Orthographic Processing: A Subcomponent or Subtype of Dyslexia?

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Cullowhee Conference
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At the end of this activity, participants will be able to.....

- describe why dyslexia assessment and intervention is best understood using the phonological processing model,
- understand that individuals with dyslexia also have varying degrees of impairment in orthographic processing that need to be addressed during evaluation and instruction,
- know how to use measures of reading and spelling to identify deficits in phonologic and orthographic processing, and
- discuss how intervention can be adjusted to address weaknesses in orthographic processing.

C.D.

- Family history of reading difficulties
- Kindergarten entry delayed due to problems with the alphabet
- Tutored after school in first grade when benchmarks showed reading delays
- Numerous errors trying to spell phonetically
- Strong math qualified her for GT program
C.D.

- End of first grade FIE did not qualify her for additional services: word reading, nonsense word decoding (NWD), spelling below 25th percentile
- IEE (7y-10m; Gr 1.9) recommended accommodations and intervention to improve accuracy/efficiency of word/passage reading: word reading, reading rate, comprehension below 25th percentile (PA and NWD above 50th percentile)
- Reading expert encourages the family to request school intervention for orthographic dyslexia

IDA and TEA Definition

Dyslexia is a specific learning disability that is neuro-biological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge.


DSM-5 Definition

SPECIFIC LEARNING DISORDER WITH IMPAIRMENT IN READING:
  word reading accuracy
  reading rate or fluency
  reading comprehension
  dyslexia is an alternative term for problems with accurate or fluent word recognition, poor decoding and poor spelling.
  assessment of cognitive processing
  not recommended or required for diagnosis

APA, 2013
Phonological Processing Model of Reading and Dyslexia

In the word *cat*, “c” is /k/, “a” is /aaa/, and “t” is /t/.


Origins of the Phonological Processing Model of Reading and Dyslexia

Segmented units of speech (phonemes) are also represented in print at the phonemic level through the alphabet.

Liberman, Shankweiler and Liberman, 1989

ALPHABETIC PRINCIPLE

Phonemic segments of spoken words map to orthographic units (letters and letter strings).

Learning to read requires the child establish mappings (connections) between letters in printed words and phonemes of spoken words.

Liberman, Shankweiler and Liberman, 1989
EVIDENCE FOR A PHONOLOGICAL PROCESSING CORE DEFICIT IN DEVELOPMENTAL DYSLEXIA

- Word identification depends heavily on the ability to learn and apply letter-sound associations to decode.
- Compared with normal readers, those who struggle to read have difficulties with phonological awareness and problems with phonological analysis that persist into adulthood.
- Phonological awareness and decoding training have beneficial effect on word identification, spelling and overall reading ability.

Vellutino et al, 2004

Cognitive Components of Reading Comprehension and Their Precursors

Pennington, 2009

TWO RECIPROCALLY RELATED COMPONENTS OF PRINTED WORD RECOGNITION

- Using letter-sound knowledge to pronounce unfamiliar words (measured by pseudoword reading, e.g. ilk, first, smaut)
- Using memory for letter, letter cluster or whole word to identify a familiar word measured by irregular/exception words (e.g. pint), or homophones (e.g. rose vs. rows)
**What is Orthography?**

![Orthography Diagram](image)


- Orthographic awareness (sensitivity to the constraints on how letters in written words are organized) contributes to learning letter-sound associations.
- Phonological and orthographic awareness interact to produce (sight) word recognition memory.
- Individuals with poor phonological awareness will have poor orthographic awareness as children and adults with dyslexia.

Vellutino et al., 2004

**REASONS FOR SPECULATION CONCERNING AN ORTHOGRAPHIC SUBTYPE OF DEVELOPMENTAL DYSLEXIA**

- Cases of adult acquired phonological/deep (problems decoding/spelling using phonics) and orthographic/surface (problems reading/spelling irregular words) dyslexia.
- Hypothetical dual route reading system with potential deficits in phonological and/or orthographic coding.
- Cases of children with adequate decoding but poor real word reading: dyseidetic dyslexia (Boder, 1973) developmental surface dyslexia (Coltheart et al, 1983) orthographic dyslexia (Roberts & Mather, 1997)
Origins of Dyslexia Subtyping Models

