



Phonological Complexity Principles:
Promoting Efficient Change
in Overall Intelligibility

Jennifer Taps Richard, M.A., CCC-SLP
SLPath
2020
jen@slpath.com



© Jennifer Taps Richard and SLPath®

1


Disclosures

- **Relevant Financial Relationships:** Jennifer Taps Richard owns and directs SLPath. She is an author/speaker and receives compensation for her presentations as well as for the sale of materials.
- **Relevant Non-Financial Relationships:** No relevant non-financial relationship exists.

© Jennifer Taps Richard and SLPath®

2


Session 1: Assessment



© Jennifer Taps Richard and SLPath®

3

Resource Website



Over 200 free resources available at:
<http://slpath.com>

- Online courses and iPad apps
- Bibliography for this course
- Free registration required to access documents

Additional resources on SLPath

© Jennifer Taps Richard and SLPath®

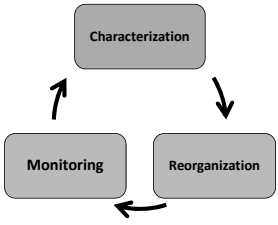
4

Handouts

- PPT Handout
- Supplementary Handout (Same for all 3 sessions)
 - Blue text boxes in PPT indicate pages of SH
 - e.g., [Supplementary Handout: pp. 2-3](#)
- Cluster Target Selection

5

Clinical Process
Elbert & Gierut, 1986



© Jennifer Taps Richard and SLPath®

6

Step 1: Characterization

- Question: What is the problem?
 - Is there a problem?
 - Normal vs. disorder
 - What is the nature of the problem?
 - Patterns of strengths/weaknesses
 - Factors causing/contributing to problem
 - How does the problem impact life?
 - Severity of the problem

(Storkel, 2010)

© Jennifer Taps Richard and SLPath™

7

In-Depth Assessment

- The success of intervention depends entirely on the overall assessment of the sound system
- An extra *hour spent on a thorough* assessment can reduce amount of *weeks spent in intervention*
- Target selection matters the most (**what** to teach more important than **how** to teach) (Gierut, 2001)

SLPath *Powerful Assessment and Analysis Course* (Taps Richard, 2014)

© Jennifer Taps Richard and SLPath™

8

Importance of Larger Samples

- Standardized tests: snapshot of child's system
- To determine patterns, need more than one attempt at a given target in a given position (Elbert & Gierut, 1986; Eisenberg & Hitchcock, 2010; Kollia & Eisenberg, 2005)
 - Deep test of articulation: Sample each target sound in each position multiple times
- Need to evaluate BOTH singletons (e.g., CV) and clusters (e.g., CCV)

(Storkel, 2010)

© Jennifer Taps Richard and SLPath™

9

What's the Nature of the Problem?

- Score the sample/organize the data
 - Relational analyses: Compare the child to the adult
 - Phonological processes (e.g., stopping of fricatives)
 - Place-voice-manner analysis (e.g., stops for fricatives)
 - Sound substitution patterns (e.g., /f/ → [p])
 - Percent consonants correct (PCC)
 - Independent analyses: Examine complexity of the child's system without regard to adult target
 - Phonetic inventory
 - Phonemic inventory

(Storkel, 2010)

© Jennifer Taps Richard and SLPath™

10

Independent Analysis

<ul style="list-style-type: none"> • Phonetic Inventory (Stoel-Gammon, 1986; Elbert & Gierut, 1986; Williams, 2003) <ul style="list-style-type: none"> • Focus on child's productions (not target) • 2 occurrences total in any word position → IN • Fewer than 2 → OUT • What sounds does the child physically produce? <ul style="list-style-type: none"> ➢ Not just target language 	<ul style="list-style-type: none"> • Phonemic Inventory (Stoel-Gammon, 1986; Elbert & Gierut, 1986; Williams, 2003) <ul style="list-style-type: none"> • Focus on child's productions (not target) • 2 occurrences total in any word position → IN • Fewer than 2 → OUT • What sounds does the child use to contrast meaning?
---	---

(Storkel, 2010)

