

Children with SLI: Associated Deficits in Phonology and Word Learning



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Associated Deficits in SLI: Word Learning

- Children with SLI tend to
 - Score lower than children with NL on vocabulary tests
 - Learn fewer words than children with NL
- Vocabulary tests (Gray et al, 1999)
 - 15% of SLI score 1.5 SD below mean
 - 7% of SLI score 2.0 SD below mean
- Word learning (Gray, 2004)
 - 35% of SLI fail to meet criterion
- Overall, 7-35% of kids with SLI have significant word learning deficits (based on small samples)

Importance of Word Learning

- Vocabulary is a good predictor of later reading ability
 - Decoding/word reading
(Metsala, 1999; Metsala & Walley, 1998; Walley et al., 2003)
 - Reading comprehension
(Chall et al., 1990; Cunningham & Stanovich, 1997; Scarborough, 1998)
- Vocabulary is related to academic success
(Baker et al., 1998; Becker, 1977; Cunningham & Stanovich, 1998)
- Children who enter school with vocabulary deficits have difficulty "closing the gap" with their peers
(Baker et al., 1998; Biemiller, 2001; Hart & Risley, 1995)

Vocabulary Differences in NL

- By 2nd grade (Biemiller & Slonim, 2001)
 - Lowest vocabulary quartile = 4,000 root words
 - Highest vocabulary quartile = 8,000 root words
- After 2nd grade (Biemiller & Slonim, 2001)
 - Rate of acquisition is similar across quartiles

Associated Deficits in SLI: Phonology

- Prevalence in general population = 3.8% (Shriberg et al., 1999)
- Co-occurrence of SLI and phonological disorders (Shriberg et al., 1999)
 - 5-8% of 6-year-old children diagnosed with SLI have phonological disorders
 - 11-15% of 6-year-old children diagnosed with phonological disorders have SLI
- Overall, 5-15% co-occurrence (conservative estimate)

Importance of Phonology

- Phonological disorders may impact:
 - Reading and writing
(Bird et al., 1995; Catts, 1993; Catts & Kamhi, 1986)
 - Academic success
(Aram, Ekelman, & Nation, 1984; Felsenfeld, Broen, & McGue, 1994; Shriberg & Kwiatkowski, 1988)
 - Social well-being
(Crowe Hall, 1991; Silverman & Paulus, 1989)

Word Learning

Focus on Assessment

Mental Lexicon

- Store of words in long-term memory
 - Sound-form of the word, e.g., /kæt/
 - Meaning of the word, e.g., *small 4-legged furry animal that purrs*
 - Connection between sound-form and meaning
 - Connection between words
- Must add words to the mental lexicon
 - Word learning
- Must access words in the mental lexicon
 - Word retrieval (production) or word recognition (comprehension)

**How do we know that a child with SLI
also has word learning difficulties?**



Standardized Vocabulary Tests

- Reportedly insensitive to word learning differences
(e.g., Gray, 2004)
- May be culturally biased
(e.g., Campbell, Bell, & Keith, 2001; Washington & Craig, 1992)
- Examine the *products*, not the *process* of word learning
(e.g., Dollaghan & Campbell, 1998)
 - Represents exposure & ability

Process of Word Learning

- Recognize that a new word was heard, triggering learning
- Hold sound-form and meaning in working memory
- Store a representation in the mental lexicon
 - Sound-form
 - Meaning
 - Link between sound-form and meaning
- Integrate new representation with other known words in mental lexicon
- Modify new representation upon subsequent exposure

Assessment Approach 1: Nonword Repetition

- Success in nonword repetition associated with success in word learning (e.g., Gathercole & Baddeley, 1990)
- Children with SLI typically perform poorly on nonword repetition tasks (e.g., Gathercole & Baddeley, 1990; Dollaghan & Campbell, 1998; Weismer et al., 2000)

Process of Word Learning

- Recognize that a new word was heard, triggering learning
- **Hold sound-form and meaning in working memory**
- Store a representation in the mental lexicon
 - Sound-form
 - Meaning
 - Link between sound-form and meaning
- Integrate new representation with other known words in mental lexicon
- Modify new representation upon subsequent exposure

Nonword Repetition Tasks

- Dollaghan & Campbell (1998) *JSLHR*, 41
 - 16 nonwords (see next slide)
 - Score = percent phonemes correct
 - Data from children age 5;8 to 12;2
 - Compute z-score based on NL mean & SD
 - $(\text{Obtained score} - 84)/7$
 - Use traditional cut-points (e.g., -1.25, -1.50, etc)
 - Report recommended cut-points
 - $\leq 70\%$ likely SLI (i.e., z-score = -2.00)
 - $\geq 81\%$ likely NL (i.e., z-score = -0.43)
 - Not culturally biased

Dollaghan & Campbell (1998)

1 syllable	2 syllables	3 syllables	4 syllables
n aɪ b	t eɪ v ə k	tʃ i n ɔɪ t aʊ b	v eɪ t ə tʃ aɪ d ɔ
v oʊ p	tʃ oʊ v æ g	n aɪ tʃ oʊ v eɪ b	d æ v oʊ n ɔɪ tʃ
t aʊ dʒ	v æ tʃ aɪ p	d ɔɪ t aʊ v æ b	n aɪ tʃ ɔɪ t aʊ v
d ɔɪ f	n ɔɪ t aʊ f	t eɪ v ɔɪ tʃ aɪ g	t æ v ə tʃ i n aɪ
12	20	28 phonemes	36 phonemes

