Aphasia, Alexia, and Phonomotor Treatment

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Outline

• Illustration of reading
• How do we read?
  • Reading theory
• Describe alexia in aphasia
  • Study 1
• Phonomotor Treatment
  • Description
  • Study 2
• Clinical Implications
Reading Test.....
sheep
president
suit
laugh
fyte
phine
pif
booch
How did you read?

• Regularly spelled words (e.g., sheep)?

• Irregularly spelled words (e.g., laugh)?

• Pseudohomophones (e.g., fyte)?

• Nonwords (e.g., booch)?
Reading models

• Different reading models hypothesize that these different word types (e.g., regular, irregular, nonwords) are processed in different fashions

• Let’s look at 2 of the most influential models of reading…..
Reading models

• Traditionally, normal and impaired reading have been modeled based on a dual route model (Marshall & Newcomb, 1973; Coltheart et al., 2001)

• More recently, parallel distributed processing (PDP) connectionist models have come into favor (Seidenberg & McClelland, 1989; Plaut et al., 1996)
Dual Route Model

• Widely used in the 1970s and 1980s

• Remains influential today

• Proposes reading involves several independent components and two separate processing routes

• Each component is dedicated to a different part of the reading process
Traditional dual route model

Ellis et al., 2000
Components of the dual route model

Ellis et al., 2000
Components of the dual route model

- Store of all familiar words recognized by sight
- Identify letters and code position

Ellis et al., 2000
Components of the dual route model

- Identify letters and code position
- Store of all familiar words recognized by sight
- Word meaning

Ellis et al., 2000
Components of the dual route model

- Identify letters and code position
- Store of all familiar words recognized by sight
- Word meaning
- Store of all familiar spoken word forms

Ellis et al., 2000
Components of the dual route model

- Identify letters and code position
- Store of all familiar words recognized by sight
- Word meaning
- Store of all familiar spoken word forms
- Vowels and consonants held online for reflection or for conversion into motor instructions

Ellis et al., 2000
Components of the dual route model

- **Identify letters and code position**

- **Store of all familiar words recognized by sight**

- **Word meaning**

- **Store of all familiar spoken word forms**

- **Vowels and consonants held online for reflection or for conversion into motor instructions**

- **Motor planning, programming, and execution of articulatory muscles**

Ellis et al., 2000
Lexical Routes:
A) Lexical semantic route
B) Lexical non-semantic route

Processes familiar real words
Cannot read unfamiliar or invented words

Sublexical Route:
C) Letter-Sound conversion

Processes only words that follow letter-sound rules:
- Regular (e.g., sheep)
- Nonword (e.g., peesh)

Cannot read irregularly spelled words (e.g., chef)
Parallel distributed processing (PDP) connectionist model

- Introduced in the 1990s
- Also known as the triangle model
- Computational model
- All words are processed in the same manner (via distributed connections between orthographic, phonologic, and semantic representations)
- Word knowledge lives in these connections
Processing units

FIG. 4.3 The triangle model (reproduced with permission from Plaut, 1997).
FIG. 4.3 The triangle model (reproduced with permission from Plaut, 1997).
Hidden units: connect units between pools

FIG. 4.3  The triangle model (reproduced with permission from Plaut, 1997).
PDP processing assumptions

• A word is a **pattern of activity distributed** over a set of orthographic units (its spelling), phonologic units (its sound), and semantic units (its meaning).

• Similar words are represented by similar patterns.

• Learning occurs gradually through experience and adjustment of the connections.

• For example, the connections between letter B to sound /b/ would be strengthened and the connections between letter B to sound /m/ would be weakened through experience.

