The Nature and Treatment of Written Language Impairment due to Extrasylvian Damage

Surface Alexia/Agraphia
Letter-by-Letter Reading

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Acquired Alexia & Agraphia Syndromes

- Reflect damage to specific processes (or combinations of processes) that support reading/spelling
- Reliance on residual abilities
- Characterized by
  - error profile and error types
- Associated with brain damage to specific cortical regions

![Diagram of brain regions and impairments]

- Semantics
- Phonology (crossed)
- Orthography (crossed)

**Impairments:**
- Phonological impairment
- Orthographic impairment
A reminder regarding blood supply to the brain

Middle cerebral artery supplies blood to perisylvian region.

Phonological impairment.

Posterior cerebral artery supplies blood to ventral cortical regions as well as medial and lateral occipital lobe.

Orthographic impairment.
Left perisylvian damage impairs phonological processing.

Results in perisylvian aphasias typically accompanied by **phonological alexia/agraphia** (including deep and global alexia/agraphia).

Damage to left posterior inferior temporo-occipital region may result in anomic or transcortical sensory aphasia, and often impairs orthographic knowledge (or access to orthography).

Results in **surface alexia/agraphia** or letter-by-letter reading.
Surface Alexia

Trouble with irregularly spelled words
Reliance on phonological strategy

Phonologically Plausible Error (PPE)

glacier
bribe “brib”
blood “blued”
tone +
shampoo +
castle

2 weeks post PCA stroke
Surface Agraphia

Trouble with irregularly spelled words
Reliance on phonological strategy

grumble
drive
honest
circuit
spring
rough
yaught
broad
round
fresh
quior
Damage to left ventral occipito-temporal cortex associated with posterior cerebral artery stroke typically affects reading and spelling. May also have anomic aphasia.
Phonological Alexia/Agraphia

Semantics

Orthography

Phonology

Semantics

Phonology

Surface Alexia/Agraphia

Semantics

Phonology

Orthography

Lexicality effect

Regular

Irregular

Nonwords

Percent correct

Regular

Irregular

Nonwords

Percent correct

Regular

Irregular

Nonwords

Regularity effect

Percent correct
Spelling Accuracy

- Real words
  - < 30% correct
  - > 30% < 90% correct

Lexical-Semantic & Phonological Impairment
- Global or Deep Alexia/Agraphia
- Predominantly Phonological Impairment
  - Phonological Alexia/Agraphia
  + Lexicality effect
  + Regularity effect

Predominantly Lexical-Semantic Impairment
- Surface Alexia/Agraphia
- Letter-by-Letter Reading
- Alexia without Agraphia
  + Regularity effect

Perisylvian Damage
- MCA Strokes

Extrasylvian Damage
- (typically due to PCA strokes)
80 y.o.
Anomic aphasia
WAB AQ = 90.4
BNT = 30/60

- Primary complaints: Reading, spelling, and coming up with the names of things

Surface pattern in reading resolved, but surface pattern in spelling remained.
Petra

The city of Petra, now an archaeological site in modern day Jordan, was at the height of prosperity in the first century B.C. Petra’s inhabitants accumulated wealth through trade of gold, silver, incense, brass, iron, saffron, sculpture, paintings and purple garments. During its heyday, which lasted for about 500 years, Petra was one of the most lavish cities in history. At its peak, the population was nearly 30,000 people.

At 3 months post-stroke, reading was slow but relatively accurate.
<table>
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<td>111</td>
<td>0</td>
</tr>
<tr>
<td>Controls</td>
<td>~200</td>
<td>0</td>
</tr>
</tbody>
</table>
He was never accused [acquised] of being honest.

Hoping for better luck, he changed [chainged] his pre-game routine.