Nonword Repetition Tasks

- Ellis Weismer et al. (2000) *JSLHR*, 43
 - Used same nonwords as D&C
 - Provide means & SD from a larger number of children (age 7;1 to 8;11)
 - Compute z-score based on NL mean & SD
 - $(\text{Obtained score} - 83.3)/9.1$
 - Use traditional cut-points (e.g., -1.25, -1.50, etc)
 - Recommended cut-points
 - ≤ 60 likely SLI (i.e., z-score = -2.56)
 - ≥ 90 likely NL (i.e., z-score = +0.74)
 - Not culturally biased

Nonword Repetition Tests

- Standardized tests
 - Comprehensive Test of Phonological Processing (CTOPP)
 - Ages 5 to 24 years
 - Preschool Comprehensive Test of Phonological and Print Processing (PreCTOPP)
 - Preschool
 - Forthcoming
 - Children's Test of Nonword Repetition
 - Ages 4 to 8 years
 - UK sample

Assessment Approach 2: Fast Mapping

- Comprehension performance in fast mapping predicts comprehension performance in word learning (Gray, 2004)
- Production performance in fast mapping predicts production performance in word learning (Gray, 2004)

Process of Word Learning

- Recognize that a new word was heard, triggering learning
- Hold sound-form and meaning in working memory
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 - Link between sound-form and meaning
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- Modify new representation upon subsequent exposure

Fast Mapping Tasks

- Gray (2004), *JSLHR*, 47
 - Preschool children (4;0-5;11)
 - 4 unknown objects and 4 common objects
 - 4 unknown objects were named with unknown words
 - All 8 objects on a table
 - Phase 1: Modeling (“This is a _____”)
 - Phase 2: Comprehension (“Point to the _____”)
 - Phase 3: Production (“What’s this?”)
 - Completion of phases 1-3 = 1 cycle
 - Complete 3 cycles

Gray (2004) Stimuli

Unknown Word	Unknown Object
tɛnət	wood peg
dʒinəs	electrical connector
hokəm	small decorative bird
fɪzək	silk flower

Gray (2004) Scoring

- Focus on the 4 unknown objects
- Count the number of correct comprehension responses across all 3 cycles (max = 12)
 - Compute z-score based on NL mean & SD
 - $(\text{Obtained score} - 8.65)/2.50$
- Count the number of correct production responses across all 3 cycles (max = 12)
 - Compute z-score based on NL mean & SD
 - $(\text{Obtained score} - 1.10)/0.91$
 - Score of 0 = -1.21 SD (lowest possible z-score)

Extensions

- Fast mapping in a naturalistic context
 - Work with teacher to determine new vocabulary in a lesson
 - Pre-test students
 - Teacher teaches lesson
 - Post-test students
 - Compare target children to rest of class
- Dynamic assessment
 - Perform a similar fast mapping task but probe for supportive cues/contexts

Assessment Approach 3: Factors that Affect Word Learning

- Phonotactic probability
 - Likelihood of occurrence of a sound sequence
 - Common sequences – e.g., “coat”
 - Rare sequences – e.g., “watch”
- Neighborhood density
 - Number of similar sounding words (i.e., share all but one sound)
 - Dense – e.g., “coat” has 31 neighbors
 - Sparse – e.g., “watch” has 5 neighbors

Assessment Approach 3: Factors Affecting Word Learning

- NL children learn common/dense sound sequences more rapidly than rare/sparse (e.g., Storkel & Rogers, 2000; Storkel, 2001)
- Phonotactic probability/neighborhood density appear to facilitate learning of
 - Sound-form and meaning association (Storkel, 2001)
 - Sound-form (Storkel, 2004)

Assessment Approach 3: Factors Affecting Word Learning

- Recent work with adults disentangling phonotactic probability and neighborhood density suggests:
 - Phonotactic probability may aid in triggering learning (Storkel, Armbruster & Hogan, in press)
 - Adults learn rare faster than common
 - Neighborhood density may aid in creating and integrating representations (Storkel et al., in press)
 - Adults learn dense faster than sparse
 - Similar results observed in children (Storkel, in progress)

Process of Word Learning

- Recognize that a new word was heard, triggering learning
- Hold sound-form and meaning in working memory
- Store a representation in the mental lexicon
 - Sound-form
 - Meaning
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- Integrate new representation with other known words in mental lexicon
- Modify new representation upon subsequent exposure

Process of Word Learning

- Recognize that a new word was heard, triggering learning
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- Modify new representation upon subsequent exposure

Assess Factors Affecting Word Learning

- Storkel (in preparation)
 - Examined items on standardized vocabulary tests
 - Phonotactic probability
 - Neighborhood density
 - Correlated on most tests
 - Possible to create subscale scores on
 - PPVT-3
 - EVT
 - ROWPVT-2

Assess Factors Affecting Word Learning

- Storkel (in preparation)
 - PPVT-3 and EVT
 - Compared overall test score to PP/ND subscale scores
 - PP/ND subscale scores generally were better predictors of word learning

