Types of developmental dyslexia: directions for diagnosis and treatment

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Dyslexias – different difficult words, different errors

- form, could, trial table, university
- could, talk, now smile, say, window
- table, fork, smile because, university
- of, because, that apple, fork, cloud

Dyslexias – themes of this talk

- Dyslexia is a deficit in reading.
- 19 types of dyslexia exist, each resulting from a different deficit in the reading model.
- What are the characteristics of these dyslexias?
- Diagnosis: are the best stimuli to detect each of them? It is crucial to identify the dyslexia to treat it correctly.
- Directions for treatment of various dyslexias
- Cognitive neuropsychology: models predict dyslexias, dyslexias modify models
**Single word reading process**

**written word**

- Orthographic-visual analysis
- Letter identification
- Letter position
- Letter-to-word binding
- Conceptual system
- Semantic lexicon
- Orthographic input lexicon
- Phonological output lexicon
- Phonological output buffer
- Grapheme-phoneme conversion
- Speech

**The direct lexical route: quick and accurate**

**written word**

- Orthographic-visual analysis
- Letter identification
- Letter position
- Letter-to-word binding
- Conceptual system
- Semantic lexicon
- Orthographic input lexicon
- Phonological output lexicon
- Phonological output buffer
- Grapheme-phoneme conversion
- Speech

**The semantic lexical route: comprehension**

**written word**

- Orthographic-visual analysis
- Letter identification
- Letter position
- Letter-to-word binding
- Conceptual system
- Semantic lexicon
- Orthographic input lexicon
- Phonological output lexicon
- Phonological output buffer
- Grapheme-phoneme conversion
- Speech

**The sublexical route: reading nonwords**

**written word**

- Orthographic-visual analysis
- Letter identification
- Letter position
- Letter-to-word binding
- Conceptual system
- Semantic lexicon
- Orthographic input lexicon
- Phonological output lexicon
- Phonological output buffer
- Grapheme-phoneme conversion
- Speech
Components shared for reading and speech

- Orthographic-visual analysis
- Letter identification
- Letter position
- Letter-to-word binding
- Conceptual system
- Semantic lexicon
- Orthographic input lexicon
- Phonological output lexicon
- Phonemic output buffer
- Speech
- Grapheme-phoneme conversion

A deficit in each of these components creates a different type of dyslexia

- Visual letter agnosia
- Letter identity dyslexia
- Letter position dyslexia
- Visual output dyslexia
- Graphemic input buffer dyslexia
- Neglect dyslexia – word
- Neglect dyslexia - text
- Attentional dyslexia
- Surface dyslexia-lex
- Surface dyslexia-lexoutput
- Surface dyslexia-interlex
- Surface dyslexia-phonlex
- Vowel dyslexia
- Phonological dyslexia: conversion
- Phonological buffer dyslexia
- Dyselexia
- Deep dyslexia (3 types)
- Direct dyslexia (hyperlexia)

Acquired

Developmental

Genetic bases for types of dyslexia

Faran, Gvion & Friedmann (2014, February)

The model: impairments in its different components create different dyslexias

Let’s go one by one
**Impaired letter identity encoding**

- Orthographic-visual analysis
- Letter identification
- Letter position
- Letter-to-word binding
- Conceptual system
- Semantic lexicon
- Orthographic input lexicon
- Phonological output lexicon
- Grapheme-phoneme conversion
- Phonemic output buffer
- Speech

**Letter identity dyslexia**

A deficit in abstract letter identification

Word reading: letter substitution and omission

- Read → road
- Tale → take
- Brother → broth
- Table → broth

Letter level: A A, a a, Aa

Visual agnosia is a deficit in visually identifying objects. Sensory perceptual functions are not impaired.
anomia

agnosia

Ar...... En!
Treatment and teaching: kinesthetic strategy

Letter position dyslexia

Friedmann & Gvion (2001), *Cognitive Neuropsychology*
Friedmann & Gvion (2005), *Behavioral Neurology*
Friedmann & Rahamim, (2007), *Journal of Neuropsychology*
Friedmann, Dotan & Rahamim (2010), *Cortex*
Friedmann & Haddad-Hanna (2012), *Behavioral Neurology*
Friedmann & Rahamim (2014), *Journal of Research in Reading*