• The hidden units capture relationships between units and induce learning and generalization.
PDP assumptions

• All units are used to process all word types (regular, irregular, or nonwords)

• The model can read a nonword it hasn’t been trained on (e.g., shoop) using the same knowledge (connections) that it uses to read known words (e.g., ship, shoot, loop)

• The model proposes that we use orthographic, phonologic, and semantic knowledge simultaneously to read all and any words
Frequency x Consistency

Plaut et al., 1996
Primary Systems Hypothesis (Patterson & Lambon Ralph, 1999)

- Motivated by Parallel Distributed Processing (PDP) theory (Plaut et al., 1996; Seidenberg & McClelland, 1989)

- Evolutionary view of reading

- Alexia is intimately connected to damage to the larger language system
Primary Systems/Parallel Distributed Processing Theory

Key points:
- distributed representations
- parallel processing
- learned neural patterns

Figure from Patterson & Lambon Ralph, 1999
Recap of reading models

- **Dual Route**
  - “box and arrow”
  - localist representations
  - serial processing
  - Reading dependent on reading-specific brain mechanisms

- **PDP/Primary Systems**
  - computational
  - distributed representations
  - parallel processing
  - Reading dependent on larger language system
Application of these models to reading disorders (alexias) in aphasia
Aphasia

• Acquired language disorder
• Result of left hemisphere brain injury, typically stroke
• 25-40% of stroke survivors present with aphasia
• Approximately 200,000 Americans acquire aphasia each year
• Approximately 1 million Americans are currently living with aphasia
Alexia
(acquired dyslexia)

• Acquired reading impairment post brain injury

• Peripheral Alexias: Affect visual perception and analysis of letters

• Central Alexias: Affect linguistic processing; difficulty deriving sounds and/or meaning from print; associated with aphasia
Central Alexia Subtypes

• 3 main subtypes:
  1. Surface alexia
  2. Phonological alexia
  3. Deep alexia

• Based on oral reading accuracy and types of oral reading errors produced
Surface Alexia

• **Irregular words** < Regular words

• **Characteristic reading error:**
  • regularization error ("pint" to rhyme with *mint*)
Phonological Alexia

• **Nonwords** < Real words (regular and irregular)

• **Characteristic reading errors:**
  • *Lexicalization* error (“black” for *blauf*)
  • Phonologic and visual errors (“single” for *signal*)
  • Morphological (“baking” for *baked*)
  • Difficulty with function words (e.g., “of”, “on”)
Deep Alexia

• Resembles phonological alexia

• Impaired reading of all word types; **nearly abolished nonword reading**

• **Characteristic reading error:**
  • **Semantic** error (“shoe” for **boot**)**
Video: Reading Aloud

- Watch this patient read aloud single words

- Based on his reading performance, what type of alexia does he likely present with?
Dual Route explanation of central alexias……
Visual Presentation of
“Word”

Lexical/Direct Route

Sub-lexical or Indirect Route

Verbal Output
Visual Presentation of "Word"

**Lexical or Direct Route**

- Involves word knowledge
- Supported by conceptual/semantics
- Regular words
- Irregular words

**Verbal Output**
Visual Presentation of
“Word”

Lexical or Direct
Route

• Irregular
tomb
yacht
laugh

• Regular
mask
star
hunter

Verbal Output
Visual Presentation of “Word”

Lexical or Direct Route

Surface Alexia
- trouble processing semantics from orthography

Verbal Output
Visual Presentation of “Word”

Lexical or Direct Route

Sub-lexical or Indirect Route

- Unfamiliar or nonwords
- Identify and parse graphemes
- Grapheme to phoneme rules
- Blending of graphemes

Verbal Output
Visual Presentation of “Word”

Lexical or Direct Route

Verbal Output

Sub-lexical or Indirect Route

- Nonwords
  - trad
  - pabe
  - jesp

- Regular words
  - beef
  - ring
  - star
Visual Presentation of “Word”

Lexical or Direct Route

Sub-lexical or Indirect Route

Phonological and Deep Alexia
-trouble processing phonology from orthography

Verbal Output

Note: Presence of semantic errors distinguishes deep from phonologic alexia
PDP/Primary Systems Explanation

Crisp & Lambon Ralph, 2006
What do we know about alexia in aphasia?
Frequency, nature, and predictors of alexia in a convenience sample of individuals with chronic aphasia

C. Elizabeth Brookshire¹, Jonathan P. Wilson², Stephen E. Nadeau³, Leslie J. Gonzalez Rothi⁴, and Diane L. Kendall¹,⁵
### Participants

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<th></th>
<th>N</th>
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<th>Education mean (SD)</th>
<th>Gender</th>
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<td>62.02 (13.20)</td>
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<td>63 M, 36 F</td>
<td>91 R, 6 L, 2 A</td>
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<td>62.79 (10.48)</td>
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<td>9 M, 20 F</td>
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<td>p-value</td>
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<td>.77*</td>
<td>.07*</td>
<td>.0026**</td>
<td>.20**</td>
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*Independent samples t-tests.