© Jennifer Taps Richard and SLPath™

11

Phonemic Inventory

- 2 examples of sound used to contrast meaning
 - i.e., two sets of minimal pairs
 - Minimal pair = 2 words differing in meaning and differing by only one sound
 - “bead” /bid/ -- “beak” /bi:k/
 - “deep” /di:p/ -- “leap” /li:p/
 - 2 sets of minimal pairs for /d/, thus /d/ = phoneme
- Organize by vowels

(Storkel, 2010)

© Jennifer Taps Richard and SLPath™

12

Thom: Phonemic Inventory

gAm	bΛs - bΛ : /s/(1)
bAs	tΛn - wΛn: /t/(1), /w/(1)
bΛ	wΛn- wΛb: /n/(1), /b/(1)
dΛk	
tΛn	
wΛn	
dΛmp	
hΛg	Look across all vowels for 2 occurrences
wΛb	

© Jennifer Taps Richard and SLPath®

13

Independent Analysis

- **Clusters Inventory** (Stoel-Gammon, 1986; Elbert & Gierut, 1986; Williams, 2003)
 - Focus on child's productions (not target)
 - At least 2 Initial clusters → IN
 - Fewer than 2 → OUT
- **Stimulability Inventory** (Glaspey & Stoel-Gammon, 2005)
 - Elicit productions of OUT sounds in isolation and syllables
 - Provide brief phonetic cues
 - Yields information about prognosis and target selection

What clusters does the child physically produce?
 > Not just target language (e.g., /pw-/ or /bw-/)

> Give credit for all clusters

In-Depth Stimulability Task

© Jennifer Taps Richard and SLPath®

14

In-Depth Phonological Assessment (IPA)

Taps Richard, 2012

- Set of independent probes
 - **Not a standardized test**
- Transcription forms available on SLPath
- Broad sampling of all consonants adjacent to at least two different vowels (Eisenberg & Hitchcock, 2010)
- Allows for full characterization of child's system

Supplementary Handout: pp. 2-3

- Linked on SLPath: Clusters Probe (McLeod & Hand, 1991)

© Jennifer Taps Richard and SLPath®

15

Multilingual Assessment

- Same principles apply across all languages
- *Assessment of Spanish Phonology* (Barlow, 2010)
- Additional Spanish documents available on SLPath
- McLeod multilingual website (link on SLPath)
 - Information about 57 languages
 - Links to independent probes for 30 languages

© Jennifer Taps Richard and SLPath®

16

Connected Speech Sample

- Representative sample with SLP or caregiver
 - Shared contexts: books, automatic sequences, toys
- Consider
 - Overall intelligibility
 - Vowels
 - Stress patterns
 - Intonation
 - Pitch
 - Rate

© Jennifer Taps Richard and SLPath®

17

Intelligibility in Context Scale

McLeod, Harrison & McCormack, 2012

- 7 questions for parents
- 5 point scale (5 = always, 1 = never)
 - Parents, immediate family, extended family, friends, acquaintances, teachers, strangers
- Link on SLPath
- Validated in English, Croatian, Traditional Chinese/Cantonese, Slovenian
- Available in English and 63 other languages

© Jennifer Taps Richard and SLPath®

18

What is the Nature of the Problem?

- Describe overall language and communication
- Frequent co-occurrence of language and phonological disorders (Shriberg & Austin, 1998; Shriberg et al, 1986; Bishop & Edmundson, 1987; Tallal et al, 1989)
- Child communicates with
 - Gestures
 - Facial expressions
 - Jargon
 - Single words
 - Two-word combinations
 - Simple sentences
 - Complex sentences

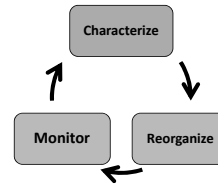
© Jennifer Taps Richard and SLPath®

19

Step 2:

Reorganization

Selecting intervention targets and planning for generalization



© Jennifer Taps Richard and SLPath®

20

What to Teach?

- Lots of possible sounds and sequences that could be targeted in intervention
- Goal: cause the greatest change in the least amount of time (intervention efficiency) → focus on overall intelligibility (Hustad, 2012)
- Leads to significant changes in overall intelligibility
- Conversely, focusing on individual sounds or patterns unlikely to impact overall intelligibility

© Jennifer Taps Richard and SLPath®

21

Big Picture:
Why should we
teach complex targets?