Impaired letter position encoding: Letter position dyslexia

Predominant error - letter migrations within words

part ons
Selective deficits have been identified:
- In letter identification (Letter Agnosia, letter identity Dyslexia)
- In letter-to-word binding (Attentional Dyslexia)

What about letter position?
The model predicts a selective deficit in letter position

Words that allow for the relevant error type to create a real word
- dairy – diary
- trial – trail
- loin – lion
- board – broad
- tort – trot
- stake – skate
- trail – trial

Deficits in visual analysis

Acquired dyslexia

Focus of hemorrhage in left parieto-occipital regions and inferior parietal lobule

Also: Developmental dyslexia

A detailed study of 65 Hebrew-speaking children and adolescents with letter position dyslexia
Transpositions in comprehension: definitions

diary – Something from a cow

could – Something that brings rain

parties - They are very brave. They are robbers of the sea.

Reading comprehension in LPD

Because migration occurs in an early stage, before access to semantics, LPD causes not only errors in reading aloud, but also in comprehension.

Clinical implications

Reading comprehension problems can result from incorrect reading, such as in LPD.

Reliance on lexical knowledge

Aoccdrnig to a rscheearch at Cmabrigde Unervtisy, it deosn't mtaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is taht the frist and lsat ltteer be at the rghit pclae. The rset can be a toatl mses and you can sitll raed it wouthit porbelm. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe.
oral reading
migratable vs. nonmigratable

- 298 migratable words
- 70 non-migratable words
- 65 participants with developmental LPD

What does it mean for diagnosis?

- We may miss LPD if the words are non-migratable.
- Words for diagnosis should include migratable words (like form-from, trail-trial).

LPD – letter position dyslexia
With migratable words, identified in

<table>
<thead>
<tr>
<th>Hebrew</th>
<th>Arabic</th>
<th>English</th>
<th>Italian</th>
<th>Turkish</th>
</tr>
</thead>
<tbody>
<tr>
<td>פзна</td>
<td>איז</td>
<td>dairy – diary</td>
<td>BORDO</td>
<td>בולמה</td>
</tr>
<tr>
<td>ישת</td>
<td>מרק</td>
<td>trial – trail</td>
<td>BRODO</td>
<td>י_recommend</td>
</tr>
<tr>
<td>לון</td>
<td>קיאל</td>
<td>loin – lion</td>
<td>LADRO</td>
<td>ליוז</td>
</tr>
<tr>
<td>בו – בורד</td>
<td>בורדו</td>
<td>board – broad</td>
<td>OLIVE</td>
<td>אוליב</td>
</tr>
<tr>
<td>דס – דיל</td>
<td>דיל</td>
<td>flies – files</td>
<td>PINGO</td>
<td>פינגו</td>
</tr>
<tr>
<td>לשון</td>
<td>לוק</td>
<td>stake – skate</td>
<td>TIAKA</td>
<td>תיאק</td>
</tr>
<tr>
<td>מונ</td>
<td>מונ</td>
<td>could – cloud</td>
<td>TROT A</td>
<td>תרט</td>
</tr>
</tbody>
</table>

Migration in migratable and non migratable words from vs. frog

<table>
<thead>
<tr>
<th>% migrations in migratable words</th>
<th>% migrations in nonmigratable words</th>
</tr>
</thead>
<tbody>
<tr>
<td>migratable</td>
<td>nonmigratable</td>
</tr>
<tr>
<td>11.5%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

Example words:
- "dairy – dairy"
- "trial – trail"
- "loin – lion"
- "board – broad"
- "flies – files"
- "stake – skate"
- "could – cloud"
Examples for migratable words in French: From PARTONS TO PATRONS

<table>
<thead>
<tr>
<th>English</th>
<th>French</th>
</tr>
</thead>
<tbody>
<tr>
<td>patrie</td>
<td>partie</td>
</tr>
<tr>
<td>violent</td>
<td>violent</td>
</tr>
<tr>
<td>signe</td>
<td>singe</td>
</tr>
<tr>
<td>pilier</td>
<td>plier</td>
</tr>
<tr>
<td>frime</td>
<td>firme</td>
</tr>
<tr>
<td>cirer</td>
<td>crier</td>
</tr>
<tr>
<td>trier</td>
<td>tirer</td>
</tr>
</tbody>
</table>

What does it mean for diagnosis?

