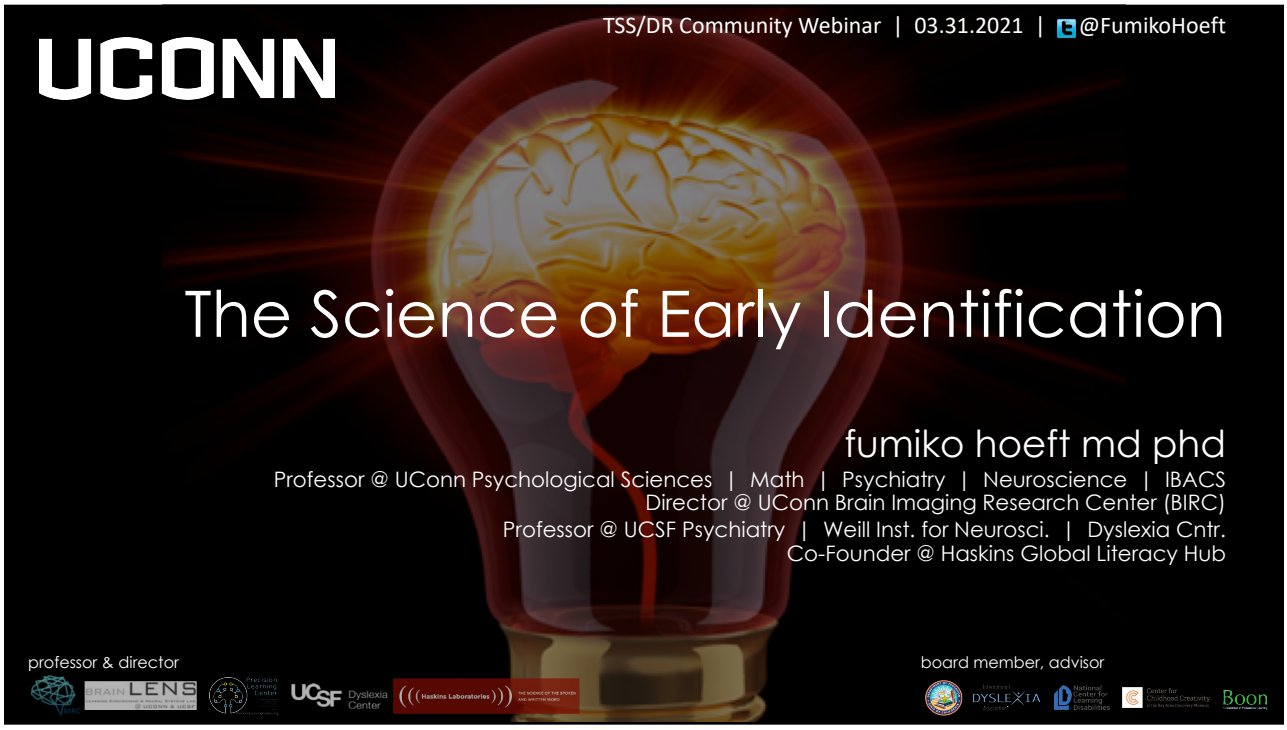
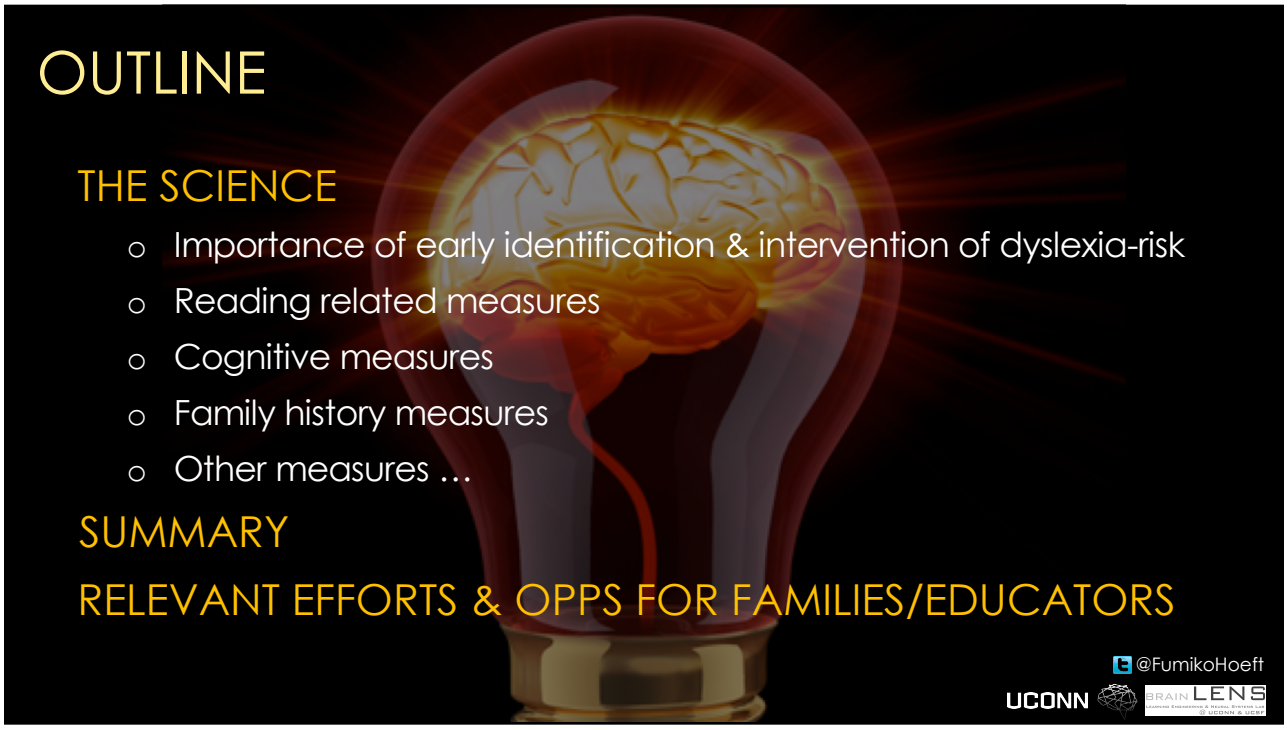