Assess Factors Affecting Word Learning

- Once published, our subscale worksheets will be posted at www.ku.edu/~wrdlrng
- In near future,
 - Compute PP/ND subscale scores on standardized vocabulary tests

Assess Factors Affecting Word Learning

- For now, you could:
 - Construct your own vocabulary probe sensitive to PP/ND
 - Examine PP/ND of words child has difficulty learning
 - Manipulate PP/ND on a fast mapping probe
- To calculate phonotactic probability
<http://www.people.ku.edu/%7Emvitevit/PhonoProbHome.html>
- To calculate neighborhood density
<http://128.252.27.56/neighborhood/Home.asp>
- For help understanding/interpreting calculations
Storkel (2004). *JSLHR*, 47 (6)

**Word Learning Take-Home Message:
*Supplement standardized vocabulary
tests to accurately identify word
learning deficits in SLI***

Suggested supplements:

Nonword repetition

Fast mapping

Subscale scores

Questions?



Phonology

Focus on treatment

Phonological Disorder

- Breakdown in the production and/or knowledge of the sound system of the surrounding speech community
- Focus: Children with functional phonological disorders
 - No obvious cause of their deficit
 - Normal oral-motor function/structure, hearing, intelligence

Components of Phonological Treatment

- Sound selection: Which sounds to treat?
- Word selection: What words to treat the sound in?
- Treatment activities: How to teach the selected sound(s)?

Sound Selection: Child Variables

- Stimulability: ability to produce a sound correctly with instruction (model, feedback, articulatory cues)
- Stimulable sounds tend to improve without treatment
- Nonstimulable sounds require treatment
- Teach nonstimulable sounds and/or establish stimulability for nonstimulable sounds
- Miccio & Elbert, 1996; Miccio, 1999; Powell, Elbert, & Dixon, 1994; Dixon, 1996; Dixon & Elbert, 1994

Sound Selection: Child Variables

- Consistency of substitutes: stability of the production of a substitute across word positions and across words
- Treatment of sounds with consistent substitutes leads to generalization across untrained word positions
- Treatment of sounds with inconsistent substitutes shows limited generalization across untrained word positions
 - A special approach may be required to produce learning
 - See Forrest & Elbert (2001)
- Forrest, Dinnsen, & Elbert, 1997; Forrest & Elbert, 2001; Forrest, Elbert, & Dinnsen, 2000

Sound Selection: Child Factors

- Knowledge: accuracy of child's sound production
 - Least knowledge: low accuracy
 - More knowledge: mid accuracy
 - Most knowledge: high accuracy (not a likely tx target)
- Treatment of least knowledge sounds leads to change in least & more knowledge sounds
- Treatment of more knowledge sounds leads to change in more knowledge sounds only
- Gierut, Elbert, & Dinnsen, 1987; Briere, 1966; Hammerly, 1982; Harman, 1993; Williams, 1991; but see Rvachew & Nowak (2001)

Sound Selection: Phonological Variables

- Developmental norms: Age when sounds are typically acquired
- Treatment of early acquired sounds (i.e., 1 year or more below CA) leads to limited sound change
- Treatment of late acquired sounds (i.e., 1 year or more above CA) leads to global sound change
- Gierut, Morrisette, Hughes, & Rowland, 1996; Powell, 1991; Powell et al, 1998; but see Rvachew & Nowak, 2001; Debate – M&G, 2003; R&N, 2003

Sound Selection: Phonological Variables

- Complexity: based on cross-linguistic and developmental patterns
 - Less complex = common x languages & early acquired (e.g., nasals, stops, glides)
 - More complex = rare x languages & late acquired (e.g., liquids, fricatives, affricates, clusters)
- Treatment of less complex sounds tends to result in limited sound change
- Treatment of more complex sounds tends to result in global sound change

Word Selection

- Word frequency: number of times a word occurs in a language
- Neighborhood density: number of phonologically similar words
- Treatment of high frequency words leads to greatest sound change
- Treatment of high density words leads to minimal sound change

Treatment Activities

- Different treatment packages
 - Cycles
 - Whole language
 - Metaphon
 - Traditional/motoric
 - Minimal pair + variants (maximal opposition; multiple opposition)
- Comparisons of packages generally fail to show a clear advantage for one package over another
 - Exception, variants of minimal pair better than traditional minimal pair (Williams, 2005; Gierut, 1991)

Phonology Take-Home Message:
***Sound and word selection are critical
to treatment success***

Recommended targets:

Nonstimulable sound
Least knowledge sound
Late acquired sound
Complex sound

Questions?



Goal Sequencing

Treatment of Phonology
& Morphology

If children with SLI have multiple deficits, how do we sequence treatment goals?

