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Nadine.gaab@childrens.harvard.edu
The typical and atypical reading brain:

How a neurobiological framework of reading development can inform educational and practice and policy

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Developmental Medicine Center
Laboratories of Cognitive Neuroscience

www.gaablab.com
Twitter: @Gaablab
Overview

- Typical and atypical reading development and its neurobiology
- The ‘Dyslexia Paradox’
- Early pre-markers of reading difficulties before reading onset
- Compensatory mechanism and protective factors in dyslexia
- Detecting children at risk for reading difficulties in infancy?
- Early screening for reading disabilities: Why, When, Whom, How?
- Educational and Clinical Implications
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Timeline of typical reading development

- **Learning to read**
  - Sound and Language Processing
  - Phonological/Phonemic Awareness
  - Letter Recognition
  - Grapheme-phoneme Mapping
  - Reading of single words
  - Reading sentences and connected text

- **Reading to learn**
  - Reading complex text
  - Reading Fluency
  - Reading Comprehension
The Many Strands that are Woven into Skilled Reading
(Scarborough, 2001)

LANGUAGE COMPREHENSION

BACKGROUND KNOWLEDGE
(facts, concepts, etc.)

VOCABULARY
(breadth, precision, links, etc.)

LANGUAGE STRUCTURES
(syntax, semantics, etc.)

VERBAL REASONING
(inference, metaphor, etc.)

LITERACY KNOWLEDGE
(print concepts, genres, etc.)

SKILLED READING:
Fluent execution and
coordination of word
recognition and text
comprehension.

WORD RECOGNITION

PHONOLOGICAL AWARENESS
(syllables, phonemes, etc.)

DECODING (alphabetic principle,
spelling-sound correspondences)

SIGHT RECOGNITION
(of familiar words)

increasingly strategic

increasingly automatic
Children with learning disabilities are less likely to complete high school or pursue higher education, and are at an increased risk of entering the juvenile justice system.

The vast majority of working-age adults with learning disabilities - 92 percent - had annual incomes of less than $50,000 within eight years of leaving high school. Sixty-seven percent earned $25,000 or less.

In the U.K., the annual cost of dyslexia has been estimated as high as 1.6 billion pounds.

---

7. KPMG foundation Annual Report 2006
Percentage of below average readers in 1st grade who were below average readers in 8th grade.

(Landerl & Wimmer, 2008)
How does Reading Improve Learning?

What are the literacy experiences for poor readers?

(Biemiller, 2005; Moats, 2001)
“Importantly, the present results suggest that it is the children’s reading ability that determines how much they choose to read, rather than vice versa”
The Matthew Effect

Students at 90th percentile may read as many words in three days as a child at the 10th percentile reads in an entire year outside of school (Anderson et al., 1988)

(Cain & Oakhill, 2011; Wigfield & Guthrie, 1997)
Factors contributing to atypical reading development

- Genetics
- Brain
- Perception & Cognition
- Environment

Atypical Reading Development
What is Developmental Dyslexia?

- Affects 10-12% of children.

- Specific learning disability with a neurobiological origin characterized by
  - difficulties with accurate and/or fluent word recognition
  - poor spelling and decoding abilities

- Cannot be explained by poor vision or hearing, lack of motivation or educational opportunities.

International Dyslexia Association, 2002
Reading Disability

Dyslexia

Reading difficulty as a result of environmental circumstances etc.
Studies of families with DD suggest that DD is strongly heritable, occurring in up to 68% of identical twins and up to 50% of individuals who have a first degree relative with DD [Finucci et al., 1984; Volger et al., 1985; Grigorenko, 2008].