1

Acknowledgement

NICHD R01HD078351 (PI: Hoeft)
NICHD R01HD086168 (PIs: Hoeft & Pugh)
NICHD R01HD096261 (PI: Hoeft)
NICHD R01HD094834 (PI: Hoeft & Hancock)
NSF BCS-2029373 (PI: Hoeft)
NIH U24AT011281 (Multi-PIs: Park, Chafouleas & Hoeft)
NIH T32DC017703 (Multi-PIs: Eigsti & Myers)
NIH R01HD094834-A01 (Multi-PIs Landi, Milham @ CMI)

2


OUTLINE
THE SCIENCE
Importance of early identification & intervention of dyslexia-risk
Reading related measures
Cognitive measures
Family history measures
Other measures …
SUMMARY
RELEVANT EFFORTS & OPPS FOR FAMILIES/EDUCATORS
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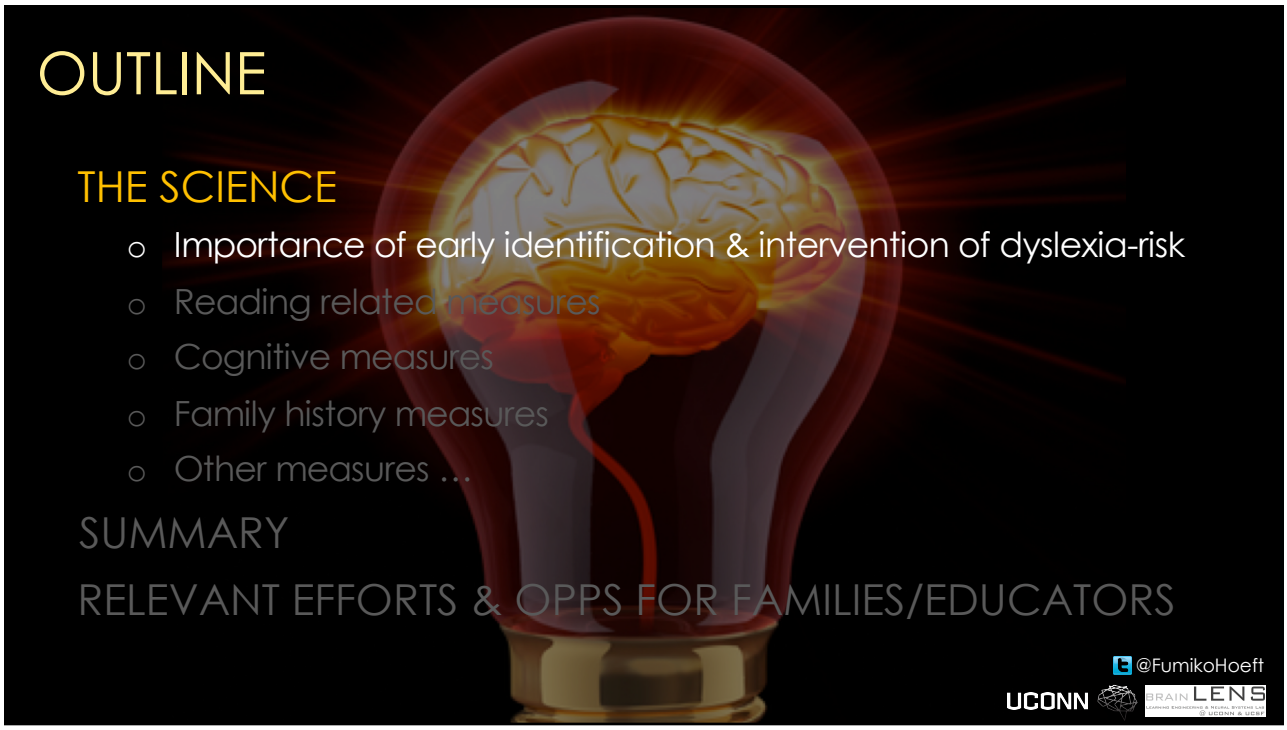
3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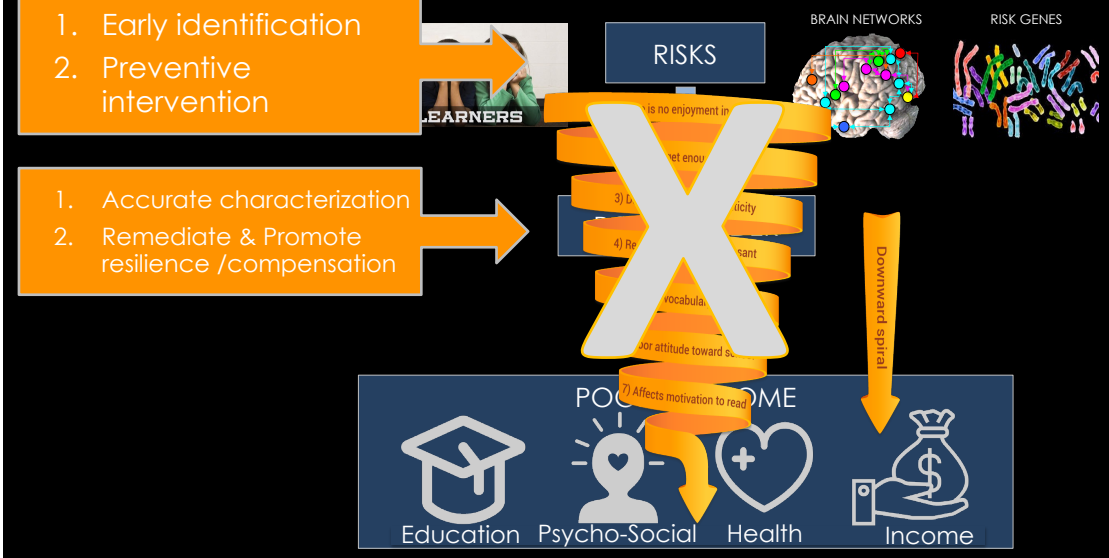
4

