School Neuropsychology of Writing and Writing Disabilities

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Developmental Stages of Spelling

(Gentry, 1992)

• **Preschool**: Letter-like forms/symbols
• **Kindergarten**: Letter abbreviations (“frm” for **from**) → Beginning phoneme-grapheme correspondence
• **First Grade**: Phonetic equivalents (“brot” for **brought**)
• **Second or Third Grade**: Spelling is accurate, follows orthographic rules, but problems with exception and sight words continue (“rite” for **right**)
• Letter reversals gone for most 8 year olds
• Spelling development parallels reading
Good vs. Poor Spellers: Frontal, Striate, Posterior Cingulate

(Richards, Berninger, & Fayol, 2009)

- Inferior Frontal Gyrus - Pars Triangularis
- Precentral Gyrus
- Postcentral Gyrus
- Broca’s and Exner’s areas should be same, if not, must ask why
- Comorbidity of oral expression (aphasia) and written expression (dysgraphia) and other fine motor apraxias) problems well known
- Intervention: Improve speaking and writing!
Neuropsychology of Handwriting

- Graphomotor: Visual-spatial, tactile, motor, visual-motor integration
- Spacing and direction
- Exner’s and Broca’s areas involved (comorbidity of aphasia and apraxia)
- Motor planning and initiation (supplementary motor)
- Premotor involvement? Modulation and intricacy in movement (novel-automatic)
- Executive circuits and motor control (what-when)
- Cerebellar functions and motor control (how)
Specialization for Written Words Over Objects in the Visual Cortex (Szwed et al., 2011)

- Greater activation in Visual Word Form Area (VWFA) with written words vs. objects
- VWFA is part of the left ventral stream (occipital-temporal)
- Children can write using dorsal (letter-by-letter) or ventral (automatic sight word retrieval) streams → look for difficulty sounding out words, whole word substitutions, oral and silent reading differences
- Frontal explanations: Exner’s Area and allographic (motor)
Writing vs. Drawing: Similarities and Differences
(Harrington, Farias, Davis, & Buonocore, 2007)

Active Regions
- Premotor
- Inferior Frontal
- Posterior-Inferior Temporal
- Parietal
- L > R for Writing
- R > L for Drawing

Contrasts
- Yellow: Drawing vs. Rest
- Red: Writing vs. Rest
- Blue: Areas active for drawing and writing
Developmental Issues in Written Language Development

- Most difficult academic subject
- Least amount of formal instruction
- Teach handwriting only?
- Myth: If you talk then you can write
- Oral and written language related but distinct
- More executive demands: Increases childhood to adolescence
- Discrepancy (even) less relevant? Writing process important
- Standardized measures of writing marginal at best
## Evaluating Written Language
(Mercer & Mercer, 2001)

<table>
<thead>
<tr>
<th>Writing Domain</th>
<th>Writing Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Content</td>
<td>• Accuracy, Ideas, Organization</td>
</tr>
<tr>
<td>• Structure</td>
<td>• Grammatical Correctness: Error Ratio</td>
</tr>
<tr>
<td>• Vocabulary</td>
<td>• Type: Diversification Index, Frequency of Common &amp; Uncommon Words</td>
</tr>
<tr>
<td>• Syntax</td>
<td>• Sentence Type &amp; Variety: T-Units</td>
</tr>
<tr>
<td>• Fluency</td>
<td>• Average Sentence Length and Total Sample Length (SPEED?)</td>
</tr>
</tbody>
</table>
The Process of Written Language

- Most complex academic task, yet little direct instruction
- Importance of writing practice – writing journal
- Content vs. mechanics
- 10-18% school-age children have significant difficulty with writing (Hooper et al. 1994)
- Children with writing SLD:
  - Write shorter sentences
  - Produce more fragments
  - Use limited vocabulary
  - Do not develop or organize ideas
  - Higher rates of grammatical errors (syntax, punctuation, capitalization, cohesive ties)
  - Males < females in orthography, spelling, handwriting, but not motor skills (Berninger et al., 2008)
<table>
<thead>
<tr>
<th>Written Language Disorder Subtypes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subtype</strong></td>
</tr>
<tr>
<td>• Linguistic and Fine Motor Problems</td>
</tr>
<tr>
<td>• Handwriting Problems with Good Spelling and Ideas</td>
</tr>
<tr>
<td>• Spelling, Organization, and Monitoring Writing</td>
</tr>
<tr>
<td>• Letter Production, Legibility, and Sequencing</td>
</tr>
<tr>
<td>Subtype</td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Average Writers (n=102)</td>
</tr>
<tr>
<td>Low Semantics (n = 31)</td>
</tr>
<tr>
<td>Low Grammar (n = 18)</td>
</tr>
<tr>
<td>Low Reading/Spelling (n = 13)</td>
</tr>
<tr>
<td>Poor Text Quality (n = 60)</td>
</tr>
</tbody>
</table>
The Neuropsychology of Written Language

Frontal Lobes
- Working Memory/Retrieval/Temporal Ordering
- Plan, Organize, Strategize, Monitor, Evaluate, Modify, & Change/Flexible Writing Product
- Attention, Concentration, Impulse Control

Left Hemisphere
- Routinized/Detailed/Local
- Convergent/Concordant
- Crystallized Abilities

Right Hemisphere
- Novel/Global/Coarse
- Divergent/Discordant
- Fluid Abilities
The Neuropsychology of Written Language

**Left Anterior**
- **Supplementary Motor**: Right Hand Motor
- **Premotor**: Verbs?
- **Exner’s Area**: Handwriting and Spelling
- **Broca’s Area**: Syntax, Expressive Language