Several genes (e.g.; ROBO1, DCDC2, DYX1C1, KIAA0319) have been reported to be candidates for dyslexia susceptibility and it has been suggested that the majority of these genes plays a role in early brain development. [e.g.; Galaburda et al., 2006; Hannula-Jouppi et al., 2005; Meng et al., 2005; Skiba et al., 2011].
“Children are wired for sound, but print is an optional accessory that must be painstakingly bolted on.” Steven Pinker, Ph.D

[in McGuinness D: Why Our Children Can't Read, and what We Can Do about it: A Scientific Revolution in Reading: Simon and Schuster; 1997 p. ix-x].
The typical reading network with its key components

The old neurological model of reading
(After Déjerine, 1892; Geschwind, 1985)

A modern vision of the cortical networks for reading

Access to pronunciation and articulation

Top-down attention and serial reading

Access to meaning

Visual word form area (« the brain's letterbox »)

[Dehaene, 2009]
The typical reading network with its key components

- Left Superior Longitudinal Fasciculus
- Left Arcuate Fasciculus
- Left Inferior Frontal-Occipital Fasciculus
- Left Inferior Longitudinal Fasciculus

Ozernov-Palchik et al; 2016
Structural and functional brain alterations in DD

[e.g. see Meta-analyses: Richlan et al., 2011, 2013; Linkerdoerfer et al., 2012, Martin et al., 20015]
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The Dyslexia Paradox ("the wait to fail approach")

Dyslexia is generally diagnosed after the most effective intervention window
Early versus late intervention

- A meta-analysis comparing intervention studies offering at least 100 sessions, reported larger effect sizes in kindergarten/1st grade than in 2nd and 3rd grades (Wanzek & Vaughn, 2007; Wanzek et al., 2013).

- When “at risk” beginning readers receive intensive instruction, 56% to 92% of at-risk children across six studies reached the range of average reading ability (Torgesen, 2004).

- Overall, converging research points to the importance of early and individualized interventions for at-risk students for improving the effectiveness of remediation (Connor et al., 2013; Catts, et al., 2015; Denton & Vaughn, 2008; Connor et al., 2009; Shaywitz, Morris, & Shaywitz, 2008, Torgesen, et al., 1999; Flynn, Zheng, & Swanson, 2012; Vellutino et al., 1996; Morris, Lovett, Wolf et al., 2012; Morris et al., 1997).
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Early behavioral predictors of dyslexia

Key childhood predictors of reading problems (e.g., Elbro et al., 1998; Scarborough, 1998, O’Connor & Jenkins, 1999; Lyytinen et al., 2001; Catts et al., 2001, 2015; Schatschneider et al., 2004, Pennington et al., 2001; Compton et al., 2006; Stanley et al., 2018):

- Phonological awareness
- Pseudoword repetition
- Rapid automatized naming
- Expressive/receptive vocabulary
- Letter (sound) knowledge
- Home literacy environment

Puolakanaho et al., 2007 showed that familial risk, letter knowledge, phonological awareness and rapid automatized naming at 3.5 years predicted later DD. Additionally, those children who later developed DD, exhibited auditory and speech processing deficits at a very early age.
The Boston Longitudinal Dyslexia Study (BOLD)

Early Identification
children at-risk

Kindergarten

3rd grade

Middle School

- Functional MRI
- Structural MRI
- Behavioral tests
- Psychophysics
- Questionnaires
- DNA

‘Diagnosis’
Dyslexia/
Reading difficulty

Follow up:
- prior to first grade
- prior to second grade
- prior to third grade

- Pre-readers (Word ID <5), reading instruction within next year.

- 165 children are enrolled longitudinally
Control task:
Voice matching
[Raschle et al., 2009; Raschle et al., 2012]
<table>
<thead>
<tr>
<th>YEAR 1</th>
<th>YEAR 2</th>
<th>YEAR 3/4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Significant differences in:</strong></td>
<td><strong>Significant differences in:</strong></td>
<td><strong>Significant differences in:</strong></td>
</tr>
<tr>
<td>Expressive and receptive language/content</td>
<td>Expressive language/language content</td>
<td>Core and receptive Language</td>
</tr>
<tr>
<td>Phonological awareness</td>
<td>Phonological awareness</td>
<td>Rapid automatized naming</td>
</tr>
<tr>
<td>Rapid automatized naming</td>
<td>Letter knowledge</td>
<td>Rapid automatized naming</td>
</tr>
<tr>
<td></td>
<td>Single word reading (timed/untimed)</td>
<td>Single word reading (timed/untimed)</td>
</tr>
<tr>
<td></td>
<td>Passage comprehension</td>
<td>Passage comprehension</td>
</tr>
<tr>
<td></td>
<td>Spelling</td>
<td>Spelling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reading Fluency</td>
</tr>
</tbody>
</table>

