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Dyslexia Interventions: What Do You Do When All Else Fails?

Dr. Matthew H. Schneps

Laboratory for Visual Learning



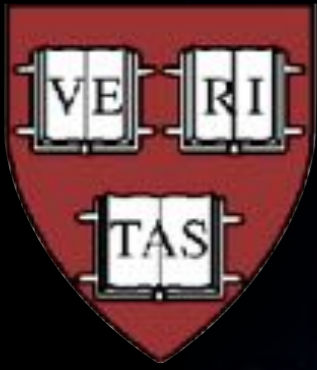
"Technology with a heart."



Thank you **LCIRT!**



sorry: old photo!



Harvard-Smithsonian Center for Astrophysics



35 years in science, science education and
science education media

supporting literacy

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Henry Sinclair Sherrill



Carol W. Greider
biochemistry

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medicine

SCIENTIFIC AMERICAN MIND

March 2015 issue

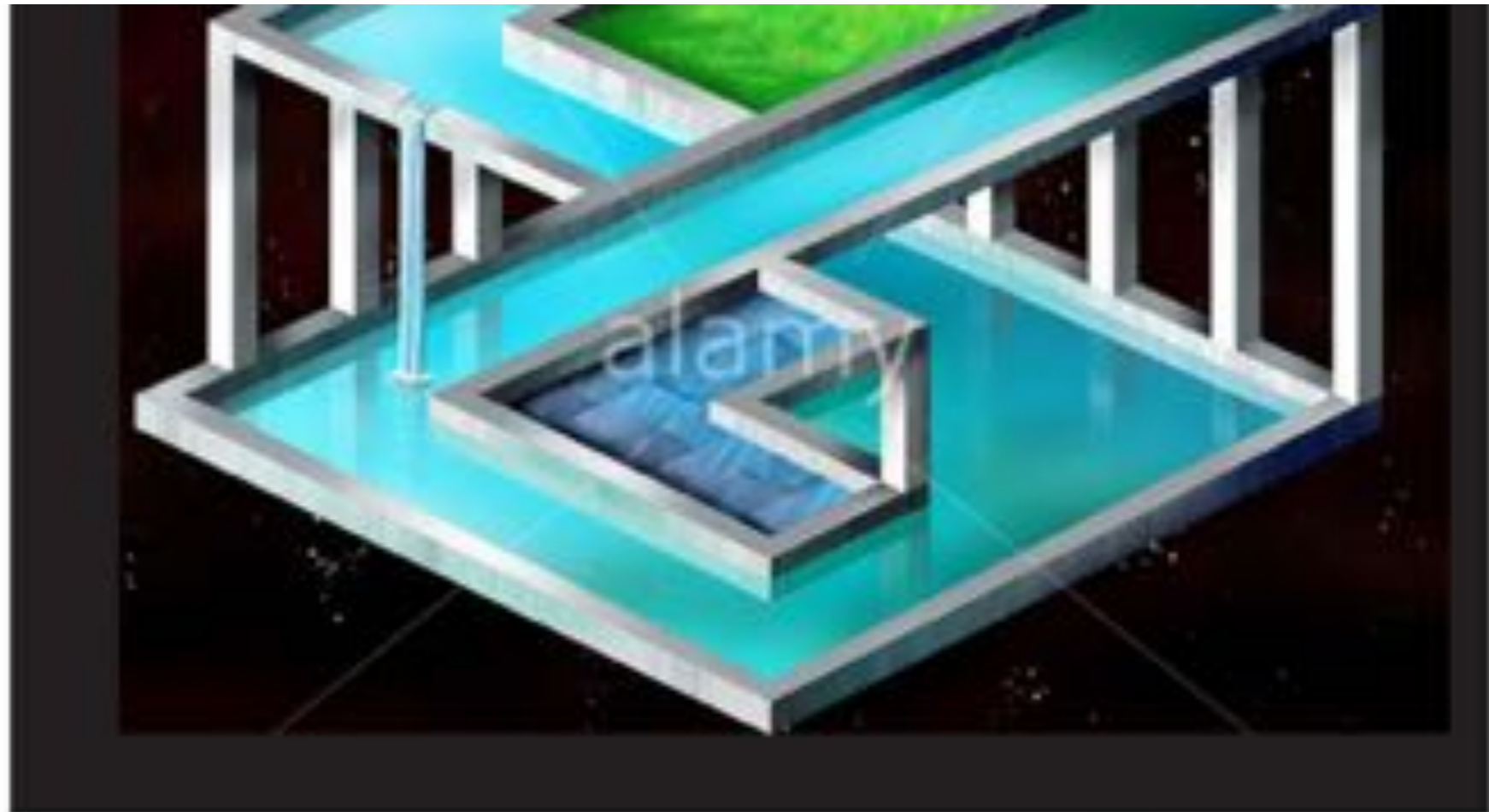
UNEXPECTED UPSIDES

The Advantages of Dyslexia

With reading difficulties can come other cognitive strengths

By Matthew H. Schneps

Many of the etchings by artist M. C. Escher appeal because they depict scenes that defy logic. His famous "Waterfall" shows a waterwheel powered by a cascade pouring down from a wooden flume. Water turns the wheel and is redi-



Dyslexi individuals may be better than nondyslexic peers at spotting an impossible figure, such as this image in the vein of M. C. Escher's etchings.

so slowly that it would typically take them months to read the same number

the larger idea that differences that some people might perceive as a source of dif-

"All the News
That's Fit to Print"

The New York Times

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ESTD 1787

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Five pages for \$6

In Gaming, He's No. 1 With a Bullet

Sponsors Help Rising Star
Train Like an Olympian

By CONOR DOUGHERTY

LOS ANGELES — Matt Haag, a professional video game player, makes over one million dollars a year sitting in a comfortable armchair, looking at a 24-inch monitor screen. He will do about anything to win it.

That is why, on a recent morning, he was in a basement in Venice Beach, Calif., training for a game. The last round produced, but his performance was not good. He was not used to the heat and the noise, where millions of spectators are watching. He was not used to the heat and the noise of a professional arena.

The arena was just the beginning of a training routine for the No. 1 player in the world at the game of League of Legends.

Mr. Haag, 27, is training for the game around the clock. He and his fellow players get about



More Agencies Undercover

No Longer Left to Fight
Adapted by I.R.S., N.S.A.

WASHINGTON — The federal government has quietly expanded its undercover operations in recent years, with officers from at least six agencies going on business trips, making speeches, political speeches and even running campaigns to win elections, according to a report by the House of Representatives.

At the Bureau of the Census, small teams of undercover officers have been sent to investigate the health care industry and the effects of the recession on the economy.

At the Internal Revenue Service, teams of undercover agents have reported on the tax industry by posing as tax preparers, accountants, auditors or public agents and even used credit cards.

At the Agriculture Department, teams of undercover agents have reported on the food industry at the National Food Processors Association and the National

AT&T 7:31 AM 100%

Top Stories

No. 1 With a Bullet: 'Nadeshot' Becomes a Call of Duty Star

By CONOR DOUGHERTY
Last Updated: November 15, 2014

LOS ANGELES — Matt Haag, a professional video game player, makes close to a million

tell me about **YOU**

- dyslexia researchers?
- special ed or dyslexia teachers/coaches?
- educators (other)
- interested parents?
- others?
- **there is much expertise in the room!**

phonological rules are difficult

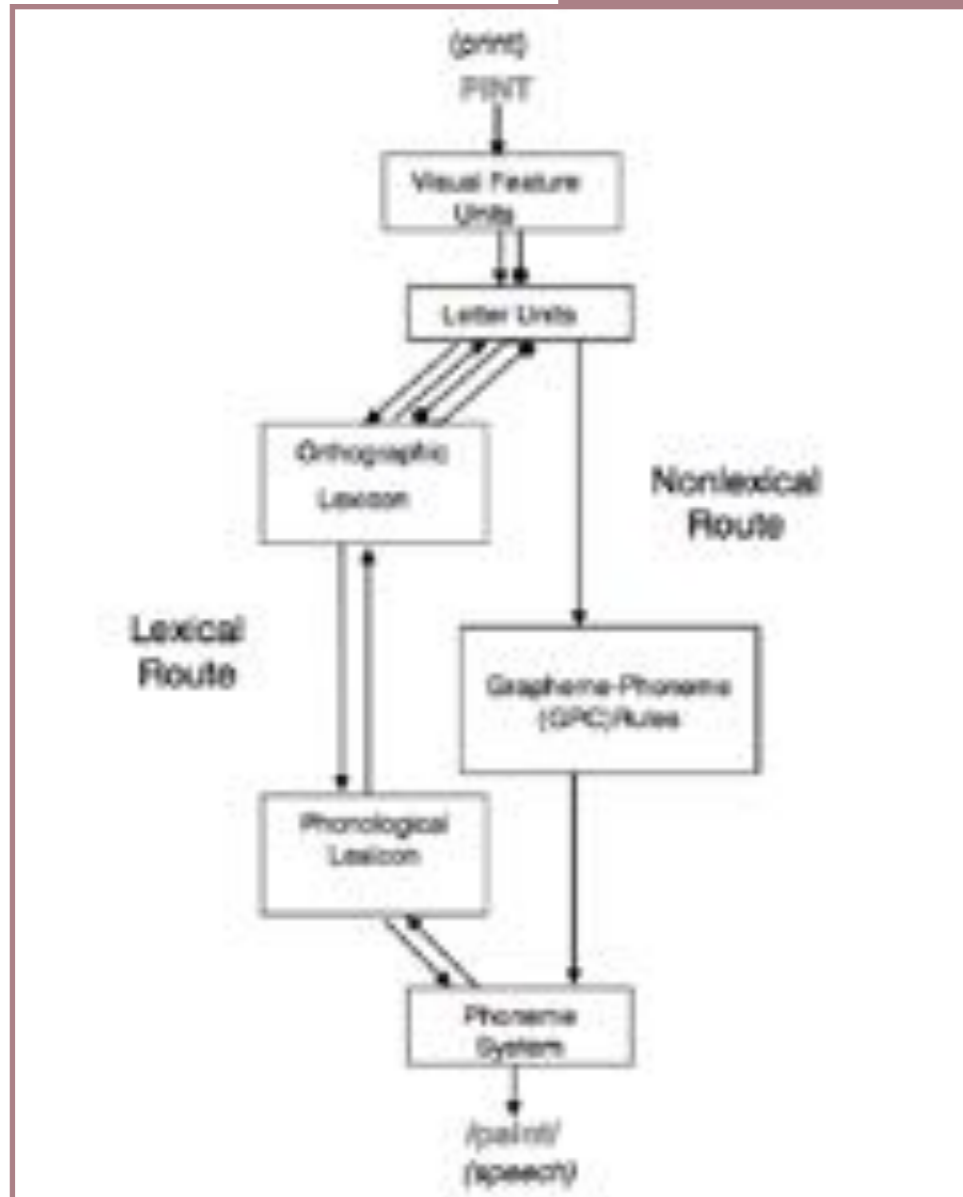
ghoti



enough
women
attention

William Ollier Jr (born 1824)

pathways for reading



dual route model...

Ziegler, J. C., Castel, C., Pech-Georgel, C., George, F., Alario, F.-X., & Perry, C. (2008). Developmental dyslexia and the dual route model of reading: Simulating individual differences and subtypes. *Cognition*, 107(1), 151–178. <http://doi.org/10.1016/j.cognition.2007.09.004>

... plus processes for fluency and automaticity

Wolf, M., Miller, L., & Donnelly, K. (2000). Retrieval, automaticity, vocabulary elaboration, orthography (RAVE-O): a comprehensive, fluency-based reading intervention program. *Journal of Learning Disabilities*, 33(4), 375–386.