Origins of Dyslexia Subtypes

G.R. (Deep Dyslexia)
- 46yo male. Missile wound in left temporo-parietal area at age 18
- Mild dysarthria
- Severe deficits in verbal short-term memory (digit-and-word-spans)
- Comprehension and object naming less affected
- Reading and spelling ‘disturbed’
  - Significant concreteness effect (50% concrete nouns vs 10% abstract nouns and function words)
  - Errors tend to be nouns, usually semantic substitutions (sp)ek → ‘talk’, sick → ‘ill’, large → ‘big’, employ → ‘factory’
  - Derivation errors (truth → ‘true’, depth → ‘deep’)

Origins of Dyslexia Subtypes

J.C. (Surface Dyslexia)
- 45yo male. Missile wound in left temporo-parietal area at age 20
- No articulation problems
- Significant impairment in reading and spelling
  - Word frequency correlated with performance
  - No semantic errors
  - Tendency to pronounce all graphemes (e.g., reign → ‘region’)
  - Grapheme-phoneme conversion variable, with vowel digraphs, consonant clusters, Cve especially difficult
  - Stress-shift errors (begin → ‘begging’)
  - Gives phonetic value to silent consonants (e.g., island → ‘izland’)
Summary of Surface Dyslexia Symptoms

- Accuracy is better for regular (care) versus irregular (choir) words
- Errors on common irregular words are often regularizations (bear → /bër/)
- Some multisyllabic words may be read with wrong stress
- Homophone matching more accurate with regular words (bole/boil vs air/heir)
- When words are read incorrectly, they are frequently misunderstood as the error response
- Homophones confusions occur in silent reading comprehension
- Spelling is poor, majority of errors phonologically correct


Diagnostic Criterion

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Regular</td>
<td></td>
<td>92</td>
<td>72</td>
<td>74</td>
<td>59</td>
<td>69</td>
<td>72</td>
<td>59</td>
</tr>
<tr>
<td>Irregular</td>
<td></td>
<td>64</td>
<td>13</td>
<td>51</td>
<td>33</td>
<td>69</td>
<td>79</td>
<td>74</td>
</tr>
</tbody>
</table>

Note: Tabled values indicate percent correct

Shallice (1988). From neuropsychology to mental structure, p. 83

Dual Route Model

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DEEP ROUTE
Sub-lexical Representation

Feature Detectors
Letter Units

Production Rules
IF
input = CVCE
THEN
M(V) = V
AND
F(V) = #

Phoneme System

Grapheme Phoneme Rules

SURFACE ROUTE
Lexical Representation

Feature Detectors
Letter Units

Orthographic Lexicon
Semantic System

Phonological Lexicon

Phoneme System

Neurological Model of Reading

Supramarginal/Angular Gyrus
Inferior Frontal Gyrus (Broca's Area)
Phonological Decoding and Production

Inferior Frontal Gyrus
Phonological Decoding and Production

Inferior Fusiform Gyrus
Association Cortex
Attention-controlled Processing

Visual Word Form Area
Language Comprehension/ Semantics

Neurological Model of Reading


Neurological Model of Reading

Neoclevy et al. (2006). Brain Topography, 18, 233-239.

Surface Dyslexia According to Dual Route Model

Phases of Reading Development

| Logographic | Partial alphabetic | Full alphabetic | Consolidated alphabetic |

Mappings between orthography and phonology allow novel words to be decoded and provide a foundation for acquisition of more automatic reading skills.

Ehri, 2005

Orthographic Reading
(Automaticity - Fluency)

Phonics

Phonemic Awareness

Charles Haynes
Aoccdrnig to rscheearch at Cmabrigde Unervtisy, it deosn’t mtaer in what oredr the litteers in a word are, the onyl iprmoetnt thng is that the frist and lsat ltteer be at the rght pclae. The rset can be a total mses and you can still raed it wouthit porbelm. This is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the word as a wlohe.