No differences in IQ, age, Home Literacy, SES

_all p<0.05_
Functional characteristics of developmental dyslexia in left-hemispheric posterior brain regions predate reading onset

Nora Maria Raschle\textsuperscript{a,b}, Jennifer Zuk\textsuperscript{a}, and Nadine Gaab\textsuperscript{a,b,c,1}

\[ \text{FSM} > \text{VM} \]

(a) FHD+ \[ z=-14 \]

(b) FHD- \[ z=-8 \]

(c) \( P < 0.005 \), \( k = 50 \), FHD- > FHD+

[\textit{Raschle et al., PNAS 2012}]
Structural brain alterations associated with dyslexia predate reading onset

Nora Maria Raschle, Maria Chang, Nadine Gaab *

[Image of brain scans with labels LTP, RTP, LOT, LFG, RLG, with coordinates X, Y, Z]

Rapid automatized naming

GM volume indices for left temporoparietal (LTP) region of interest

GM volume indices for left occipitotemporal/fusiform (LTO/LFG) region of interest

[Graphs showing correlation between naming scores and brain volume indices]

[Raschle et al., Neuroimage 2010]
Sulcal pattern (global pattern of arrangement, number and size of sulcal segments) has been hypothesized to relate to optimal organization of cortical function and white matter connectivity (Van Essen, 1997; Klyachko and Stevens, 2003; O’Leary et al., 2007; Fischl et al., 2008).

Individuals with DD may undergo atypical sulcal development. Moreover, global sulcal pattern is determined during prenatal development and may therefore better reflect genetic brain development (Rakic, 2004; Kostovic and Vasung, 2009).
Four groups:
1. Beginning readers FHD-
2. Beginning readers FHD+
3. Developmental Dyslexia
4. Typical developing children

- The pattern of sulcal basin area in the left parieto-temporal and occipito-temporal regions was significantly atypical in children with DD compared to controls.

- Significantly atypical sulcal area pattern was also confirmed in kindergarteners with a familial risk of DD compared to controls.

Im et al., in 2015
Development of Tract-Specific White Matter Pathways During Early Reading Development in At-Risk Children and Typical Controls

Yingying Wang¹,²,³, Meaghan V. Mauer¹, Talia Raney¹, Barbara Peysakhovich¹, Bryce L. C. Becker¹, Danielle D. Sliva¹ and Nadine Gaab¹,²,⁴

- 78 healthy, native English-speaking children (45 FHD+, 33 FHD-)

- Among them, 45 children (23 FHD+ and 22 FHD-) had at least two scans and composed a longitudinal cohort.

- Three time points: re-reading, beginning reading, fluent reading

[Wang et al., 2016]
Cross-sectional results (n = 78): Arcuate Faciculus

[Image of graphs showing Fractional Anisotropy (F) in different brain regions for pre-readers, beginning readers, and fluent readers.]

[Text references to [Wang et al., 2016]]
Longitudinal Analysis: Development rate of the AF (n=45)

Wang et al., 2016
The READ Study
(Researching Early Attributes of Dyslexia)


- Invited children with and without risk for dyslexia to participate in a follow-up study including brain imaging with MRI and EEG (n =180 for EEG and n=160 for MRI).

- Following these children to see which measures from kindergarten best predict reading ability at the end of 1st and 2nd grade.
READ at a Glance

• 21 schools: inner-city charter schools, private, suburban district-run schools, and Archdiocese schools
• Free/reduced lunch eligibility from 0% to 80%
• Ethnically diverse student population (49% minority)
• Teacher professional developments and parent presentations conducted in all schools
• Brain awareness days conducted in various schools

“We very much enjoyed everything you and your staff provided. You are warm and professional and certainly put your subjects at ease...It’s exciting to see such cutting-edge research from the inside out!” (Parent, Wheeler School)

“...They were excellent presenters. The students had a wonderful time and were very engaged in the activities.” (Teacher, Lowell Elementary)

“Your whole team was terrific in making the afternoons lots of fun and educational” (Parent, Hosmer Elementary)
Six Distinct Cognitive Profiles of Early Reading

Ozernov-Palchik et al., 2016

Latent Profile analysis model for the Identification of Reading Subgroups:
PA-phonological awareness, WM-working memory, RAN-rapid automatized naming,
LSK-letter sound knowledge [n = 1,215 children].

