
</tr>
<tr>
<td>Stone Gone</td>
<td>Tornado</td>
</tr>
</tbody>
</table>

**Diagram:**
- *Y-axis:* How often a certain thing happens
- *X-axis:* How often some other thing happens
Bench & Bedside
The Future?

- Understanding underlying mechanisms
- Assessment, classification, diagnosis
- Management
- Practice
Understanding Underpinnings: Some Questions

- To what degree are limb motor control & its disorders similar & different from speech motor control & MSDs?
  - The spinal system versus bulbar system

- What is the nature & strength of the relationship between CNS control & movements of speech structures during speech versus nonspeech movements?
  - To what degree can the study of one inform the understanding of the other?
  - Implications for behavioral therapies
    - (e.g., the validity of nonspeech oromotor exercise for MSDs)
Understanding Underpinnings: Some Needs

Underpinnings extend to communicative interactions

For example: (thanks to Yorkston & Beukelman, *Perspectives* systematic review update, 2013)

- How do MSDs affect conversation & how do communication partners manage conversational exchanges?

  - Answers may teach us how to help affected people better manage conversation in real-life environments.

  - Being studied in speakers with ALS or Parkinson’s disease & their frequent communication partners (Bloch, 2011; Bloch & Wilkinson, 2009).
Address the relatively neglected issue of the perceptual & anatomic distinctiveness of AOS from UUMN dysarthria & other dysarthria types (Duffy, 2013; Ziegler, Aichert, & Staiger, 2012).

- Results might require re-thinking the origin of some of the surface features of AOS & might alter how we think about the disorder.
Address competing explanations for specific aspects of AOS. For example:
- Are programs damaged, cannot be accessed, or cannot be created? (McNeil, Ballard, Duffy, & Wambaugh, under review)

Are there AOS subtypes?
(e.g., Croot, 2002; Duffy & Josephs, 2012; Varley & Whiteside, 2001; Wertz, LaPointe & Rosenbek, 1984).
What can be done to make perceptual, acoustic, physiologic, & neuroimaging studies of MSDs maximally informative?

- Tendency has been to compartmentalize efforts.
  - level of speech system (e.g., laryngeal, articulatory)
  - method (perceptual, acoustic, kinematic, neuroimaging)
  - research discipline (e.g., speech science, speech pathology, neurology, genetics, epidemiology).

- Pursue multidisciplinary & multitechnology studies (Kent, 2000).

- Organize consortiums that use standard protocols to collect data on large #s of people with MSDs (Weismer, 2006)
How might our general approaches to describing MSDs be refined or strengthened?

- Formally recognize subtypes of major dysarthria categories
  - Flaccid (affected cranial & spinal nerves)
  - Hyperkinetic (tremor, dystonia, etc.; affected subsystem)

- Investigate possibility of subtypes of major categories
  - ataxic
  - hypokineti

- Develop methods to improve perceptual skills
  - Regardless of classification approach!
  - Auditory perceptual analyses are indispensable as reference for objective procedures such as acoustic & physiologic analyses

(Kent & Ball, 2000)
Clinical perceptual characteristics will likely remain:

- The “gold standard” - or at least the entry door - for MSD clinical diagnosis.
  - What is used to define the clinical condition & distinguish it from other speech, language & cognitive disturbances.

- Physiologic & neuroimaging studies of MSDs of limited value without a clear description—if not classification—of the speech abnormalities under study.

- An integral part of speaker-oriented speech treatment

- A source of many of the crucial variables that reflect functional gains with treatment.
Diagnostic Consensus Criteria? - Example

Ataxic Dysarthria

- The presence of two or more of the following:
  - irregular articulatory breakdowns
  - abnormal variations in pitch, loudness, or duration (dysprosody)
  - excess & equal syllabic stress
  - distorted vowels
  - irregular AMRs

- The absence of features associated with other dysarthria types but not with ataxic dysarthria
  - strained-strangled voice quality
  - continuous breathiness or nasality
  - Rapid or accelerating rate
  - rapid or blurred AMRs
  - oral mechanism findings not consistent with ataxic dysarthria (e.g., atrophy, fasciculations, dystonic movements) and that might explain some perceived deviant speech characteristics.

adapted from Kent et al (2000)
Investigate contribution of visual & tactile observations to diagnosis.

Continue to assess (or improve) capacity of acoustic measures to predict dysarthria type (& intelligibility).
  - e.g. Rhythm metrics, envelope modulation spectra, F2 slope
Will DAB System Be Replaced?

