Understanding and Treating Acquired Impairments of Written Language
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Written language is better-preserved than spoken language

Broca's Aphasia evolved to Anomic Aphasia

Spoken language is better-preserved than written

No aphasia but persistent spelling and reading difficulties.

What is the nature of these problems ... and how might we treat them?

First, let’s consider how spoken and written language skills develop

We derive meaning from what we hear and see.

Audition

Vision

Concepts
We derive meaning from what we hear and see.

Knowledge of lexical representations develops

... for spoken words

<table>
<thead>
<tr>
<th>Phono</th>
<th>Orthogr</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;dog&quot;</td>
<td>dog</td>
</tr>
<tr>
<td>&quot;mommy&quot;</td>
<td>mommy</td>
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<tr>
<td>&quot;car&quot;</td>
<td>car</td>
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<tr>
<td>&quot;hammer&quot;</td>
<td>hammer</td>
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<tr>
<td>&quot;flower&quot;</td>
<td>flower</td>
</tr>
<tr>
<td>&quot;house&quot;</td>
<td>house</td>
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</tbody>
</table>

... for written words

<table>
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<tr>
<th>Phonology (spoken words)</th>
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<td>flower</td>
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</table>

Knowledge of lexical representations develops

... for spoken words

<table>
<thead>
<tr>
<th>Phonology (phemes)</th>
<th>Orthography (graphemes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>/d/</td>
<td>d</td>
</tr>
<tr>
<td>/h/</td>
<td>h</td>
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<tr>
<td>/k/</td>
<td>k</td>
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<tr>
<td>/m/</td>
<td>m</td>
</tr>
<tr>
<td>/j/</td>
<td>/</td>
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</tbody>
</table>

... and sublexical knowledge as well

Knowledge of lexical representations develops

... for spoken words

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<td>/k/</td>
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<tr>
<td>/m/</td>
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<tr>
<td>/j/</td>
<td></td>
</tr>
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</table>

Viewed as a cognitive model

<table>
<thead>
<tr>
<th>Semantics</th>
<th>Speech Sounds</th>
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<tbody>
<tr>
<td>Phonemes</td>
<td>Lexical</td>
</tr>
<tr>
<td></td>
<td>Orthographic</td>
</tr>
</tbody>
</table>

words sounds letters
Left perisylvian damage impairs phonological processing

- Resulting in Broca’s, Wernicke’s, Conduction, and Global Aphasia
- Mostly due to left middle cerebral artery stroke

Marked impairment of spelling knowledge for words (< 30% correct)
Marked impairment of phonology (unable to spell nonwords)

Lexical
Sub-lexical
Global
Alexia

Global Aphasia

Writing to Dictation

Real Words
Nonwords

stop
pillow
doubt
castle
type

flig
hoach
snite
glope
boak

Doubt

Deep
Alexia

Deep
Agraphia

Damage to Lexical-Semantic and Sublexical Processes

"apple"

"orange"

with semantic errors

"copyright"

Deep
Alexia

Deep
Agraphia

Damage to Perisylvian Regions

"apple"

Lexical
Lexical

Phonologic
Orthographic
Lexicon
Lexicon

Sublexical
Sublexical

Nonwords

Percent Correct

Regular
Irregular

Large MCA stroke

Global
Agraphia

Resulting in Severe Agraphia

"stop"

"pillow"

"doubt"

"castle"

"type"

"flig"

"hoach"

"snite"

"glope"

"boak"

"Fane"

"Home"

"Sine"

"Gone"

"Bone"
Deep Agraphia
Writing to Dictation (semantic errors)

- hard
- shrug
- summer
- debt
- enough
- bake
- worm

- talk
- develop
- grab
- bride
- shove
- outside

Global/Deep Agraphia Errors

- single letter error
- multiple errors
- semantic error
- multiple errors

Assessment Materials
for Single Word Reading & Spelling

- Arizona Battery for Reading and Spelling*
- 40 regular, 40 irregular words
- balanced for length, frequency, imageability
- 20 pronounceable nonwords