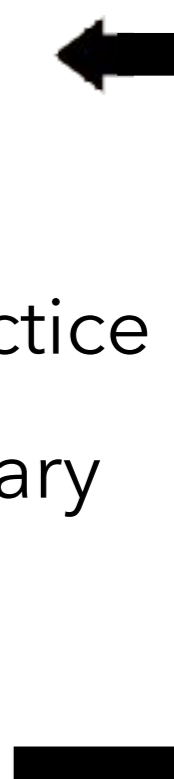
treatments

essential components of reading

1. **Phonemic awareness:** awareness of the basic units of speech (phonemes)
2. **Phonics:** knowledge of how letters and sounds correspond to form words
3. **Sight word acquisition:** automatic reading of words by sight
4. **Vocabulary:** storage of word meanings and an ability to access this
5. **Comprehension of text:** the ability to think what is read while reading

a spiral to illiteracy



- ↓ poor decoding
 - ↓ slower reading
 - ↓ diminished practice
 - ↓ poorer vocabulary
 - ↓ less reading
 - ↓ poor decoding
- 

**early intervention is
essential**

intervention helps!

variants of Orton-Gillingham methodologies

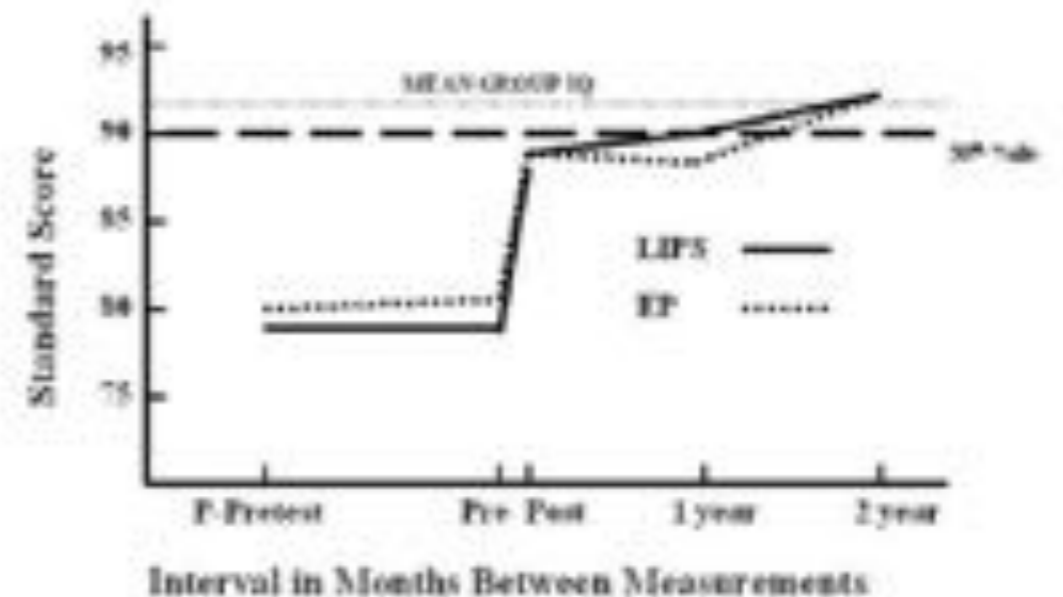
Intensive multi-sensory instruction and practice in phonics and language rules.

- improvements can be small in practice
- some do not appear to benefit
- many regress

Alexander, A. W., & Slinger-Constant, A.-M. (2004). Current Status of Treatments for Dyslexia: Critical Review. *J Child Neurol*, 19(10), 744–758. <http://doi.org/10.1177/08830738040190100401>

8-11 yr old children
9 weeks of intensive

GROWTH IN TOTAL READING SKILL DURING, AND FOLLOWING INTENSIVE INTERVENTION



EP = embedded phonics
LIPS = Lindamood Phoneme Sequencing

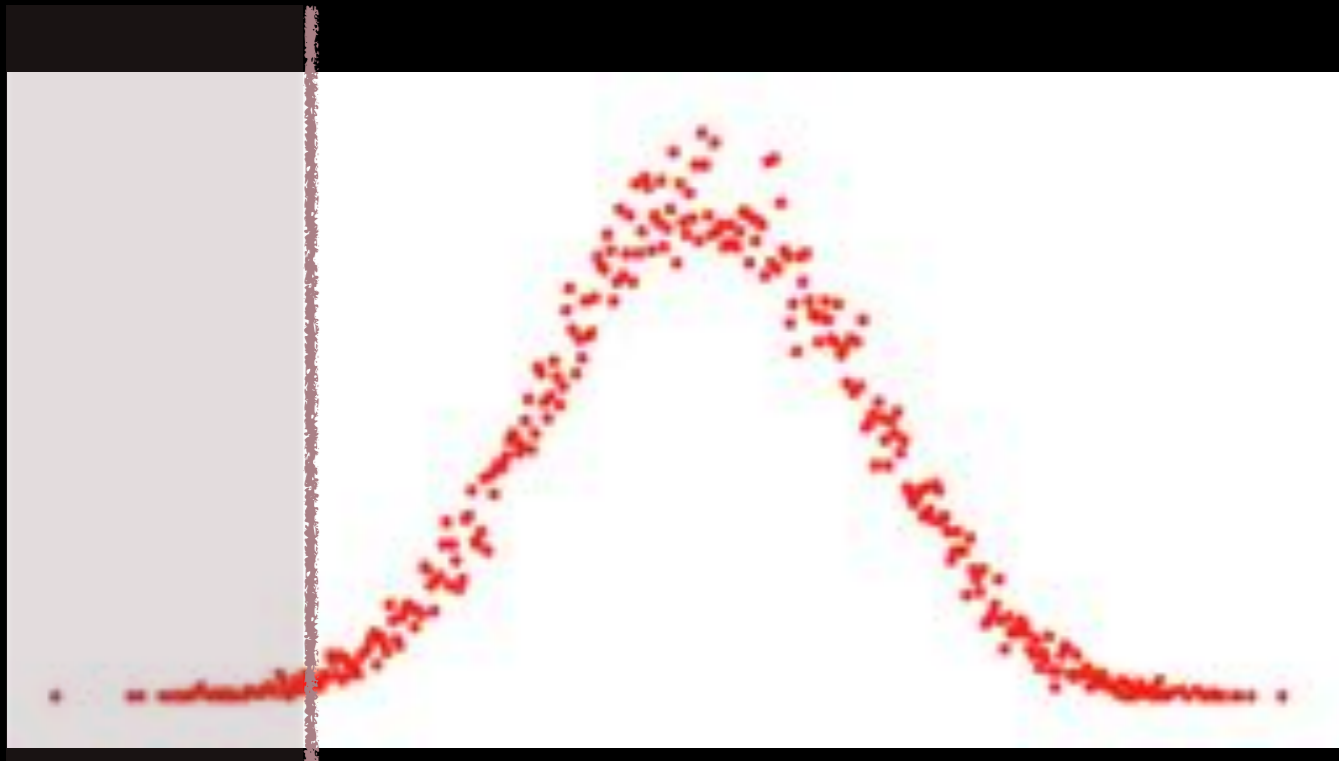
your stories?

- successes!
- ...and disappointments

traditional instruction fails?

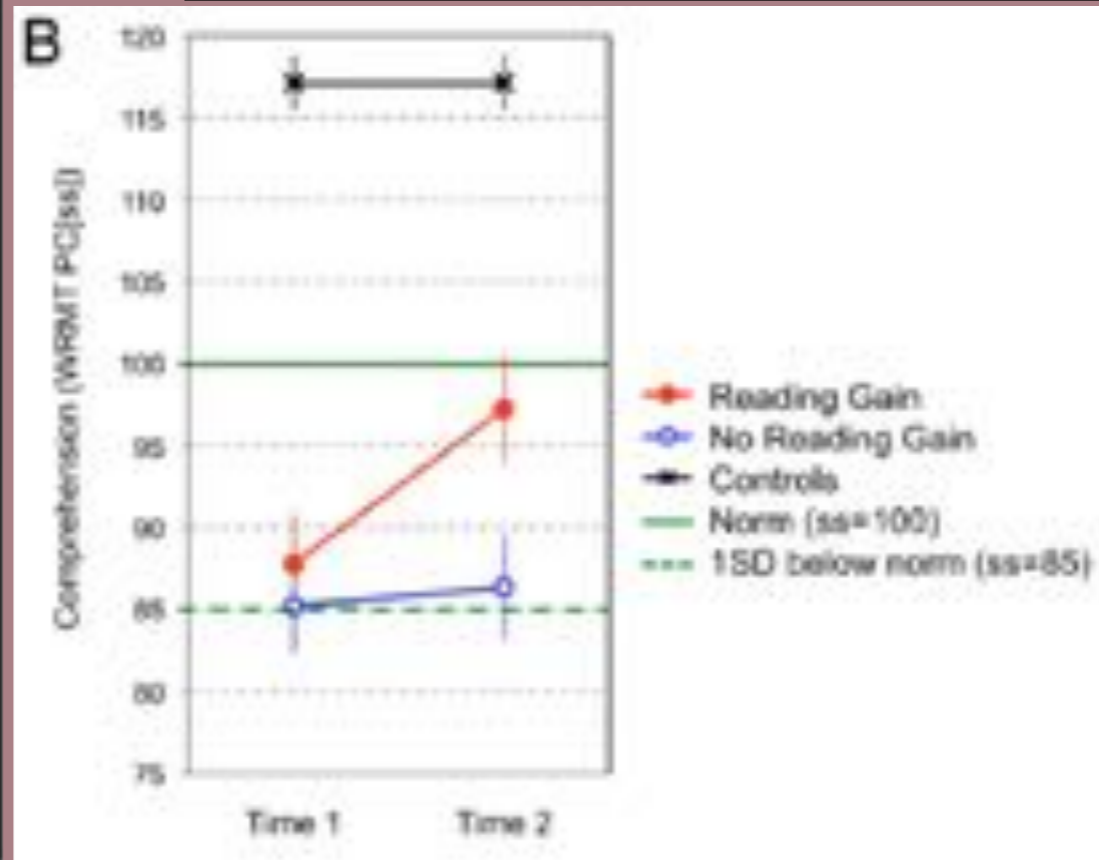
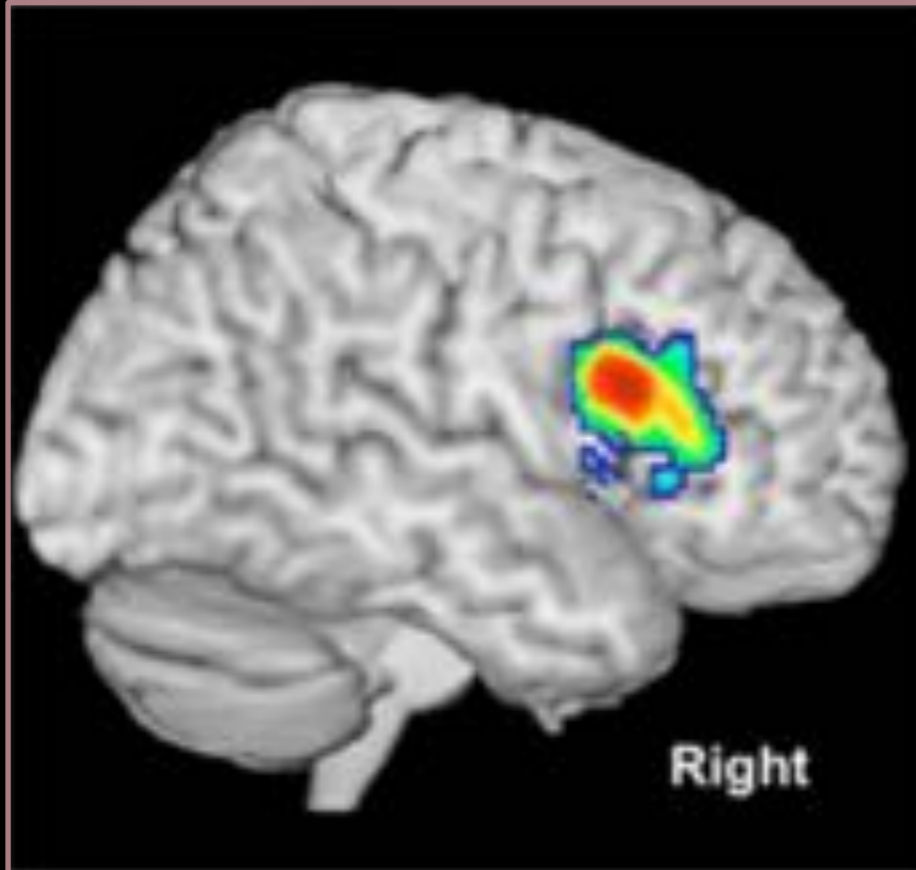
Dyslexia is largely an impairment in phonological processing. And yet, many practitioners and an increasing number of researchers find that traditional instruction encouraging phonological awareness is not effective for all students with dyslexia.