stopping the downward spiral is important

1. Early identification
2. Preventive intervention

1. Accurate characterization
2. Remediate & Promote resilience /compensation



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stopping the downward spiral is important & possible

Early intervention
4x effective

Return of investment
$16 to 31 per $1 spent

Solution for dyslexia
Works for all

Waiting 1 year
25-50% diminished

Risk prediction
60-80% accurate

Critical Importance of science-based identification & preventive intervention at the earliest stage.

Al Otaiba & Fuchs. J Learn Dis 2006; Wanzek & Vaughn. School Psych Rev 2007 – MetaAnalysis; Beddington et al. Nature 2008; Therrien. Remedial & SpEd 2004 – MetaAnalysis; Ehri et al. Read Res Quart 2001 – MetaAnalysis; House of Common Report 2009; ***Assuming*** *exchange rate of $1.50 to £1*

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OUTLINE

THE SCIENCE

- Importance of early identification & intervention of dyslexia-risk
- Reading related measures
- We have known for decades now of the importance of early identification.
- Is there brain evidence?
- What is the best combination of predictors to date?

SUM

RELE TORS

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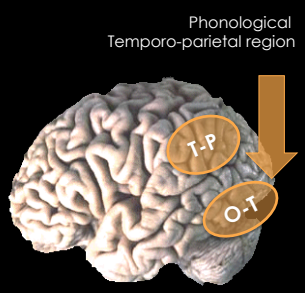
7

EVIDENCE 1a. Dyslexic Brains

But note that there is large individual variability



They will NOT grow out of it
Hoeft et al. J Neurosci '06; PNAS '07

The definition does not matter. Even "good readers" if "disproportionate", they will show dyslexia brain patterns
Tanaka … Hoeft. Psychol Sci '11
Hancock Gabrieli Hoeft. TiNE '16

Hiroko Tanaka PhD

Roeland Hancock PhD

It's neurobiological, not cultural
Xia … Hoeft… et al. Neuropsychologia '16
Rueckl … Hoeft … et al. PNAS '16

Zhichao Xia PhD

Predicts reading acquisition
Myers … Hoeft. Psychol Sci '14

Chelsea Myers MEd

At-risk prereaders already show the sign
Vandermosten … Hoeft. COBS '16; Black … Hoeft. Neuroimage '11; Hosseini … Hoeft. Neuroimage '12

Maaike Vandermosten PhD

Jessica Black PhD

Hadi Hosseini PhD

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NIH K23HD054720 ('08-'13)
R01HD078351 ('15-'20)

Black Xia Hoeft. Lang Ling Compass '17; Xia Hancock Hoeft. Lang Ling Compass '17

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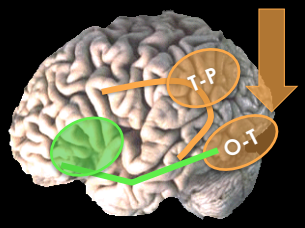
EVIDENCE 1b. Dyslexic Brains

Brain imaging evidence converges with Simple view of reading & Computational models

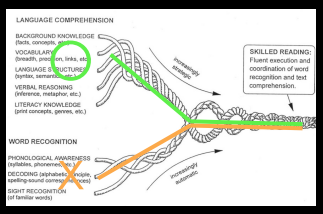
1. BRAIN IMAGING
Phonological
Temporo-parietal region



Orthographic
Occipto-temporal region

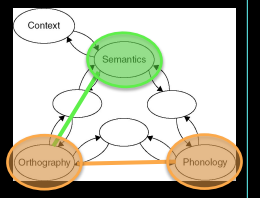
2. SIMPLE VIEW
~~Word recognition~~
Language comprehension

Hollis Scarborough & others (Gough and Tunmer. 1986)



3. COMPUTATIONAL MODEL (TRIANGLE MODEL)
~~Dorsal orthographic to phonological pathway~~
Ventral orthographic to semantic pathway

Mark Seidenberg & others (Plaut, Seidenberg, McClelland, and Patterson. 1996)



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R01HD078351 ('15-'20)