<table>
<thead>
<tr>
<th>Regular Words</th>
<th>Irregular Words</th>
<th>Nonwords</th>
</tr>
</thead>
<tbody>
<tr>
<td>broom</td>
<td>yacht</td>
<td>flig</td>
</tr>
<tr>
<td>mile</td>
<td>circuit</td>
<td>hoach</td>
</tr>
<tr>
<td>spring</td>
<td>doubt</td>
<td>snite</td>
</tr>
<tr>
<td>branch</td>
<td>choir</td>
<td>snite</td>
</tr>
<tr>
<td>fact</td>
<td>sword</td>
<td>glope</td>
</tr>
<tr>
<td>hunch</td>
<td>island</td>
<td>boak</td>
</tr>
<tr>
<td>slate</td>
<td>debt</td>
<td>cheed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>merber</td>
</tr>
</tbody>
</table>

*http://web.me.com/pelagie1/Aphasia_Research_Project/Welcome.html

Resources available at our website
http://web.me.com/pelagie1/Aphasia_Research_Project

Aphasia Research Project
Dedicated to the understanding and treatment of language impairments in adults

The Aphasia Research Project of the University of Arizona works to better understand acquired disorders of language (aphasia) caused by stroke or other neurological disease.

Treatment Approach for Global Agraphia

retrain spellings for specific words
Lexical Writing Treatment

- **Purpose**
  - Strengthen lexical-semantic and orthographic representations for specific words
- **Goal**
  - To retrain single-word written vocabulary for use in communicative interactions
  - To establish written “key words” for use in later stages of treatment
- **Approach**
  - Train 24 written words using Copy and Recall Treatment approach (CART)
    - Trained as 4 groups of 6 words

Lexical Spelling Treatment

**Copy and Recall Treatment (CART)**

*“Book.”*  
*“Write ‘book’?”*

- Correct: present next word
- Incorrect: proceed

Lexical spelling treatment (also includes repetition of spoken words)

- **Video**
  - Listen, repeat word, copy word.

Homework for Copy and Recall Treatment

- “talking” photo album

**Copy and Recall Homework**

- Daily homework pages for repeated copy practice
- Review each session for accountability

Homework is fun!

Example Response to CART

- 4 sets/6 words trained to >80% accuracy. Treatment duration ~ 6-8 weeks
Global Agraphia

<table>
<thead>
<tr>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphasia</td>
<td>Wernicke</td>
<td>Broca*</td>
<td>Broca*</td>
<td>Wernicke</td>
<td>Broca*</td>
<td>Wernicke</td>
</tr>
<tr>
<td>Aph Q</td>
<td>61.8</td>
<td>45.2</td>
<td>22.1</td>
<td>27.6</td>
<td>35.2</td>
<td>51.7</td>
</tr>
<tr>
<td>Read</td>
<td>2.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Spell</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2.5</td>
<td>0</td>
</tr>
</tbody>
</table>

* with apraxia of speech

Response to Lexical Treatment
Spelling and Naming of Trained Words

Group Performance on Trained Items Pre-Post Treatment
(14 participants; 24 spellings each)

All but 1 of 14 participants met criterion for spellings of targeted words. Spoken naming also improved.

Lexical treatment with personalized word lists

- Personally relevant words
  - Work with patient and family to select words
  - Select words that are not easily communicated by pointing or gesture
  - Include important people, places, and things (including proper names)

Would CART treatment work for texting?

- T-CART (texting)
  - Cell phone with a slide-out QWERTY keyboard

Individual with severe Broca’s aphasia and apraxia of speech

Composite of Tx Response

Spelling and Spoken Naming Accuracy

Better long-term retention for CART vs T-CART
What about those who are less impaired?

Relatively preserved lexical knowledge with marked impairment of phonological skills (e.g., nonword spelling).

Phonological Impairment

Phonological Alexia

“dust?”