Variables Related to Reading

Z-Score Performance Across Measures

Class 1: Average, Class 2: Low-average, Class 3: High, Class 4: DD risk, Class 5: RAN risk, Class 6: PA risk
Tracking the Roots of Reading Ability: White Matter Volume and Integrity Correlate with Phonological Awareness in Prereading and Early-Reading Kindergarten Children

Zeynep M. Saygin,1* Elizabeth S. Norton,1* David E. Osher,1 Sara D. Beach,1 Abigail B. Cyr,1 Ola Ozernov-Palchik,3 Anastasia Yendiki,4 Bruce Fischl,2,4 Nadine Gaab,3 and John D.E. Gabrieli1

The Journal of Neuroscience, August 14, 2013 • 33(33):13251–13258 • 13251

![Graph showing correlation between volume (mm³) and Blending Words Raw Score.](image)

\[ r = 0.38, P = 0.015 \]
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Compensatory mechanisms, resiliency and protective factors

Not all children with early risk for reading difficulties subsequently become poor readers (e.g., Regtvoort et al., 2006; Compton, 2006; Leppanen et al., 2011).

Several protective factors proposed:

→ Vocabulary knowledge (e.g., Hulme et al., 2015)
→ Articulation accuracy (e.g., Carroll, Mundy & Cunningham, 2014)
→ Nonverbal cognitive abilities (e.g., Torppa et al., 2010)
Compensatory mechanisms, resiliency and protective factors

- What is the brain basis of compensation or resilience?
  - Typical development?
  - Alternative pathway(s)?

Who does compensate and how?
Brain measures predicted with 92% accuracy which individual children improved and which individual children did not improve 2.5 years later.
Of 21 FHD+ children, 11 developed into good readers, while 10 FHD+ developed into poor readers. The subsequent good readers show significant higher FA development rates in right SLF (p = 0.01).
Control task: Voice matching
Slides with preliminary results removed
Variant functions in dyslexia-susceptibility genes

Subtle cortical and white matter malformations during early brain development, including the corpus callosum

Positive Environmental influences (e.g., home literacy environment; socio-economic status; instructional approach)

Development of a larger corpus callosum

Neural alterations in the left-hemispheric reading network

Enhanced inter-hemispheric connectivity and right-hemispheric activation

Neural alterations in the left-hemispheric reading network/reduced left-lateralization

Poor Reading outcomes among children with familial risk for dyslexia Good

[Yu et al., in press]
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Investigating 4-12 months old infants with and without a family history of dyslexia

To date:
n= 126 (74 FHD-/52 FHD+)
(n= 25 parents)
Protocol:
T1 MPRAGE
Resting state
DTI
FMRI (passive speech)
MRS

[Methods: Raschle et al., 2012]
Dhaka, Bangladesh: First non-sedated infant research MRI
White Matter Alterations in Infants at Risk for Developmental Dyslexia

Nicolas Langer¹,³,†, Barbara Peysakhovich¹,†, Jennifer Zuk¹,³, Marie Drottar², Danielle D. Sliva¹,², Sara Smith¹, Bryce L. C. Becker¹, P. Ellen Grant²,³ and Nadine Gaab¹,³,⁴

FHD+ infants exhibit significantly lower FA values compared to FHD- infants in red regions (all \( p < 0.02 \), controlled for multiple comparisons)

Multivariate pattern analysis (MVPA):
MVPA (using FA at each node of the left AF as input) was performed to determine whether FA can distinguish FHD+ and FHD- infants

- 82% prediction accuracy (\( p = 0.001 \))
Slides with preliminary results removed
Atypical development of AF from infancy to late elementary school