Would likely require identification of anomalies or alternative approaches

Right now - No major anomalies to justify its rejection & no obvious alternatives that accomplish similar goals.

- But there are – and should be - alternatives that accomplish different goals
  - intelligibility, acoustics, functional limitations, disease course
Assessment - Some Future Goals?

Establish accepted standard protocol(s) for clinical assessment of MSDs

An example re AOS: (McNeil, Ballard, Duffy, Wambaugh, under review)

- A theoretically-grounded reliable & valid assessment protocol with high sensitivity & specificity (in the next decade?)
  - May include set of perceptual & acoustic measurements taken from small set of well-designed speech tasks.
  - Customized software routines to automatically extract selected relevant acoustic measures & generate reports of performance against stored normative databases.
Assessment - Some Future Goals?

- Develop more efficient measures of intelligibility
  - Automated acoustic estimates?
  - On-line scoring services (e.g., Munich Intelligibility Profile; Ziegler & Zierdt ’08)

There is no standard measure of speech severity in dysarthria
(Kent et al., 1989).

- Develop a measure or profile of measures that captures MSD severity (not just intelligibility)
  - Intelligibility
  - Comprehensibility
  - Efficiency
  - Functional impact
Management – The Big Issues!

Which approaches to management are the most (& least!) effective & efficient, for whom, & under what circumstances?

- Variables that require investigation are multiple & complex, including at the least:
  - medical, prosthetic, & behavioral speech-oriented & communication-oriented approaches
  - Range of MSD severity (& types)
  - Nature & course of underlying neurologic disease.
  - Settings/circumstances under which tx is provided
How do MSDs in children differ from acquired MSDs in adults?

How should the evaluation, classification, & management of MSDs differ between developmental & acquired forms?

- Disorders that affect speech motor learning in children may be fundamentally different from the disorders that disrupt previously acquired speech motor skills in adults (Kent, 2000)

- Beyond broad categorization, it may be unwise to impose clinical nosology for adults on children.
Management

Acquire evidence that addresses efficacy of nonspeech oromotor exercises & stimulation to treat acquired & developmental MSDs

- Particularly important because such exercises seem frequently used (or “shunned”) in clinical practice in spite of meager evidence for their effectiveness or lack thereof.
- Further examination of principles of motor learning, including:
  - Dysarthria management
  - Listener & speaker-listener interaction strategies
Enormous benefits of technology!

- Capacity for rapid, storable acquisition of speech samples now accessible & feasible with respect to cost, skill, & time required.

- Proliferation of portable computers, tablets, smartphones, etc.
  - Easy to obtain speech recordings @ bedside or elsewhere of suitable quality for many acoustic analyses, some free & automated (e.g., Pocket WavePad, © NCH Software; www.phon.ucl.ac.uk/resource/software.php; (e.g., Boersma 2001; www.praat.org; -www.phon.ucl.ac.uk/resource/software.php; Hosom et al., 2004; Vogel et al., 2012; Ahmed et al., 2012; icSpeech at www.rose-medical.com)

- Facilitate consultation re diagnosis & management
Some advances in technology have or will become a standard part of many clinical practices

- Telepractice
- Telediagnostic intelligibility assessment (e.g., Ziegler & Zierdt, 2008)
- Text to speech software & digital photography for augmentation of speech in severe MSDs
- Voice banking
- Speech recognition
- Avatars for delivery of therapy
**Management**

People with MSDs will be able to use technology to:

- Record performance on treatment tasks @ home
- Upload speech samples to remote server for analysis by SLP
- Permit interactive monitoring & adjustment of home-based practice
- Efficient generation of reports
  - Visual representations of performance on key speech measures

Basics of such systems exist & are undergoing experimental testing & refinement

*McNeil, Ballard, Duffy, & Wambaugh,, under review*
A Treatment Taxonomy?

ASHA Ad hoc Committee on Treatment Taxonomy

- Addressing many aspects of SLP practice; e.g.,
  - motor speech
  - language comprehension & expression
  - dysphagia

- Working to develop a common set of definitions & format for describing treatment

- Applicable to clinical practice & treatment research
A Treatment Taxonomy?

For example:

- **Aims** - Increase intelligibility
  - **Targets** (can involve skilled practice; cognitive-affective (e.g., understanding why); or organ structure/function modifications (e.g., palatal lift)
    - Increase articulatory accuracy
    - Increase loudness
  - **Ingredients** (what is done)
    - Practice production of words of increasing length
    - LSVT
THE QUESTIONS

THE ANSWERS