She attempted vainly to suppress [suprese] her cough.
Spelling Accuracy

Real words

< 30% correct

> 30% < 90% correct

> 90% correct

Spelling preserved

Lexical-Semantic & Phonological Impairment
Global or Deep Alexia/Agraphia

Predominantly Phonological Impairment
Phonological Alexia/Agraphia

+ lexicality effect

Predominantly Lexical-Semantic Impairment
Surface Alexia/Agraphia

+ regularity effect

Letter-by-Letter Reading
Alexia without Agraphia

Individuals with surface agraphia respond to interactive treatment to promote use of residual lexical and sublexical spelling knowledge. Kim et. al (2015)
Interactive Spelling Treatment

Facilitate interactive use of residual orthography, phonology & semantics


Problem-solving approach to detect and self-correct phonologically plausible errors

q-u-i-e-r \rightarrow choir

"choir"
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* phonology to sound-out plausible spellings
- Identify and correct errors
- Use of electronic spell-checker to aid in error correction
Interactive Spelling Treatment

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.
Response to Treatment (Generalization)

Spelling Accuracy

- Reg
- Irreg
- Non

- Speller
- Post
- Pre

*Corrected with spell checker
Spelling Accuracy

real words

< 30% correct

>30% <90% correct

+ lexicity effect

+ regularity effect

spelling preserved

Lexical-Semantic & Phonological Impairment
Global or Deep Alexia/Agraphia

Predominantly Phonological Impairment
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Predominantly Lexical-Semantic Impairment
Surface Alexia/Agraphia

Letter-by-Letter Reading
Alexia without Agraphia

Lexical Spelling Tx

Phonological Tx

Interactive Tx

Text Reading Tx

Lexical Retrieval Treatment
Letter-by-letter reading

“apple”

Acoustic Analysis

Phonological Lexicon

Phonemes

“apple”

Orthographic Lexicon

Graphemes

Orthographic Analysis

Visual Analysis

Semantics

Lexical

sublexical

Letter naming a-p-p-l-e

Impaired access to orthography
Pure Alexia (when spelling is preserved)

- Pure Alexia refers to isolated impairment of reading
  - Disconnection of visual input to cortical regions involved in orthographic processing
  - Typically results in **letter-by-letter reading**
    - Characterized by word-length effect
      - Shorter words read more accurately and faster than long words
Letter-by-letter Reading

Slow, laborious reading with evidence of letter-by-letter strategy.

book
bear
wood
earth
heart
blood

Rapid, correct recognition of orally spelled words.

c-r-i-s-i-s
b-e-l-i-e-f
Pure Alexia: Letter–by–Letter Reader

“I just don’t read, okay. One word at a time, I can pick it out if I work at it.” “... I have to spell things. Sometimes I put my finger and block out a long word so that I take it apart, take the word apart and figure it out that way. I have to do that.”
Locks and keys have been in use for thousands of years. Why? Because there have always been thieves.
Multiple Oral Rereading (MOR)
(after Moyer, 1979. See Beeson, 1998)

- **Goal**
  - Increase reading rate and accuracy for novel text

- **Approach**
  - Repeated oral reading of same texts
  - Daily homework

- **Candidacy**
  - Word length effect for single words
  - Slow reading rate for text

- Relatively preserved visual perception of orthography
  - relatively good letter identification (letter naming)
  - relatively good single word reading accuracy (despite slowness)
Multiple Oral Rereading

- **Expectation**
  - increased reading rate for new text
  - improved access to orthography, so that reliance on letter-by-letter reading decreases and whole-word recognition improves

- **Why treat at text-level rather than single words?**
  - Word recognition is assisted by
    - syntactic constraints of sentences
    - semantic content and memory from repeated reading
  - Text reading is the ultimate goal
Multiple Oral Rereading (MOR)

- Reading Materials
  - From any source, but need to control for difficulty
    - Determine grade level using readability statistics in Microsoft Word
  - We have used passages from Scientific Research Associates Reading Laboratory (SRA, 1978)
    - Controlled for length and complexity
    - Reading levels range from grade 1 to grade 6
    - Most content is interesting and appropriate for adult readers
Determining Reading Level of Text

- Microsoft Word
  - File → Options → Proofing
  - Check “Show readability statistics”
  - Flesch–Kinkaid grade level will show up when you run spelling/grammar check.

