Assessment and Intervention for Children with Speech Sound Disorders

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Why focus on speech sound disorders?

- 10% of school-age children have speech sound disorders.
- 80% are estimated to need services.
- 50-70% will have academic difficulty with risk for literacy problems.
- Children with speech sound disorders represent the largest percentage of school-based clinicians' caseloads.

(Gierut, 1998)

Perspectives

Phonetic

Perceptual

Oral Motor

Phonemic/Phonological

Phonetic Perspective

- Motor based
- Behavioral influence
- Focus on individual phonemes one at a time
- Traditional therapy
- Production errors
- Non stimulable sounds

Perceptual Perspective

- Lack of discrimination of sound contrasts
  - Perception of another's production
  - Perception of self production

Oral Motor Perspective

- Assumption that both speech and non-speech oral movements are deficient
- Assumption that non-speech oral exercises will assist in development of speech movements
- Frequency associated with apraxia diagnosis

Review of Literature regarding Non-speech Oral Motor Exercises

(Forrest, 2002)

"Until evidence from carefully controlled studies is presented to validate the utility of oral motor exercises, the inclusion of non-speech activities in treatment of children with PAD [phonological/articulatory disorders] simply may deplete resources that could otherwise be used for effective intervention procedures."

Making Decisions Based on the Evidence (Lof, 2007)

- Non speech oral exercises are not supported by:
  - Empirical research
  - Underlying theory
  - What we know about speech production and function

Making Decisions Based on the Evidence (Lof, 2007)

- Some clinicians use non-speech oral motor exercises without evidence for children with:
  - Hearing impairment
  - Phonological disorders
  - Childhood apraxia of speech
  - Articulation disorders (/s/, /r/)

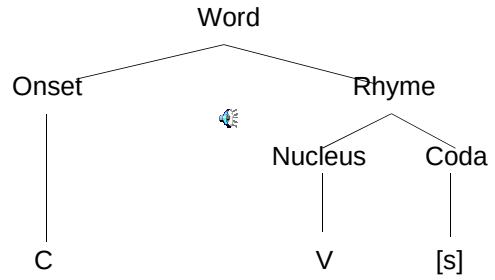
Phonemic/Phonological Perspective

- Severe to profound impairment
- Focus on child's sound system
- Facilitation of patterns
- Focus on assessment
- Focus on target selection
- Target occasional use
- Consider stimulability

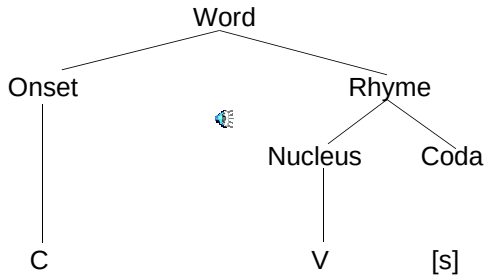
Nonlinear Phonology

- Autosegmental Phonology
  - Representations include separable and independent levels called tiers
  - The units are the tiers are called autosegments
  - Tiers are connected by association lines
  - If a segment is not linked to a position on another tier it will not be phonetically realized even though it may be available in an underlying representation
  - *This theory can capture contextually based limitations in development and disorders.*

Autosegment Chart



Auto Segment Chart



Non Linear Phonology

- Metrical Phonology
  - Deals with the relative prominence of syllables, feet, words, and larger units in the hierarchical representation
- Lexical Phonology
  - Relevant features include underspecification of features, phrasal phonology, inflectional morphology
- Feature Geometries
  - Specifies relationship of features to each other rather than considering them a random bundle

Optimality Theory

- Maintains relationship between input and output or between underlying mental representation and surface representation or realization
- Input and output are mediated by two processes:
  - GENerator – generates all possibilities
  - EVALuator – evaluates possibilities and chooses phonetic form that is optimal for grammar

Input = /kip/

- GEN: generates candidates which compete for output

tip, kit, ki, it, mu, bib, bob, tub, kop, top, etc.