- Words for diagnosis should appear isolated and not in text

How can we rule out vision problems?

Test number reading
### Migrations in Words and Numbers

<table>
<thead>
<tr>
<th>χ²</th>
<th>Migrations in NUMBERS</th>
<th>Migrations in WORDS</th>
<th>LPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.93</td>
<td>2%</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>47.24</td>
<td>2%</td>
<td>43%</td>
<td></td>
</tr>
<tr>
<td>9.98</td>
<td>1%</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td>37.78</td>
<td>2%</td>
<td>37%</td>
<td></td>
</tr>
<tr>
<td>26.21</td>
<td>2%</td>
<td>28%</td>
<td></td>
</tr>
<tr>
<td>11.24</td>
<td>2%</td>
<td>16%</td>
<td></td>
</tr>
<tr>
<td>48.80</td>
<td>0%</td>
<td>39%</td>
<td></td>
</tr>
<tr>
<td>15.34</td>
<td>0%</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td>21.21</td>
<td>3%</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>0.24</td>
<td>12%</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>T = 0</td>
<td>3%</td>
<td>25%</td>
<td>average</td>
</tr>
</tbody>
</table>

### Comparing Various Treatment Directions for LPD

- Spacing between letters
- Each letter in a different color
- Sign between migratable letters
- Sign after 1st letter
- Finger tracking


General attention and LPD?
A dissociation between dyslexia and good attention: The types of dyslexia among individuals with intact attention and impaired reading (n=28)

<table>
<thead>
<tr>
<th>Dyslexia</th>
<th>Number of participants with intact attention who showed these dyslexias</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPD</td>
<td>5</td>
</tr>
<tr>
<td>LPD, attentional dyslexia</td>
<td>3</td>
</tr>
<tr>
<td>Phonological buffer dyslexia</td>
<td>1</td>
</tr>
</tbody>
</table>

21 individuals with letter position dyslexia, 13 with attentional dyslexia, 2 with neglect dyslexia, 12 with surface dyslexia, 11 with vowel dyslexia, 1 with phonological buffer dyslexia with good attention.

A dissociation between attention disorders and good reading: The various attention deficits among individuals with intact reading and impaired attention (n=27)

<table>
<thead>
<tr>
<th>Attention deficits</th>
<th>Number of participants with intact reading who showed these attention deficits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustained</td>
<td>5</td>
</tr>
<tr>
<td>Orienting</td>
<td>3</td>
</tr>
<tr>
<td>Executive</td>
<td>1</td>
</tr>
<tr>
<td>Selective</td>
<td>1</td>
</tr>
<tr>
<td>Sustained and Orienting</td>
<td>4</td>
</tr>
<tr>
<td>Sustained and Executive</td>
<td>4</td>
</tr>
<tr>
<td>Sustained and Selective</td>
<td>2</td>
</tr>
<tr>
<td>Orienting and Executive</td>
<td>2</td>
</tr>
<tr>
<td>Selective and Executive</td>
<td>1</td>
</tr>
<tr>
<td>Sustained, Orienting, and Executive</td>
<td>1</td>
</tr>
</tbody>
</table>
| Sustained, Selective, Orienting, and Executive | 2

Attentional dyslexia

Impaired letter position encoding:

Orthographic-visual analysis
- Letter identification
- Letter position
- Lexical search
- Semantic input lexicon
- Orthographic input lexicon
- Phonological output lexicon
- Phonemic output buffer
- Speech

Grapheme-phoneme conversion
- Conceptual system

Letter migrations between words:

GOAT COAL
GOAT  COAL  GOAT  COAT
Attentional dyslexia is a peripheral dyslexia, i.e., a dyslexia that results from a deficit at the early stage of orthographic-visual analysis. Attentional dyslexia is a deficit in letter-to-word binding, which results in migrations of letters between words.