dyslexia ?



medical model

dyslexia varies

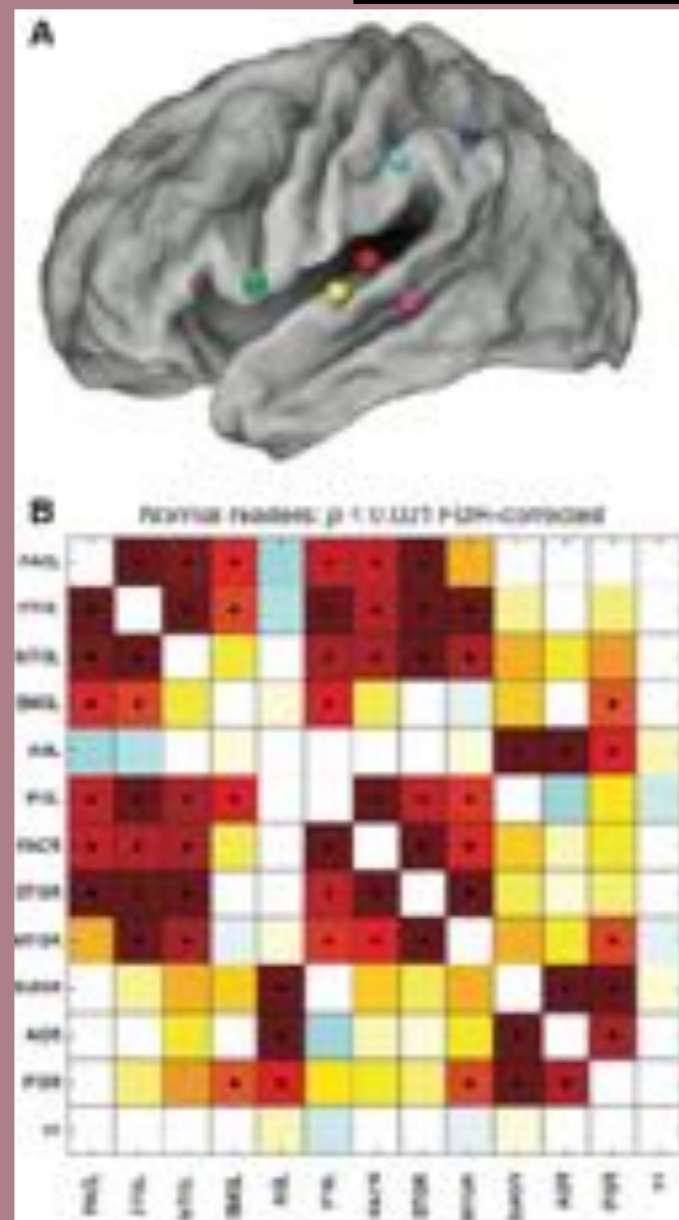


those who fail to respond to phonological instruction showed pre-instruction differences in right prefrontal brain areas

Hoefl, F., McCandliss, B. D., Black, J. M., Gantman, A., Zakerani, N., Hulme, C., et al. (2011). Neural systems predicting long-term outcome in dyslexia. *Proceedings of the National Academy of Sciences of the United States of America*, 108(1), 361–366.

multiple causes

access
matters



phonological
representations intact

**but access is
impaired**

Boets, B., Op de Beeck, H. P., Vandermosten, M., Scott, S. K., Gillebert, C. R., Mantini, D., et al. (2013). Intact but less accessible phonetic representations in adults with dyslexia. *Science* (New York, NY), 342(6163), 1251–1254. doi:10.1126/science.1244333

a syndrome

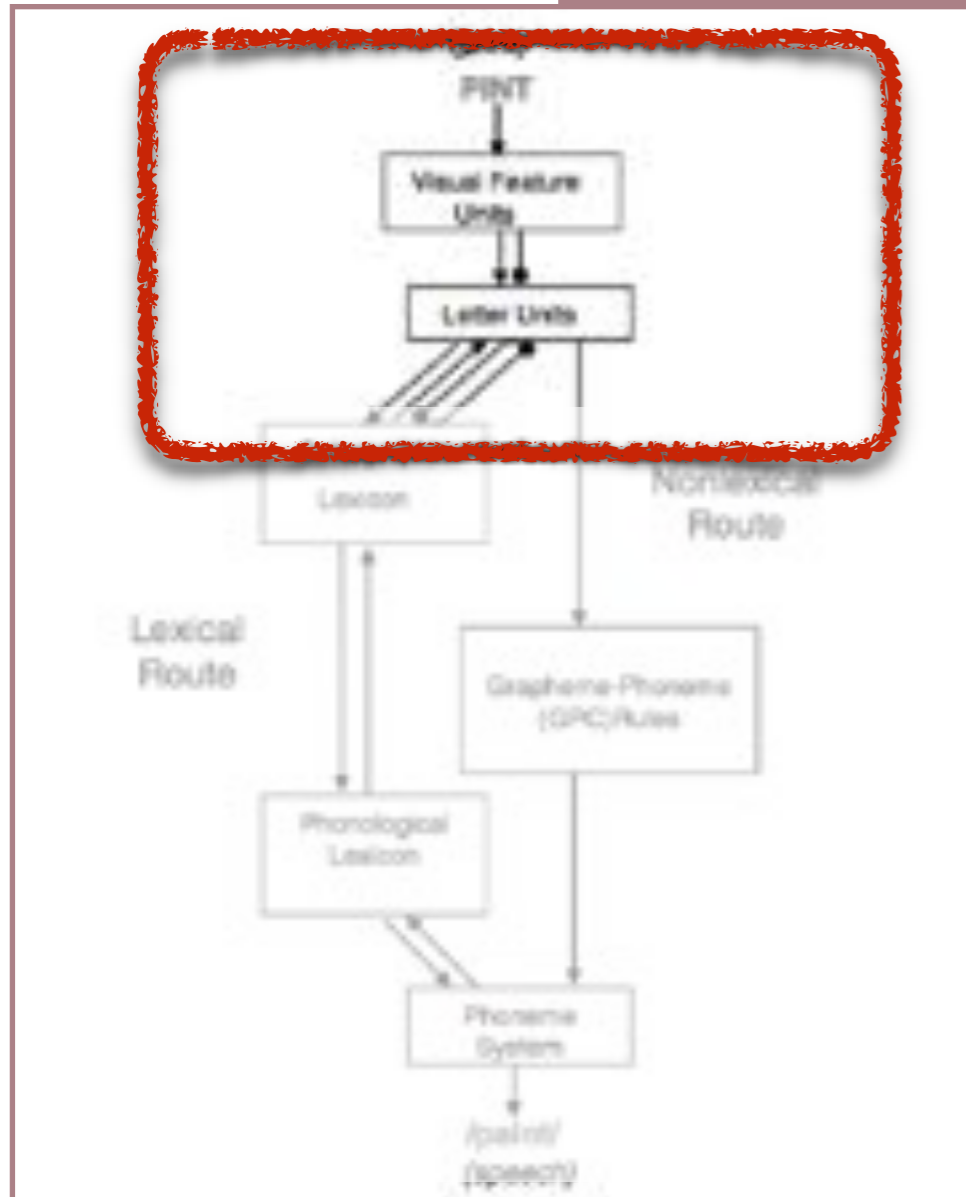
a constellations of
symptoms

**no one symptom
rises to level of
accommodation**

**...but together
severe**



pathways for reading



what if the problem is impaired

ORTHOGRAPHIC decoding?

... plus processes for fluency and automaticity

drill and practice may not help much

People with dyslexia, who ordinarily struggle to read, sometimes remark that reading is easier when e-readers are used. Here, we used eye tracking to observe high school students with dyslexia as they read using these devices. Among the factors investigated, we found that reading using a small device resulted in substantial benefits, improving reading speeds by 27%, reducing the number of fixations by 11%, and importantly, reducing the number of regressive saccades by more than a factor of 2, with no cost to comprehension. Given that an expected trade-off between horizontal and vertical regression was not observed when line lengths were altered, we speculate that these effects occur because sluggish attention spreads perception to the left as the gaze shifts during reading. Short lines eliminate crowded text to the left, reducing regression. The effects of attention modulation by the hand, and of increased letter spacing to reduce crowding, were also found to modulate the oculomotor dynamics

what orthographic impairments may feel like

thanks to
Mary Johnson

potential factors impairing orthographic processing

Even when phonological processing deficits fundamentally impair reading in dyslexia, other impairments--such as those in orthographic processing that overlay reading--can also take their toll.