Black Xia Hoeft. Lang Ling Compass '17; Xia Hancock Hoeft. Lang Ling Compass '17

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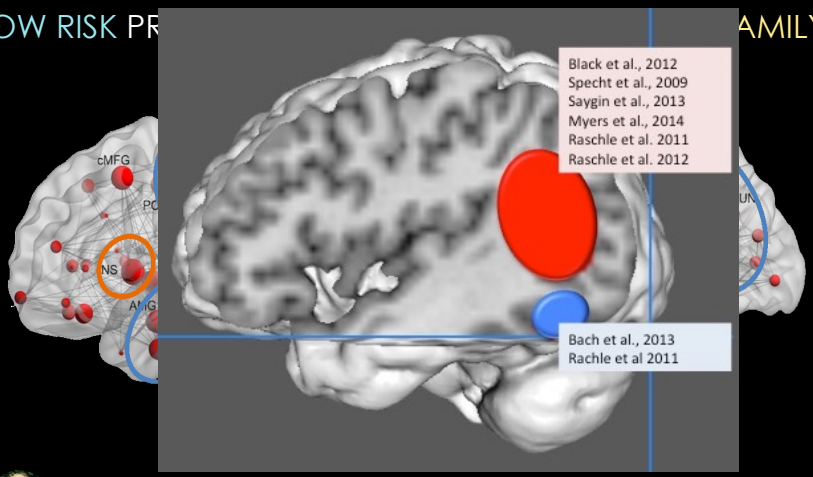
EVIDENCE 2. High-risk children show different patterns in the reading-brain even BEFORE THEY LEARN TO READ

LOW RISK PR AMILY MEMBERS)



Jessica Black · Hadi Hosseini · Maaike Vandermosten

Vandermosten et al. Curr Opin Beh Sci. '16; Hosseini et al. NeuroImage '13; Black et al. NeuroImage '12

NIH K23HD054720 ('08-'13)
R01HD078351 ('15-'20)

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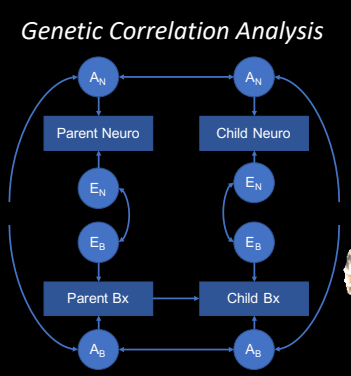
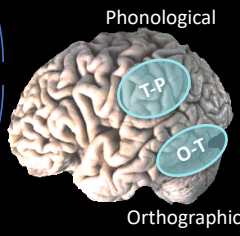
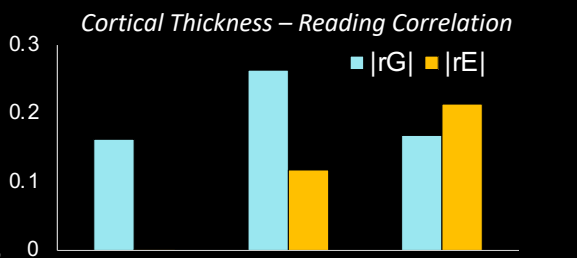
EVIDENCE 3. Nature (Genetic) x nurture (Environment) may suggest modifiable systems to target







Phonological processing shows high heritability (62-75%). Orthographic processing shows low (31%)
(Stevenson et al. J Child Psych Psychol 1987)

Roeland Hancock

NIH R01HD094834 ('19-'24)

Hoeft & Hancock. Geschwind-Galaburda Hypothesis: 30 years later '17; Hancock/Hoeft. in prep.

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EVIDENCE 4. Reading-related measures predict dyslexia risk

Risk can be identified in preschool-K with 50-70% accuracy:

- **Phonological awareness**
- **Letter (sound) knowledge**
- **Rapid naming**
- **Vocabulary & oral language**

Risk can be identified in 1st grade with 92% accuracy:

ADHD + Male + Family history + Low scores (Rick Wagner '18 IDA Orton Lecture, NDCAD)

Low scores on a composite of:

- **non-word fluency,**
- **oral reading fluency,**
- **RTI (response to intervention),**
- **listening-reading comprehension discrepancy**

Al Otaiba & Fuchs. J Learn Dis 2006; Wanzek & Vaughn. School Psych Rev 2007 – MetaAnalysis

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READING-RELATED MEASURES: SUMMARY

- Brain signatures of early reading and dyslexia risk exist

- Simple measures of PA, letter knowledge, rapid naming, and oral language / vocabulary, listening-reading comprehension discrepancy, response to intervention (RTI) predict outcome with 50-92% accuracy.
  Notes:
  - Not as many with PA deficit as once thought.
  - ADHD, Male gender, Family history and possibly other measures are important also

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OUTLINE

THE SCIENCE

- Importance of early identification & intervention of dyslexia-risk
- Reading related measures
- Cognitive measures

- Many of us in the reading field think:
  - Cognitive measures that predict reading outcome are reading/language specific (e.g. verbal working memory).
  - Cognitive training is ineffective & controversial.
  - Therefore, measuring cognitive outcome is a waste of time.
- But we argue otherwise, or rather, the jury is still out.

oeft
NS

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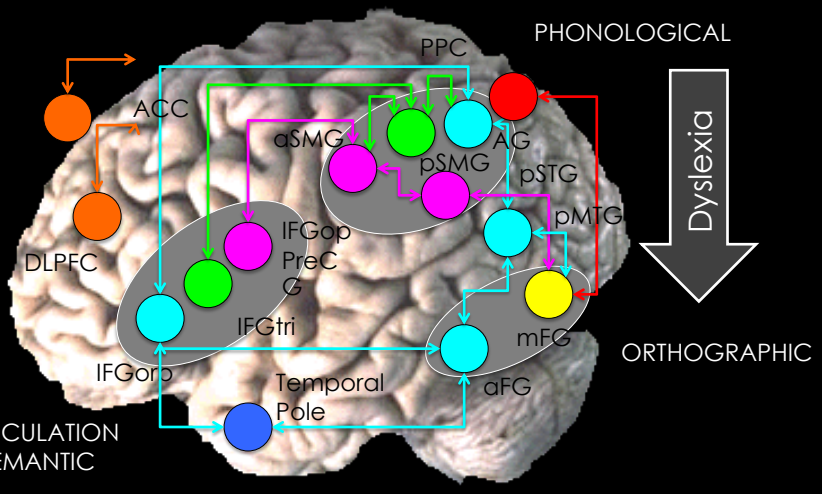
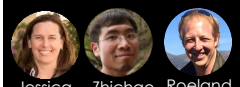
EVIDENCE 1. Cognitive networks are involved in reading