Focus on phonology
and morphosyntax

Tyler & Sandoval (1994)

- Preschool children with SLI and phonological disorders
- 3 Groups
 - Treat phonology only
 - Treat morphology only
 - Treat phonology & morphology
- Results
 - Phonology only – improvements in both phonology & morphology
 - Morphology only – minimal improvements
 - Phonology & morphology – improvements in both
- Conclusion
 - Treat phonology only but select targets relevant to morphology
 - Treat both phonology & morphology

Tyler, Lewis, Haskill, & Tolbert (2002)

- 20 preschoolers with SLI & phonological disorder
- 3 groups
 - No treatment control group
 - Phonology 12-week block – morphology 12-week block
 - Morphology 12-week block – phonology 12-week block
- Results
 - Both treatments better than no treatment
 - Similar results at the end of both treatments
- Conclusion:
 - No clear sequence effect

Tyler, Lewis, Haskill, & Tolbert (2003)

- 47 preschoolers with SLI and phonological disorders
- 5 groups (24 weeks of treatment)
 - No treatment control group
 - Morphology 12-week block – phonology 12-week block
 - Phonology 12-week block – morphology 12-week block
 - Weekly alternating morphology and phonology
 - Simultaneous morphology and phonology (same ssn)
- Results
 - Equal gains in phonology across treatments

Goal Sequencing Take-Home Message:
*Alternate morphology and phonology
goals on a weekly basis*



Questions?



Additional Resources



Nonsense Words Varying in Phonotactic Probability/Neighborhood Density

For creating a fast
mapping probe

Storkel & Rogers, 2000

High Phonotactic Probability	Low Phonotactic Probability
kisaim	tʃeɪθəs
saɪpəm	ɡɪʃaɪb
veɪtəl	kaɪðəv
fɪkeɪd	dʒeɪɡaɪb
peɪbaɪn	faɪðɪɡ
taɪsɪv	zɪɡeɪz

**Unusual objects taken from the Macmillan Visual Dictionary

Storkel, 2001; Storkel, 2003

High phonotactic probability/ High neighborhood density	Low phonotactic probability/ Low neighborhood density
wæt	naub
hʌp	gim
pin	mɔɪd
kouf	jeɪp

****Unusual objects taken from children's stories (e.g., Dr. Seuss,**

Storkel, Armbruster, & Hogan (in press)

High Probability		Low Probability	
High density	Low density	High density	Low density
pim	han	jeim	faug
joun	neɹ	feig	jʌd
mɛk	jɪb	hif	waf
wæd	paɪb	naut	mug

Resources for Computing Word Frequency and Neighborhood Density for Real Words

For creating a vocabulary probe or selecting words for phonological treatment

Online search

- Dr. Mitchell Sommer's website (Washington U)

<http://128.252.27.56/neighborhood/Home.asp>

link from Word & Sound Learning webpage

- Operational definitions

HIGH FREQUENCY = 100 or greater

LOW FREQUENCY = 99 or less

HIGH DENSITY = 10 or more

LOW DENSITY = 9 or less

http://128.252.27.56/neighborhood/Home.asp

The screenshot shows a Microsoft Internet Explorer browser window. The title bar reads "WU Speech & Hearing Lab Neighborhood Database Site - Microsoft Internet Explorer". The address bar contains the URL "http://128.252.27.56/neighborhood/Home.asp". The page content features a dark red header with the Washington University logo on the left and the text "Speech & Hearing Lab Neighborhood Database" on the right. Below the header is a grey bar with the word "Home" centered. The main content area lists four items, each with a blue bullet point and a link:

- [Getting Started](#) General instructions for using this site and information about it.
- [Item Search](#) Lookup information for particular orthographic or phonological targets.
- [Neighborhood Search](#) Generate orthographic or phonological neighborhoods for either orthographic or phonological targets.
- [Acknowledgment](#)

At the bottom of the content area, there is a link: "Questions, Problems? E-Mail the [Webmaster](#)".

The browser's status bar at the bottom shows "Done" on the left and "Internet" on the right. The Windows taskbar at the very bottom includes the "start" button and various system icons, with the time "2:55 PM" displayed on the right.

Select *Item Search*

2nd tab on right

Item Search (top)

Washington
WASHINGTON UNIVERSITY IN ST. LOUIS

Speech & Hearing Lab
Neighborhood Database

Item Search

[Home](#) >> Item Search

Target(s)

Target Type: Phonology Orthography CV Pattern (phonemes)
 Use Wild Cards (_ and %)

Filter Options

Frequency:	Low:	<input type="text"/>	High:	<input type="text"/>
Log Frequency:	Low:	<input type="text"/>	High:	<input type="text"/>
Length (Letters):	Low:	<input type="text"/>	High:	<input type="text"/>
Length (Phonemes):	Low:	<input type="text"/>	High:	<input type="text"/>
Familiarity:	Low:	<input type="text"/>	High:	<input type="text"/>
Density A:	Low:	<input type="text"/>	High:	<input type="text"/>
Mean Frequency A:	Low:	<input type="text"/>	High:	<input type="text"/>

Result

Items are alphabetically ordered on target type.

Item Search (middle)

The screenshot shows a web browser window displaying the 'Item Search' page of the Washington University Speech & Hearing Lab Neighborhood Database. The browser's address bar and menu bar are visible at the top. The page header features the Washington University logo and the text 'Speech & Hearing Lab Neighborhood Database'. Below the header, the page title is 'Item Search', and a breadcrumb trail shows 'Home >> Item Search'.

The main content area is divided into two sections: 'Filter Options' and 'Result'.