Amzanig, huh

### Dual Route Developmental Model

![Dual Route Developmental Model Diagram]

- **Letter Units**
- **Orthographic Lexicon**
- **Grapheme-Phoneme Rules**
- **Receptive Vocabulary**
- **Output**
- **Phonemic System**

### Developmental Dyslexia Subtypes

<table>
<thead>
<tr>
<th>Construct</th>
<th>Phonologic</th>
<th>Orthographic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early speech/language</td>
<td>Articulation errors</td>
<td>Slow retrieval on MAN tasks</td>
</tr>
<tr>
<td></td>
<td>Mispronunciation of words</td>
<td></td>
</tr>
<tr>
<td>Symbol recognition and recall</td>
<td>Poor result of sound/symbol relationship</td>
<td>Confusion of similar graphemes (j/s)</td>
</tr>
<tr>
<td></td>
<td>Confusion of similar phonemes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor result of letter sequence</td>
<td>Difficulty with rapid recognition of high frequency sounds</td>
</tr>
<tr>
<td></td>
<td>Difficulty recognising syllables</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overuse of decoding strategies</td>
<td></td>
</tr>
<tr>
<td>Word identification</td>
<td>Poor result of letter sounds</td>
<td>Overuse of context</td>
</tr>
<tr>
<td></td>
<td>Poor decoding</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overuse of context</td>
<td></td>
</tr>
<tr>
<td>Spelling</td>
<td>Poor sequence of sounds</td>
<td>Reversals based on similar appearing phonemes</td>
</tr>
<tr>
<td></td>
<td>Errors based on similar sounding phonemes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Addition and omission of sounds</td>
<td>Overgeneralization of spelling rules</td>
</tr>
<tr>
<td></td>
<td>Poor knowledge of rules</td>
<td>Rule-based errors</td>
</tr>
<tr>
<td></td>
<td>Overuse of visual features</td>
<td>Use of impossible patterns</td>
</tr>
<tr>
<td></td>
<td>(because/because)</td>
<td>Overuse of auditory features</td>
</tr>
<tr>
<td></td>
<td>(because/because)</td>
<td>Overuse of visual features</td>
</tr>
</tbody>
</table>

MEASURING ORTHOGRAPHIC ABILITY

ERROR ANALYSIS

* reading and spelling of acquired cases (Marshall and Newcombe, 1973)
* spelling error analysis for intervention (Moats, 2010)
* developmental spelling inventories
* prescriptive assessment software
  SPELL-2 (Masterson, Apel and Wasowicz, 2006)

---

**CF CA 14-5 GR 8.8**

PC: problems with reading fast enough and spelling
HX: good at spoken language, higher thinking and math
family had difficulty learning to read

<table>
<thead>
<tr>
<th>spelling errors</th>
<th>error type</th>
</tr>
</thead>
<tbody>
<tr>
<td>carless/careless</td>
<td>orthography (VCE or misuse dropping rule)</td>
</tr>
<tr>
<td>couldn’t/couldn’t</td>
<td>orthography (contraction)</td>
</tr>
<tr>
<td>rough/rough</td>
<td>orthography (MGR)</td>
</tr>
<tr>
<td>riding/ridding</td>
<td>morphology (rules for adding suffix)</td>
</tr>
<tr>
<td>design/design</td>
<td>orthography (MGR)</td>
</tr>
<tr>
<td>climb/climbed</td>
<td>morphology (suffix omission)</td>
</tr>
<tr>
<td>whistle/whistle</td>
<td>orthography (Cle)</td>
</tr>
<tr>
<td>strength/strength</td>
<td>phoneme confusion (? dialect)</td>
</tr>
</tbody>
</table>

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**C.F.**

<table>
<thead>
<tr>
<th>CA 14-5 GR 8.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTOPP pa SS 109</td>
</tr>
<tr>
<td>CTOPP ns SS 112</td>
</tr>
<tr>
<td>WRMT watt SS 94</td>
</tr>
<tr>
<td>WRMT wid SS 83</td>
</tr>
<tr>
<td>GORT-4 rate SS 6</td>
</tr>
<tr>
<td>WRMT pt SS 84</td>
</tr>
<tr>
<td>WAT-II spell SS 75</td>
</tr>
</tbody>
</table>
C.F. School dyslexia services grades 3-4
TSRHC Dyslexia Lab grades 7-8