Infants

Pre-readers (A)

Beginning readers (B)

Fluent readers (C)
Slides with preliminary results removed
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Solving the Dyslexia Paradox

Replacing “the wait to fail approach” with a support model

Comprehensive early risk screening and evidence-based response to screening (within general education)

Lower rates of dyslexia/reading disability diagnoses and improved reading outcome in children with a diagnosis
**Recommended Screening Battery**

<table>
<thead>
<tr>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phonological awareness</td>
</tr>
<tr>
<td>Phonological short-term memory</td>
</tr>
<tr>
<td>Rapid automatized naming</td>
</tr>
<tr>
<td>Letter (sound) knowledge</td>
</tr>
<tr>
<td>Vocabulary</td>
</tr>
<tr>
<td>Oral listening comprehension</td>
</tr>
<tr>
<td>Family history</td>
</tr>
<tr>
<td>[Socio-economic status]</td>
</tr>
</tbody>
</table>

**Warning:** None of it will matter if the intervention does not target the deficit with evidence-based instruction specific to the deficit identified.
Many ‘paper-pencil’ screening tools currently exist...

<table>
<thead>
<tr>
<th>Measure</th>
<th>Peer-reviewed</th>
<th>Admin Time</th>
<th>Grades</th>
<th>Skills Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aimsweb Test of Early Literacy</td>
<td>N</td>
<td>4 min</td>
<td>pK</td>
<td>YES</td>
</tr>
<tr>
<td>Basic Reading Inventory (BRI)</td>
<td>N</td>
<td>20 min</td>
<td>K</td>
<td>YES</td>
</tr>
<tr>
<td>Dynamic Indicators of Basic Early Literacy</td>
<td>Y</td>
<td>2-6 min</td>
<td>K</td>
<td>YES</td>
</tr>
<tr>
<td>Dyslexia Quest</td>
<td>N</td>
<td>20 min</td>
<td>1</td>
<td>YES</td>
</tr>
<tr>
<td>Early Reading Assessment</td>
<td>N</td>
<td>10-15 min</td>
<td>2</td>
<td>YES</td>
</tr>
<tr>
<td>Florida Assessments for Instruction in</td>
<td>Y</td>
<td>15 min</td>
<td>3</td>
<td>YES</td>
</tr>
<tr>
<td>Reading (FAIR)</td>
<td>N</td>
<td>5-10 min</td>
<td>PA</td>
<td>YES</td>
</tr>
<tr>
<td>International Dyslexia Association (IDA)</td>
<td>N</td>
<td>2-3 min</td>
<td>Phonics</td>
<td>YES</td>
</tr>
<tr>
<td>Dyslexia Screener</td>
<td>N</td>
<td>&lt;40 min</td>
<td>Fluency</td>
<td>YES</td>
</tr>
<tr>
<td>Learning Ally Dyslexia Screener</td>
<td>N</td>
<td>&lt;5 min</td>
<td>Vocab</td>
<td>YES</td>
</tr>
<tr>
<td>Lexercise Dyslexia Test</td>
<td>N</td>
<td>&lt;10 min</td>
<td>Comp</td>
<td>YES</td>
</tr>
<tr>
<td>Lexia RAPID Assessment</td>
<td>N</td>
<td>16-45 min</td>
<td>RAN</td>
<td>YES</td>
</tr>
<tr>
<td>Measures of Academic Progress (MAP)-</td>
<td>Y</td>
<td>&lt;30 min</td>
<td>Ortho</td>
<td>YES</td>
</tr>
<tr>
<td>Growth K-2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shaywitz Dyslexia Screen</td>
<td>N</td>
<td>5 min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texas Primary Reading Inventory (TPRI)</td>
<td>Y</td>
<td>20 min</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ILLUSTRATIVE, NOT EXHAUSTIVE**

Current screeners may or may not be evidence based, are often not comprehensive screeners, and do not connect to personalized interventions.
What should early screening look like?

We recommend eight key characteristics when determining an optimal screening battery for an individual classroom, school, or district. The first letters of these characteristics spell the acronym SCREENED.