**Significant lexical effect:**
Migrations occur when they create existing words.

**Implication for diagnosis:**
Use word pairs in which migrations create existing words:
- fend rond
- lame rime
- mont sent
- mûrs sers
- puis sois
- sait toit
- aide vise
- aire pile
- aire cime
- bons sois
- bout toit
- cape page
- dont mort

<table>
<thead>
<tr>
<th>Target</th>
<th>Reading Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANIE MARGE</td>
<td>MARIE MARGE</td>
</tr>
<tr>
<td>MANIE MARGE</td>
<td>MANIE MANGE</td>
</tr>
<tr>
<td>MANIE MARGE</td>
<td>MARIE MANGE</td>
</tr>
</tbody>
</table>

Migration of letters between words:

- MANIE MARGE MARGE MANIE MARGE MANIE MANGE MANIE MARGE MARIE MANGE
migrations preserve within-word position
most of the migrations (94%) preserve the relative position within the word

Not: bad cab

Two different functions:
- letter position encoding within words
- letter position encoding between words

In a study we are doing now, with 231 individuals with developmental dyslexia, 79 have letter position dyslexia without attentional dyslexia. 24 have attentional dyslexia without letter position dyslexia.

Implication for treatment: Once we know the dyslexia we can treat it.
Between-word migrations can occur without within-word migrations. The participants made significantly more between-word migrations than within-word migrations.

- Similarity: There was no significant difference between the error rates in word pairs of the same and of different lengths. When the words in the word pair differed only in one letter, this yielded the least errors. More than one non-shared letter yielded significantly more between-word errors.
- There was a significantly higher rate for between-word migrations in nonword pairs compared to word pairs (but no significant difference in the rate of other between-word errors).

**Treatment: reading window**

<table>
<thead>
<tr>
<th>Reading window</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>GY</td>
<td>50%</td>
</tr>
<tr>
<td>TW</td>
<td>35%</td>
</tr>
<tr>
<td>AV</td>
<td>40%</td>
</tr>
<tr>
<td>RA</td>
<td>25%</td>
</tr>
<tr>
<td>RR</td>
<td>30%</td>
</tr>
<tr>
<td>IF</td>
<td>35%</td>
</tr>
<tr>
<td>TA</td>
<td>40%</td>
</tr>
<tr>
<td>YA</td>
<td>20%</td>
</tr>
</tbody>
</table>


**Visual output dyslexia**


A deficit in all outputs of the visual analysis stage. As a result, individuals with visual dyslexia produce mainly visual errors in reading: letter omission, substitution, migration within and between words. For example, reading:

- read ➔ road / lead / red
- tale ➔ take / pale
- brother ➔ broth/ rather
- form ➔ from/ farm/ fork
Neglect dyslexia
• at the word level
• at the sentence and text level

word-based neglexia


single word reading

Neglect of left (final) letters: 21(!) children with neglexia

<table>
<thead>
<tr>
<th>Participant</th>
<th>% correct reading words</th>
<th>Left letter substitution</th>
<th>Left letter omission</th>
</tr>
</thead>
<tbody>
<tr>
<td>NT</td>
<td>42%</td>
<td>55%</td>
<td>40%</td>
</tr>
<tr>
<td>IZ</td>
<td>32%</td>
<td>42%</td>
<td>53%</td>
</tr>
<tr>
<td>ID</td>
<td>30%</td>
<td>57%</td>
<td>43%</td>
</tr>
<tr>
<td>VL</td>
<td>71%</td>
<td>55%</td>
<td>36%</td>
</tr>
<tr>
<td>SP</td>
<td>8%</td>
<td>2%</td>
<td>9%</td>
</tr>
<tr>
<td>SS</td>
<td>54%</td>
<td>33%</td>
<td>58%</td>
</tr>
<tr>
<td>AR</td>
<td>58%</td>
<td>56%</td>
<td>23%</td>
</tr>
<tr>
<td>ST</td>
<td>63%</td>
<td>30%</td>
<td>70%</td>
</tr>
<tr>
<td>DN</td>
<td>59%</td>
<td>27%</td>
<td>41%</td>
</tr>
<tr>
<td>AB</td>
<td>48%</td>
<td>39%</td>
<td>44%</td>
</tr>
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<td>TM</td>
<td>28%</td>
<td>24%</td>
<td>71%</td>
</tr>
<tr>
<td>AO</td>
<td>41%</td>
<td>42%</td>
<td>33%</td>
</tr>
<tr>
<td>DR</td>
<td>21%</td>
<td>21%</td>
<td>78%</td>
</tr>
<tr>
<td>AD</td>
<td>37%</td>
<td>30%</td>
<td>46%</td>
</tr>
<tr>
<td>NO</td>
<td>57%</td>
<td>36%</td>
<td>46%</td>
</tr>
<tr>
<td>UR</td>
<td>36%</td>
<td>57%</td>
<td>11%</td>
</tr>
<tr>
<td>OM</td>
<td>54%</td>
<td>53%</td>
<td>17%</td>
</tr>
<tr>
<td>Average</td>
<td>43%</td>
<td>39%</td>
<td>46%</td>
</tr>
</tbody>
</table>
Reading characteristics in various tasks