- Orthography
- Phonology
- Semantics
- Sentence / Syntax
- Vocabulary
- Attention
- Executive Function

- Major Reading Systems



ACC: anterior cingulate cortex; AG: angular gyrus; DLPFC: dorsolateral prefrontal cortex including superior/middle/dorsal inferior frontal gyri; a/mFG: anterior/mid fusiform gyrus (visual word form area, VWFA); IFGorb/tri/oper: inferior frontal gyrus orbitalis, triangularis, opercularis; PPC: Posterior parietal cortex; PreCG: precentral gyrus; a/pSMG: anterior/posterior supramarginal gyrus; pS/MTG: posterior superior/middle temporal gyrus;



Jessica Black Zhichao Xia Roeland Hancock

Black et al. Lang Ling Compass '17; Xia et al. Lang Ling Compass '17

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EVIDENCE 2. Executive functions predict early reading

- **EXECUTIVE FUNCTIONs (EFs):** Working memory, cognitive flexibility, inhibitory control
- **PREDICTING RTI:** EF may NOT predict RTI (Miciak, Cirino, Ahmed, Reid, Vaughn. Learn Disabil Q 2019).
- **PREDICTING READING FAILURE (in K)**
  - K with working memory deficits experience 2.8 times higher risk in Gr3. Inhibitory control deficits experience almost 2 times higher risk. All EFs predict outcome uniquely. (N=11,000; Morgan et al. Child Development 2019; Morgan et al. Early Childhood Read Q 2019).
  - "Cool" inhibitory control measures (= without extrinsic motivator) rated by teachers is predictive predicting reading. (75 studies; Allan et al. Dev Psychol 2014).
- **SUPPORTING THOSE WITH WEAK EF:** Working memory / attention predicts oral comprehension more than reading. So if they have EF + reading challenges, likely they have oral language issues also. So materials delivered orally may not always help (LRRC et al. Reading & Writing 2018).

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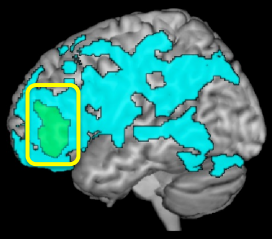
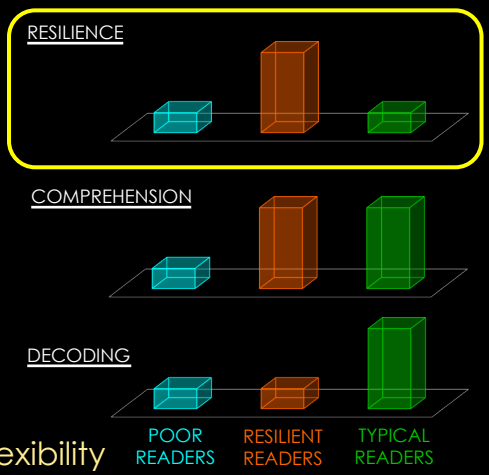
EVIDENCE 3. Left prefrontal cortex (PFC) important for learning, memory and cognitive flexibility predicts "resilience" in dyslexic children

RESILIENT READERS:
Good comprehension despite poor decoding.

Resilient > Poor readers
Resilient > Typical readers





PFC of pre-readers predicts later resilience

Related to learning, memory & cognitive flexibility

Smadar Patael

NIH K23HD054720 ('08-'13) R01HD078351 ('15-'20)

Patael et al. PLoS ONE. 2018

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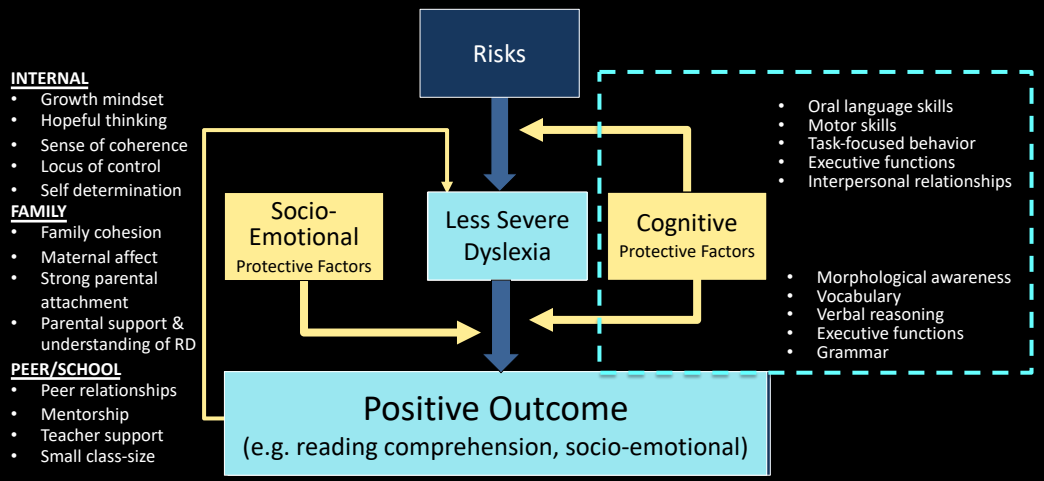
EVIDENCE 4. Resilience framework shows importance of cognitive factors in early positive outcome