- **S**hort
- **C**omprehensive
- **R**esourceful
- **E**arly
- **E**SL/Dialect Inclusion
- **N**eurobiology/Genetics
- **E**vidence-based response to screening
- **D**evelopmentally appropriate

Gaab, 2017 (IDA, Examiner)
How should we screen?

- Integrating existing predictive dyslexia assessments into a mobile platform

- Screening for early indicators of reading impairments in children as young as four years of age providing the opportunity to intervene during a period of increased brain plasticity.

- The App will offer a list of resources if a risk is detected. It will further link to resources that offer teaching solutions and list intervention programs for teachers, parents and other professionals to address the instructional needs of children at-risk (evidence-based response to screening).
Slides with preliminary results removed
Where should we screen?

- Pediatrician’s offices (e.g. at 4 or 5 year well visit)
- Children’s homes
- Preschools/Day Cares
- Pre-kindergarten info sessions
- Summer Camps
- Children’s Museum
- Speech and Language Therapy/Occupational Therapy sessions
- Libraries
- Etc.
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Variant function in any number of **Generalist genes**, such as COMT, VAL/MEL, FOXP2

**Dyslexia susceptibility genes**, such as ROBO1, DCDC2, DYX1C1, KIAA0319

- Atypical neuronal migration, and/or synaptic/cell development
- Atypical axonal growth, glutamatergic transmission, subcortical malformations, atypical sulcal pattern, atypical neural response characteristics, and/or neurometabolites Cho and Glu

- Atypical development of cortical thickness, myelination, functional activity pattern, and/or functional connectivity

- Atypical development of structural and functional connectivity of the reading circuitry

**Complex interactions among different levels**

**Environmental factors**

**Perceptual Cognitive level**

**Brain level**

**Protective factors and compensatory mechanisms in typical readers with familial risks**

- Protective environmental variables (e.g., home literacy, teaching efficiency etc.)
- Protective cognitive abilities (e.g., high IQ, high vocabulary etc.)

- Compensatory neural mechanisms (e.g., increased involvement of the right hemisphere)

- Ineffective schooling, limited instructional resources, and/or insufficient involvement of parents

**Low home literacy, low parental educational background and socioeconomic status, adverse neighborhood characteristics, and/or cultural influences**

**Atypical sensorimotor (vision and hearing) and/or perceptual functions**

**Atypical development of language and/or attention functions**

**Perceptual/Cognitive Level**

**Birth**

**Environmental Factor**

**Prenatal**

**Postnatal**

Ozernov-Palchik et al., 2016
(A) Gray matter (volumetric analyses)
- Left Inferior Frontal Gyrus
- Left Precuneus
- Left Parieto-Temporal Area
- Left Occipito-Temporal Area
- Left Planum Temporale
- Left/Right Fusiform Gyrus

(B) Gray matter (functional analyses)
Dys < Control
- Left Inferior Frontal Gyrus
- Left Parieto-Temporal Area
- Left Occipito-Temporal Area

Dys > Control
- Left Precentral Gyrus
- Right Inferior Frontal Gyrus

(C) White matter
- Left Superior Longitudinal Fasciculus
- Left Arcuate Fasciculus
- Left Inferior Frontal-Occipital Fasciculus
- Left Inferior Longitudinal Fasciculus
- Corpus Callosum
  (forceps minor - genu and major - splenium)

(D) Sulcal pattern
- Left Parieto-Temporal and Occipito-Temporal Areas
Educational and clinical implications

- Early identification may reduce the clinical, psychological and social implications of DD.

- Understanding the complex etiology of specific learning disabilities and their co-occurrences will be essential to underpin the training of educators and clinicians, so that they can reliably recognize and optimize the learning contexts for each learner → personalized education (Butterworth & Kovas, 2013)

- Development and implementation of early and customized remediation programs (who should get which intervention) → Subtyping and early customized remediation; optimal intervention window

- Informing (early) diagnostic guidelines

- Changes in educational policies (early IEPs; design and implementation of customized curriculums for children at-risk)?

- Evaluation and improvement of existing remediation programs will likely prove cost-efficient as programs are made more effective.