<table>
<thead>
<tr>
<th>Participant</th>
<th>Word reading</th>
<th>Left letter substitution</th>
<th>Left letter omission</th>
<th>Letter-by-letter reading</th>
<th>Nonword reading</th>
<th>Vertical presentation</th>
<th>Synthesis</th>
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<tbody>
<tr>
<td>NT</td>
<td>(22%) 36.6%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>LZ</td>
<td>(12%) 62.0%</td>
<td>40%</td>
<td>40%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>JD</td>
<td>(35%) 85.9%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>VL</td>
<td>(15%) 75.0%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>SP</td>
<td>(14%) 65.4%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>SS</td>
<td>(15%) 78.4%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>AR</td>
<td>(35%) 90.6%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>ST</td>
<td>(35%) 85.9%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>DN</td>
<td>(15%) 75.0%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>AB</td>
<td>(14%) 65.4%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>TM</td>
<td>(22%) 45.6%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>AO</td>
<td>(45%) 94.5%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>LR</td>
<td>(35%) 85.9%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>AD</td>
<td>(15%) 75.0%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>NO</td>
<td>(15%) 75.0%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>LA</td>
<td>(15%) 75.0%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>OM</td>
<td>(15%) 75.0%</td>
<td>55%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>Average</td>
<td>43%</td>
<td>39%</td>
<td>46%</td>
<td>88%</td>
<td>54%</td>
<td>59%</td>
<td>62%</td>
</tr>
</tbody>
</table>

Text-based Neglexia and syntactic structure


The research question

Does syntactic structure modulate reading in text-based neglexia?
Namely…

Patients with text-based neglexia tend to omit optional elements but not obligatory elements that are required by the syntactic structure or by the lexical-syntactic requirements of the verbs.

Syntactic structure modulates reading in text neglexia.

Reading comprehension in dyslexias of the visual analysis stage

Impaired.

Impaired lexical route: surface dyslexia
Kan yu reed watts riten hir in thi prezentaishn?

Slow reading

Inaccurate reading of words that cannot be unambiguously converted from letters to sound “irregular words”

Impaired comprehension of homophones (depending on the type of surface dyslexia) (Write-right)

Surface dyslexia in English

**READING ALOUD**

% errors due to non-lexical reading

<table>
<thead>
<tr>
<th>Participant</th>
<th>% errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>SH</td>
<td>35</td>
</tr>
<tr>
<td>GL</td>
<td>38</td>
</tr>
<tr>
<td>OF</td>
<td>25</td>
</tr>
<tr>
<td>YR</td>
<td>52</td>
</tr>
<tr>
<td>TM</td>
<td>49</td>
</tr>
<tr>
<td>NT</td>
<td>51</td>
</tr>
<tr>
<td>OM</td>
<td>35</td>
</tr>
<tr>
<td>BZ</td>
<td>23</td>
</tr>
<tr>
<td>AS</td>
<td>26</td>
</tr>
<tr>
<td>OS</td>
<td>44</td>
</tr>
<tr>
<td>AK</td>
<td>22</td>
</tr>
<tr>
<td>AM</td>
<td>33</td>
</tr>
<tr>
<td>AL</td>
<td>20</td>
</tr>
<tr>
<td>KR</td>
<td>24</td>
</tr>
<tr>
<td>NF</td>
<td>33</td>
</tr>
<tr>
<td>IR</td>
<td>14</td>
</tr>
<tr>
<td>YD</td>
<td>12</td>
</tr>
<tr>
<td>control</td>
<td>1-5%</td>
</tr>
</tbody>
</table>
An important predictor to whether there was an error in reading the words aloud: whether they had a potentiophone