reading as technology

the **romantic**
idealization of reading





reading is
an invention

technology

optimized for

writing

not reading

hours to write



minutes to read



typography
minimizes production costs
at expense of legibility

minimum
minimum

optimized for writing
not for reading

visual crowding

a property of vision



text is **crowded**

•
r u e
•

precise fixation is required

text is **crowded**

covert visual attention

precise fixation is required

text is **crowded**

covert visual attention

precise fixation is required

text is **crowded**

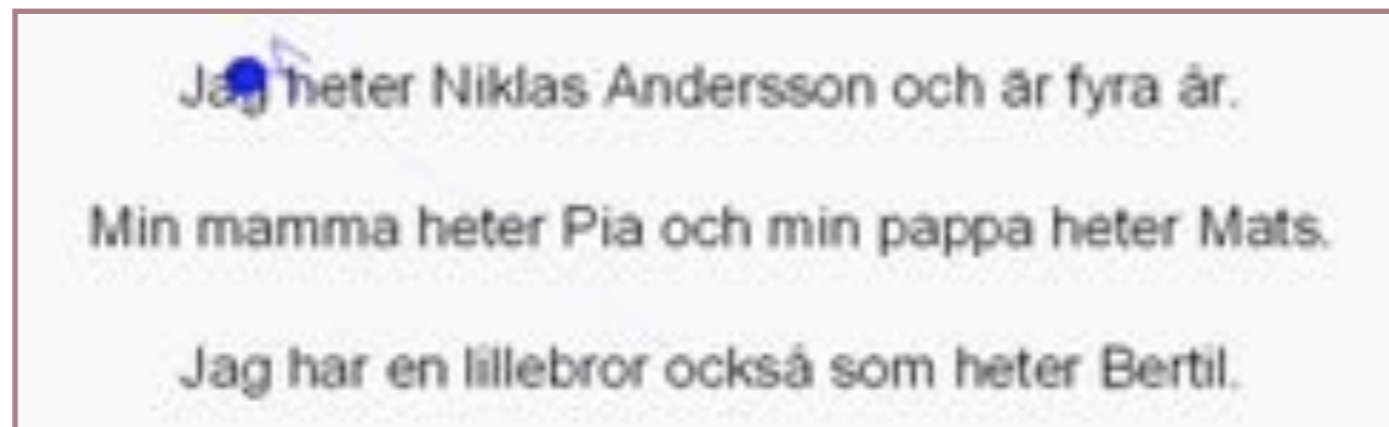
c o v e r t u a t t e n t i o n

precise fixation is required

reading requires

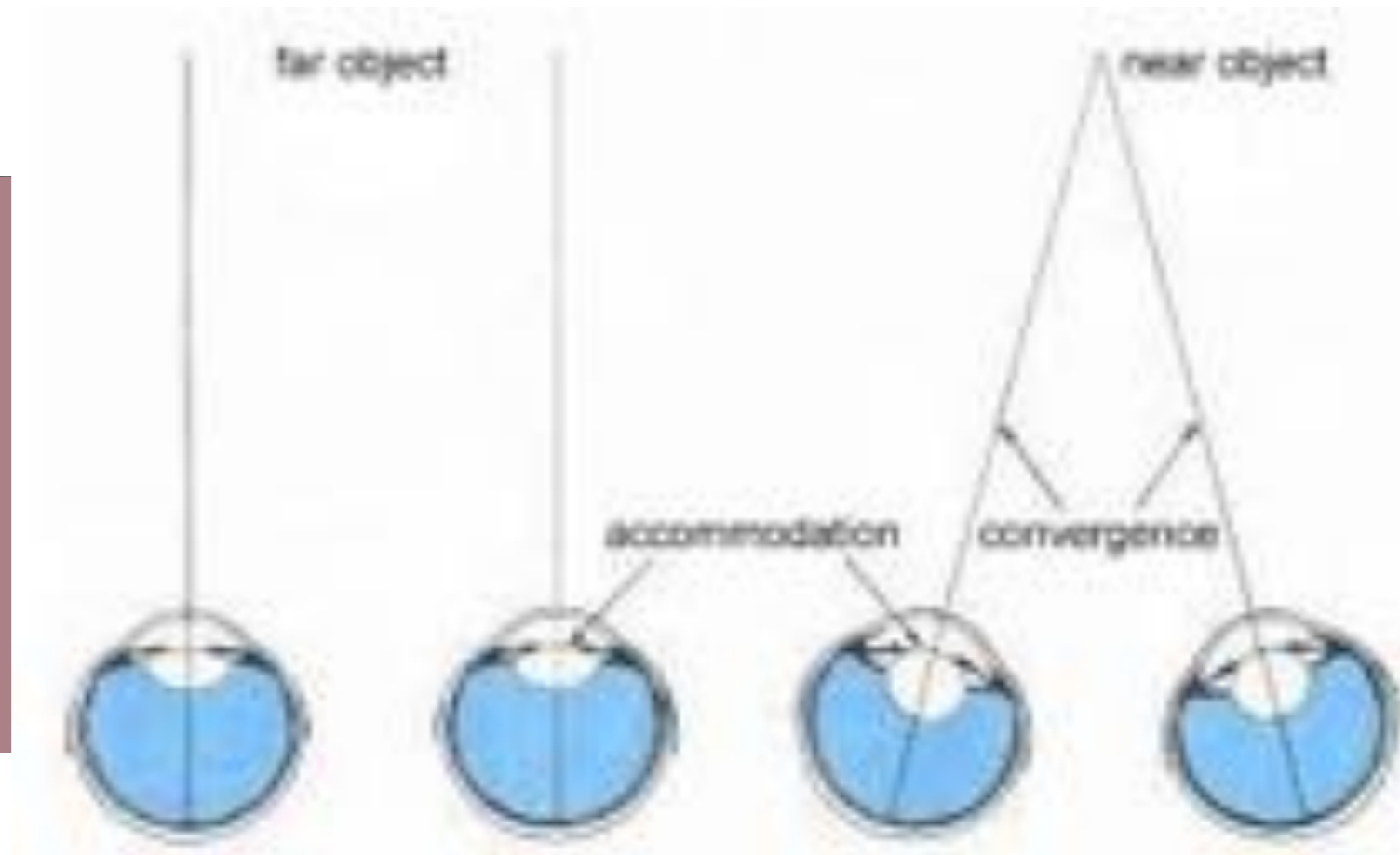
- Text is crowded, therefore we cannot read covertly.
- Eyes must move.

crowding



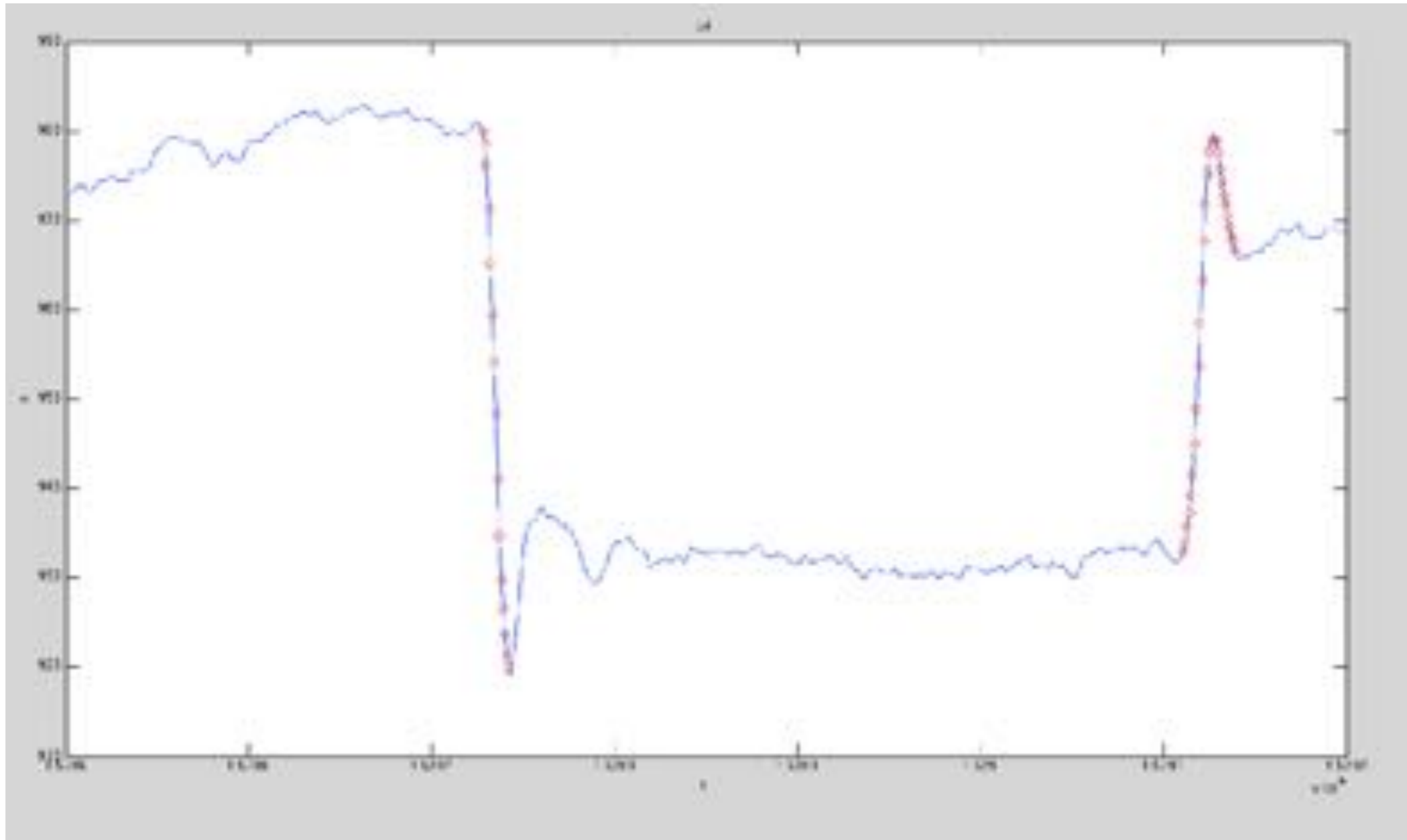
requires that eyes move to read

reading makes high demands on oculomotor control



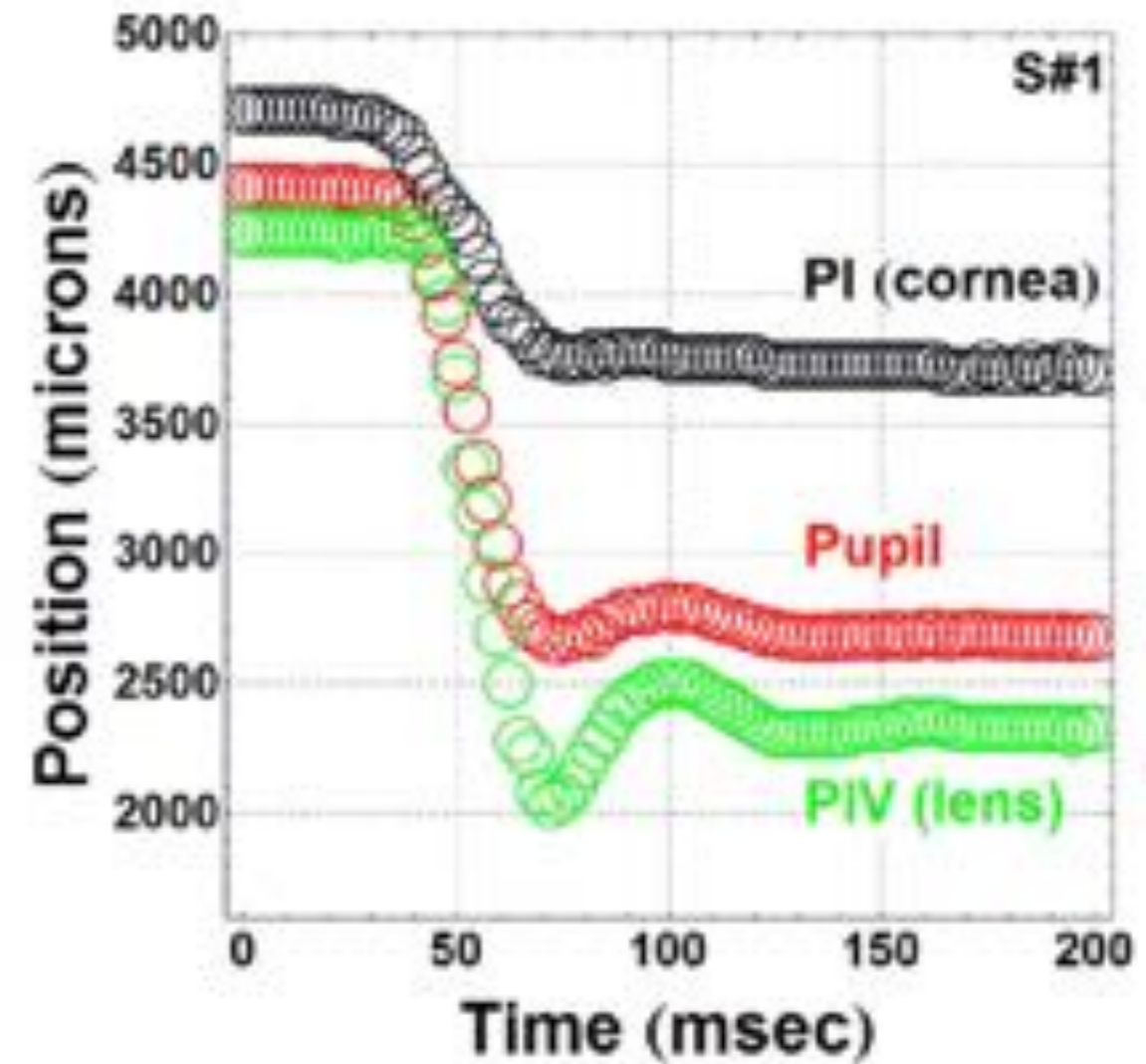
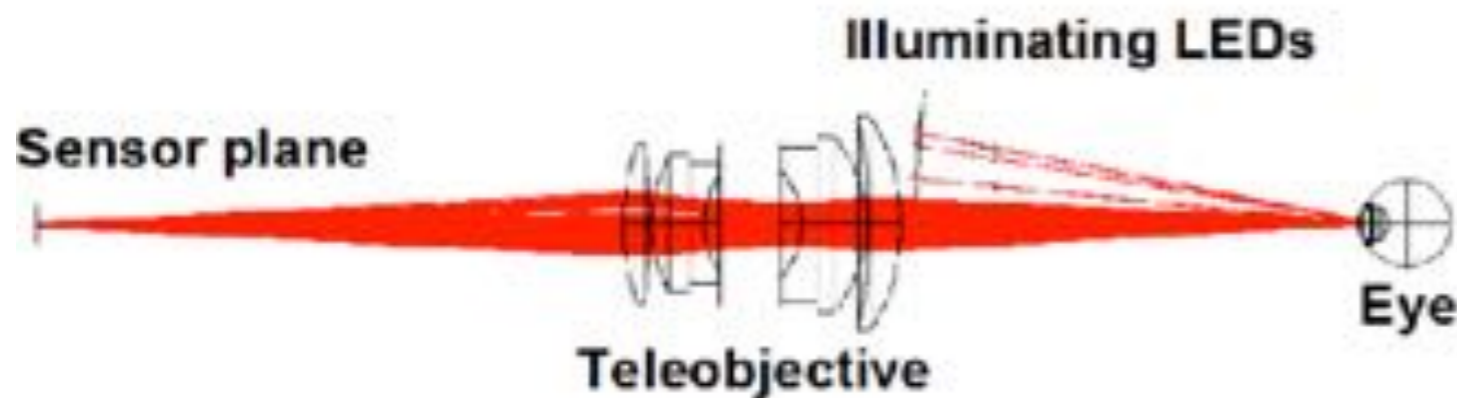
impairments in these functions will make
reading difficult