Phonological Agraphia

“dusp”

Phonology

Lexicality Effect

- Difficulty with nonwords compared to regular & irregular words

Regular Words
- bake +
- count +
- platform +

Irregular Words
- walk +
- blood +
- castle +

Nonwords
- flig -
- glope -
- merber -

*Stimuli available at http://web.me.com/pelagie1/Aphasia_Research_Project/Welcome.html

Phonological Agraphia

Also associated with poor written performance at the sentence level. Difficulty with functors & verb inflections.

Functional implications of phonological impairment (10 years post stroke)

Phonological Agraphia

Aphasia

Conduction

Broca

Anomic

Conduction/

A

Anomic

Aphasia Q

66.7

82.2

73.6

76

83.5

Read Words

27.5

97.17

80.0

83.33

93.75

Spell Words

27.5

36.66

50.0

60.0

96.25

* with apraxia of speech
Phonological Treatment

- **Purpose**
  - To strengthen sound-letter correspondences
  - Improve phonological manipulation abilities.

- **Goal**
  - To use phonological information to assist in reading and spelling.

- **Approach**
  - Establish “Key Words” to assist in relearning sound-letter and letter-sound correspondences (20 consonants, 12 vowels)
  - Re-train sound-letter correspondences for each targeted phoneme

- **Prerequisite skills**
  - Able to read, write, and name 24 key words
    - high frequency, concrete, regularly spelled nouns
    - used to retrain sound-letter (and letter-sound) correspondences
  - Train with lexical approach if necessary

### Example Training Sequence

**http://web.me.com/pelagie1/Aphasia_Research_Project/CART.html**

**Key words-Consonants**
- Set 1: rug, top, leaf, safe, pet
- Set 2: cake, fire, moon, pie, dog
- Set 3: book, goat, zoo, ship, yan
- Set 4: hat, web, chin, judge, three

**Key words-Vowels**
- Set 1: hat/van, cake/safe, ship/chin, fire/pig, net/web, leaf/three
- Set 2: top/dog, bone/goat, rug/judge, moon/zoo, cow/mouth, foot/book

### Phonological Treatment: Sound-to-Letter Training

**Clinician**
- Say /p/
- *What is your key word for /p/?* (Show picture if necessary).
- Write your key word for /p/
- Underline /p/ in your word
- Now say the sound /p/

**Patient**
- *pie*

### Phonological Treatment: Letter-to-Sound Training

**Clinician**
- Show the letter “s”
- *What is your key word for this?*
- Show the picture if necessary
- *Your key word is “safe”, write “safe”*

**Patient**
- *safe*
- *What’s the 1st sound?*
- *Show the letter “s”*
- *What is this sound?*

**Clinician**
- *sss*

**Patient**
- *sss*
Phonological Tx Homework
- Daily homework
- Videotaped (DVD) stimuli

Example Response to Phonological Treatment
20 Consonants
Trained in 4 sets of 5.
Sound → Letter → Sound
Trained to >80% accuracy.
Treatment duration ~ 6-8 weeks

Example Response to Nonword Spelling Training
Nonword Spelling
4 Sets of 5 Nonwords
Trained to >80% accuracy.
Treatment duration ~ 6-8 weeks

Advanced Phonological Treatment: Nonword Spelling
- 20 Nonwords
  - 4 sets of 5
  - e.g. mog, noash, gipe, zook, peth
  - Probes: written spelling to dictation
  - Therapy tasks
    - Focus on "sound it out strategy" using nonwords
    - Practice complex phonological manipulation tasks
      e.g. phoneme replacement with nonwords
  - Criteria to master a set of 5
    - 80% accuracy across 2 consecutive sessions
- Homework: Videotape or DVD for stimuli

Phonological Agraphia Response to Phonological Treatment
Improved Sound-Letter Correspondence
Improved reading/spelling of real and nonwords
Before Tx

Heidi and Robert are going on a picnic. Max is flying a kite. Devon is making a sandcastle. Ed and Chris are sailing a boat. Shech is fishing. It is a _______ day.