© Jennifer Taps Richard and SLPath®

22

Practical Considerations

- Return students with phonological disorders to classroom instruction ASAP
- Keep caseload numbers in check
 - Best for students with significant needs
- Group intervention found to be as effective as individual intervention (Law, Garrett & Nye, 2010)

© Jennifer Taps Richard and SLPath®

23

Complexity Approach




- Indiana University Learnability Lab – Gierut et al
- (Almost) more research on complexity than other four major methodologies **combined** (Kamhi, 2006)
- More evidence than normative approach (Baker & McLeod, 2008)
 - 8:1 ratio
 - need better levels of evidence

© Jennifer Taps Richard and SLPath®

24

Complexity Approach



- Children in studies range in age
 - 2;8 to 7;11 (most around 4;0)
- Complexity “may assist a range of populations and disorder types” (Gierut, 2005)
 - 40 case studies in SDUSD

© Jennifer Taps Richard and SLPath®

25

Data Analysis: Damon (Age 4;4)

← /skw-/, /spl-/ →


Targets	6/25/10 & 7/9/10	12/9/10 & 1/26/11	5/4/11
→ peach	pi	pitʃə	pitʃ
→ bread	bwɛ	bɹɛ	bɹɛd
→ cereal	ʃjɪdɔʊ	ʃɪɹdɪɔʊ	sɪɹɪɔʊl
→ chip	tʃɪ	tʃɪp	tʃɪp
→ star	da	ta	star

What changed for each target?

© Jennifer Taps Richard and SLPath®

26

Complexity Principles

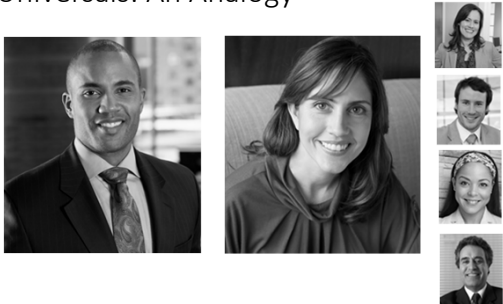


- Guided by language laws and sound features
- intervention targets sounds - nonstimulable, phonetically-complex and later-developing
- Results in generalization to untreated sounds and contexts → Global change in least amount of time
- Significant increases in **overall intelligibility**
- Defining article on complexity (Gierut, 2007)
<http://www.indiana.edu/~sndlrng/papers/Gierut07.pdf>

© Jennifer Taps Richard and SLPath®

27


Universals: An Analogy



© Jennifer Taps Richard and SLPath®

28

Language Laws



- Universals - implicational relationships found across languages
- Laws can be used to guide intervention
- More complex (marked) implies less complex (unmarked)
 - Treating marked structures creates change in unmarked structures

Supplementary Handout: pp. 4-5

© Jennifer Taps Richard and SLPath®

29

Phonemic Laws

- Affricates → Fricatives (Gierut et al, 1994; Ingram et al, 1980; Schmidt & Meyers, 1995)
- Teach affricates to create change in the sound system

Affricates: /tʃ dʒ/

Fricatives: /f v θ ð s z ʃ ʒ/

© Jennifer Taps Richard and SLPath®

30

Example:
William
(Age 5;0)

Singletons	11/4/04	3/29/05	9/20/05
giraffe	dɪwæs	dɪwæs	dʒɪwæs
sandwich	wænwis	fænwis	sænwitʃ
finger	wɪndə	fɪndə	fɪŋgə
shirts	wɔʃ	wɔʃ	ʃɪrts
father	wədə	fədə	fədə
fish	wɪs	fɪs	fɪʃ
wave	weɪs	weɪs	weɪv
chair	dɛʀ	tɛʊʀ	tʃɛr

Baseline:
IN: /s/
OUT: /f v θ ð z ʃ ʒ dʒ/

- Targeted an affricate /dʒ/
- Change occurred for /f v s z ʃ ʒ dʒ/

change
adult-like

© Jennifer Taps Richard and SLPath

31

Phonemic Laws

- Fricatives → Stops (Dinnsen & Elbert, 1984; Elbert et al, 1984; Cataño et al, 2009)

Fricatives: /f v θ ð s z ʃ ʒ/
Stops: /p b t d k g/

© Jennifer Taps Richard and SLPath

32

Example:
William
(Age 5;0)