oculomotor overshoots



saccades during reading

lens oscillations

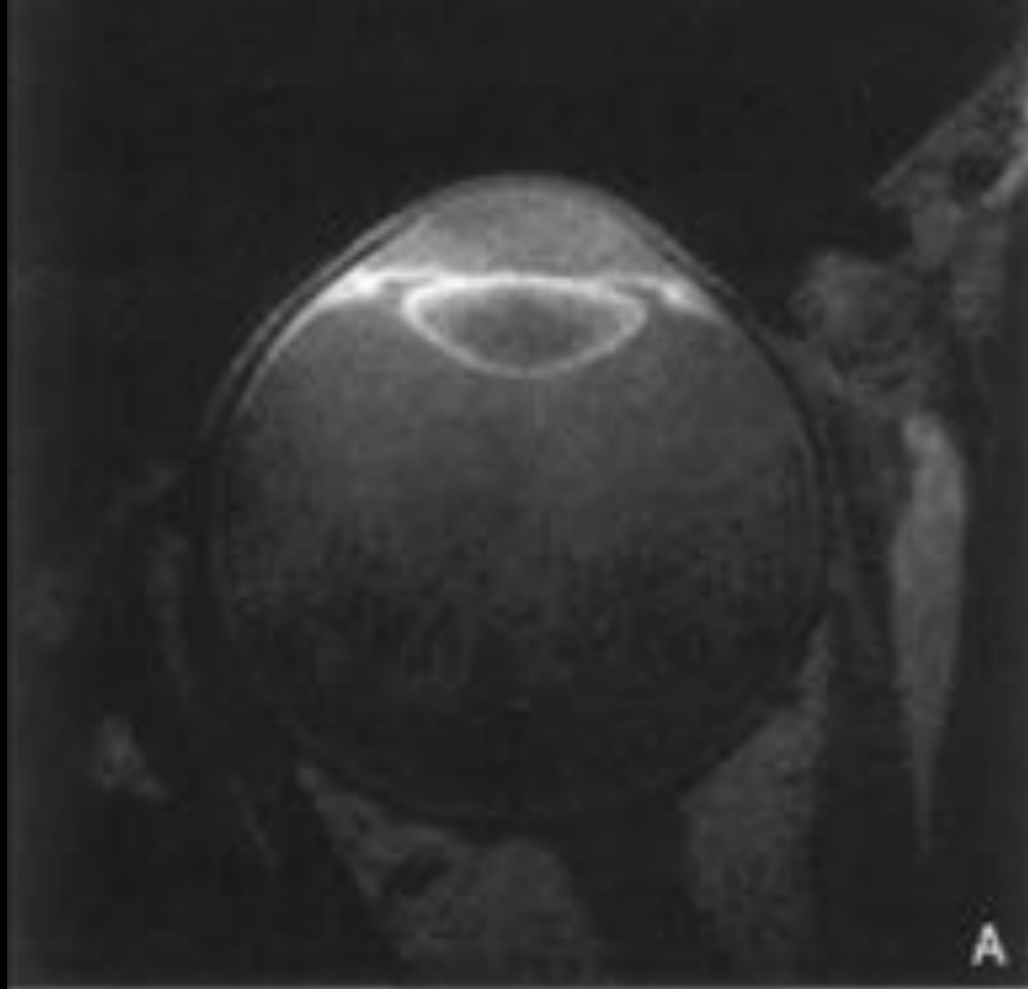


Taberno, J., & Artal, P. (2014). Lens Oscillations in the Human Eye. Implications for Post-Saccadic Suppression of Vision. *PLoS ONE*, 9(4), e95764. <http://doi.org/10.1371/journal.pone.0095764>

Deubel, H., & Bridgeman, B. (1995). Perceptual consequences of ocular lens overshoot during saccadic eye movements. *Vision Research*, 35(20), 2897–2902. [http://doi.org/10.1016/0042-6989\(95\)00042-X](http://doi.org/10.1016/0042-6989(95)00042-X)