Filter Options: This section contains a vertical list of 14 filter categories, each with 'Low:' and 'High:' input fields:

- Frequency:
- Log Frequency:
- Length (Letters):
- Length (Phonemes):
- Familiarity:
- Density A:
- Mean Frequency A:
- SD Mean Frequency A:
- Mean Log Frequency A:
- SD Mean Log Frequency A:
- Density B:
- Mean Frequency B:
- SD Mean Frequency B:
- Mean Log Frequency B:

Result: This section displays the search output. At the top, it shows 'Output Format: Orthography, Frequency, DensityB'. Below this is a large, empty text area with a vertical scrollbar. At the bottom of the result section, it indicates 'Items Returned: 778 Search duration: 1 sec' and 'Items are alphabetically ordered on target type.'

Item Search (bottom)

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Speech & Hearing Lab
Neighborhood Database

Item Search

[Home](#) >> Item Search

Mean Log Frequency A:	Low: <input type="text"/>	High: <input type="text"/>
SD Mean Log Frequency A:	Low: <input type="text"/>	High: <input type="text"/>
Density B:	Low: <input type="text"/>	High: <input type="text"/>
Mean Frequency B:	Low: <input type="text"/>	High: <input type="text"/>
SD Mean Frequency B:	Low: <input type="text"/>	High: <input type="text"/>
Mean Log Frequency B:	Low: <input type="text"/>	High: <input type="text"/>
SD Mean Log Frequency B:	Low: <input type="text"/>	High: <input type="text"/>

Output Options

Output Format:

Variable Names (first line only)
 Short Names (8 char. Max.) Long Names

Variables For Output:

<input checked="" type="checkbox"/> Orthography	<input type="checkbox"/> Phonology	<input type="checkbox"/> Syntactic Code
<input type="checkbox"/> Content Function	<input type="checkbox"/> Vowel Consonant Structure	<input type="checkbox"/> Letter Count
<input type="checkbox"/> Phoneme Count	<input checked="" type="checkbox"/> Frequency	<input type="checkbox"/> Log Frequency
<input type="checkbox"/> Familiarity	<input type="checkbox"/> Density A	<input type="checkbox"/> Mean Frequency A
<input type="checkbox"/> SD Mean Frequency A	<input type="checkbox"/> Mean Log Frequency A	<input checked="" type="checkbox"/> Density B
<input type="checkbox"/> Mean Frequency B	<input type="checkbox"/> SD Mean Frequency B	<input type="checkbox"/> Mean Log Frequency B

Result

Output Format: Orthography, Frequency, DensityB

Items Returned: 778 Search duration: 1 sec
Items are alphabetically ordered on target type.

To Find Words for Vocabulary Probe

- Enter search criteria on the left side of the page
- In the middle section, select frequency and density values
 - Low frequency, low density
 - Frequency: High = 99
 - Density B: High = 9
 - High frequency, high density
 - Frequency: Low = 100
 - Density B: Low = 10

To Find Words for Vocabulary Probe

- In the middle section, select frequency and density values (cont)
 - High frequency, low density
 - Frequency: Low = 100
 - Density B: High = 9
 - Low frequency, high density
 - Frequency: High = 99
 - Density B: Low = 10
- Can specify additional criteria related to:
 - Word length
 - Familiarity (on a 7-point scale with 7 being highly familiar to college students)

To Find Words for Vocabulary Probe

- In the bottom section, select output
 - Orthography
 - Phonology (pronunciation)
 - Frequency
 - Density B
 - Any other criteria you would like listed in the output
- Click *Search*
- Results appear on the right side of the screen

Output

WU Speech & Hearing Lab Neighborhood Database Site - Microsoft Internet Explo...

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Refresh Mail Print Print Preview

Address <http://128.252.27.56/Neighborhood/SearchHome.asp> Go Links

Google Search 238 blocked Check AutoLink AutoFill Options

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**Speech & Hearing Lab
Neighborhood Database**

Item Search

[Home](#) >> [Item Search](#)

Output Options

Output Format:
 Variable Names (first line only)
 Short Names (8 char. Max.) Long Names

Variables For Output:

<input checked="" type="checkbox"/> Orthography	<input checked="" type="checkbox"/> Phonology	<input type="checkbox"/> Syntactic Code
<input type="checkbox"/> Content Function	<input type="checkbox"/> Vowel Consonant Structure	<input type="checkbox"/> Letter Count
<input type="checkbox"/> Phoneme Count	<input checked="" type="checkbox"/> Frequency	<input type="checkbox"/> Log Frequency
<input type="checkbox"/> Familiarity	<input type="checkbox"/> Density A	<input type="checkbox"/> Mean Frequency A
<input type="checkbox"/> SD Mean Frequency A	<input type="checkbox"/> Mean Log Frequency A	<input checked="" type="checkbox"/> Density B
<input type="checkbox"/> Mean Frequency B	<input type="checkbox"/> SD Mean Frequency B	<input type="checkbox"/> Mean Log Frequency B