After Tx

Biff and I were out here having a picnic. Max was flying a kite and Lucy was standing near him. Devon and Andrew were sailing along. Grandma and Poppy were fixing dinner. This was a wonderful day.

A reminder regarding blood supply to the brain

- middle cerebral artery
- anterior cerebral artery
- posterior cerebral artery

Left inferior temporo-occipital region is critical for reading and spelling. Such damage spares the left perisylvian region, thus preserving phonological skills.

Reliance on phonology leads to regularity effect

- Difficulty with irregularly spelled words compared to regular words & nonwords.

Regular Words
- bake +
- count +
- platform +

Irregular Words
- choir -
- blood -
- castle -

Nonwords
- flig +
- glope +
- merber +

Damage to Orthography

Surface Alexia
- Lexical
- Sub-lexical

Surface Agraphia
- Lexical
- Sub-lexical
Surface Agraphia

Regularity Effect: regular > irregular

Interactive Treatment

Facilitate interactive use of residual orthography, phonology & semantics

Examples of Spell Check

   Target | Phonologically Plausible Misspelling | Franklin Speller | Microsoft Word Spell Check
---|---|---|---
circuit | serkit | circuit | serf, spirit, straight, sari, merit
subtle | subtle | subtle | settle, scuttle, shuttle, subtle
pursuit | persuit | pursuit | per soot, person, presort, persiat

Surface Agraphia

<table>
<thead>
<tr>
<th></th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphasia</td>
<td>95</td>
<td>89.4</td>
<td>90.4</td>
<td>91.4</td>
<td>98.8</td>
</tr>
<tr>
<td>Read Words</td>
<td>96.25</td>
<td>86.25</td>
<td>95</td>
<td>91.25</td>
<td>95</td>
</tr>
<tr>
<td>Spell Words</td>
<td>68.75</td>
<td>61.25</td>
<td>87.5</td>
<td>73.75</td>
<td>77.5</td>
</tr>
</tbody>
</table>

Interactive Spelling Treatment

Purpose
- Strengthen the interactive use of orthography and phonology

Goal
- To improve spelling accuracy by increasing self-detection and correction of errors

Approach
- Use residual or re-trained phonology to sound-out plausible spellings
- Identify and correct errors
- Use of electronic spell-checker to aid in error correction

Examples of Spell Check Instructions
1. Listen to the word.
2. Repeat it.
3. Try to spell it.
4. Look at it carefully. Is it as close as you can get? If not, try again.
5. When you get as close as you can, enter it into the spell checker.
6. Look through the list and choose the correct spelling.
7. Remember to press “say” to double check!
8. Copy the correct spelling.
9. Circle the words that you get by using the spell checker.
Interactive Tx (Surface Agraphia)

- Phonologically plausible attempts
- Best guess entered into spell checker

Surface Agraphia Interactive Treatment

Reading and Spelling of Untrained Words & Nonwords

Examining Lexical Spelling Treatment in Global/Deep Agraphia

14 Participants (12 male; 2 female)

- Age: mean 56.1 yrs. (range 29-77)
- Education: mean 14.9 yrs. (range 10-20)
- Time Post Onset: mean 4.1 yrs. (range .33-12)
- Aphasia Quotient: mean 52.4 (range 22.1-79.1)
- Perisylvian Aphasia Types
  - 7 Broca's Aphasia
  - 3 Conduction Aphasia
  - 4 Wernicke's Aphasia
- Severe impairment of single-word spelling

A Treatment Sequence for Written Language Impairment

(Beeson, Rising, Kim, Andersen, & Rapcsak, in prep)
Global Agraphia response to Lexical → Phonological Treatment

Phonological tx prompted additional improvement of sublexical skills

n = 7

Average Self Ratings Post Treatment
Lexical→Phonological Group

Since treatment, how would you rate your:

- Overall Spelling Ability?
- Overall Communication Ability?