<table>
<thead>
<tr>
<th>CLINIC CA 9-9 GR 4.1</th>
<th>PRE-TEST CA 12-8 GR 7.0</th>
<th>POST-TEST CA 14-5 GR 8.8</th>
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<tbody>
<tr>
<td>IQ</td>
<td>WISC-III FSIQ 92</td>
<td></td>
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<tr>
<td>PA</td>
<td>TAAS inadq. CTOPP SS 70</td>
<td>CTOPP SS 109</td>
</tr>
<tr>
<td>RN</td>
<td>CTOPP SS 79</td>
<td>CTOPP SS 112</td>
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<tr>
<td>Decoding 0.52 MS</td>
<td>WRMT walt SS 82</td>
<td>WRMT walt SS 94</td>
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<tr>
<td>0.39 PS</td>
<td>SWR</td>
<td></td>
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<tr>
<td>RN</td>
<td>DST ar gr 3.3</td>
<td>GORT-4 rate SS 4</td>
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<tr>
<td>RC</td>
<td>WRMT pc SS 83</td>
<td>WRMT pc SS 84</td>
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<tr>
<td>Spelling</td>
<td>WRMT SS 71</td>
<td>WRMT-III SS 78</td>
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</tbody>
</table>

ORTHOGRAPHIC DEFICITS FOLLOWING TSRHC DYSLEXIA LAB INTERVENTION (2003 - 2014)

"FIVE BLOCK" SPELLING ERROR ANALYSIS OF WORDS WIAT PRE/POST FOR N=29 (Ortho Gp.)

LESS % PHONO ERRORS AT POST-TEST

MEAN % NON-PA AT PRE-TEST .57
MEAN % NON-PA AT POST-TEST .70

OA + MA + MGR + SA = % NON-PA ERRORS
PA = OA + MA + MGR + SA
14/29 had at least .10 increase in % NON-PA errors pre to post significant difference pre-posttest, t(29) = 3.1, p < .01
MEASURING ORTHOGRAPHIC ABILITY

DIAGNOSTIC READING TASKS (Castles and Coltheart, 1993)
Detect difference in reading:
- regular (e.g., check)
- irregular (e.g., break)
- nonword (e.g., drick)

MEASURING ORTHOGRAPHIC ABILITY

HOMOPHONE CHOICE (Stanovich et al., 1991)
“Which is a flower?” rose - rows

ORTHOGRAPHIC AWARENESS (Siegel et al., 1995)
“Which is legal in English?” folk – filv

ORTHOGRAPHIC CHOICE (Olson et al., 1994)
“Which is a real word?” bloo - blue

MEASURING ORTHOGRAPHIC ABILITY

EMBEDDED WORDS (Hultquist, 1997)
“Where’s the word?” xKlbinefqq

TEST OF SILENT WORD READING FLUENCY (Mather et al., 2014)
“Draw a line between as many words as you can.” (3 min.)
e.g. Seeheinmygoetoupgreentwodress

TEST OF IRREGULAR WORD READING EFFICIENCY (Reynolds and Kamphaus, 2007)
Reading irregular words in a list format while being timed. (2 min.)
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Process Assessment of the Learner


Test of Orthographic Competence

* Punctuation (e.g., tom was born on june 25 1986)
* Abbreviations (e.g., Tues.; etc.)
* Letter choice (pdbq) (e.g., re_; _saint)
* Word Scramble (ti; kckon)
* Sight Spell (tw_; __rcle)
* Homophone Choice

Mather et al. (2008), Pro-ed, Inc.
'Pure' Subtype Prevalence

<table>
<thead>
<tr>
<th></th>
<th>Castles &amp; Coltheart</th>
<th>Manis et al.</th>
<th>Stanovich et al.</th>
<th>Peterson et al.</th>
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<tbody>
<tr>
<td>Phonological</td>
<td>15%</td>
<td>10%</td>
<td>9%</td>
<td>16%</td>
</tr>
<tr>
<td>Surface</td>
<td>17%</td>
<td>10%</td>
<td>12%</td>
<td>2%</td>
</tr>
<tr>
<td>Mixed</td>
<td>62%</td>
<td>75%</td>
<td>75%</td>
<td>62%</td>
</tr>
</tbody>
</table>

Percentage below age level on one or both dimensions (nonword or exception word reading).