- Improved psycho-social development (reduced child stress, parental stress, improved overall family dynamic).
ASK YOUR STATE LEGISLATORS TO ACTIVELY SUPPORT
2017 MA DYSLEXIA SCREENING LEGISLATION
H.330 - H.2872 - S.313 - S.294

1. THE SCIENTIFIC DEFINITION OF DYSLEXIA; Accepted by the National Institute of Health (NIH)

2. EARLY SCREENING STARTING NO LATER THAN AGE 5;
   Including the key indicators predicting students at risk for dyslexia
   A. Phonemic Awareness (PA)
   B. Rapid Automatized Naming (RAN)
   C. Letter Sound Knowledge (LSK)
   Leading to Evidence-based Reading Instruction Specific to Dyslexia

3. A Task Force or Committee of Dyslexia Statewide Guidance; Collaboration including Neuroscience, Speech and Language, Developmental Pediatrics, and other Dyslexia Specialists along with Educators, Policy makers and Parents to improve awareness and evidenced based practices through out the Commonwealth.

4. Board Dyslexia Endorsement; Regulations specifying subject matter knowledge, skills, and competencies required for endorsement; coursework and field experience for licensed general and special education teachers to acquire the competencies necessary to use the scientifically based reading research and evidenced based practices to instructing and remediating students with dyslexia.

www.decodingdyslexiama.org
Educational neuroscience as a “collaborative attempt to build methodological and theoretical bridges between cognitive neuroscience, cognitive psychology, and educational practice without imposing a knowledge hierarchy” [Howard-Jones et al., 2016; p.625].

This can only be done through fostering of mutual respect for the diverse fields on both sides, common terminology, the creation of a learning environment for all parties involved and clear, frequent and bi-directional communication between neuroscientists, educators and parents.
Dissemination as a key characteristics of ‘translational neuroscience’

Academy of Orton-Gillingham Practitioners and Educators Conference in Charlotte, NC
Reading in the City Conference, International Dyslexia Association, Denver, CO
Dyslexia Society of Connecticut Conference, Westbrook, CT
Brazilian Dyslexia Association, Sao Paulo, Brazil
4th Brazilian Meeting on Brain and Cognition. São Bernardo do Campo, Brazil.
Special Education Parent Advisory Council, Somerville, MA
Commonwealth Learning Center, Danvers, MA
Special Education Parent Advisory Council, Brookline, MA
Quincy Parent Advisory Council, Quincy, MA
Special Education Parent Advisory Council, Georgetown, MA
Special Education Parent Advisory Council, Concord, MA
Decoding Dyslexia event, Belmont, MA
Screening & Intervention workshop at Tufts University, Medford, MA
Cambridge Science Festival, Cambridge, MA
Baby Drool Expo, Boston, MA
Martha Elliot Health Fair, Jamaica Plain, MA
Parent Association, Landmark School, Beverly, MA
Brain Awareness Workshop at Haggerty School, Cambridge, MA
Aim Academy, Conshohocken PA
Education Collaborative for Greater Boston, Bedford, MA
Briefing for Dyslexia Legislation, Speaker’s Lounge, Massachusetts State House
Testimony at Massachusetts State House in favor of early screening bills

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Sara Beach (former RA)
MRI Team, Children’s Hospital Boston & MIT

- National Institutes of Health
  - BOLD/BabyBOLD: (2RO1HD065762-06)
  - READ: (1RO1HD067312-05)
  - FASD (1U01AA023503-01)
- Harvard Catalyst (Infants)
- Bill and Melinda Gates Foundation
- Harvard Mind/Brain/Behavior Award
- Charles H. Hood Foundation
- Grammy Foundation
- William Randolph Hearst Foundation (Infants)
- Children’s Hospital Boston Pilot Award (BOLD)
- Developmental Medicine Center Young investigator Award
- Victory Foundation
- Tower foundation
- Poses family foundation
- Heckscher foundation
- Oak foundation
- Tremaine foundation
The typical and atypical reading brain:

How a neurobiological framework of reading development can inform educational and practice and policy

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