Interactive Tx
(Global Agraphia)

- Degraded orthographic knowledge
- Some reliance on re-trained phonology
- Use of spell checker
Global Agraphia: Response to Lexical → Phonological → Interactive Tx

Improvement of sublexical, lexical, and problem-solving skills -

Average Self Ratings Post Treatment
Lexical→Phonological→Interactive Group
Since treatment, how would you rate your:

- Overall Spelling Ability?

- Overall Communication Ability?

Phonological Agraphia (n = 10)

Phonological Alexia/Agraphia
10 Participants (4 male; 6 female)

- Age: 62.9 yrs. (37-79)
- Education: 15.3 yrs. (12-20)
- Time Post Onset: 4.5 yrs. (33-9.5)
- Aphasia Quotient: 83.7 (66.7-96.4)
- Aphasia Types:
  - 3 Conduction Aphasia
  - 4 Anomic (evolved from Broca’s)
  - 1 Anomic (evolved from Conduction)
  - 2 Very mild anomic

Lesion Overlap

Phonological Agraphia Response to Phonological Treatment

Improvement of sublexical, lexical, and problem-solving skills
Average Self Ratings Post Treatment

**Phonological→Interactive Group**

Since treatment, how would you rate your:

- **Overall Spelling Ability?**
  - Patients
  - Spouses
  - A lot worse
  - Worse
  - Somewhat worse
  - Unchanged
  - Somewhat better
  - Better
  - A lot better

- **Overall Communication Ability?**
  - A lot worse
  - Worse
  - Somewhat worse
  - Unchanged
  - Somewhat better
  - Better
  - A lot better

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**Spelling Accuracy**

- Real words: < 30% correct
- > 30% < 90% correct
- Spelling preserved

- **Lexical Spelling Tx**
- **Phonological Spelling Tx**
- **Interactive Tx**
- **Text Reading Tx**

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**Surface Agraphia with Letter–by–Letter Reading**

- Word length effect for reading reaction time
- **Hard**
- **Mile**
- **Grumble**
- **Circuit**
- **Learn**
- **Routine**
- **Fact**
- **chant**
- **Bowl**
- **Charge**
- **Vague**
- **Debt**
- **Cross**

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**Letter–by–Letter Reading**

- Often accompanied by right visual field cut
- Right upper quadrantanopia
- Spoken language may be unimpaired
- or anomia

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**Surface Agraphia**

- Lexical-Semantic & Phonological Impairment
- Global or Deep Agraphia
- Phonological Agraphia
- Predominantly Lexical-Semantic Impairment
- Surface Agraphia
- Lexical Agraphia
- Predominantly Phonological Impairment
- Agraphia without Agraphia

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**Reading Reaction Time**

- Reaction Time (msec)
- Four
- Five
- Six
- Seven

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**Video**

- bump
debtpint
Multiple Oral Reading Tx (MOR)

- **Goal**
  - Increase reading rate and accuracy for novel text
- **Approach**
  - Repeated oral reading of the same text
  - Daily homework
- **Candidacy**
  - Word length effect for single words
  - Slow reading rate for text
  - Relatively preserved visual perception of orthography
  - Letter identification and single word reading relatively accurate

Evaluating Text for MOR Tx

Example Response to MOR Tx in Letter-by-Letter Reader

Response to Tx: Improved Reading Reaction Times (single words)

Average Self Ratings Post Treatment
Interactive + MOR Tx
Since treatment, how would you rate your:

- Overall Spelling Ability?
- Overall Reading Ability?
- Overall Communication Ability?

In Summary

- We provided the rationale and support for these treatment approaches
  - Lexical Treatment for Global/Deep Agraphia
  - Phonological Treatment for Phonological Agraphia
  - Interactive Treatment for Surface Agraphia
  - Multiple Oral Re-reading Treatment for Letter-by-Letter Reading
- We advocate for the implementation of a treatment sequence to maximize recovery
  - Current research extends the sequence discussed with additional focus on spoken language
Aphasia Research Project

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Christine Shipman  Andrew DeMarco
Kristina Higgenson

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