Singletons	11/4/04	3/29/05	9/20/05
sock	wɔʔ	wak	sɔk
cage	teɪs	teɪs	keɪdʒ
couch	təʊs	kəʊs	kəʊtʃ
rug	wʌŋ	wʌŋ	wʌg
lady bug	wædi bʌŋ	lædi bʌŋ	lædi blɜg
leg-i	wɪʔi	lɛʔi	lɛgi

Baseline:
IN: /p b t d s/
OUT: /k g/
/f v θ ð z ʃ ʒ/

- Targeted an affricate /dʒ/
- Change occurred for /k g f v s z ʃ ʒ dʒ/

change
adult-like

© Jennifer Taps Richard and SLPath

33

Phonemic Laws

- Voiced obstruents → Voiceless obstruents (McReynolds & Jetzke, 1986; Dinnsen & Elbert, 1984; Cataño et al, 2009)
- Obstruents: stops, fricatives and affricates

Voiced: /b d g v z ʒ ð dʒ/
Voiceless: /p t k f s ʃ θ tʃ/

© Jennifer Taps Richard and SLPath

34

Example: William


- Targeted a voiced obstruent /dʒ/
- Change occurred for /k f s ʃ ʒ/

© Jennifer Taps Richard and SLPath

35

Debrief with Neighbors

- What do you think of these principles?
- How does it align with your current practices?
- What questions do you have?



© Jennifer Taps Richard and SLPath

36

Clusters!

© Jennifer Taps Richard and SLPath®

37

Clusters

- 1/3 of monosyllabic English words begin with cluster (Locke, 1983)
- Significantly impact intelligibility
- **37+ initial clusters in English** (depending on dialect/if count /j/ clusters /mj-, vj-, fj-, bj-, pj-, kj-/ and less common but permissible /dw-, gw-, skl-/)
- Word-final clusters acquired before word-initial (Chervela, 1981; Macken, 1977, Lleó & Prinz, 1996)

© Jennifer Taps Richard and SLPath®

38

Clusters

- 50% of 2-year-olds produce some clusters (Stoel-Gammon, 1987)
- 3½-year-olds produce full clusters 75% of the time (Roberts et al, 2001; Goldman & Fristoe, 2015)

© Jennifer Taps Richard and SLPath®

39

Syllable Structure Laws

- Clusters → Singletons (Gallagher & Shriner, 1975)

© Jennifer Taps Richard and SLPath®

40

Syllable Structure Laws

- Clusters → Affricates (Gierut & O'Connor, 2002; Gierut, 2008)
- Clusters: /bl- pl- kl- gl- sl- fl- fr- spl- br- pr- kr- gr- tr- dr- str- skr- spr- jr- θr- sw- skw- sn- sm- sp- sk- st-/
- Affricates: /tʃ dʒ/
- Side note: other affricates (e.g., /ts/ /dʒ/) satisfy this relationship

© Jennifer Taps Richard and SLPath®

41

A Word About Affricates...

- Cluster wannabes
- Consist of stop + fricative mashed together acting as one consonant
- Stop and fricative in similar places of articulation (e.g., /tʃ dʒ ts dz tθ/)
- Full list of affricates and audio of some: https://en.wikipedia.org/wiki/Affricate_consonant

© Jennifer Taps Richard and SLPath®

42

Cascading Laws

Gierut, 2007; Anderson, 2002; Barlow, 2005; Lleó & Prinz, 1997; Gierut & Champion, 2001; Gierut & O'Connor, 2002; Elbert & McReynolds, 1979; Gallagher & Shriner, 1975; Gierut 1998, 1999; Maas et al, 2002; Williams, 1986, 1988

Clusters → Affricates → Fricatives → Stops

© Jennifer Taps Richard and SLPath®

43

Syllable Structure Laws

- Fricative + Liquid Clusters → Stop + Liquid Clusters (Elbert et al, 1984)
- Fricative + Liquid Clusters: /sl- fl- fr- jr- θr-/
- Stop + Liquid Clusters: /bl- pl- kl- gl- br- pr- kr- gr- tr- dr-/