- EVAL: applies constraints

Output = [kip]

Optimality Theory

- Uses universal, violable constraints rather than rules or processes
- Two types of constraints
  - Faithfulness constraints -- be faithful to input
  - Markedness constraints -- use unmarked (easier) value
    - Most unmarked or default: alveolar, stop, voiced
- Grammars, including those of languages and children, differ in the ranking of these constraints
  - Crucial rankings
  - Non-crucial or equal rankings

Faithfulness Constraints

- MAX
- DEP
- Ident-Feature
- Ident-[cons]
- Ident-[cont]
- No deletion
- No insertion
- Don't change features
- Don't change [consonantal]
- Don't change [continuant]

Markedness Constraints

- *Complex
- *Coda
- *Fricatives
- *Liquids
- *Liquid - [l]
- *Liquid - [r]
- *velar
- No clusters
- No final consonants
- No fricatives
- No liquids
- No liquid [l]
- No liquid [r]
- No velars

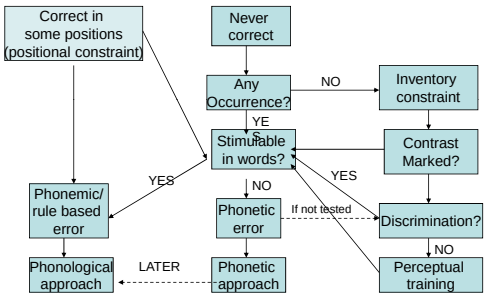
Assessment and Intervention

- Everyone has an EVAL that contains all of the constraints we need. Initially, the constraints are in a default ranking. As phonological knowledge grows. children learn the correct constraint ranking for the native language. Children with phonological disorders maintain the default ranking or have a mixed up ranking. The SLP's goal is to facilitate re-ranking of constraints.

/kip/	*CODA	MAX
a. [kip]	Fatal violation	
b. [ki] Optimal output		Constraint violation

Treatment Decisions

Adapted from Flipson, University of Tennessee



Implications of the Phonological Perspective for Clinical Practice

- Assessment
- Target Selection
- Intervention??

John is unintelligible at age 7

What do we need to do?

- Collect a connected speech sample
- Collect a single word speech sample
- Use a published analysis procedure?

John is unintelligible at age 7
What do we need to know?

Independent Analysis
Child's Phonological Grammar
- Phonemic and phonetic inventory
- Syllable/word structure
  - (CV, CVC, CCV, CCVC)
- Stress Patterns

John is unintelligible at age 7
What do we need to know?

Relational Analysis
Comparison to Adult Grammar
- Error patterns (stopping, velar fronting, liquid gliding, final consonant deletion, cluster reduction, etc.)
- Position constraints

- Stimulability
- Consistency

John's analysis

- Eyeball the sample
- Look for the major patterns
- Look for counter examples
- Look for relationships and contexts
- Consider errors that don't fit the major patterns
- Determine which patterns are important
- Prioritize patterns

John's patterns

- Final consonant deletion
- cluster reduction
- stopping
- liquid gliding
- nasal assimilation
- velar fronting
- /w/ substitution in medial position when target sound is not acquired

Treatment Approaches

- Traditional
- Motoric Automaticity
  - (begin at syllable level)
- Cycles
- Minimal Pairs

Target Selection

Assumptions about Target Selection

- Earlier or later developing sounds?
- Absent or inconsistent sounds?
- Stimulable or non-stimulable sounds?
- Less or more linguistic complexity?
- One or more than one target sound?
- Targets from the same class or different classes?
- Clusters or singletons?

Target Selection

Based on the Work of
Gierut and Colleagues

Types of Phonological Knowledge

- **Articulation**
- **Perception**
- **Phonological rules and phonotactic constraints**

Evidence of Phonological Knowledge

- Perception
- Stimulability
- Production
- Acoustic/Instrumental

Perception (Rvachew, 2005)

- Structural and functional integrity of the auditory and speech perception mechanisms
- Appropriate input for contrasting phoneme categories
- Appropriate cognitive/linguistic processing
- Rvachew (2004) found that traditional articulation therapy + perceptual training, and training in letter identification, sound-symbol relationship and onset identification resulted in greater progress than articulation therapy alone.