**Left Posterior**
- **Temporal**: Semantics (Narratives-Anterior and Expository-Posterior)
- **Occipital-Temporal**: Word Spelling
- **Parietal**: Right Hand Somatosensory Feedback and Phoneme-Grapheme Spelling

**Right Anterior**
- **Prefrontal**: Divergent Thought, Executive Processes, and Attention/Impulse Control
- **Broca’s Area**: Complex Syntax

**Right Posterior**
- **Temporal**: Implicit and Complex Semantics: Multiple Word Meanings
- **Occipital-Temporal**: Visualization
- **Parietal**: Graphomotor ➔ Spatial Feedback
Ideas? Good vs. Poor Idea Generation in Written Expression (Berninger et al., 2009)

**Good Writers**
- More frontal and left hemisphere activation
- More cerebellar and supplementary motor
- Better executive-language-motor interactions

**Poor Writers**
- More right frontal activation and nonverbal working memory
- Poorer search and integration of thought and mechanics
SNAP-FIT Writing Disability Case Study: Greg’s Limited Written Language Output
Delivered by emergency cesarean following fetal distress, APGARS 4 and 6 led to NICU treatment.

Mildly delayed milestones, with preschool speech and physical therapy interventions.

Recurrent otitis media and tonsillitis led to myringotomy tubes.

Greg described as sweet and caring, with low frustration tolerance and self-deprecating comments, with occasional noncompliance and aggression.

Work completion hindered by poor attention, limited self-monitoring/evaluation, dysgraphia, and oppositional behavior.

Teacher reported “visual problem” with handwriting.

WIAT-II scores mostly in average range, although some difficulty with Pseudoword Decoding (SS = 88) and low average Written Expression (SS = 82).

Oral and Written Language Scales (OWLS) Written Expression Scale even poorer (SS = 78).

Greg was compliant and pleasant during testing, with flat affect.

Frequently asked for repetition and his attention was variable.

Oral expression minimal with frequent sequencing errors and syntax, both phonemic and semantic paraphasias.
Comprehensive Evaluation for Special Education Determination and Service Delivery

The Cognitive Hypothesis Testing Model

1. Presenting Problem
2. Intellectual/Cognitive Problem
3. Administer/Score Intelligence Test
4. Interpret IQ or Demands Analysis

Theory

Interpretation

Hypothesis

Data Collection
<table>
<thead>
<tr>
<th>WISC-IV Screening Results for Greg</th>
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<tbody>
<tr>
<td><strong>Verbal Comprehension (SS = 91)</strong></td>
</tr>
<tr>
<td>Scale Score</td>
</tr>
<tr>
<td>Similarities</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td>Vocabulary</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>Comprehension</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td><strong>Working Memory (SS = 97)</strong></td>
</tr>
<tr>
<td>Scale Score</td>
</tr>
<tr>
<td>Digit Span</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>Letter-Number Sequencing</td>
</tr>
<tr>
<td>11</td>
</tr>
</tbody>
</table>
Comprehensive Evaluation for Special Education Determination and Service Delivery

The Cognitive Hypothesis Testing Model

1. Presenting Problem
5. Cognitive Strengths/Weaknesses
2. Intellectual/Cognitive Problem
6. Choose Related Construct Test
3. Administer/Score Intelligence Test
7. Administer/Score Related Construct Test
4. Interpret IQ or Demands Analysis
8. Interpret Constructs/Compare

Theory

Interpretation

Data Collection

Hypothesis
## Hypothesis Testing Results for Greg

<table>
<thead>
<tr>
<th>Auditory-Verbal-Linguistic Measures</th>
<th>Scale Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEPSY-II Phonological Processing</td>
<td>6</td>
</tr>
<tr>
<td>NEPSY-II Word List Interference</td>
<td>11/14</td>
</tr>
<tr>
<td>NEPSY-II Comprehension of Instructions</td>
<td>12</td>
</tr>
<tr>
<td>NEPSY-II Narrative Memory</td>
<td>8/8</td>
</tr>
<tr>
<td>NEPSY-II Speeded Naming</td>
<td>6</td>
</tr>
<tr>
<td>CELF-4 Word Classes Receptive</td>
<td>9</td>
</tr>
<tr>
<td>CELF-4 Formulated Sentences</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Visual-Spatial-Constructional Measures</th>
<th>Scale Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEPSY-II Block Construction</td>
<td>9</td>
</tr>
<tr>
<td>NEPSY-II Design Copying</td>
<td>5/6/6/5</td>
</tr>
<tr>
<td>NEPSY-II Visuomotor Precision</td>
<td>4</td>
</tr>
<tr>
<td>NEPSY-II Finger Tapping Dominant</td>
<td>6</td>
</tr>
<tr>
<td>NEPSY-II Finger Tapping Nondominant</td>
<td>9</td>
</tr>
</tbody>
</table>
Implications for Intervention
Cognitive Hypothesis Testing Model

1. Presenting Problem
2. Intellectual/Cognitive Problem
3. Administer/Score Intelligence Test
4. Interpret IQ or Demands Analysis
5. Cognitive Strengths/Weaknesses
6. Choose Related Construct Test
7. Administer/Score Related Construct Test
8. Interpret Constructs/Compare
9. Intervention Consultation
10. Choose Plausible Intervention
11. Collect Objective Intervention Data
12. Determine Intervention Efficacy
13. Continue/Terminate/Modify
Greg’s Oral and Written Content

Baseline  Oral-Cues Intervention

Oral Story
Written Story

Greg’s T-Units/Sample

0  5  10  15  20  25

1  2  3  4  5  6  7  8  9  10  11  12  13
THANK YOU!

QUESTIONS? COMMENTS?

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