© Jennifer Taps Richard and SLPath®

44

Cluster Cliques

- Two-element **true clusters** impact other **true clusters only** (Gierut, 1999; McReynolds & Elbert, 1981)
 - /fl- fr- θr- jr- bl- br- dr- gl- gr- pl- pr- tr- kl- kr- dw- gw- tw- kw-/
- Two-element **/s/ clusters** impact other two-element **/s/ clusters only** (Gierut, 1999; McReynolds & Elbert, 1981)
 - /sm- sn- sl- sw- st- sp- sk-/

© Jennifer Taps Richard and SLPath®

45

Syllable Structure Laws

- 3-element clusters → 2-element clusters (both kinds) (Gierut & Champion, 2001; Maas et al, 2002)*
- Typically last sequences to be acquired

*Caveat: 3-element clusters impact both cluster types and promote system-wide change; however, results significant only if **Consonant 2 and Consonant 3** already in system (i.e. teach /skr-/ only if /k/ and /r/ already in **phonemic** inventory)

© Jennifer Taps Richard and SLPath®

46

Clusters – Peter (Age 5;8)

Target	12/7/06	4/17/07	Target	12/7/06	4/17/07
snake	neik	sneik	spoon	pun	spun
squid	swi	swid	split	plit	split
squirrel	swεoθ	skwɹl	swing	swiŋ	swiŋ
spider	paɪdə	spaidə	sled	sled	sled
friend	fwen	fren	french fries	fwen fwaɪ	fren fraɪ
stripe	sraɪp	straɪp	princess	prinsek	pristet
fly	flai	flai	<ul style="list-style-type: none"> • Targeted /spl-/ and /str-/ • Increase 12 → 25 clusters in 10 hours of group intervention 		
dragon	dræŋɪn	dræŋɪn			
smoke	noʊk	smook			
crayon	kwæn	kræn			

change
adult-like

© Jennifer Taps Richard and SLPath®

47

Three-Element Clusters

- /str-/
- /spr-/
- /skr-/
- /spl-/
- /skw-/
- /skl-/ (permissible but uncommon)

Supplementary Handout: pp. 6-7

© Jennifer Taps Richard and SLPath®

48

Prior Knowledge for /s/CC Clusters	Prior Knowledge for CC Clusters
<ul style="list-style-type: none"> Child must have C2 and C3 in /s/CC (three-element) clusters in phonemic inventory (Gierut & Champion, 2001; Maas et al, 2002) No prior knowledge of /s/ in /s/CC required (okay if nonstimulable) 	<ul style="list-style-type: none"> No prior knowledge of either sound in CC clusters required in phonemic inventory In fact, nonstimulable sounds shown to create more change e.g., teach /fl-/ if /f/ and /l/ absent and nonstimulable

© Jennifer Taps Richard and SLPath®

49

Phonemic Inventory Probe (PIP)

Taps, 2010

- Determines if sCC cluster viable target for this child
- Targets second and third consonants in sCC clusters
- Contrast among sounds – /p t k w l r/
- Two occurrences needed to count in phonemic inventory (Stoel-Gammon, 1986; Elbert & Gierut, 1986)
- Long and short versions (both PPTs)
- Transcription forms set up strategically

All PIP documents

Supplementary Handout: p. 16-17

© Jennifer Taps Richard and SLPath®

50

Complex Two-Element (CC) Clusters

- Sonority Sequencing Principle for Clusters** (adapted from Gierut, 1999; Morrisette et al, 2006)

Supplementary Handout: p. 8

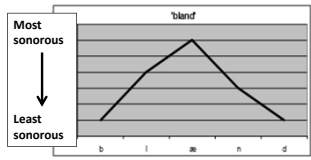
- Clusters from most complex (sm-, sn-) to least complex (tw-, kw-)
- If several clusters missing from repertoire, treat more complex clusters to create change
- Three-element clusters so cool that they operate by their own rules

© Jennifer Taps Richard and SLPath®

51

Sonority Sequencing Principle for Clusters

- Sonority – inherent loudness of sounds relative to one another (greater the sonority, wider the mouth is and the more vowel-like a sound is) (Barlow, 2000)
- Onsets must rise in sonority and codas must fall in sonority (Gierut, 1999; Morrisette et al, 2006)