Stimulability (Rvachew, 2005)

- Structural and functional integrity of the speech mechanism
- Appropriate input (visual, tactile, kinesthetic information) about the required articulatory gestures
- Imitation skills
- Focus and motivation

Relationship between phonemic perception and stimulability across 3 studies with 53 children (Rvachew, 2005)

Study	+Perceive +Stimulable	-Perceive -Stimulable	+Perceive -Stimulable	-Perceive +Stimulable
Lof, 1996	6	10	9	5
Rvachew et al., 1999a	10	3	1	7
Rvachew et al, 1999b	10	2	6	8
TOTALS	26	15	16	20

Six types of Productive Phonological Knowledge displayed by children with phonological disorders (Gierut, 1987)

	Lexical Representation	***Breadth of Distribution***	***Phonological Rule***
1	adult-like	all pos/all mor	none
2	adult-like	all pos/all mor	optional or obligatory rules
3	adult-like	all pos/some mor	fossilized forms
4	adult-like	some pos/all mor	positional constraint
5	adult-like	some pos/ some mor	combination of types 3 and 4
6	non-adult-like	all pos/all mor	inventory constraint

Six types of phonological Knowledge (Gierut et al., 1987) Type 1

- A child displaying Type 1 knowledge of target /s/ would produce this sound correctly in all word positions and for all morphemes. /s/ would never be produced incorrectly.
- Examples:
  - [si] see
  - [sup] soup
  - [mɛsi] messy
  - [mɪsɪŋ] missing
  - [mɪs] miss

Six types of phonological Knowledge (Gierut et al., 1987) Type 2

- A child displaying Type 2 knowledge of target /s/ would produce the sound correctly for all morphemes and positions. However, a phonological rule would apply to account for observed alternations between, for example, /s/ and /t/ in morpheme-final position.
- Examples:
  - [si] see
  - [sup] soup
  - [mɛsi] messy
  - [aɪs] ice
- BUT
  - [kɪs]~[kɪt] kiss
  - [mɪs]~[mɪt] miss

Six types of phonological Knowledge (Gierut et al., 1987) Type 3

- A child displaying Type 3 knowledge of target /s/ would produce this sound correctly in all positions. However, certain morphemes that were presumably acquired early and acquired incorrectly (fossilized forms) would always be produced in error.
- Examples:
  - [si] see
  - [mɛsi] messy
  - [mɪs] miss
- BUT
  - [nænə] Santa
  - [wu] juice

Six types of phonological Knowledge (Gierut et al., 1987) Type 4

- A child displaying Type 4 knowledge of target /s/ would produce the sound correctly for all morphemes in, for example, initial position. However, production of /s/ would be incorrect for all morphemes in medial and final positions.
- Examples:
  - [si] see
  - [sup] soup
- BUT
  - [mɛti] messy
  - [mɪtɪŋ] missing
  - [mɪt] miss
  - [kɪt] kiss

Six types of phonological Knowledge
(Gierut et al., 1987) Type 5

- A child displaying Type 5 knowledge of target /s/ would produce the sound correctly in, for example, initial position. However, only some morphemes in this position would be produced correctly. All /s/ morphemes in post-vocalic positions would be produced incorrectly.

- Examples:
  - [si] see
  - [sup] soup
- BUT
  - [top] soap
  - [tɑk] sock
  - [mɛti] messy
  - [kɪt] kiss

Six types of phonological Knowledge
(Gierut et al., 1987) Type 6

- A child displaying Type 6 knowledge of target /s/ would produce this sound incorrectly in all word positions and for all morphemes. /s/ would never be produced correctly.

- Examples:
  - [ti] see
  - [tup] soup
  - [mɪtɪŋ] missing
  - [mɪt] miss
  - [kɪt] kiss

Target Selection Issues:
(Gierut et al.)

WHAT to work on:

- Stimulable/non-stimulable
- Most/least phonological knowledge
- Early/late developing
- Least/most marked
  (linguistically complex)

Markedness and Major Sound Classes

- Markedness
  - **Order of least to most markedness**
  - **Obstruants**
    - stops -- fricatives – affricates
  - **Sonorants**
    - nasals -- glides – liquids
  - **More marked assumes less marked**
    - If the child can make the more marked (harder) sound, he can make the less marked (easier) sound.

Target Selection based on **Phonological Knowledge**
(Gierut, Elbert, Dinnsen, 1987)

- Examined children's phonological knowledge before and after treatment
- 6 children
- Began treatment at different points on the continuum of their phonological knowledge

Target Selection based on **Phonological Knowledge**
(Dinnsen & Elbert, 1984; Elbert et al., 1984; Gierut et al., 1987)

- **Target selection based on sounds with most phonological knowledge provides faster generalization of the target sound to other contexts.**
- **Target selection based on least phonological knowledge provided greater generalization to other sounds and sound classes.**

Implications for target selection based on **Stimulability**
(Powell, Elbert & Dinnsen, 1991)

- Targeting stimulable sounds provides faster generalization of production of the target sound in other contexts.
- Targeting non-stimulable sounds provides more widespread generalization to other sounds and sound classes.