Locks and keys have been in use for thousands of years. Why? Because there have always been thieves.

In Greece, long ago people had locks and keys. But they had a hard time taking their keys with them when they left their homes. That’s because the keys were too big. They were so big that they had to be carried on people’s backs. Some people left their key with a man who sat near their front door. He unlocked the door for the family or their friends. But if thieves came, he used the big key to fight them off.
The city of Petra, now an archaeological site in modern day Jordan, was at the height of prosperity in the first century B.C. Petra’s inhabitants accumulated wealth through trade of gold, silver, incense, brass, iron, saffron, sculpture, paintings and purple garments. During its heyday, which lasted for about 500 years, Petra was one of the most lavish cities in history. At its peak, the population was nearly 30,000 people. The citizens of Petra were unique in the ancient world for their abhorrence of slavery, for the prominent role women played in political life and for their egalitarian approach to governing.
Collect reading rate and accuracy data
  ◦ Baseline: Three sessions prior to starting treatment
    • Rate (words per minute) = (#words/#seconds) x 60 seconds
    • Accuracy (errors per 100 words) = (#errors/#words) x 100
  ◦ Probe at beginning of each session for practiced and new text

Treatment sessions
  ▸ Repeated oral reading of targeted text
  ▸ Clinician point out errors and provide assistance with difficult words or passages.

Daily homework!
  ◦ Oral reading of practice text at least 3–5 times per day
  ◦ Homework log for accountability
Locks and keys have been in use for thousands years. Why? Because there have always been thieves.

Beeson, 1998
Improved Reading Rate on New Text (not practiced)

- Improved reading rate while maintaining good accuracy
- Resumed work as plumber
- Resumed pleasure reading

Beeson, 1998

9 months post stroke;
6 months of MOR Tx
Improved Reading Rate

Gray Oral Reading Test-R

Words per Minute

PreTx  9 mos.  24 mos

Level 1  Level 2  Level 3  Level 4  Level 5  Level 6  Level 7  Level 8
Another Letter-by-Letter Reader

Weeks Post Onset

Words per Minute

No Tx

Multiple Oral Rereading Tx

rate

errors

Spelling Accuracy

- real words

< 30% correct

>30% <90% correct

+ lexicality effect
+ regularity effect

Lexical-Semantic &
Phonological Impairment
Global or Deep
Alexia/Agraphia

Predominantly
Phonological
Impairment
Phonological
Alexia/Agraphia

Predominantly
Lexical-Semantic
Impairment
Surface
Alexia/Agraphia

spelling preserved

Letter-by-Letter
Reading
Alexia
without Agraphia

Lexical Spelling Tx

Phonological Tx

Interactive Tx

Text Reading Tx

Lexical Retrieval Treatment
Sometimes pure alexia is not so pure!

76 yo male; 14 years education
Mild Anomic aphasia
WAB AQ: 91.4; BNT: 50/60

bump
debt
pint

Word-length effect, but also evidence of surface errors (phonologically plausible)

PCA stroke
Letter-by-Letter Reading with Surface Agraphia

Word length effect for reading time

- Single Word Reading Accuracy: 96%
- Overt letter-by-letter reading

Phonologically plausible spelling errors

Surface agraphia profile
Response to Multiple Oral Rereading Tx

- 12 1-hr Tx sessions for 6 weeks with daily reading/spelling homework

![Graph showing reading rate (wpm) for Practiced Text and reading reaction time (msec) before and after treatment.](image)

Reading rate (wpm) for Practiced Text

(Participant 3) Kim, Rising, Rapcsak & Beeson (2015) *JSLHR*
Reading Untrained Text: Pre–Post Treatment

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<tr>
<td>Pre-Tx</td>
<td>51.6</td>
<td>4</td>
<td>28.8</td>
</tr>
<tr>
<td>Post-Tx</td>
<td>92.3</td>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td>Controls</td>
<td>~200</td>
<td>0</td>
<td>~140</td>
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Pre–post reading rate (wpm) and accuracy (errors/100 words)
Response to Multiple Oral Re-reading + Interactive Tx

Improved spelling accuracy

![Graph showing improved spelling accuracy for regular and irregular words with and without the use of a spell checker.]