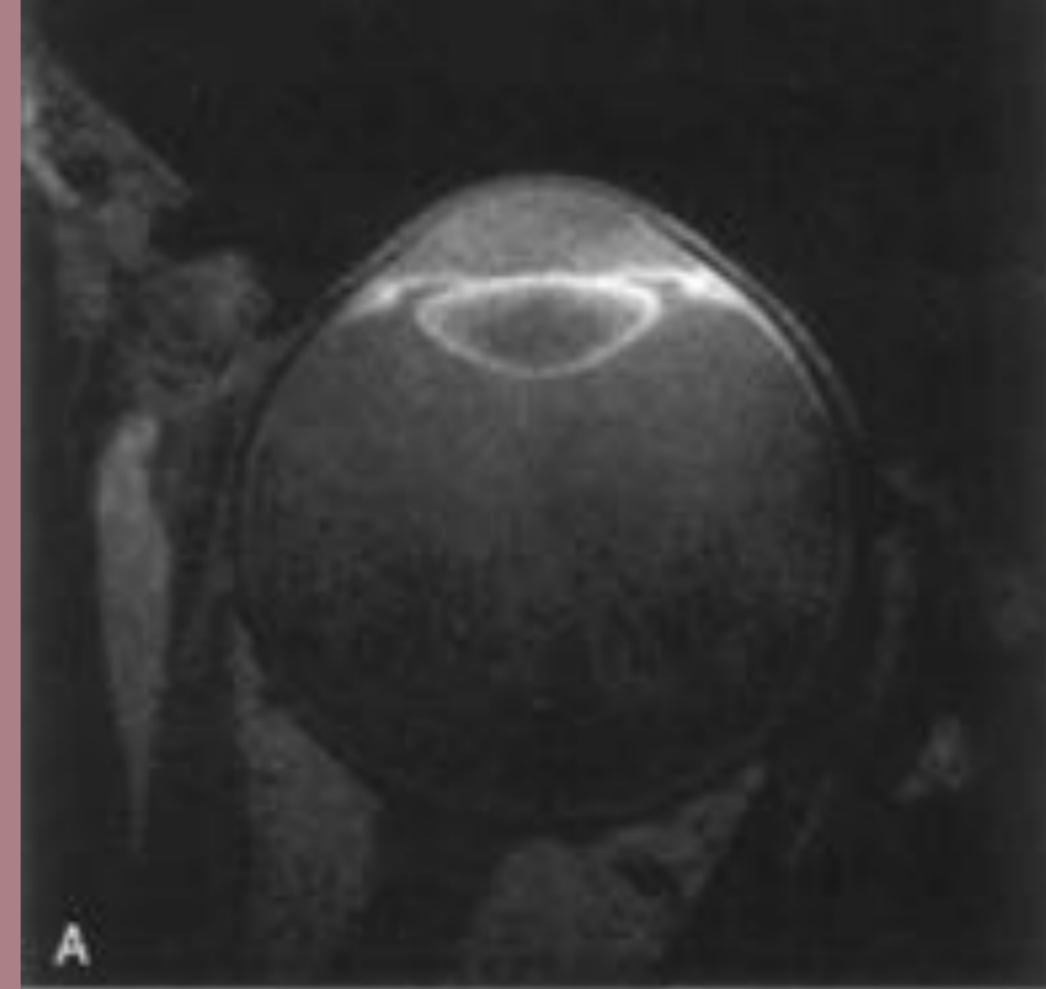
binocular phenomenon

two eyes must align in vergence, version, and accommodation

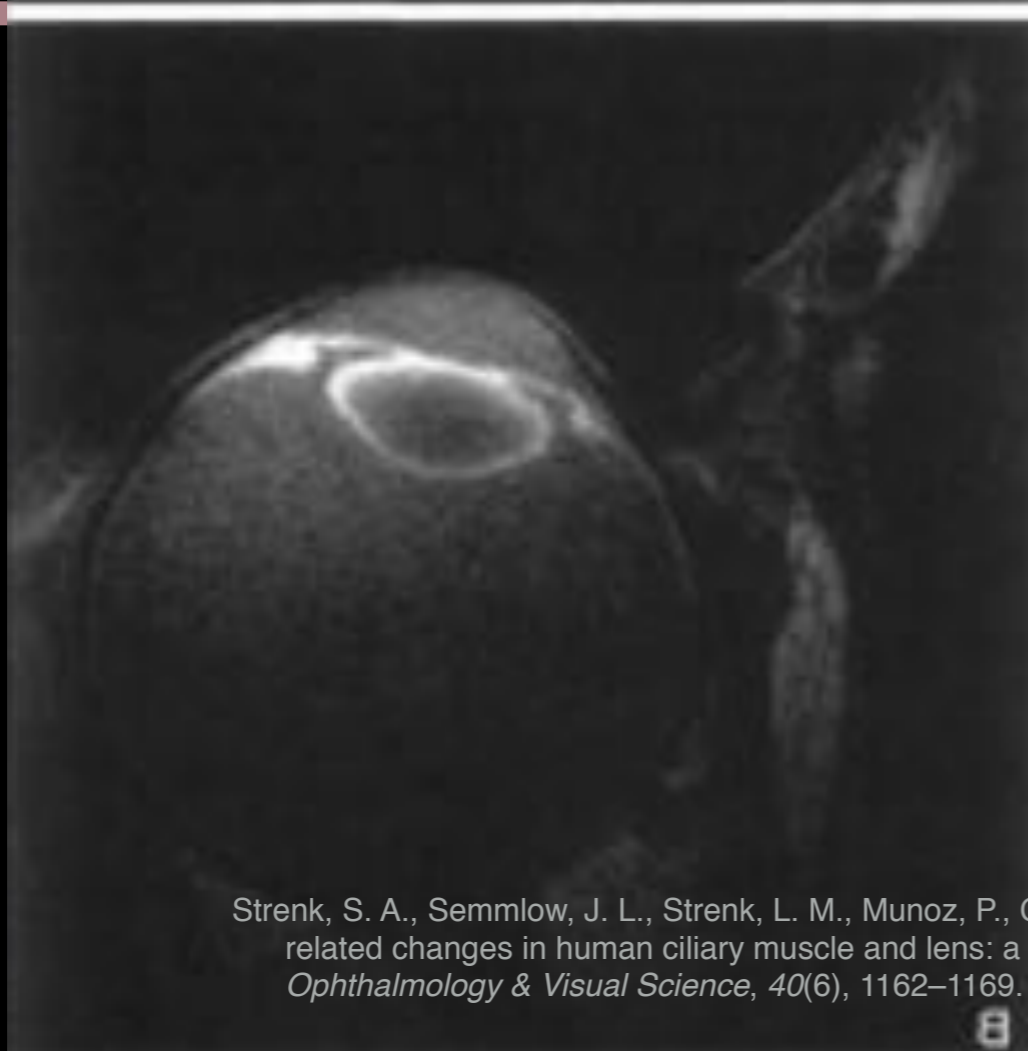


A

far

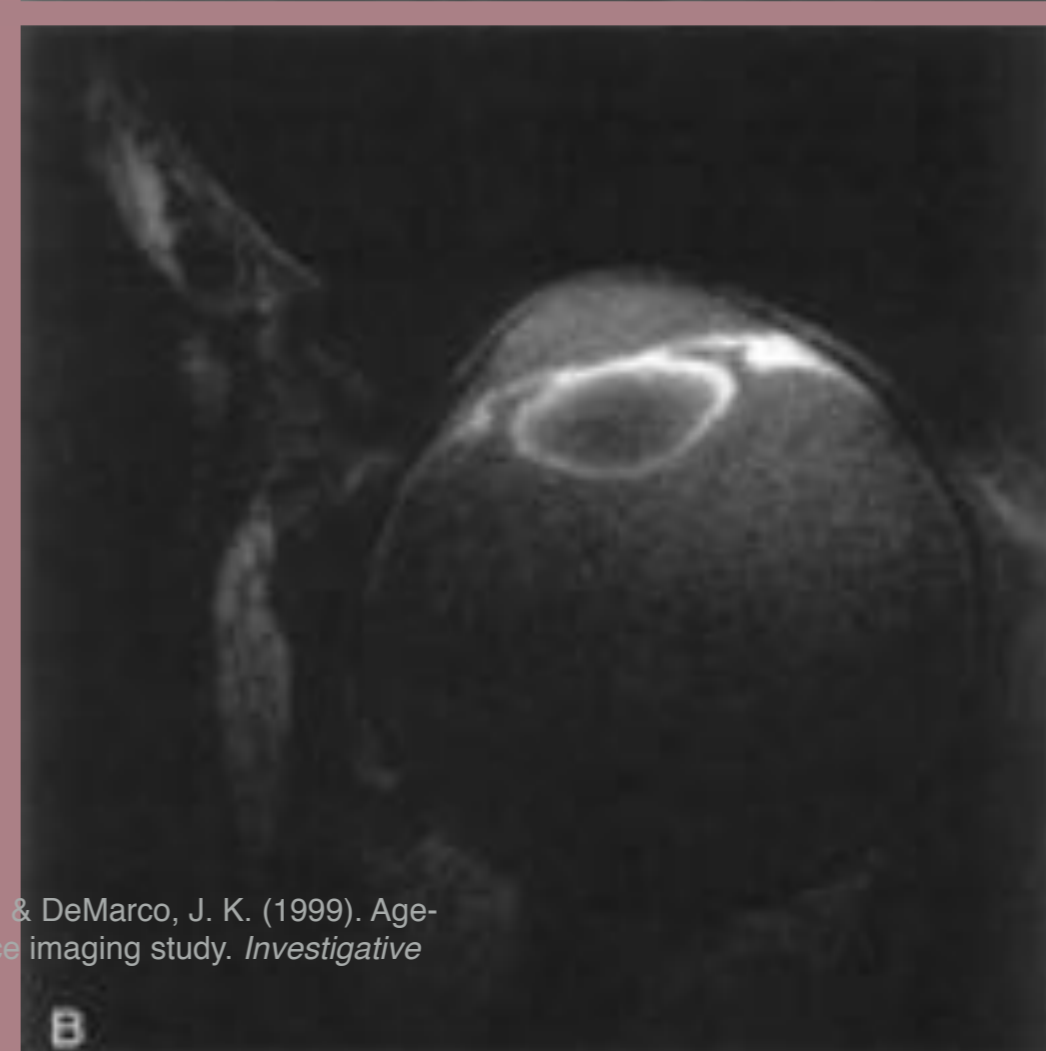


A



B

near



B

Strenk, S. A., Semmlow, J. L., Strenk, L. M., Munoz, P., Gronlund-Jacob, J., & DeMarco, J. K. (1999). Age-related changes in human ciliary muscle and lens: a magnetic resonance imaging study. *Investigative Ophthalmology & Visual Science*, 40(6), 1162–1169.

reading demands

precise fixation every 200 ms

binocular alignment of

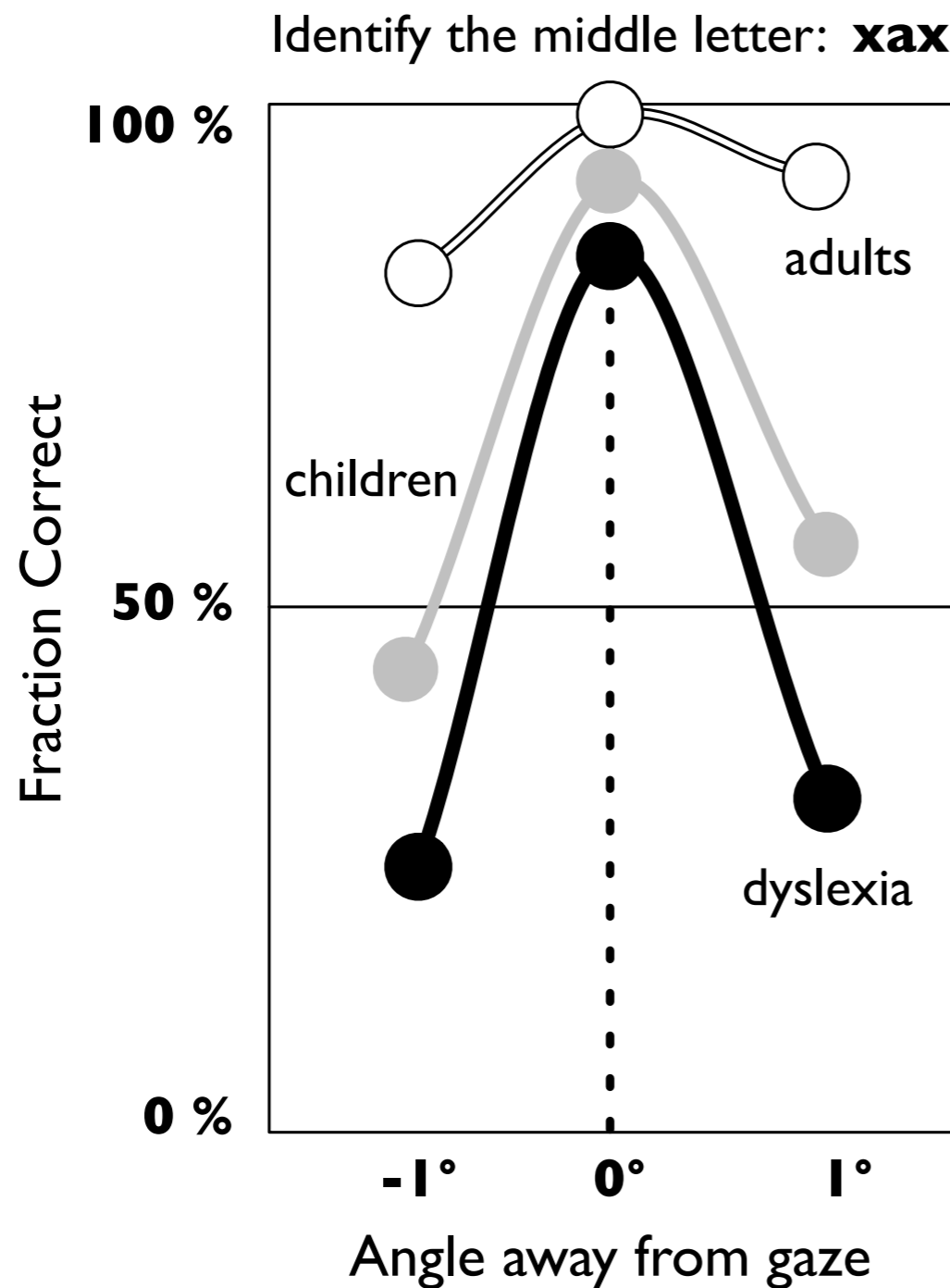
version, vergence, and accommodation

within 50 ms of word onset

oculomotor control

infants develop adult-like facility in the first 6 mo





**children learn
to deal
with crowding**

but some people
never do

Bouma, H., & Legein, C. P. (1977). *Neuropsychologia*, 15(1), 69–80.

Cassim, R., Talcott, J. B., & Moores, E. (2014). *PLoS ONE*, 9(9), e106191.

dyslexia: oculomotor instability

- fixation (“immature” Tiadi et al 2016)
- vergence (Stein, Liddell, Fowler 1988,)
- binocular accommodation (Quaid & Simpson 2012)

Tiadi, A., Gerard, C.-L., Peyre, H., Bui-Quoc, E., & Bucci, M. P. (2016). Immaturity of Visual Fixations in Dyslexic Children. *Frontiers in Human Neuroscience*, 10, 58. <http://doi.org/10.3389/fnhum.2016.00058>

Stein, J., Riddell, P., & Fowler, S. (1988). Disordered vergence control in dyslexic children. *Br J Ophthalmol*, 72(3), 162–166.

Quaid, P., & Simpson, T. (2013). Association between reading speed, cycloplegic refractive error, and oculomotor function in reading disabled children versus controls., *251*(1), 169–187. <http://doi.org/10.1007/s00417-012-2135-0>

binocular pathologies

- **amblyopia** - unexplained visual deficits
- **strabismus** - misaligned eyes
- **anisometropia** - difference in refractive error
- **spasm of accommodation**
- **oculomotor nerve palsy** ("oculomotor neuropathy")

not routinely diagnosed in ophthalmological exams

takeaways

- Text is **CROWDED**.
- You must accurately **FIXATE** on word to decode it.
- The eyes must **MOVE**.
- Reading is **DYNAMIC**.
- Decisions are made **RAPIDLY**. (4 times per sec!)
- **VARIOUS** impairments affect oculomotor control.
- Text is **NOT DESIGNED** for reading.
- Its **AMAZING** that people can read at all!

comments?

- **NEXT:** we will talk about what can be done about this.

benefits and pitfalls of tech

If phonological instruction fails to provide benefits, what is a practitioner to do? Here, we will discuss some of the research in this area, and talk about the benefits and pitfalls of assistive technologies intended to help those who struggle with reading and writing.

your stories

This will be an interactive session, so please come prepared with stories and examples from your own practice or experience to share with the group. (What problems did you encounter? Did you find solutions? Did technology help?)

Thank you, Carol Veninati (LCIRT note taker)!

reading

"All the News
That's Fit to Print"

The New York Times

VOL. CLXXIV No. 55,667

EST. 1787

NEW YORK, MONDAY, NOVEMBER 18, 2014

Five pages for the

In Gaming, He's No. 1 With a Bullet

Sponsors Help Rising Star
Train Like an Olympian

By CONOR DOUGHERTY

LOS ANGELES — Matt Haag, a professional video game player, makes over one million dollars a year sitting in a comfortable armchair, looking at a 24-inch monitor screen. He will do about anything to win it.

That is why, on a recent morning, he was in a basement in Venice Beach, Calif., training for a game. The last round produced, but Haag's practice partner with experience like his and other pros, whose salaries of up to \$1 million a year are not unheard of, was trained to a level that is not even close to that.

The session was just the beginning of a training routine that Haag, 28, has followed since he was 16. Haag's sponsors, organized to help and



POWERUP
The 16-year-old
in 2008, Haag
training that he
was around 16,
he and his fellow
players got their

More Agencies Undercover

No Longer Left to FBI
Adapted by I.R.S., N

By MICHAEL W.

WASHINGTON — The federal government has reportedly expanded its undercover operations in recent years, with officers from at least six agencies going on business trips, making speeches, political speeches and even running campaigns to win elections, according to a report by the Washington Post.

At the Bureau of Tax, and even at undercover officers from as little as four agencies, officers are being sent to work in the field, working to connect with the public.

At the Internal Revenue Service, dozens of undercover agents have reported to avoid the workload by using other programs, including that of the Internal Revenue Service and even, in some cases, the FBI.