Target selection based on **Order of Acquisition of Sounds**
(Powell & Elbert, 1984)

- Examined treatment of early and later developing clusters -- stop liquid and fricative liquid
- 6 children
- Children could produce all sounds as singletons prior to treatment unlike previous study

Target selection based on **Order of Acquisition of Sounds**
(Powell & Elbert, 1984)

- Targeting earlier and later developing clusters both provided generalization to both treated and untreated categories.
- Differential learning patterns were noted among children.
- One child who was taught early developing did not generalize to later.
- All children who were taught later developing did generalize to earlier.

Target selection based on **Order of Acquisition of Sounds**
(Gierut, Morrisette, Hughes, Rowland, 1996)

- Within and across subject comparison of treatment of early versus late developing sounds
- Examined learning of the treated sounds and generalization to other sounds
- 9 subjects

Target selection based on **Order of Acquisition of Sounds**
(Gierut, Morrisette, Hughes, Rowland, 1996)

- Greater learning occurred for later developing sounds.
- Later developing sounds showed more continued improvement post treatment.
- Teaching later developing sounds produced greater system wide change.

Target selection based on **Order of Acquisition of Sounds**
(Gierut, Morrisette, Hughes, Rowland, 1996)

- Targeting early developing sounds provided greater generalization of the sound to other contexts.
- Targeting later developing sounds provided greater generalization to other sounds and sound classes.

Target Selection based on
Order of Acquisition & Phonological Knowledge
(Rvachew & Nowak, 2001)

- 48 children with moderate to severe phonological disorder
- 24 received treatment on early developing sounds with greater productive knowledge
- 24 received treatment on later developing sounds with little or no knowledge
- Measured progress toward acquisition during 2 blocks of 6 weekly sessions for 2 sets of 2 sounds

Target Selection based on
Order of Acquisition & Phonological Knowledge
(Rvachew & Nowak, 2001)

- Children treated on early developing/greater knowledge sounds showed greater progress toward acquisition of target sounds during therapy sessions
- Generalization to other untreated sounds was similar for the two groups
- Both groups added approximately 2.5 untreated phonemes to their inventories (range 0-7)

Target Selection based on
Order of Acquisition & Phonological Knowledge
(Rvachew & Nowak, 2001)

- Improvement occurred for untreated stimulable phonemes, but little improvement occurred for untreated unstimulable phonemes
- Confirmed the need to find ways to help children imitate sounds

Target Selection
(Elbert, Dinnsen, Powell, 1984)

- Three research questions:
  - Generalization to treated sound classes versus untreated?
  - Performance on known versus unknown sound classes?
  - Implicational factors?
- Six children in pairs
- Treated on stop-liquid OR fricative liquid
- Traditional minimal pair treatment

Target Selection
(Elbert, Dinnsen, Powell, 1984)

- Generalization occurred only to stop liquid when stop liquid was trained and child had no knowledge of fricative liquid.
- Generalization occurred to both stop liquid and fricative liquid when fricative liquid was trained and/or when child had some phonological knowledge of fricative liquid.

Teaching Clusters
(Williams, 1991)

- Hypothesis based on Gierut's work:
  - Teaching two new sounds in a cluster may result in acquisition of two new sounds and clusters.
- Results:
  - If the child had some knowledge of the sounds and no sequences, learning occurred.
  - If the child had sequences and inventory constraints for the sounds, learning occurred.
  - If the child had inventory constraints for the sounds and did not have sequences, learning did not occur.

Clusters and Adjuncts
(Gierut, 1999)

- Real clusters versus adjuncts
  - Clusters: from less to more sonority
    - stop glide, fricative glide
  - Adjuncts: /s/ stop
- Sonority Sequencing Principle
  - Easier clusters are those which have the greatest difference in sonority between the first and second segment: /pl/ over /fl/

Clusters & Adjuncts
(Gierut, 1999)

- Markedness
  - **Distinctive feature markedness**
    - stops -- fricatives -- affricates
    - nasals -- glides -- liquids
  - **Sonority sequence markedness**
    - most to least sonorant versus similarity
  - **More marked assumes less marked**

Clusters & Adjuncts
(Gierut, 1999)