**Fisher’s exact test. Handedness: right versus nonright.
## Stimuli and Procedure

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<th>Irregularly spelled words</th>
<th>Pseudohomophones</th>
<th>Nonwords</th>
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<td>jounaethawn</td>
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<td>imbecility</td>
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<td></td>
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<tr>
<td>generosity</td>
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</tbody>
</table>

*Standardized Assessment of Phonology in Aphasia (SAPA; Kendall et al., 2010)*
Results: Frequency of Alexia in Aphasia

- PWA (n=32)
- PWA and co-occurring alexia (n=67)

- 32%
- 68%
Results: Nature of Alexia in Aphasia

Brookshire, Wilson, Nadeau, Gonzalez-Rothi, & Kendall, 2014
Results: Predictors of Alexia in Aphasia

| Simultaneous multiple linear regression model results for 67 PWA and alexia |
|-----------------------------------|---|---|---|---|---|
|                                | $b$ | SE  | $t$ | $p$-Value | $\beta$ |
| **SAPA total reading**          |     |     |     |           |         |
| Education                        | 0.012 | 0.007 | 1.84 | .070 | 0.15 |
| WAB-AQ                           | 0.007 | 0.001 | 9.61 | <.001* | 0.76 |
| **SAPA regular + irregular words** |     |     |     |           |         |
| Education                        | 0.013 | 0.009 | 1.51 | .137 | 0.12 |
| WAB-AQ                           | 0.009 | 0.001 | 9.57 | <.001* | 0.76 |
| **SAPA pseudohomophones + nonwords** | | | | | |
| Education                        | 0.011 | 0.006 | 1.88 | .064 | 0.19 |
| WAB-AQ                           | 0.003 | 0.001 | 5.51 | <.001* | 0.56 |

$R^2$ adjusted = .60

$R^2$ adjusted = .59

$R^2$ adjusted = .34

SAPA = Standardised Assessment of Phonology in Aphasia (Kendall et al., 2010). WAB-AQ = Western Aphasia Battery Aphasia Quotient (Kertesz, 1982).
A likely underlying contributor to reading difficulty in aphasia with co-occurring alexia....

• A general impairment in **phonology**

• Break down in connection between the letters and their corresponding sounds
Developmental connection between phonology, orthography and reading

• Before we learn to read, we first learn the connections between semantics (word meanings) and phonology (sounds) for spoken communication

• Then we use phonology to map sounds onto letters to achieve meaning from print

• This skill is crucial because phonology and orthography have far less arbitrary relationship then the relationship between semantics and orthography
A good predictor of reading performance…..

- **Phonological awareness:** the ability to identify, think about, and manipulate the individual sounds (phonemes) in words

- It allows phonologic information to be held online and used as a comparator function (e.g. “fip” vs. “vip”)
Best Predictor of Developmental Dyslexia: phonologic awareness skills

Torgesen, 1994

• Nonword repetition
  – say “chootee"

• Elision
  – Say the word "blend" without saying /l/

• Blending
  – what word do these sounds make? /k/ /a/ /t/

• Segmenting
  – say "pit" one sound at a time

• Reversal
  – say "foob"; now say "foob" backwards

*Note: You can look at these same skills in PWA with phonologic and reading impairment

Why only non-words?
Study 2

Effects of Intensive Phonomotor Treatment on Reading in Eight Individuals With Aphasia and Phonological Alexia

C. Elizabeth Brookshire, Tim Conway, Rebecca Hunting Pompon, Megan Oelke and Diane L. Kendall

(2014, 23, S300-S311)


- (VA RR&D Merit Review Grant # C6572R)
Research Questions

1) Does phonomotor treatment improve phonological processing?