(Participant 3) Kim, Rising, Rapcsak & Beeson (2015) *JSLHR*
Recall this Individual

Interactive spelling treatment paired with Multiple Oral Rereading Tx

L PCA stroke

Reading Rate in Words/Minute

Novel Text

4.5-6.0 grade level

Reading Rate in Words/Minute

Practiced Text

Reading Rate in Words/Minute

Novel Text

4.5-6.0 grade level

Interactive spelling treatment paired with Multiple Oral Rereading Tx
Response to Treatment (Generalization)

**Single Word Reading Accuracy – 95%**

- **Pre**: 
  - Reading reaction time in msec

- **Post**: 
  - Reading reaction time in msec

**Spelling Accuracy**

- **Reg**: 
  - Speller
  - Post
  - Pre

- **Irreg**: 
  - Speller
  - Post
  - Pre

- **Non**: 
  - Speller
  - Post
  - Pre
"I think I’ve improved a lot. I read faster. I identify the words faster."

"I’m reading a book. The words are printed large (so it is thick), but I’m up to page 400. I like it."
Spelling Accuracy

- real words
  - less than 30% correct
  - more than 30% to less than 90% correct
  - spelling preserved

Lexical-Semantic & Phonological Impairment
  - Global or Deep Alexia/Agraphia
    - Lexical Spelling Tx
    - Phonological Tx

Predominantly Phonological Impairment
  - Phonological Alexia/Agraphia
    - Lexical Spelling Tx
    - Phonological Tx

Predominantly Lexical-Semantic Impairment
  - Surface Alexia/Agraphia
    - Interactive Tx
  - Letter-by-Letter Reading Alexia without Agraphia
    - Text Reading Tx

Lexical Retrieval Treatment
Summary

Treatment for reading and spelling for individuals with acquired alexia/agraphia due to extrasylvian lesions.

- Pure Alexia or LBL Reading
  - Individuals respond to **multiple oral re-reading treatment (MOR)**
    - Decreased word length effect
    - Increased rate of single word and text level reading
- Surface Alexia/Agraphia
  - Surface alexia often resolves spontaneously
  - Surface agraphia can be addressed with **interactive spelling treatment**, improving self-detection and correction of errors.

The two treatments can be implemented concurrently!

- Pure alexia may not be “pure.” People may have letter-by-letter reading profile + surface agraphia. Addressing reading and spelling simultaneously is appropriate and efficient.
Spelling Accuracy

- real words
  - < 30% correct
  - >30% < 90% correct
  - spelling preserved

Lexical-Semantic & Phonological Impairment
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Predominantly Phonological Impairment
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Alexia without Agraphia

Lexical Spelling Tx

Phonological Tx

Interactive Tx

Text Reading Tx

Lexical Retrieval Treatment
Overall Summary

- Consider aphasia rehabilitation as a sequence of treatments that can build upon one another

- We reviewed
  - Lexical → Phonological → Interactive training sequence to improve written language for individuals with perisylvian lesions (global and phonological alexia/agraphia)
  - Oral reading treatments at the text level for individuals with phonological alexia
  - Interactive spelling treatment and/or text reading treatment for individuals with extrasylvian lesions (LBL reading and/or surface alexia/agraphia)
Relevant References

Articles
  • This is a single case of treatment for letter-by-letter reading using Multiple Oral Re-reading.
  • This paper shows recovery before and after treatment for letter-by-letter reading using Multiple oral re-reading.
  • This small case series shows treatment for both reading (letter-by-letter reading) and spelling (surface agraphia).
  • These two cases were the first presentation of interactive treatment.

Chapter
  • This chapter provides the treatment protocol for a range of acquired alexia and agraphia subtypes. It should be helpful to reinforce the nature of the impairment and the treatment procedures.