**Potentiophones**
- now-know
- come-comb
- resent-recent
- bear-beer
- angle-angel
- talk-talc
- whose-hose

All surface dyslexics had more errors when reading via grapheme-phoneme conversion created a word. Some ONLY made errors in such words

A new study with 94 surface dyslexics

**Implication for diagnosis**

Present irregular words that are potentiophones Namely, that create other words
Where exactly is the deficit in surface dyslexia?

Subtypes of surface dyslexia

Predictions for the different subtypes

- Reading aloud via grapheme-to-phoneme-conversion
- All subtypes will show impaired reading aloud
  - impaired reading of irregular words, regularization errors.
  - Errors in underspecified phonemic features: stress position etc.

Predictions for the different subtypes

**Impaired Orthographic Lexicon SD**

- Poor lexical decision (leksikal)
- Impaired homophone comprehension (which-witch)
Predictions for the different subtypes

**Orthographic Lexicon output SD**
- Good lexical decision (leksikal)
- Impaired homophone comprehension (which-witch)

**Interlexical SD** (impaired connection between lexicons)
- Good lexical decision (leksikal)
- Good homophone comprehension (which-witch)

**SD in the phonological lexicon**
- Good lexical decision (leksikal)
- Good homophone comprehension (which-witch)
- Poor picture naming

**TASKS**
- Reading aloud
- Lexical decision
- Homophone comprehension

Do they read via grapheme-to phoneme conversion?
Can they recognize a word in the lexicon?
Can they access semantics from the lexicon?
Clinical implications

Surface dyslexia:
All impaired in reading aloud (irregular, potentiophones)

- Impaired orthographic lexicon – work on the lexicon.

- Good orthographic lexicon and good access to semantics – good comprehension when not reading aloud – clinician should recommend: Try to understand, do not read aloud!

Impaired sublexical route: phonological dyslexia
Phonological dyslexics cannot read nonwords or new words.

Learning to read in a new language

Good word reading

- book ✔
- walk ✔
- read ✔
- door ✔
- taxi ✔
- stomach ✔

Impaired reading of nonwords

- BOG X
- DANO X
- FIGE X
- BACHA X
- DOL X
- BER X
- PARID X
### Stimulus type most appropriate for detecting phonological dyslexia?

- nonwords.

### Types of phonological dyslexia

- Impaired letter-phoneme conversion
- Impaired multi-letter conversion *(ch, sh, made)*
- Impaired conversion selective to a specific feature
- Impaired phonological output buffer

**Impairment even in single letters**

- ch, sh,
- made
- -ons
- gn
**Types of phonological dyslexia**

- Impaired conversion selective to a specific feature
  - PACK-BAG
  - GOAT- COAT
  - TOWN- DOWN


- Impaired conversion selective to a specific feature
  - BAD-MAD
  - NOT-DOT

  *Dyscravia: Voicing substitution dysgraphia.*

  *Dyslexia in vowel letters (DIVL). Language and Brain, 10, 65-106.*

- Impaired conversion selective to a specific feature
  - BOAT- bat, bit, bate, bet
  - FORM- farm, from, frame, forum