Clear Search

Result

Output Format: Orthography, Phonology, Frequency, DensityB

```
Ortho, Phono, Freq, DenB
aardvark, ardvar, 1, 0
aback, xb@k, 2, 3
abacus, @bxxxs, 1, 0
abaft, xb@ft, 1, 0
abalone, @bxloni, 1, 1
abandon, xb@ndn, 17, 0
abase, xbes, 1, 4
abash, xb@S, 1, 2
abate, xbet, 1, 7
abatis, @bxti, 1, 3
abattoir, @bxtwar, 1, 0
abbacy, @bxsi, 1, 2
abbe, @be, 3, 4
abess, @bxs, 1, 4
abbot, @bxt, 2, 3
abbreviate, xbriviet, 1, 0
abbreviation, xbriviesn, 1, 0
abdicate, @bdiket, 1, 0
```

To Find Words for Vocabulary Probe

- Highlight output
- Copy output
- Paste output into text file (e.g., Notepad)
- Save text file
- Import into Excel
 - Open excel
 - File – open – select your text file
 - Select delimited (next)
 - Select comma (finish)
- Select words

Note

- Density varies depending on word length
 - Short words tend to be high density
 - Long words tend to be low density
- Other cut-offs for high versus low density can be selected
 - Storkel (2004) *JSLHR* -- see next slide
 - $>$ median = high density for that word length
 - \leq median = low density for that word length

Storkel (2004) Table 2

Length	Median Density		Length	Median Density
1 sound	25		7 sounds	0
2 sounds	23		8 sounds	0
3 sounds	18		9 sounds	0
4 sounds	6		10 sounds	0
5 sounds	1		11 sounds	0
6 sounds	0		12 sounds	0

Selecting Words for Phonological Treatment

- Target box
 - Specify the sound pattern for treatment
 - e.g., r% = /r/ with 0 or more sounds following (/r/ in initial position)
 - Check *phonology*
 - Check *use wildcards*
- Filter options
 - Set *low frequency* filter to 100 (high frequency)
- Variables for output
 - Check *orthography*
 - Check *frequency*
 - Check *density B*

Output: High Frequency /r/-initial Words

Washington
WASHINGTON UNIVERSITY IN ST. LOUIS

Speech & Hearing Lab
Neighborhood Database

Item Search

[Home](#) >> Item Search

Target(s)

r%

Target Type: Phonology Orthography CV Pattern (phonemes)
 Use Wild Cards (_ and %)

Filter Options

Frequency:	Low: 100	High:
Log Frequency:	Low:	High:
Length (Letters):	Low:	High:
Length (Phonemes):	Low:	High:
Familiarity:	Low:	High:
Density A:	Low:	High:
Mean Frequency A:	Low:	High:

Result

Output Format: Orthography, Frequency, DensityB

Ortho, Freq, DenB
rather, 373, 3
ran, 134, 28
run, 212, 26
running, 123, 1
wrong, 129, 13
red, 197, 29
ready, 143, 6
radio, 120, 2
range, 160, 8
race, 103, 29
rest, 164, 20
rate, 209, 39
reaction, 124, 0
reach, 106, 20
read, 178, 28
reading, 140, 1
record, 137, 2
real, 260, 16
really, 275, 4

Items Returned: 39 Search duration: <1 sec
Items are alphabetically ordered on target type.

Selecting Words for Phonological Treatment

- Like vocabulary probe words, you can copy and paste the output to a text file and then import to Excel
- Notes on specifying word position
 - Sound% = word-initial
 - r%
 - %sound% = any word position (initial, medial, final)
 - %r%
 - %sound = word-final
 - %r

Selecting Words for Phonological Treatment

- Specifying sounds
 - For most sounds, use the IPA symbol
 - Exceptions (IPA symbols that don't use standard letters):
 - Use G for /ŋ/
 - Use y for /j/
 - Use T for /θ/
 - Use D for /ð/
 - Use S for /ʃ/
 - Use Z for /z/
 - Use C for /tʃ/
 - Use J for /dʒ/

