Using a Theoretical Framework to Guide the Clinical Management of Intelligibility Disorders

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Learning Objectives

• Learners will explain how speech degradation interferes with cognitive-perceptual processes associated with speech understanding.
• Learners will recognize the missing relationship between an etiology-based classification system of dysarthrias and available treatment options.

Outline of Today’s Talk

• What is an intelligibility disorder?
• Current Practice
• Theoretical perspective
• Clinical perspective: Concepts of remediation
  ◦ Modification of the speech signal
  ◦ Activation of lexical candidates
  ◦ Perceptual training
• How can we use a theoretical framework to guide our clinical practice?
What is an intelligibility disorder?

A breakdown in the reception of a spoken message.

Possible sources of intelligibility breakdowns:
- Acoustic signal
  - Dysarthria
  - Stuttering
  - Cleft palate
  - Non-native speech
  - Cochlear implant signal
  - Synthesized speech (AAC)
- Transmission
  - Noisy environments
  - Cell phone
  - Acoustic reverberation
  - Cocktail party
- Reception
  - Hearing loss
  - Auditory comprehension deficits
  - Lack of experience or familiarity with distorted signal
Let's take a look at **Dysarthria**

- Motor speech disorder
- Results from neurological injury due to damage in the Central or Peripheral Nervous Systems
- Affects one, many, or all speech subsystems (respiration, resonance, phonation, articulation)

**Differential diagnosis**

- Physical oral mechanism exam
- AMR, SMR
- Sustained /a/
- Measures of intelligibility

...but largely, via the associated medical diagnosis

- Hyperkinetic dysarthria- Huntington’s Disease
- Hypokinetic dysarthria- Parkinson’s Disease
- Mixed spastic-flaccid dysarthria- ALS
- Ataxic dysarthria- cerebellar degeneration

(Mayo Classification System- Danley, Aronson, and Brown)

**Mayo clinic classification approach**

- Hyperkinetic
- Spastic
- Flaccid
- Hypokinetic
- Ataxic
- Mixed
But does it matter?

- Does the “dysarthria subtype” dictate your clinical decision making?
  - Probably not!

Mayo Clinic approach

1) there is considerable overlap in speech symptoms among the classification categories, and
2) speech symptoms within a given classification may differ along the severity dimension.
- This classification approach does not map well to the resulting communication disorders or to intervention targets.
  - It does help diagnose neurologic disease!
- Bottom line: we can’t treat the diagnosis, we need to treat the resulting intelligibility disorder!

What do I mean by that?

- We identify what is wrong and we try and fix it!
- Theory will tell us what will have the largest impact on the listener.
Speech Perception Theory

A theory is a set of interrelated principles and definitions that present a systematic view of phenomena by specifying relationships among variables with the purpose of explaining natural phenomena.

“Intelligibility is as much in the ear of the listener as it is in the mouth of the speaker.”

(Martin & Weismer, 1992)

Theoretical perspective

- Dysarthria interferes with perceptual processes:
  - Activation of an optimal lexical candidate pool
  - Competition among lexical candidates
  - Application of strategies to lexically segment the connected speech
How does it do that?

- To understand this interference, let's take a look at "normal" speech perception

Namely:
- How do listeners understand single words? and connected speech?
- How does dysarthria interfere with these processes?

Models of Spoken Word Recognition
(e.g. Logogen, Cohort, Trace, Shortlist, Neighborhood Activation, PARSYN)

Commonly assume that at least two fundamental processes underlie spoken word recognition:

**lexical activation**: When a listener encounters a spoken word, certain aspects of the acoustic signal serve to activate a set of possible lexical candidates.

**lexical competition**: This is followed by competition among these candidates for the best fit with the input, and the winner of this competition is the recognized word.

Time Course

- Time course
  - Left-to-right processing of acoustic information
  - Delay decision until whole word is spoken
Dysarthric speech and word recognition models

- Distortions
- Omissions
- Substitutions
- Vowel reductions

“dip”

- tip
- top
- tap
- dip
- dot
- dab

“_ip”

- it
- if
- in
- is
There is very little predictive value in single word intelligibility
Perceiving connected speech is a very different beast!
Deciphering Connected Speech
- Lexical activation and lexical competition are strongly influenced by the message
  - Semantic, syntactic, knowledge of topic, knowledge of speaker: all serve to prime the lexical candidates and facilitate efficient competition
- The quality of the acoustic signal is not critical as listeners listen for words, not phonemes
  - Phonemic restoration
- Listeners perform “lexical segmentation”

Lexical Segmentation
- A fundamental process in deciphering degraded speech that determines “word size frames” for lexical access.