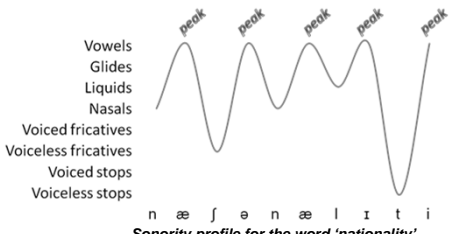


(Barlow, 2010)

© Jennifer Taps Richard and SLPath®

52

Peaks in sonority correspond to the number of syllables in a word



Sonority profile for the word 'nationality'
(Barlow, 2010)

© Jennifer Taps Richard and SLPath®

53

Least to Most Sonorous

Steriade, 1990

- 7 = voiceless stops
- 6 = voiced stops
- 5 = voiceless fricatives
- 4 = voiced fricatives
- 3 = nasals
- 2 = liquids
- 1 = glides

© Jennifer Taps Richard and SLPath®

54

Small Sonority Distance

sonority distance = 2
voiceless fricative + nasal
/sm-/
/sn-/
/mj-/

sonority distance = 3
voiceless fricative + liquid
/lh-/
/lv-/
/br-/
/bl-/
/fl-/
/pl-/
/sl-/
/sk-/ (This cluster does not occur in English. However, children with disordered phonologies (and those with typically-developing phonologies) often produce this combination, which suggests knowledge of clusters with a sonority distance of 3.

Something different about /sm-/, /sn-/ – more on this later → stay tuned!

© Jennifer Taps Richard and SLPath™

55

Application

- Language universal:
 - Clusters with a small sonority distance → Clusters with a large sonority distance (Gierut, 1998, 1999; Gierut & O'Connor, 2002; Morrisette et al, 2006; Anderson, 2002; Barlow, 2005; Broselow & Finer, 1991; Eckman, 1991; Eckman & Iverson, 1993; Elbert et al, 1984; Elbert & McReynolds, 1979; Lleó & Prinz, 1997)
 - Treat clusters with small distance to create change throughout the system

© Jennifer Taps Richard and SLPath™

56

Adjunct Clusters

- /sp-/, /sk-/, /st-/
- Violate the SSP (Sonority distance of -2) (Barlow, 2001b; Gierut, 1999; Smit, 1993; Smit et al, 1990)
- Treating these may inhibit generalization to other clusters
- Led to overgeneralization of /s/ onset clusters
- May also include /sm-/, /sn-/, /sl-/, /sw-/ for some children

© Jennifer Taps Richard and SLPath™

57

English /s/ clusters violate sonority sequencing

- Onsets must rise in sonority, but /sp-/, /st-/, /sk-/ occur

Two peaks... two syllables?

Vowels
Glides
Liquids
Nasals
Voiced fricatives
Voiceless fricatives
Voiced stops
Voiceless stops

s t a p

Barlow, 2010

© Jennifer Taps Richard and SLPath™

58

James Dean of Clusters

1. Violate SSPC (see last slide)
2. English does not prefer clusters consisting of same place of articulation (and yet... /sn-/, /st-/, /sl-/)
3. Language preference: smallest sonority distance within clusters of 3 (and yet... /sm-/, /sn-/ with SD of 2)

© Jennifer Taps Richard and SLPath™

59

True vs. Adjunct Clusters

fl- in English

flop

st- in English

stop

© Jennifer Taps Richard and SLPath™

60

Bottom Line

- First choice: three-element (sCC) clusters
- Next best thing: two-element clusters with a sonority distance of 3
 - Follow rules
 - Imply clusters with a distance of 4, 5, 6 as well as affricates, fricatives, and stops
 - Entry point to introduce complexity into system
 - /fl-/, /fr-/, /sl-/, /θr-/, /ʃr-/

Cluster Target Selection

© Jennifer Taps Richard and SLPath™

61

Multilingual Students

- Practice in both languages
 - intervention in one language may or may not transfer to other language (Goldstein, 2010)
- Example: 3rd graders – Vietnamese (initial /l/) and English practice (/fl-/) together
- Example: K student practicing /fl-/ in English and Spanish at school; /fl-/ in Spanish at home

Interventions for Supporting Sound Acquisition at Home
(English & Spanish)

© Jennifer Taps Richard and SLPath™

62

Debrief with Neighbors

- How could you apply these principles with one student?
- What resources and materials could you utilize?



© Jennifer Taps Richard and SLPath™

63