- Adjuncts (s-stop clusters) are less marked (easier) than other clusters and therefore do not generalize to clusters.
- More marked clusters generalize to many clusters. /fl/ to /pl/, /br/, /kw/
- Less marked clusters generalize only to in-class clusters, not to others.
  - /pl/ to /bl/, /kl/, /gl/

Selection of Words for Target Sound Practice

Influence of Word Frequency on Phonological Change (Morrisette & Gierut, 2002)

- 4 children who were trained with either high frequency or low frequency words
- Treatment of high frequency words resulted in greater generalization to treated and untreated sounds within and across sound classes

Designing Phonological Intervention

Minimal Pair Selection

The work of Gierut and Others

Principles of Phonological Intervention (Fey, 1992)

- modification of groups of sounds that share a common pattern
- less emphasis on correct sound production and focus on neutralized contrasts
- more emphasis on using speech sounds for communication purposes

Phonological Intervention (Fey (1992)

"I believe that there is only one therapy procedure that embodies all of the three principles … the notion of minimal contrasts … and the functional use of speech to transmit unambiguous messages."

Assumptions about the nature of the contrasting pairs

- Target versus substituted sound
- Target versus another established sound
- Two new target sounds
- Multiple targets versus substituted sounds

Minimal Pairs

- Definition
  - Two words that differ by only one phoneme

Types of Feature Oppositions in Minimal Pairs

Minimal Oppositions Child's error contrasted to target

• [we]	• ray
• [wek]	• rake
• [tot]	• coat
• [ti]	• see
• [ti]	• she
• [wek]	• lake
• [do]	• go

Minimal Feature Oppositions

- toe
- hit
- toe
- goat
- nail
- bat
- comb
- do

- sew
- hick
- doe
- coat
- sail
- back
- cone
- zoo

Maximal Oppositions:
Maximal number of features

- run
- sew
- fast
- cone
- show
- peal
- man
- lead

- pun
- go
- last
- phone
- bow
- zeal
- ran
- feed

Maximal Pair Treatment
Child's target contrasted to maximally different sound

Child's production		Target	Contrast
/we/	new & old	re	pe
/to/	new & old	sew	bow
/tæn/	new & old	can	man
/wet/	two new	late	Kate
/tu/	two new	coo	sue
/to/	two new	show	go

Maximal Pair Treatment
Teaching 2 new phonemes

- Child's repertoire

p t
b d
f h
v
m n

Maximal Pair Treatment
Teaching 2 new phonemes

- Child's repertoire

p t
b d
f h
v
m n

- Contrasts to teach

/s/ /l/

OR

/k/ /r/

Minimal Pair Selection
(Gierut et al.)

HOW to work on it: Minimal Pair Contrasts

- Minimal/maximal oppositions
- One/two new sound(s)

Target Selection: Nature of Oppositions (Gierut, 1989)

- *Maximal Opposition Approach to Phonological Treatment*
  - one child
    - initial consonant deletion with nearly complete phonetic inventory except /f, v, r/
    - /m, b, w, j/ used in initial position
  - Paired a sound that he used in the initial position contrasted with a maximally different sound: e.g. /s/ contrasted with /m, b, w/

Target Selection: Nature of Oppositions (Gierut, 1989)

- The child learned 16 new initial consonants with only 3 sets of maximal oppositions.
- The child reorganized his phonological system to include word initial consonants.

Target Selection: Nature of Oppositions (Gierut, 1990)

- *Differential Learning of Phonological Oppositions*
  - 3 subjects - missing sounds:
    - 1: /θ, ɚ, s, z, ʃ, tʃ, ʤ, l, r/
    - 2: /k, g, f, v, θ, ɚ, l, r/
    - 3:/k, g, v, θ, ɚ, z, tʃ, ʤ, l, r/
  - Paired a sound that they **used** with a maximally different sound and with a minimally different sound in two conditions.

Target Selection:Nature of Oppositions (Gierut, 1990)

- Maximal pairs resulted in greater improvement in target sounds, more additions of untreated sounds and less over generalization to known sounds.
- Learning was enhanced by maximal differences and major class distinctions:
- multiple and major class distinctions > multiple distinctions > few distinctions

Target Selection: Nature of Oppositions (Gierut, 1992)

- Replication of previous studies investigating:
  - number of feature differences in pairs
  - nature of feature class distinctions
  - relationship to child's pre-treatment grammar
- Added treatment of two new sounds
- 4 children

Target Selection: Nature of Oppositions (Gierut, 1992)

- **Greatest widespread system change**:
  - minimal pairs comparing two new phonemes differing by maximal and major class features.
  - The major class distinction may be more important than the number of features.