What is the Core Deficit?

Surface Dyslexia Core Deficit

* Sample with dyslexia (n=51), same-age controls (n=51) and reading-level matched younger controls (n=27)
* Instruments
  - Nonword oral reading (baich, sleesh)
  - Exception word list (e.g., sword, bouquet)
* Relative deficits determined by using 95% CI band from regression of exception word reading and nonword reading performance

Surface Dyslexia Core Deficit

20/51 below 95% C1 band for exception relative to nonwords

15/51 surface dyslexics (worse on exception words)

5/51 mixed (exception + nonwords)

Surface Dyslexia Core Deficit


Surface Dyslexia Core Deficit


Treatment of Orthographic Deficits

Logographic
Partial alphabetic
Full alphabetic
Consolidated alphabetic

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Print Exposure

<table>
<thead>
<tr>
<th>Estimated Words Read Outside School</th>
<th>10th Iile</th>
<th>50th Iile</th>
<th>90th Iile</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,000,000</td>
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<tr>
<td>4,500,000</td>
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<td>0</td>
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</table>

Note: n=155 5th grade students.


FOUR PROCESSING SYSTEMS IN WORD READING

- **Context Processor**: sentence context, background information
- **Meaning Processor**: vocabulary, morphological awareness
- **Orthographic Processor**: letter/word recognition, fluency
- **Phonological Processor**: letter-sound mapping, decoding

Comprehensive Reading Instruction

- **Logographic**: Morphology, Instant Words
- **Partial Alphabetic**: Instant Words
- **Full Alphabetic**: Phonics, Phonological awareness
- **Consolidated Alphabetic**:
TREATMENT OF ORTHOGRAPHIC DEFICITS

- Identify PWD-WR, reduced reading rate, relative absence of single grapheme-phoneme spelling errors.
- Research on effective methods for remediating orthographic processing problems is limited.
- Direct instruction should address problems related to reduced exposure to text and underdeveloped knowledge of conventional spellings.
- Reduce orthographic deficits by encouraging more accurate word and connected text reading at each level of instruction (role for supportive reading technology).

TREATMENT OF ORTHOGRAPHIC DEFICITS

- Use multi-sensory (Fernald) technique where the child looks at the word, says the word, pronounces it while tracing it several times, then writes it from memory (Mather and Wendling, 2012).
- Provide extra practice reading/spelling high frequency irregular words (e.g. once, said) from word lists and student’s errors, emphasizing irregular elements (e.g. color or enlarge letters) using a flow list procedure.
- Promote speed in word recognition using Rapid Word Recognition Chart with irregular words (Birsh, 2005).

TREATMENT OF ORTHOGRAPHIC DEFICITS

- Build reading fluency with repeated reading of texts at the independent reading level (Meyer and Felton, 1999).
CONCLUSIONS

• Word reading development typically progresses from a primitive, visually based logographic strategy, via an alphabetic-phonological stage, to an advanced, automatic visual-orthographic strategy.
• Processing of phonology, orthography and semantics/context all contribute to word reading ability and dysfunction (dyslexia).
• Relative contributions of phonological and orthographic processing to word reading deficits (dyslexia) can be inferred by analysis of reading/spelling errors and measures of phonological processing/coding and orthographic processing/coding.

CONCLUSIONS

• Significant difficulty reading irregular/exception words relative to regular words is the most basic distinguishing feature of surface/orthographic deficits.
• Pure developmental dyslexia subtypes (i.e. only phonological, only orthographic) are rare, so most need multi-component intervention that includes direct, explicit instruction in:
  • Phonological processing/phonics/decoding
  • “Sight word” high frequency word practice
  • Fluency development with repeated reading
  • Vocabulary-word meaning in varied contexts
  • Use of literal and inferential comprehension strategies
  • Logic of English spelling, emphasizing patterns, word origin and morphology
CONCLUSIONS

• Empirical support for phonological training in dyslexia is greater than it is for orthographic training but both are typically necessary.
• The pattern of orthographic deficits is often the result of insufficient exposure to written language, sometimes is evident following intensive phonological training and less commonly is produced by a biologically based neuro-cognitive difference.
• The orthographic subtype label overstates the prevalence of dyslexia largely due to orthographic deficits and ignores co-existing phonological deficits.
• Clinicians should be prepared to flexibly evaluate and remediate all factors contributing to the reading impairments of children with dyslexia according to a student’s needs rather than rigidly following approaches dictated by labels.