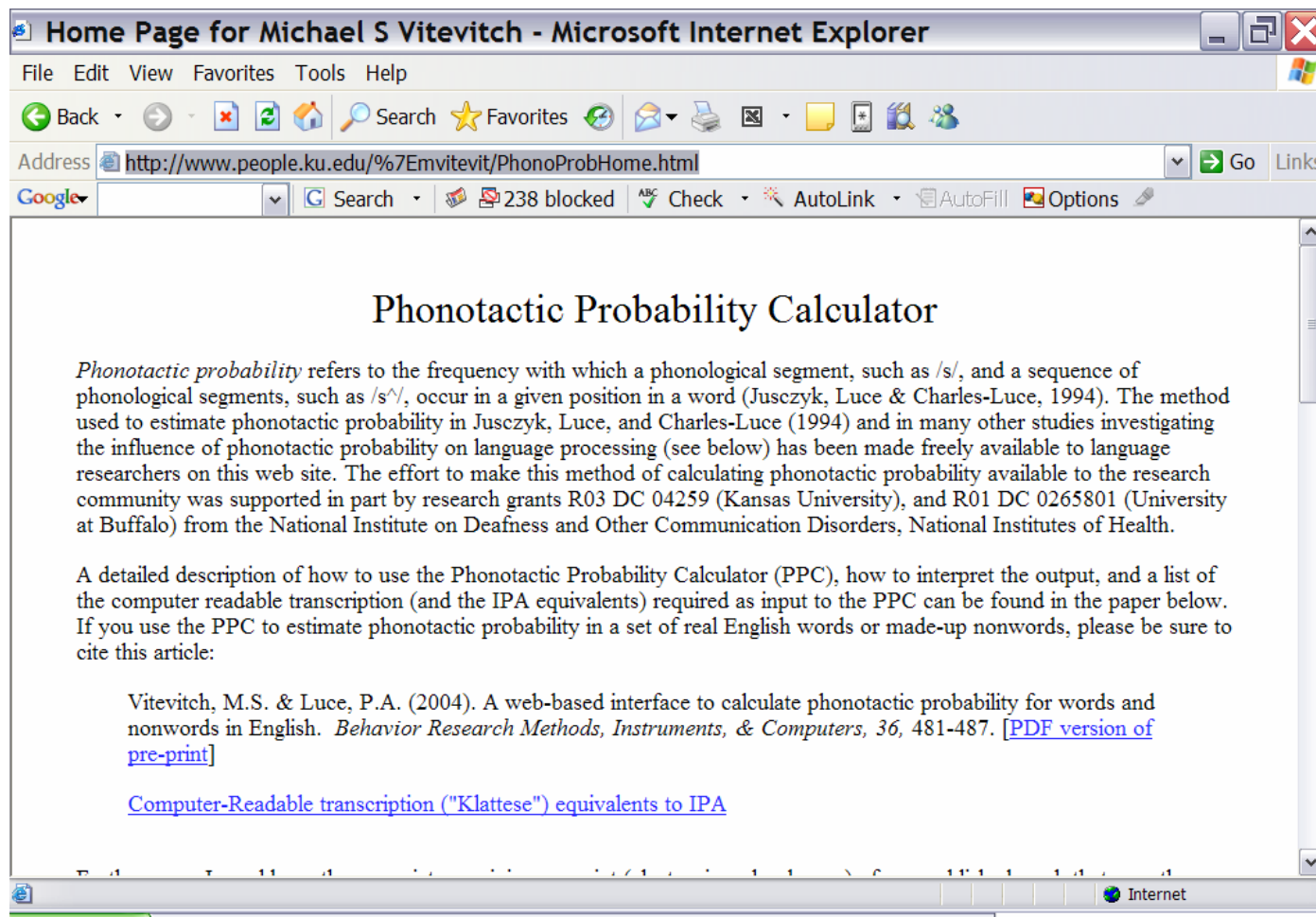
Resources for Computing Phonotactic Probability for Nonsense Words or Real Words

For creating a fast mapping or vocabulary probe

Online Search

- Dr. Michael Vitevitch's Phonotactic Probability Calculator (KU)
 - <http://www.people.ku.edu/%7Emvitevit/PhonoProbHome.html>
 - Link from Word & Sound Learning Lab website

<http://www.people.ku.edu/%7Emvitevitch/PhonoProbHome.html>



The screenshot shows a Microsoft Internet Explorer browser window. The title bar reads "Home Page for Michael S Vitevitch - Microsoft Internet Explorer". The address bar contains the URL "http://www.people.ku.edu/%7Emvitevitch/PhonoProbHome.html". The page content includes a title "Phonotactic Probability Calculator" and several paragraphs of text explaining the concept of phonotactic probability and providing a citation for Vitevitch and Luce (2004). There are also links to a PDF version of a pre-print and to computer-readable transcription equivalents to IPA.

Phonotactic Probability Calculator

Phonotactic probability refers to the frequency with which a phonological segment, such as /s/, and a sequence of phonological segments, such as /s^/, occur in a given position in a word (Jusczyk, Luce & Charles-Luce, 1994). The method used to estimate phonotactic probability in Jusczyk, Luce, and Charles-Luce (1994) and in many other studies investigating the influence of phonotactic probability on language processing (see below) has been made freely available to language researchers on this web site. The effort to make this method of calculating phonotactic probability available to the research community was supported in part by research grants R03 DC 04259 (Kansas University), and R01 DC 0265801 (University at Buffalo) from the National Institute on Deafness and Other Communication Disorders, National Institutes of Health.

A detailed description of how to use the Phonotactic Probability Calculator (PPC), how to interpret the output, and a list of the computer readable transcription (and the IPA equivalents) required as input to the PPC can be found in the paper below. If you use the PPC to estimate phonotactic probability in a set of real English words or made-up nonwords, please be sure to cite this article:

Vitevitch, M.S. & Luce, P.A. (2004). A web-based interface to calculate phonotactic probability for words and nonwords in English. *Behavior Research Methods, Instruments, & Computers*, 36, 481-487. [[PDF version of pre-print](#)]

[Computer-Readable transcription \("Klattese"\) equivalents to IPA](#)

Using the Calculator

- Click on the link Computer-Readable transcription ("Klattese") equivalents to IPA
- All real words or nonsense words entered must be entered by their pronunciation
 - Link above will take you to a table showing you the symbols you need to use to show pronunciation

Connect to Calculator

The screenshot shows a Microsoft Internet Explorer browser window. The title bar reads "Phonotactic Probability Calculator Page - Microsoft Internet Explorer". The address bar contains the URL: <http://www.parsons.lsi.ku.edu/FMPro?-db=biphones.fp5&-lay=CGI&-format=/biphones/calc.html&-script=ClearF>. The page content is titled "CALCULATE PHONOTACTIC PROBABILITY". It features two text input areas. The left area is labeled "Type or copy and paste your data here. Press [Enter] after each line." and is currently empty. The right area is labeled "The results of your calculation are displayed here. You may copy and paste results to another program for further analysis." and is also empty. Below the left input area are two buttons: "Calc your Entry" and "Clear your Entry". At the bottom right of the page, there is a blue hyperlink: "Return to Phonotactic Probability Home Page". The browser's taskbar at the bottom shows the "Internet" icon and the system tray.