2) Does treatment generalize to the following untrained items?
   a) oral reading of nonwords
   b) oral reading of real words
   c) reading comprehension of single words and passages

3) Are treatment effects maintained at 3-months post treatment?
## Participants

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age (years)</th>
<th>Months poststroke</th>
<th>Education</th>
<th>Diagnoses</th>
<th>WAB AQ (out of 100)</th>
<th>BNT (out of 60)</th>
<th>Ravens (out of 36)</th>
<th>SAPA (out of 151)</th>
<th>WRMT–R Reading Cluster (M = 100)</th>
<th>Real word (RW) reading range (± 1 SEM)</th>
<th>Nonword (NW) reading range (± 1 SEM)</th>
<th>Difference between RW and NW reading ranges</th>
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<tr>
<td>1</td>
<td>74</td>
<td>8</td>
<td>18</td>
<td>Aphasia, alexia</td>
<td>91.3</td>
<td>51</td>
<td>35</td>
<td>105</td>
<td>98</td>
<td>85.8%–76.30%</td>
<td>55.56%–37.78%</td>
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<td>2</td>
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<td>5</td>
<td>33</td>
<td>50</td>
<td>29</td>
<td>34.91%–47.35%</td>
<td>22.22%–8%</td>
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<td>3</td>
<td>78</td>
<td>41</td>
<td>13</td>
<td>Aphasia, alexia</td>
<td>90.2</td>
<td>46</td>
<td>29</td>
<td>105</td>
<td>95</td>
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<td>50</td>
<td>33</td>
<td>110</td>
<td>96</td>
<td>90.57%–83.02%</td>
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<td>18</td>
<td>32</td>
<td>124</td>
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<td>91.50%–83.95%</td>
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<td>30</td>
<td>78</td>
<td>49</td>
<td>41.51%–33.98%</td>
<td>24.44%–6%</td>
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<td>M (SD)</td>
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<td>41.51%–33.98%</td>
<td>24.44%–6%</td>
<td>9.52%</td>
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</tbody>
</table>

Note. WAB AQ = Western Aphasia Battery (Kertesz, 1982) aphasia quotient; BNT = Boston Naming Test (Kaplan et al., 1983); Ravens = Coloured Progressive Matrices (Raven, 1978); SAPA = Standardized Assessment of Phonology in Aphasia (Kendall et al., 2010); WRMT–R = Woodcock Reading Mastery Tests—Revised (Woodcock, 1987).
Motivating Theory: Connectionist model of phonological processing

Press tongue against alveolar ridge and turn on voice

Nadeau, 2001
Phonomotor Treatment program

- Multi-modal approach

- Starting at sounds in isolation, building to single, then multi-syllabic combinations
  - Train nonwords and then real words

- 2 hrs/day, 5 days/week over 6 weeks (60 hours)
TWO PHASES OF TREATMENT

(I) Phonemes in Isolation
• Seek to improve awareness of linguistic (phoneme) representations: articulatory movements, voicing, auditory perception, and orthographic representations

(II) Phoneme Sequences
• Mono- and multi-syllabic phonological sequences are trained to improve access to phonological representations
• Help participants learn how phonemes behave in words
• Phonological awareness tasks are scaffolded into reading and spelling tasks.
Phonomotor treatment stimuli

• English phonemes in isolation (n= 40), and one- and two-syllable nonwords (n=72) and real words (n=42)

• Real words were controlled for the following linguistic properties: frequency, imageability, age of acquisition, syllable number and complexity, and semantic category.