At the Agriculture Department, which has 20 undercover agents, the report says that the agency has a number of undercover agents in the field, including those in the

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Top Stories

No. 1 With a Bullet: 'Nadeshot' Becomes a Call of Duty Star

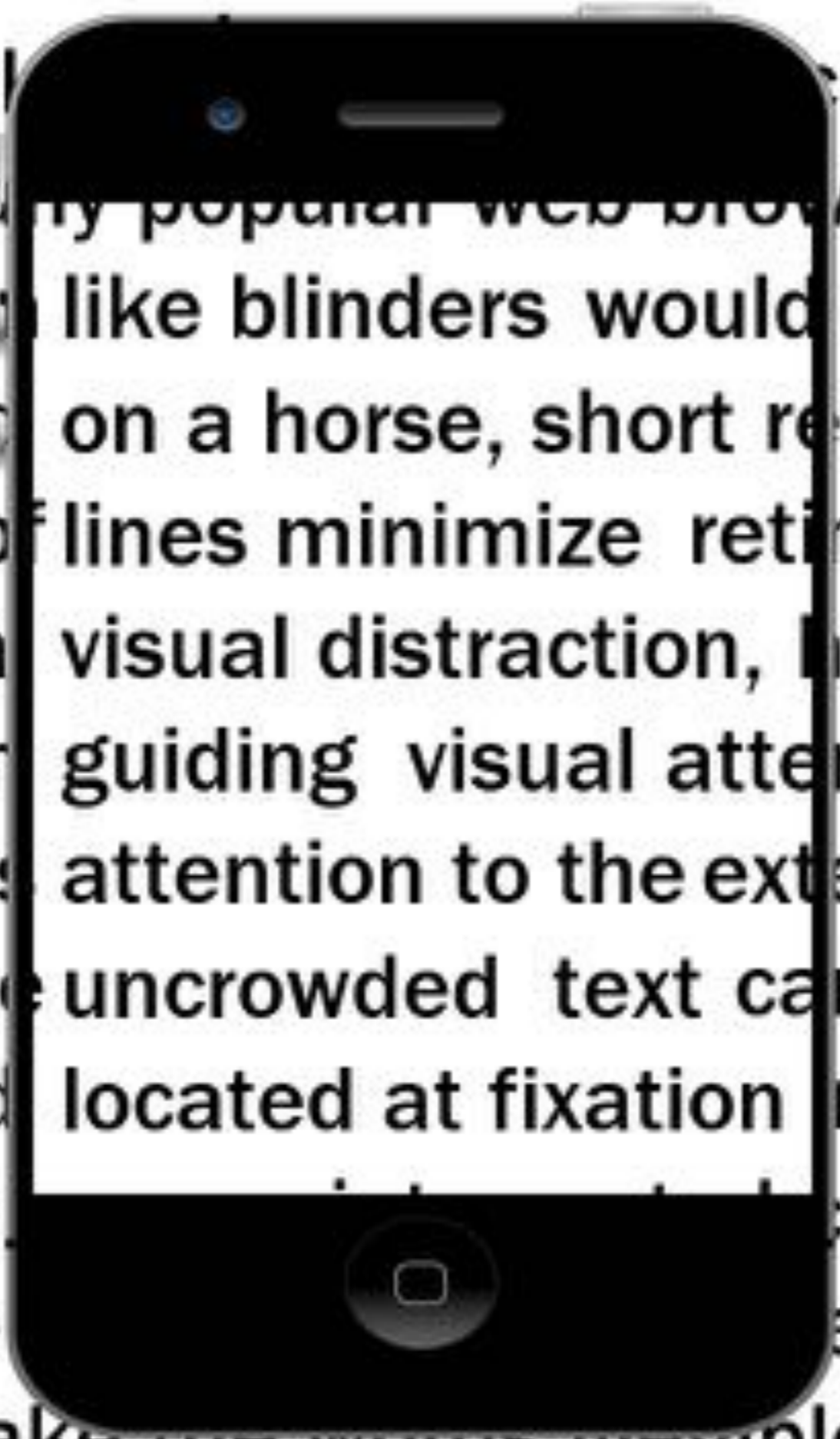
By CONOR DOUGHERTY
Last Updated: November 15, 2014

LOS ANGELES — Matt Haag, a professional video game player, makes close to a million

tools to control attention include screen limiters included in many popular web browsers that serve as a to limit vs pan like blinders would act to prevent clutter. Placed on a horse, short retinal segments foveal streak of lines minimize retinotopic clutter and peripheral visual distraction, hypersensitivity concentrate on guiding visual attention.

Crowding leads attention to the exterior portions of fonts, hence uncrowded text cannot be parsed hindering word located at fixation intrude and interfere. This causes interrupted comprehension that otherwise divert, crowding letters, to cause clutter that make the words illegible in dyslexia

tools to control screen limiters included in many popular web browsers that serve a to limit vspan like blinders would act to prevent clutter. Placed on a horse, short retinal segments foveal streak of lines minimize retinotopic clutter and peripheral visual distraction, hypersensitivity concentrate on guiding visual attention. Crowding leads attention to the exterior portions of fonts, hence uncrowded text cannot be parsed hindering words located at fixation intrude and interfere. This comprehension that otherwise letters, to cause clutter that make the words illegible in dyslexia





**like blinders
on a horse, short
lines minimize
visual distraction,
guiding visual
attention to the
uncrowded text
located at fixation**

A black smartphone is shown vertically, centered against a white background. The screen is white and contains black text. The text is arranged in seven lines, centered horizontally. The text reads: "like blinders on a horse, short lines minimize visual distraction, guiding visual attention to the uncrowded text located at fixation". The phone has a small blue light at the top left of the screen, a horizontal slot at the top center, and a square home button at the bottom center.

like blinders
on a horse, short
lines minimize
visual distraction,
guiding visual
attention to the
uncrowded text
located at fixation

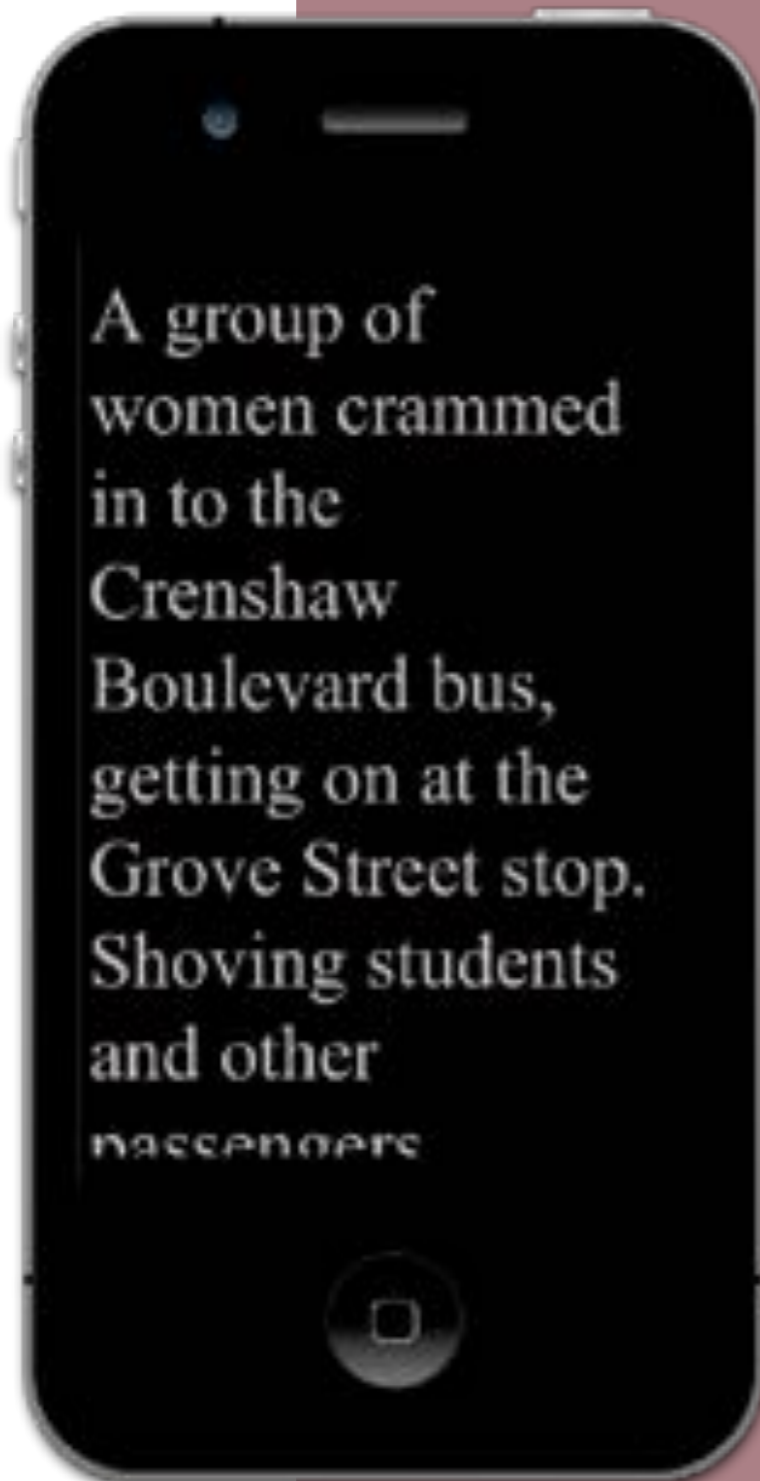
blinders on a horse

narrow format shields
peripheral distractions

distraction from
neighboring text



pilot test of theory



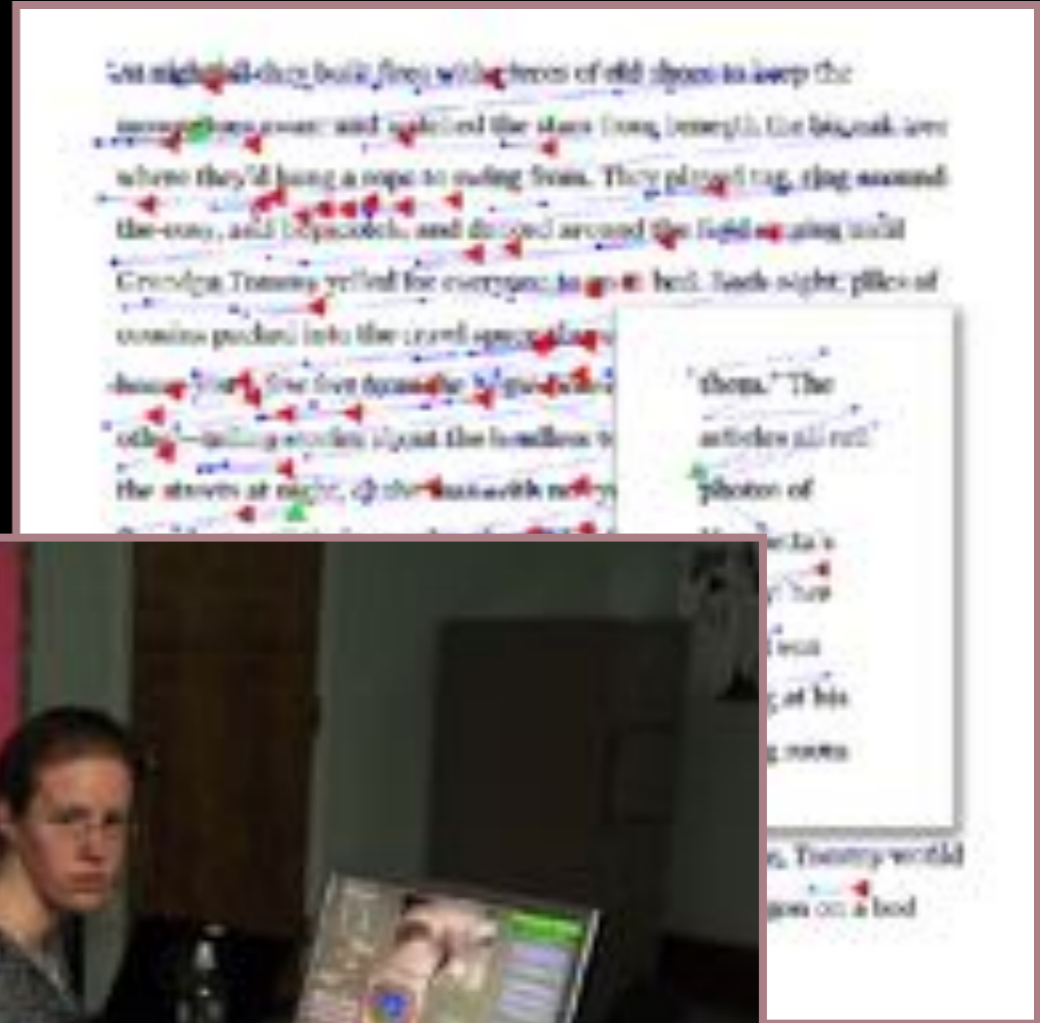
narrow formats were as successful as practiced accommodations