Why is Dyslexia Assessment and Intervention Best Understood Using the Phonological Processing Model?

• Deficits in phonological processing are the most important neurocognitive contributor to the word reading problems of individuals with dyslexia.
• Measures of phonological processing are the best predictors of word recognition development.
• Systematic instruction in phonological awareness and phonics produce the greatest gains in the word reading skills of children with dyslexia.
• Phonologic deficits almost always accompany problems with orthographic processing in developmental dyslexia (i.e. orthographic dyslexia subtype “neglects” this).

Why is it Important to Evaluate and Treat the Problems with Orthographic Processing of Individuals with Dyslexia?

• Most individuals with dyslexia have problems with orthographic processing.
• Phonological and orthographic processing are reciprocal and interact with semantics (and context) to support word reading.
• Orthographic processing is necessary for skilled reading.
How Can Deficits in Phonologic and Orthographic Processing be Distinguished Using Measures of Reading and Spelling?

- Phonologic processing problems cause: difficulty decoding nonsense words (e.g. zut); addition, omission or confusion of sounds (e.g. flat/fat, dank/drank, bop/pup); over reliance on visual features (e.g. becuas/because)

- Orthographic processing problems cause: difficulty with rapid word recognition, esp. low frequency or phonologically irregular words (e.g. yacht); use of impossible orthographic patterns (e.g. eggzit/exit); over reliance on auditory features (e.g. becu/because)

What are the Most Effective Methods for Remediating Orthographic Processing Problems?

- Instruction that uses repeated reading to develop automatic recognition of sub-word patterns (e.g. syllables), words and continuous text.

- Teaching word study with an emphasis on morphological awareness, syllable structure and spelling rules.
What is Orthography?

Orthographic Knowledge
Stored information in memory for the correct way to write a language’s orthography

Mental Graphemic Representations (MGRs)
Stored mental representations of specific written words or word parts

Orthographic Rules
Rules that govern how speech must be represented in writing

Rules for how a letter or letters represent SPEECH SOUNDS (including alphabetic principle)

Rules for what letters can and cannot be combined (vid is legal, xqr is illegal)

Positional and contextual constraint rules for the use of letters (i.e., orthotactic rules) (k cannot precede o in the initial position)

# Phases of Reading Development

<table>
<thead>
<tr>
<th>Prealphabetic</th>
<th>Partial Alphabetic</th>
<th>Full Alphabetic</th>
<th>Consolidated Alphabetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>May or may not know letters</td>
<td>Most letter shapes and names known; incomplete knowledge of GPs</td>
<td>Major GPs of writing system known</td>
<td>Grapho-syllabic spelling units known</td>
</tr>
<tr>
<td>Lack of phoneme awareness</td>
<td>Limited phonemic awareness; benefit of articulatory awareness instruction.</td>
<td>Full phonemic awareness: segmentation and blending</td>
<td>Grapho-syllabic connections predominate</td>
</tr>
<tr>
<td>No GP connections between spellings and pronunciations</td>
<td>Partial GP connections formed</td>
<td>Complete GP connections formed</td>
<td>Sight words learned primarily by grapho-syllabic connections</td>
</tr>
<tr>
<td>Sight words learned by remembering salient visual or context cues</td>
<td>Sight words learned by remembering partial GP connections</td>
<td>Sight words learned by remembering complete GP connections</td>
<td>Sight word memory: accurate, automatic, unitized, growing, limited mainly to shorter words</td>
</tr>
<tr>
<td>Sight word memory: unreliable, semantic errors, reading the environment</td>
<td>Sight word memory: Confusion of similarly spelled words</td>
<td>Sight word memory: accurate, automatic, unitized, growing, limited mainly to shorter words</td>
<td>Sight word memory: accurate, automatic, unitized, expanding rapidly; multisyllabic words easier to learn</td>
</tr>
<tr>
<td>No non-word decoding ability</td>
<td>Little or no non-word decoding ability</td>
<td>Growing ability to decode unfamiliar words and nonwords</td>
<td>Can decode unfamiliar words and nonwords proficiently</td>
</tr>
<tr>
<td>Cannot analogize</td>
<td>Analogizing precluded by partial memory for word spellings</td>
<td>Some use of analogizing but limited by smaller sight vocabulary</td>
<td>Greater use of analogizing as sight words accumulate</td>
</tr>
<tr>
<td>Unfamiliar words predicted from context</td>
<td>Unfamiliar words predicted using initial letters and context</td>
<td>Unfamiliar words in context read by decoding; context used to confirm or disconfirm words read</td>
<td>Unfamiliar words in context read by decoding or analogy; context used to confirm or disconfirm words read</td>
</tr>
<tr>
<td>Words spelled nonphonetically</td>
<td>Partial phonetic spellings invented; weak memory for correct spellings</td>
<td>Phonetically accurate GP spellings invented; growing memory for correct spellings</td>
<td>Grapho-syllabic and GP units to invent spellings; proficient memory for correct spellings</td>
</tr>
</tbody>
</table>