Using Calculator

- Enter the pronunciation of your words in the left-hand box
 - Enter only one word per line
- Click *Calculate your entry*

Output

Phonotactic Probability Calculator Page - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Refresh Print Mail Stop Taskbar Home Add-ons

Address <http://www.parsons.lsi.ku.edu/FMPro> Go Links

Google Search 238 blocked Check AutoLink AutoFill Options

CALCULATE PHONOTACTIC PROBABILITY

Type or copy and paste your data here. Press [Enter] after each line.

The results of your calculation are displayed here. You may copy and paste results to another program for further analysis.

dɔg	.0518	.0165	.0179
kət	.0008	.0008	
ʃ^g	1.0862	1.0016	
Cit			
kət	.0927	.0794	.0660
	.0122	.0059	
	1.2381	1.0181	
ʃ^g	.0138	.0392	.0179
	.0014	.0013	
	1.0709	1.0027	
Cit	.0089	.0318	.0660
	.0006	.0023	

Calc your Entry

Clear your Entry

[Return to Phonotactic Probability Home Page](#)

Done Internet

Output

- Results appear in the right-hand column
- The third line for each word is the line of interest
 - 1st number = positional segment frequency sum + 1
 - 2nd number = biphone frequency sum + 1
- Subtract “1” from those numbers to get the “true” sum
 - Create an average
 - Divide 1st number by the # of segments in the transcription
 - Divide 2nd number by (# of segments - 1)

Interpretation

- Storkel (2004) *JSLHR* provides medians by word length
 - See next slide
 - $>$ median = high probability for that word length
 - \leq median = low probability for that word length

Storkel (2004) Table 2

Length	Median Segment Average		Length	Median Segment Average
1 sound	0.0075		7 sounds	0.0485
2 sounds	0.0282		8 sounds	0.0507
3 sounds	0.0453		9 sounds	0.0524
4 sounds	0.0463		10 sounds	0.0571
5 sounds	0.0459		11 sounds	0.0564
6 sounds	0.0473		12 sounds	0.0608

Storkel (2004) Table 2

Length	Median Biphone Average		Length	Median Biphon Average
1 sound	N/A		7 sounds	0.0047
2 sounds	0.0010		8 sounds	0.0053
3 sounds	0.0023		9 sounds	0.0061
4 sounds	0.0033		10 sounds	0.0071
5 sounds	0.0037		11 sounds	0.0069
6 sounds	0.0043		12 sounds	0.0070

Resources for Finding Evidence



Finding Evidence: Evidence Reviews

- ASHA's National Center for Evidence-Based Practice
<http://www.asha.org/members/ebp/guidelines/N-CEP-Registry>
- Cochrane Collaboration
<http://www.cochrane.org/index0.htm>
- Campbell Collaboration
<http://www.campbellcollaboration.org>
- What Works Clearinghouse <http://www.whatworks.ed.gov>
- Agency for Healthcare Research and Quality
<http://www.ahrq.gov>
- National Guideline Clearinghouse
<http://www.guideline.gov>

Finding Evidence: Special Reports/Lists

- ASHA
<http://www.asha.org>
- National Institute on Deafness and Other Communication Disorders
<http://www.nidcd.nih.gov>
- Bamford-Lahey Children's Foundation
<http://www.bamford-lahey.org/ebp.html>
- National Reading Panel
<http://www.nationalreadingpanel.org/Publications/publications.htm>

Finding Evidence: Databases for Searches

- PubMed
<http://www.ncbi.nlm.nih.gov/entrez/query.fcgi>
- ASHA full text journals (1990 ff)
<http://www.asha.org/members/deskref-journals/journals/journals-default>
- Google Scholar
<http://scholar.google.com>
- Ingenta Connect
<http://www.ingentaconnect.com>
- <http://www.science.gov>

Finding Evidence: Full-Text Articles

- PubMed Central
<http://www.pubmedcentral.nih.gov>
- ASHA full text journals (1990 ff)
<http://www.asha.org/members/deskref-journals/journals/journals-default>
- Author's website
use Google Scholar, University digital archive, or OAIste
<http://oaister.umdl.umich.edu/o/oaister>
- Ingenta Connect (for a fee)
<http://www.ingentaconnect.com>

Finding Evidence: TOC Alerts

- PubMed's "My NCBI"
<http://www.ncbi.nlm.nih.gov/entrez/query.fcgi>
Click "My NCBI"
- ASHA Journals TOC Alerting
<http://www.asha.org/about/publications/journal-abstracts/journal-list.htm>
- Ingenta Connect
<http://www.ingentaconnect.com>

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www.ku.edu/~wrdrng