INTERNAL
- Growth mindset
- Hopeful thinking
- Sense of coherence
- Locus of control
- Self determination

FAMILY
- Family cohesion
- Maternal affect
- Strong parental attachment
- Parental support & understanding of RD

PEER/SCHOOL
- Peer relationships
- Mentorship
- Teacher support
- Small class-size

- Oral language skills
- Motor skills
- Task-focused behavior
- Executive functions
- Interpersonal relationships

- Morphological awareness
- Vocabulary
- Verbal reasoning
- Executive functions
- Grammar

Stephanie Haft

OAK FOUNDATION ORIO-16-012

Haft, Myers, Hoeft. Curr Opin in Behav Sci '16; Haft et al. JACP '18; Haft et al. CAMH '19

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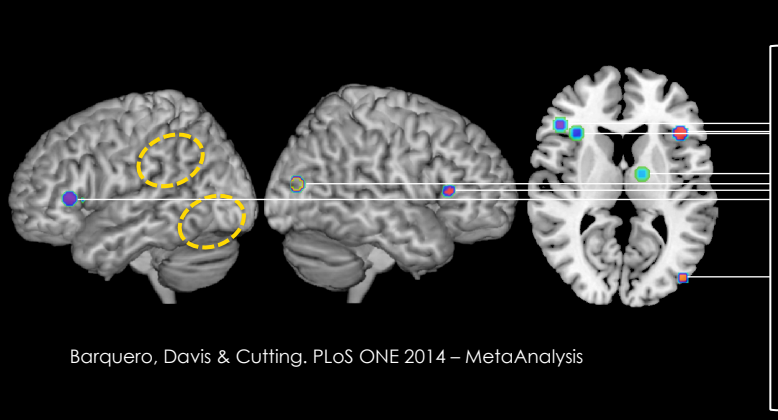
EVIDENCE 5: Cognitive networks may be important for reading intervention



phono/ortho | word/sentence | language | cognitive | others

Barquero, Davis & Cutting. PLoS ONE 2014 – MetaAnalysis

Hoeft. Unpublished

Devin Kearns

OAK FOUNDATION OCAY-19-215
NIH R01HD096261 (PI; 18-23)

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EVIDENCE 6: ADHD is important in early identification & intervention

- ADHD increases the chance of having dyslexia by fourfold (400%). (Willcutt et al 2003)
- Male + ADHD + Family history + Low score at 1st grade* = 92% increase in probability to be poor reader in Gr2; tested in 31,339 children (Wagner et al. NDCAD 2019)
  * Measures included: Phonics, Fluency, Response-to-intervention, Poor reading vs. listening comprehension [1-2 SD difference]
- ADHD comorbidity predicts poor response to reading intervention in young children (Rabiner & Malone, 2004; Alexander & Slinger-Constant, 2004; Snow et al., 1998)
- When there are ADHD symptoms, it is important to treat them independently (e.g. meds, behavioral) of reading challenges (Tamm, L. et al. 2017, largest RCT)

Wagner, Edwards, Malkowski, Schtschneider, Joyner, Wood & Zirps. NDCAD 2019

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EVIDENCE 7a: Interventions related to cognition (executive functions)

"Brain Train" programs are controversial in improving EF or reading.

- CogMed near 0 effect (Aksayli et al. Educ Res Rev 2019). No effect esp. in populations like dyslexia (Takacs & Kasai. Psychol Bull 2019).
- 51% show far transfer (but many not independent studies), 16% show long term effects (Rossignoli-Palomeque et al. Front Psychol 2018).

Other kinds of training might improve EF.

- w SPECIAL NEEDS: Self-regulation strategies including biofeedback-enhanced relaxation & strategy teaching programs. TYPICAL: Mindfulness practices & computerized/non-computer training of EF. 90 studies (Takacs & Kasai. Psychol Bull 2019).
- Address emotional, social, and physical needs (Diamond & Ling DCN 2016).
- Music effect via phonological awareness. 13 studies (Gordon, Fehd, McCandliss. Front Psychol 2015). Also possibly via EF, temporal processing (Patel & Kraus 2010), and procedural/implicit learning (Bonacina et al. Front Psychol 2015).

Reading strategies may relate to EF, and improve reading.

- "Setting reading goals"* in whole classroom settings most effective. Works esp. in Gr6-8 w long-term effects. 52 studies (Okkinga et al. Educ Psychol Rev 2018). * Procrastination and common EF ability are related, and that this relationship is driven primarily by genetic influences shared between procrastination, EFs, and everyday goal-management ability (Gustavson, Miyake et al. JEGP 2015)
- Computerized reading program + "Stop & Think" (van de Sande & Verhoeven 2016); or + "Oral Correction" strategies (Kegel & Bus 2012) in 5-6 yo.

@ronnikofoeft

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EVIDENCE 7b: MULTI-TASK V.G. IMPROVES FOCUS IN ADHD

Overall action VG improve thinking skills (Bediou et al. Psychol Bull 2018)

Sesame street, PBS are good for young kids (AAP recommendation 2016)

EndeavorRX is the first FDA approved prescribable video game for inattention in ADHD ages 8-12 developed by Akili

https://www.endeavorrx.com/

Kollins et al (2021). Nature Digit. Med. 4, 58. https://doi.org/10.1038/s41746-021-00429-0

Kollins et al. (2020). Lancet Digital Health 2020; 2(4): PE168-E178 doi: https://doi.org/10.1016/S2589-7500(20)30017-0

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COGNITIVE MEASURES: SUMMARY

- Each EF measures provides unique contributions – working memory, cognitive flexibility, inhibitory control, in predicting reading outcome and those with deficits are at risk.
- Some may be important in predicting RTI (ADHD symptom) and positive reading outcome (EF measures).
- There may not be bullet proof interventions… yet. But those that : (1) include reading strategies (e.g. reading goals), (2) include self-regulation strategies (biofeedback, strategies teaching, mindfulness), and (3) target ADHD/multitask-focused video games may be effective for reading, EF or attention. Note that materials delivered orally may not always help if they have EF (working memory/attention) problems.