Metrical Segmentation Strategy
(Cutler & Norris, 1987)
- When listeners encounter degraded speech
- They listen for STRONG (stressed) syllables
- Treat them as WORD ONSETS
- And they’ll most often be right in English
Lexical Segmentation

- Semantically anomalous, syntactically correct

Cues to syllable strength

- Fundamental frequency variation
- Loudness variation
- Syllable/一点儿 duration
- Strong versus weak vowels

If you don’t "chop up" the acoustic stream into words correctly…

You have no chance at using all available acoustic and top-down information to make a best match for the words.
Regardless of “dysarthria type,” different types of degradation patterns (e.g. slow rate, reduced pitch and loudness variation, consonant imprecision), yield different perceptual errors.

THIS is the intelligibility disorder!

Different patterns yield different errors

- Equivalent intelligibility
- Phonetic errors
- Segmentation errors

Listeners are flexible

- They use the available acoustic cues, even when they’re degraded;
- They can switch the amount of reliance on various cues, depending on which are most robust and systematic;
- They use their “higher level” knowledge to facilitate and guide speech understanding
  - Semantics, syntax, phonotactics, knowledge of topic/speaker
“Signal-Complementary Information”
Lindblom, 1990

- Speech Signal transmitted
- Listener manipulation
- Augmented perceptual processing
- Listener applies information
- Improved performance
- Increased intelligibility

Activating optimal lexical candidates

- Alphabet cueing
  - e.g. Hustad, Jones, & Dailey, 2003; Hustad, 2005
- Providing topic cues
  - e.g. Hustad, Auker, Natale, & Carlson, 2003; Jones, Mathy, Azuma, & Liss, 2004; Utianski, Azuma, and Liss, 2010
- Providing semantic context
  - e.g. Dongilli, 1994; Hammen, Yorkston, & Dowden, 1991

Lexical competition

- Providing a syntactic template or structure
- Creating semantically and syntactically predictable utterances
- Using supplementary cues such as first-letter, word-class cues, or gestures
Perceptual training

- Training material
  - Talker-specific
  - Disorder-specific
- Feedback type and frequency
  - Passive exposure vs. training
  - Generalization of minimal exposure/training
- Training regimen and intensity

Comprehensibility

- Visual information
- Gestural information

Research-practice divide

Current pitfalls in the remediation of intelligibility disorders
Theoretical and Clinical Perspectives

Theoretical Goal: Advance knowledge about basic mechanisms and processes

Clinical Goal: Determines how characteristics of a particular clinical population relate to hypotheses generated from a theory or model.

(Bernstein & Weismer, 2000)

Treating Intelligibility Disorders

Speaker-based approaches to remediation

- Subsystem Approach
  - Respiration
  - Phonation
  - Resonance
  - Articulation
- Global Approaches
Respiration
- Modify posture, tone, strength
- Improve control of exhalation
- Use biofeedback or visual feedback
- Modify abnormal breathing pattern
- Compensation (breath groups)

Phonation
- Hyperadduction: relax
- Hypoadduction: pushing/pulling, maximum performance tasks
- Traditional voice therapy

Resonance
- Prosthetic device/surgery
- Tactile/kinesthetic feedback
- Visual feedback
- Contrast drills
- CPAP
Articulation

- Articulation drills
- Contrast drills
- Oral strengthening
- Range-of-motion exercises

Modification of speech signal

- Reducing speaking rate
- Speaking louder
  - Is reduced loudness the problem?
- Modifying prosody
  - Reduced pitch loudness and variation?
  - Monopitch and monoloud?

Typical Approaches to Characterizing Intelligibility

- Single-word intelligibility tests
- Sentence intelligibility tests
- Estimates from reading passages or spontaneous connected speech

The estimates of single-word intelligibility are generally poor predictors of connected speech intelligibility, except at very mild and very severe ends of the continuum.
Why is this the case?

- Listeners don’t listen for phonemes in connected speech. They listen for words or even phrases.
- Listeners apply their knowledge of syntax, semantics, and phonotactics, and knowledge of the speaker to problem-solve degraded stretches of speech.
- Equivalent intelligibility ratings

Treating Motor speech disorders

How can we use a theoretical framework to guide clinical practice?
Face-to-face communication
- Face the listener
- Get the listener's attention before speaking
- Audio-visual enhancement for comprehensibility

Transmission:
Minimize environmental interference
- Optimize the environment
- Reduce background noise (the dishwasher, too; not just the tv!)
- Avoid communication over a distance

Activate optimal lexical pool:
Alphabet Supplementation
- Use an alphabet supplementation board, pointing to the first letter of each word as it is spoken.
• What if hypernasality is interfering with activation of the target lexical item?

Syllable segmentation

• Slow speaking rate
• Pausing between words but without separating syllables within words

Influence of familiarity

• Measures of speech intelligibility are subject to bias.
• Are speakers improving, or are you becoming a better listener?
Ways to quantify change to overcome bias
• Rate
• Loudness
• Digital advances

Clinical decision-making

Thank you!