  *Vowel letter dyslexia*
Errors almost exclusively in vowel letters

<table>
<thead>
<tr>
<th>Target</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>stremba</td>
<td>stra, strambas</td>
</tr>
<tr>
<td>gupico</td>
<td>gu, gu, +</td>
</tr>
<tr>
<td>nemmeno</td>
<td>nema, +</td>
</tr>
<tr>
<td>comango</td>
<td>comaga, comanga, +</td>
</tr>
<tr>
<td>zura</td>
<td>zu, zu, +</td>
</tr>
<tr>
<td>sfogo</td>
<td>sfago</td>
</tr>
<tr>
<td>lirica</td>
<td>liri, +</td>
</tr>
<tr>
<td>peravotto</td>
<td>peravatto...+</td>
</tr>
<tr>
<td>anagrafe</td>
<td>ano, anagràfe</td>
</tr>
<tr>
<td>cortile</td>
<td>cort, +</td>
</tr>
<tr>
<td>limite</td>
<td>li, +</td>
</tr>
<tr>
<td>debito</td>
<td>debi, +</td>
</tr>
<tr>
<td>fosforo</td>
<td>fo, fo, +</td>
</tr>
<tr>
<td>mensile</td>
<td>mansile, +</td>
</tr>
<tr>
<td>mentolo</td>
<td>mentola</td>
</tr>
<tr>
<td>porcile</td>
<td>por-ci, +</td>
</tr>
<tr>
<td>corsaro</td>
<td>cor, +</td>
</tr>
<tr>
<td>bibita</td>
<td>bibite, +</td>
</tr>
</tbody>
</table>

Vowel error distribution

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Migration</th>
<th>Addition</th>
<th>Omission</th>
<th>Substitution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vowel</td>
<td>11.2%</td>
<td>6.3%</td>
<td>2.2%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

Written word

Orthographic-visual analysis
- Letter identification
- Letter position
- Letter-to-word binding

Semantics

Orthographic input lexicon

Phonological output lexicon

Phonemic output buffer

Grapheme-phoneme conversion

Speech
Implication for the model: modification needed

Types of phonological dyslexia

Impaired phonological output buffer

- Impaired reading of nonwords
- Impaired reading of morphologically complex words
- Impaired reading of multi-digit numbers
- Impaired repetition of the same items.

Impaired access to semantics: “direct dyslexia”
Deep dyslexia

Impaired sublexical route and interlexical disconnection: deep dyslexia

Orthographic input lexicon

Phonological output lexicon

Grapheme-phoneme conversion

Speech buffer

Conceptual system

Semantic lexicon

Orthographic input lexicon

Phonological output lexicon

Phonemic buffer

Semantic errors

gift    present
round   circle
style   dress
happy   smile
sorry   sad
of      I don’t know...
because for
jacket  jeans
Palestinian Arabic differs substantially in lexical items and syntax from Standard Arabic.

Standard Arabic serves as the written language.

Standard Arabic "is nobody's mother tongue". It is mainly learned through schooling and used exclusively for official, academic, or formal functions.

What is to be expected if such reading via semantics is employed?


SU is 16 years old female, 10th grader, a native speaker of Palestinian Arabic, with Hebrew and Standard Arabic as a second language. Studies in an Arabic-speaking school.

"classic" semantic errors

Blackboard → eraser
Blind → eye
Port → water
Driver → taxi

she often read the Palestinian Arabic counterpart of the target

Doctor → طبيب
Eye → عين
Port → ميناء
Driver → سائق
we presented FA with a list of words in Standard Arabic that have common synonyms in Palestinian Arabic or in Hebrew. FA could not read correctly even a single word from this list.

FA read دار, DAR ‘house’ in SA, as “bet”, house in PA,

he read هاتف HATF ‘phone’ in SA as “telefun”

---

**Dyslexias – summary**

- 19 types of dyslexia exist, each resulting from a different deficit in the reading model.
- Each dyslexia affects different word types, and causes different error types, and hence – requires different diagnosis.
- To diagnose different dyslexias, one has to use the appropriate stimuli: migratable words (form) for LPD, migratable word pairs (goat coal), irregular words (walk) for surface dyslexia, nonwords for phonological dyslexia, etc.
- Directions for treatment depending on the dyslexia–reading window, finger tracing, silent reading etc.
- Fruitful interaction between the cognitive model and dyslexias: predictions and modifications.

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**Thank you!**

**merci!**