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OUTLINE

THE SCIENCE

- Importance of early identification & intervention of dyslexia-risk
- Reading related measures
- Cognitive measures
- Family history measures

- Runs in family. Risk is 4-8 times higher than general population. 1 in 2 to 3 will develop dyslexia (DSM5).
- Is there neural evidence?
- What is the best way to capture family history?

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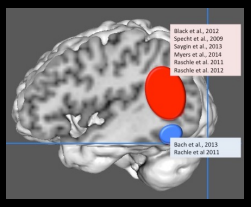
EVIDENCE 1: Family risk show dyslexia-related neural signature in pre-reading already.

Parent's reading history predicts:

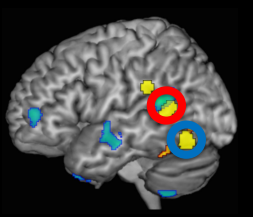
- Prereading ability in K
- Prereading brain. In particular, in K, cortical surface area (genetic/prenatal) but not thickness (more environmental), suggesting genetic/prenatal.
- Reading skills in Grade 3 (~21%)



Parent's brain predicts child's reading ability:

Paternal
Lt pSTG: phonological region

Maternal
Lt ITG: orthographic region



Jessica Black · Hadi Hossein · Chelsea Myersi · Maaike Vandermosten

Vandermosten et al. Curr Opin Beh Sci. '16; Hosseini et al. NeuroImage '13; Black et al. NeuroImage '12; Myers et al. Psychol Sci '14

NIH K23HD054720 ('08-'13)
R01HD078351 ('15-'20)

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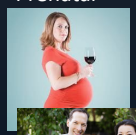
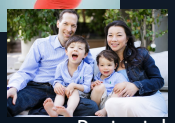
EVIDENCE 2: PARENTAL IMPACT ON DYSLEXIA IS PRIMARILY GENETIC

PARENTAL INFLUENCE ON CHILDREN

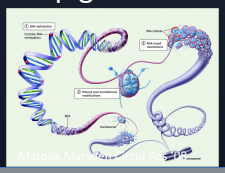
Environment
Prenatal





Postnatal

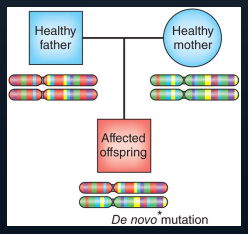
Epigenetics



No DNA change.
Mechanism for regulating gene activity.
Waddington '42

Genetics
(Inherited)

***De Novo* Mutation**
(Heritable but not inherited)



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EVIDENCE 3: A small set of questions predicts child's dyslexia risk & reading better than longer questions

We developed & validated this 6-item questionnaire that is useful if:

1) You are an adult and want to find out you may have had dyslexia.
2) You are a parent and want to find out if your pre-reading child may be at risk for dyslexia (If the parent has dyslexia, your child is at 4 to 8 times increased risk for being a struggling reader later on).

Instructions:

- Obtain from both parents and use the average score.
- Add all points and divide it by 24.
- Threshold is 0.32

To get the more information:

- Contact brainLENS@uconn.edu or brainLENS@UCSF.edu

ABBREVIATED ADULT READING HISTORY QUESTIONNAIRE (ARHQ-Brief)

PLEASE NOTE: This reading history questionnaire applies to **you** and **not to your children.** Please circle the number of response that most nearly describes your attitude or experience for each of the following questions or statements. If you think your response would be between numbers, place an "X" where you think it should be.

1. How much difficulty did *you* have *learning to read* in elementary school?

None				A great deal
0	1	2	3	4

2. Did *you* ever reverse the order of letters or numbers when you were a child?

No				A great deal
0	1	2	3	4

3. Did you have difficulty learning letter and/or color names when you were a child?

No				A great deal
0	1	2	3	4

4. All students struggle from time to time in school. In comparison to others in your class, how much did you struggle to complete your work?

Not at all	Less than most	About the same	More than most	Much more than most
0	1	2	3	4

5. Did you experience difficulty in high school or college English classes?

No; enjoyed and did well		Some		A great deal; did poorly
0	1	2	3	4

6. How would you compare your current spelling to that of others of the same age and education?

Above Average		Average		Below Average
0	1	2	3	4

From: Feng L, Hancock R, Watson C, Bogley R, Miller Z, Gorno-Tempini ML, Briggs-Gowan MJ, Hoeft F. (2020) A Development of an Abbreviated Adult Reading History Questionnaire (ARHQ-Brief) Using a Machine Learning Approach. PsyArXiv. September 17. doi: 10.31234/osf.io/8u5fe http://psyarxiv.com/8u5fe

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FAMILY HISTORY: SUMMARY

- Family history reflects primarily genetic component, not environment.
- Parents' childhood reading history predict parent reading and child's reading/dyslexia.
- Child's reading and phonological component is best predicted by family history – consistent with phonological processing being more hereditary than others.
- About 6 simple questions are as good as the full questionnaire.