Target Selection: Nature of Oppositions (Gierut, 1992)

- **“**This result suggests that it may be unnecessary to teach children that newly learned phonemes are in some way related to other existing phonemes in their grammar by setting up explicit minimal pair comparisons” (p. 1056)

Target Selection: Nature of Oppositions (Gierut, 1992)

- “Thus, the evidence implies that treatment comparing two new phonemes may be an important structural variable in conditioning phonological change.
- The results also suggest that treatment involving two new phonemes may motivate change in untreated phonemes, but perhaps only when pairs differ by a major class feature . . .” (p. 1056)

Target Selection: Multiple Oppositions (Williams, 2000)

- Larger treatment sets of multiple phonemic contrasts
- Intervention across a broader spectrum of a child’s error pattern, rule or phoneme collapse.
- Contrast single substitution with multiple targets that are collapsed to that substitution

Target Selection: Multiple Oppositions (Williams, 2000)

- Child’s system: l/s, ʃ, w
  - Contrast Pairs:
  - let – set
  - lee – she
  - lay – way
- h/f, ɤ, s, z, ʃ, tʃ, ʤ
  - hat – fat
  - hay – they
  - he – she
  - hi – sigh
  - who - chew

Target Selection: Multiple Oppositions

- Child’s system: t/s, ʃ, tʃ, k
  - Contrast Pairs:
  - tea - see
  - tea - she
  - tea - key
  - two - chew
- Child’s system: d/z, g, ʤ, ɤ
  - do - zoo
  - doe - Joe
  - doe - go
  - doe - though
  - D - Z

Target Selection for John

- Minimal oppositions with his error
- Maximal opposition with his target sound and another sound he can produce
- Maximal opposition with two new sounds
- Multiple oppositions

Strategies for John

- Minimal oppositions with his error
  - /t/ & /s/ tea & see
- Max opposition with his target and another sound he can produce
  - /r/ & /t/ rake & take
- Maximal opposition with two new sounds
  - /s/ & /r/ say & ray

Strategies for John

- Multiple oppositions
  - t & s tea & see
  - t & tʃ too & chew
  - t & θ tie & thigh
  - t & k tea & key
  - t & ʃ tea & she

Relationship between Language and Phonology

- Children with phonologic disorders
- Children with language disorders
- Synergistic relationship
- Current theories of language and phonologic acquisition

Assumptions about Intervention

- Does work on phonology help language skills?
- Does work on language skills help phonology?
- Where is it best to target phonology?

Treatment Strategies

- Phonology treatment only
- Language treatment only
- Sequential phonology and language treatment
- Simultaneous language and phonology treatment - non integrated
- Integrated phonology and language treatment

Research Findings: Implications for Treatment

- Generalization across domains
- No generalization across domains
- Generalization only in one direction

Research Findings

- Generalization from language-based intervention to phonologic domain (Hoffman et al.,1990; Hoffman et al., 1996; Tyler et al., 2002)
- Little generalization from language to phonology (Tyler & Waterson, 1991; Tyler & Sandoval, 1994; Fey et al., 1994)
- Generalization from morphosyntax to phonology (Tyler et al., 2002)
- Generalization from phonologic treatment to language domain (Fey et al., 1994)

Possible Explanations for Discrepancies

- Severity of impairments across studies
- Differences in methodology
- Differences in treatments
- Duration of treatment programs
- Differences in outcome measures

Scheduling Language Goals
(Tyler et al., 2003)

- 12 week block phonological intervention, followed by 12 week morphosyntax block intervention
- Order of interventions reversed
- Alternating conditions of phonolgy and morphosyntax on a weekly basis
- Simultaneous phonological and morphosyntax each session
- Control group

Scheduling Language Goals
(Tyler, et al., 2003)

- Morphosyntactic change greatest for children receiving weekly alternating strategy
- No strategy superior in facilitating gains in phonological performance

What treatment decisions will you make for your children with speech sound disorders?

- What is the evidence base?
- How can we each contribute to the evidence?
- How do we combine research evidence with what we know about THIS child?
- What will you do on Monday that is difference from what you did last Wednesday?
- Which of the following will you read?

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