• Real words and nonwords consisted of low phonotactic probability and high neighborhood density values.
### Appendix A. Phono-motor treatment stimuli (nonword orthography from LIPS program)

<table>
<thead>
<tr>
<th>IPA symbol</th>
<th>Trained phonemic representation(s)</th>
<th>Sounds in isolation</th>
<th>Real words</th>
<th>Nonwords</th>
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<td>p</td>
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Phonomotor Treatment
Outcome measures

• Pre-, post-, and 3 months post-treatment

• **Measures of phonological processing**
  • Standardized Assessment of Phonology in Aphasia (SAPA; Kendall et al., 2010)
  • Nonword repetition task

• **Measures of reading**
  • Woodcock Reading Mastery Test-Revised (WRMT-R; Woodcock, 1987)
    • Oral reading of real words and nonwords
    • Reading comprehension of words and passages
Results (n=8)

Brookshire, Conway, Hunting Pompon, Oelke, & Kendall, 2014
No improved group reading comprehension

• One participant improved by 1.5 SD on single words and paragraph levels

• Consider
  • Pt profile (e.g., alexia severity)
  • Treatment duration
  • Reading comprehension outcome measures
Emerging data from ongoing Phonomotor treatment study....
Psycholinguistic Assessment of Language Processing in Aphasia (PALPA, Kay et al., 1992)
Psycholinguistic Assessment of Language Processing in Aphasia (PALPA, Kay et al., 1992)
Psycholinguistic Assessment of Language Processing in Aphasia (PALPA, Kay et al., 1992)
SAPA: Pseudohomophones

Standardized Assessment of Phonology in Aphasia (SAPA; Kendall et al., 2010)
Clinical Implications
Assessment Considerations

• Use reading models to identify level of break down in reading

• Use real words and nonwords (i.e., regular, irregular, pseudohomophone, nonwords)
  • Arizona Reading and Spelling Battery (ARBS, Beeson et al., 2010)
  • Standardized Assessment of Phonology in Aphasia (SAPA; Kendall et al., 2010)
  • Psycholinguistic Assessment of Language Processing in Aphasia (PALPA; Kay et al., 1992)

• Which type of alexia?
  • Sublexical or lexical impairment?
  • Deep/phonologic alexia vs surface alexia?

• Knowing the type of alexia can help determine direction of treatment
Standardized Assessments of Reading

• Psycholinguistic Assessment of Language Processing in Aphasia (PALPA; Kay et al., 1992)
• National Adult Reading Test (NART; Nelson 1982)
• Gates-MacGinitie Reading Test (Gates & MacGinitie, 1965)
• Reading Comprehension Battery for Aphasia (RCBA-2; LaPointe & Horner, 1998)
• Gray Oral Reading Test (GORT; Wiederholt & Bryant, 1992)
• Woodcock Reading Mastery Test Revised (WRMT-R; Woodcock, 1998)
• Discourse Comprehension Test (Brookshire & Nicholas, 1997)
Unstandardized Tasks

• **Peripheral assessment**
  • Shape/letter matching

• **Visual word recognition**
  • Written lexical decision (real or nonword)

• **Semantic processing**
  • Category sorting (sort written words into categories)
  • Cross-modality matching (match single word to picture or object)

• **Phonological processing**
  • Graphemic parsing (cat -> k, a, t)
  • Graphemic blending (k, a, t, -> cat)
  • Grapheme to phoneme conversion ( “sh” -> /ʃ/)
  • Nonword reading

• **Non-orthographic phonologic processing**
  • rhyme decision, rhyme production, minimal pair discrimination
    auditory parsing and blending of sounds with real words and nonwords
Stimuli selection

• Carefully select your reading stimuli
• Be aware of these lexical variables:
  • Frequency (dog vs. ornament)
  • Consistency (have vs. gave)
  • Imageability (tree vs. honesty)
  • Part of speech (nouns > verbs > adjectives > function words)
• Incorporate real words and nonwords
A word on reading comprehension

• Assess at the single word, sentence and text levels

• Compare oral reading abilities and reading comprehension abilities

• See if context aids comprehension

• See if oral reading aids comprehension
Treatment Considerations

• Train phonology in a multi-modal manner to improve reading
  • Target sounds auditorily, pictorially, tactile-kinesthetically, and via letter-sound connections

• Incorporate semantic tasks to target reading comprehension

• Focus more on letter-sound and sound-letter tasks if main outcome is reading and spelling
Find more alexia treatment ideas...

• ANCDS Aphasia Treatment Evidence Tables:  
  http://aphasiatx.arizona.edu/

• Reading treatments:  
  http://aphasiatx.arizona.edu/written_reading
Thank you

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- University of Washington Aphasia Research Laboratory

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