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OUTLINE

THE SCIENCE

- Importance of early identification & intervention of dyslexia-risk
- Reading related measures
- Cognitive measures
- Family history measures
- Other measures: *e.g. Socio-emotional factors, Socio-Economic Status (SES), English Learners, Home Literacy Env., Perinatal environment (e.g. maternal substance use)*

SUMMARY

RELEVANT EFFORTS & OPPS FOR FAMILIES/EDUCATORS

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OUTLINE

THE SCIENCE

- Importance of early identification & intervention of dyslexia-risk
- Reading related measures
- Cognitive measures
- Family history measures
- Other measures …

SUMMARY

RELEVANT EFFORTS & OPPS FOR FAMILIES/EDUCATORS

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SUMMARY

- Early identification & intervention is important and possible
- Reading-related measures are strong predictors (phonological awareness, rapid naming, letter (sound) knowledge, oral language
- Cognitive measures also predict literacy outcome and can add to risk (EFs, ADHD)
- Family history is important and can be measured easily
- Other measures can add to risk but also be protective (e.g. SES, home literacy, perinatal environment, socio-emotional factors)

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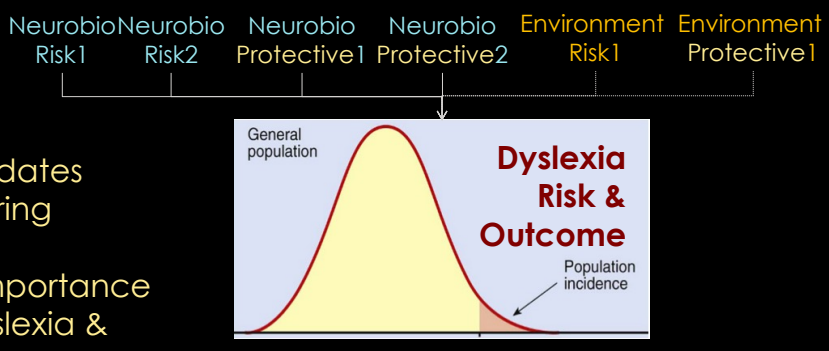
REALLY OLD MODEL: Single Liability Model
OLD MODEL: Multifactorial Liability Model
NEW MODEL: Cumulative Risk & Protection ('CRAP'!) Model



New model accommodates importance of considering protective factors.
Both models suggest importance of "other" factors in dyslexia & their outcome.

Multiple deficit model: *Pennington. Cognition '06. Pennington et al. J Abnorm Psychol '12*
Diathesis-stress model: *Rosenthal ed. "The Genain Quadruplets" '64*
Liability threshold model: *Gottesman & Shields. PNAS '67*

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OUTLINE

THE SCIENCE

- Importance of early identification & intervention of dyslexia-risk
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SUMMARY

RELEVANT EFFORTS & OPPS FOR FAMILIES/EDUCATORS

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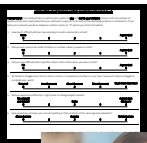
RELEVANT EFFORTS & OPPORTUNITIES



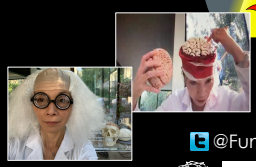
- Brief Family History Q. A validated 6-item questionnaire that could be a **first stage screener for dyslexia-risk in pre-reading children/babies** by identifying parents who may have been poor readers.
  Feng …. Hoeft. J Learn Dis (under revision). PsyArXiv 2020 https://doi.org/10.31234/osf.io/8u5fe brainLENS@uconn.edu

- APPRISE Project. Teachers, help us develop & validate a comprehensive early screener app **(4-8yo).** https://www.appriseproject.org/ apprise@uconn.edu

- Project R.E.S.C.U.E. Gain access to an early literacy (phonics, decoding) game app GRAPHOLEARN & get progress monitoring in your kids **(K-2)** during COVID (ends end of March).
  http://haskinsglobal.org/graphogame/rescue/ rescue@yale.edu

- Summer B.R.A.I.N. Camp. A FREE all inclusive, in-person, 5-week summer day-camp at UConn (Storrs) including support in reading (phonics, morphology), math, cognitive skills, art, sports & neuroscience for **in-coming Gr3/4.**
  https://braincamp.education.uconn.edu/ braincamp@uconn.edu

- Ask A Brain Scientist Live-Webinars for kids. Free webinars for kids on brain sciences on topics such as "dyslexia", "magic", "sleep", and "electronics". Ending soon but may start again in fall 2021.
  http://haskinsglobal.org/ask-a-brain-scientist/



- OTHERS.

(1) Family Brain Project (how parents share brain and behavior with their children)
https://www.familyBrainProgram.org family@ucsf.edu familyBrainProgram@uconn.edu

(2) Adult Reading Strategies Program (how young adults acquire compensatory skills in reading)
https://www.brainlens.org/strategies AdultReadingStrategies@uconn.edu

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For parents, teachers and school/district administrators around the US with children/students 4-8
http://APPRISEproject.org
@APPRISEproject
APPRISE is a fun, universal screener that assesses *language, literacy & cognition* in young learners of ages 4-8 in the form of an app. **Free**.
For educators, parents, and pediatricians.
We are currently validating our product for a future release.
APPRISE
Application for Readiness in Schools and Learning Evaluation
UCSF Dyslexia Center
Gorno-Tempini
Charles and Helen Schwab foundation
Chan Zuckerberg Initiative
California Newsome
UCONN
Hoeft/Kearns
Massachusetts Institute of Technology
Gabrieli/Falke
Learning Ally
Curious Learning
FCRR
Petscher/Catts
Digital Promise

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can we help our children succeed?
YES
you can!
VISIT OUR WEBSITE:
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CONTACT US:
APPRISE@UCONN.EDU
@FumikoHoeft
UCONN
Success kid meme: http://www.cosmopolitan.com/uk/entertainment/news/a37593/what-success-kid-meme-boy-looks-like-today/

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