*Note. Grapho-syllabic spelling units include subsyllabic units such as rime spellings, spellings of syllables, and spellings of morphemes including root words and affixes. GP = grapheme-phoneme connections.*

# Developmental Dyslexia Subtypes

<table>
<thead>
<tr>
<th>Construct</th>
<th>Phonologic</th>
<th>Orthographic</th>
</tr>
</thead>
</table>
| Early speech/language            | • Articulation errors  
• Mispronunciations of words                                                 | Slow retrieval on RAN tasks                                                  |
| Symbol recognition and recall    | • Poor recall of sound-symbol relationships  
• Confusion of similar phonemes (p/b)                                            | • Poor recall of letter appearance  
• Confusion of similar graphemes (p/q)                                         |
| Word identification              | • Poor recall of letter sounds  
• Poor decoding  
• Overuse of context                                                               | • Poor recall of letter sequence  
• Difficulty with rapid recognition of high frequency words  
• Difficulty recognizing syllables  
• Overuse of decoding strategy                                                  |
| Spelling                         | • Poor sequence of sounds  
• Errors based on similar sounding phonemes  
• Addition and omission of sounds  
• Poor knowledge of rules  
• Overuse of visual features (becuaes/because)                                   | • Reversals based on similar appearing graphemes  
• Transposition of letters (tow/two)  
• Overgeneralization of spelling rules (rede/read)  
• Use of impossible patterns (eggzit/exit)  
• Overuse of auditory features (becaws/because)                                   |
The table below outlines various types of spelling errors and their corresponding analyses:

<table>
<thead>
<tr>
<th>Word Errors</th>
<th>Phonemic Awareness</th>
<th>Orthographic Awareness</th>
<th>Morphological Awareness</th>
<th>Mental Graphemic Representation</th>
<th>Semantic Awareness</th>
<th>Letter Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>a consonant or vowel representing a sound/phoneme is omitted, added, confused or out of place</td>
<td>Illegal substitutions &amp; situational spelling rules: (phonetically plausible)</td>
<td>affix is missing, spelled incorrectly or its addition to base word not appropriately modified; base word not used to spell derived form; misspelling of modifications</td>
<td>word is phonetically accurate and does not break a rule concerning an orthographic pattern or morphology (flote)</td>
<td>word is misspelled based on meaning (homophone confusion: there/their, be/bee, one/won)</td>
<td>(reversals/inversions)</td>
<td></td>
</tr>
<tr>
<td>Vowel (V)</td>
<td>vowel digraphs/diphthongs, VCe, vowel-r, consonant digraphs/trigraphs, /k/ (c,k,ck,ch,x,qu), consonant doubling, Cle</td>
<td>Ex: -ed=/t/, -y=/e/</td>
<td>tion=shun, Photo=foto, busy for bizness, calves for calves</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consonant (C)</td>
<td>Omission-O</td>
<td>Addition-A</td>
<td>Transposition-T</td>
<td>Confusion-C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on Kenn Apel’s model of “The Five Blocks of Word Study”
Orthographic Dyslexia Seminar

References


Jeffrey L. Black, M.D.
Cullowhee Conference, 2016