Schneps, M. H., O'Keeffe, J. K., Heffner-Wong, A., & Sonnert, G. (2010). Using Technology to Support STEM Reading. *Journal of Special Education Technology, 25*(3), 21–32.

reading tech



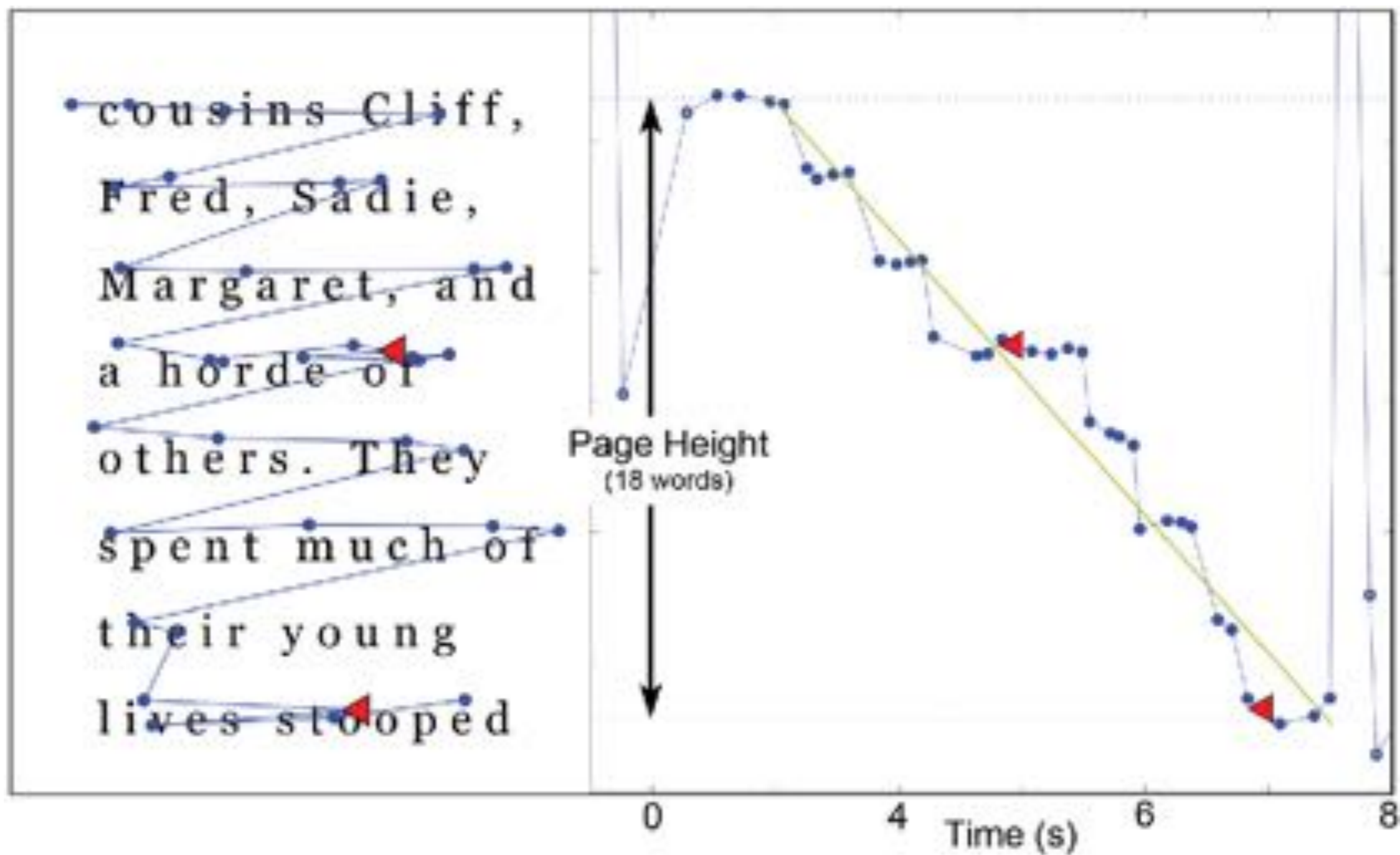
Massachusetts
Institute of
Technology



A group of women crammed in to the Crenshaw Boulevard bus, getting on at the Grove Street stop. Shoving students and other passengers

Schneps, M. H., Thomson, J. M., Sonnert, G., Pomplun, M., Chen, C., & Heffner-Wong, A. (2013). Shorter Lines Facilitate Reading in Those Who Struggle. *PLoS ONE*, 8(8), e71161.



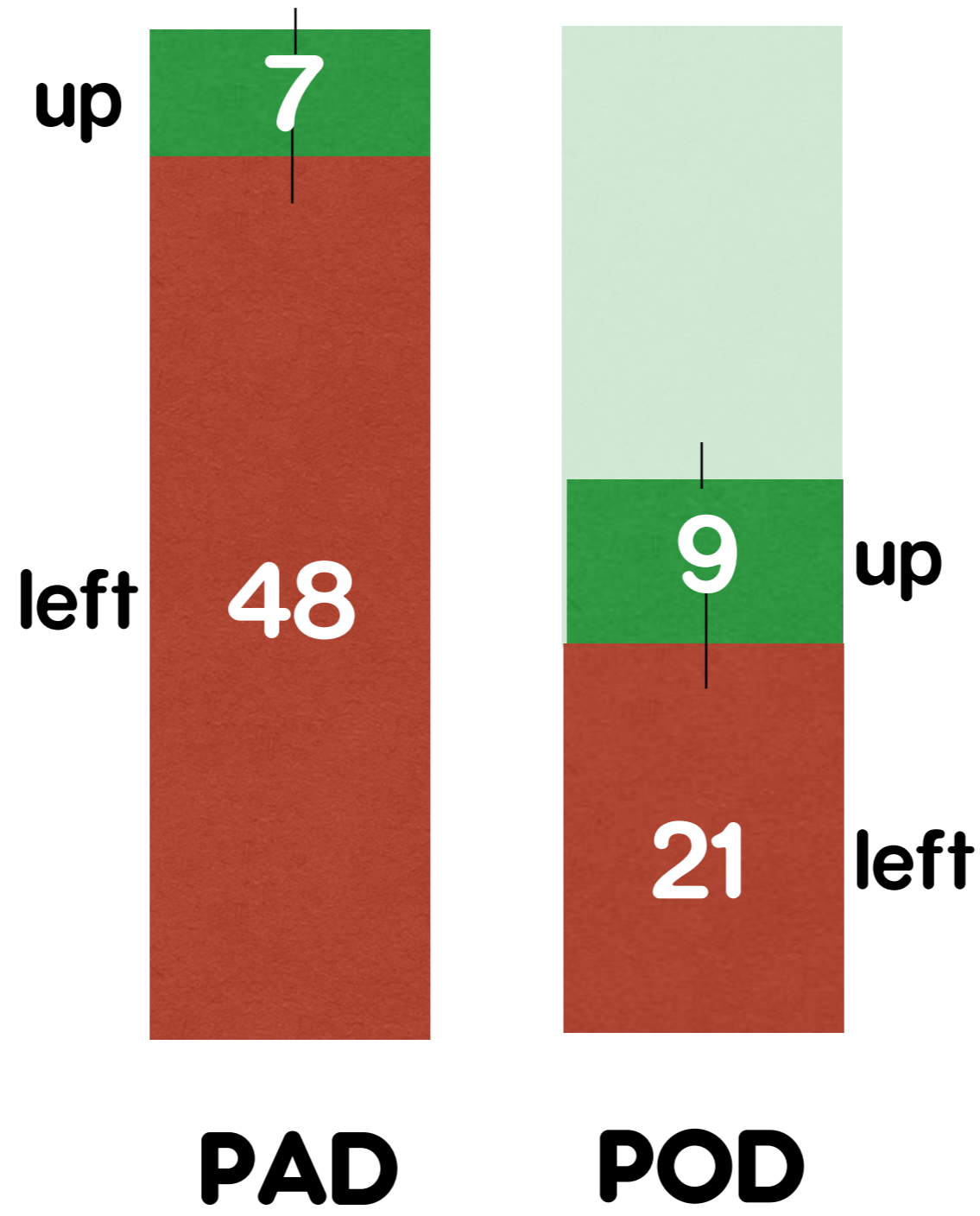


At nightfall they built fires with pieces of old shoes to keep the mosquitoes away, and watched the stars from beneath the big oak tree where they'd hung a rope to swing from. They played tag, ring-around-the-rosy, and hopscotch, and danced around the field singing until Grandpa Tommy yelled for everyone to go to bed. Each night, piles of cousins packed into the crawl space above the house just a few feet from the hog house other—telling stories about the headless to the streets at night, or the man with no eye then slept until their grandmother ElJoe and woke them to the smell of fresh biscuits during harvest season. Grandpa Tommy had and readied them to ride into the town of nation's second-largest tobacco market, with Tobacco pageant, and a port where boats of people around the world to smoke. Before leaving home, Tommy would call for the young cousins, who'd nestle into the flat wagon on a bed

END

them." The articles all ran photos of Henrietta's family: her oldest son sitting at his dining room

iPod better



iPod better

read 27% faster

11% fewer eye movements

regressions cut in half!

no loss in comprehension

comprehension

Paper Version

STUDENT NAME: _____ Date: _____

Tutor's Initials: _____ Period: _____

Time it took student to read first pass through: ____ min ____ sec

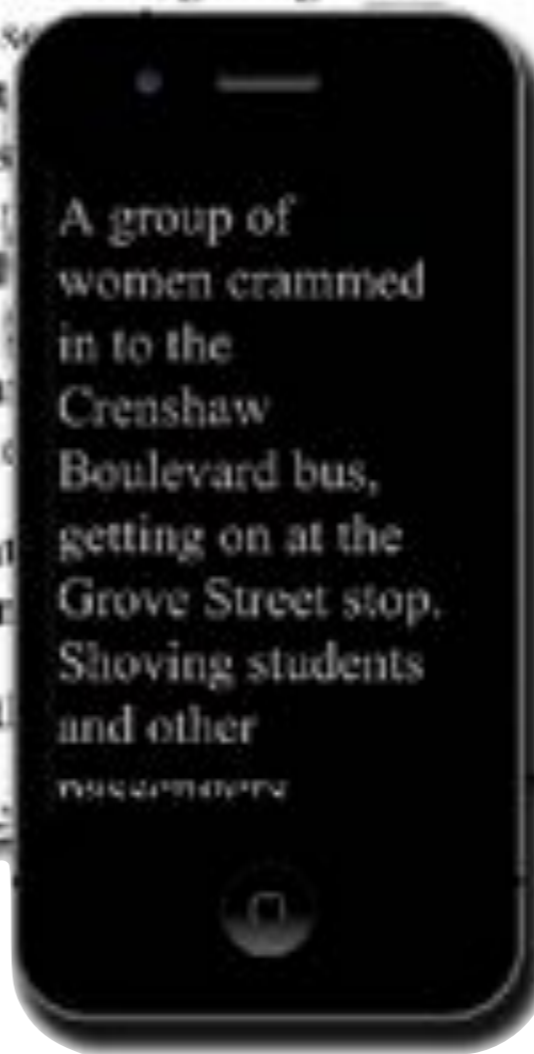
A group of women crammed in to the Crenshaw Boulevard bus, getting on at the Grove Street stop. Shoving students and other passengers in line, by pushing and heaving, they forced themselves into the bus to make room for themselves where none seemed to be. As the bus started the long RUN to Huntington Street, the women settled into their private worlds, creating the illusion of space for themselves by separating them from the others on the bus. The worlds they made for themselves were made from newspapers and magazines, behind blank spaces on the wall at the panels of advertising that lined the space above the seats.

2-1. Why was it difficult to get on the bus?

- A. The bus tried to skip the stop.
- B. The bus was under construction.
- C. The bus had lots of people on it.
- D. Everyone had backpacks.

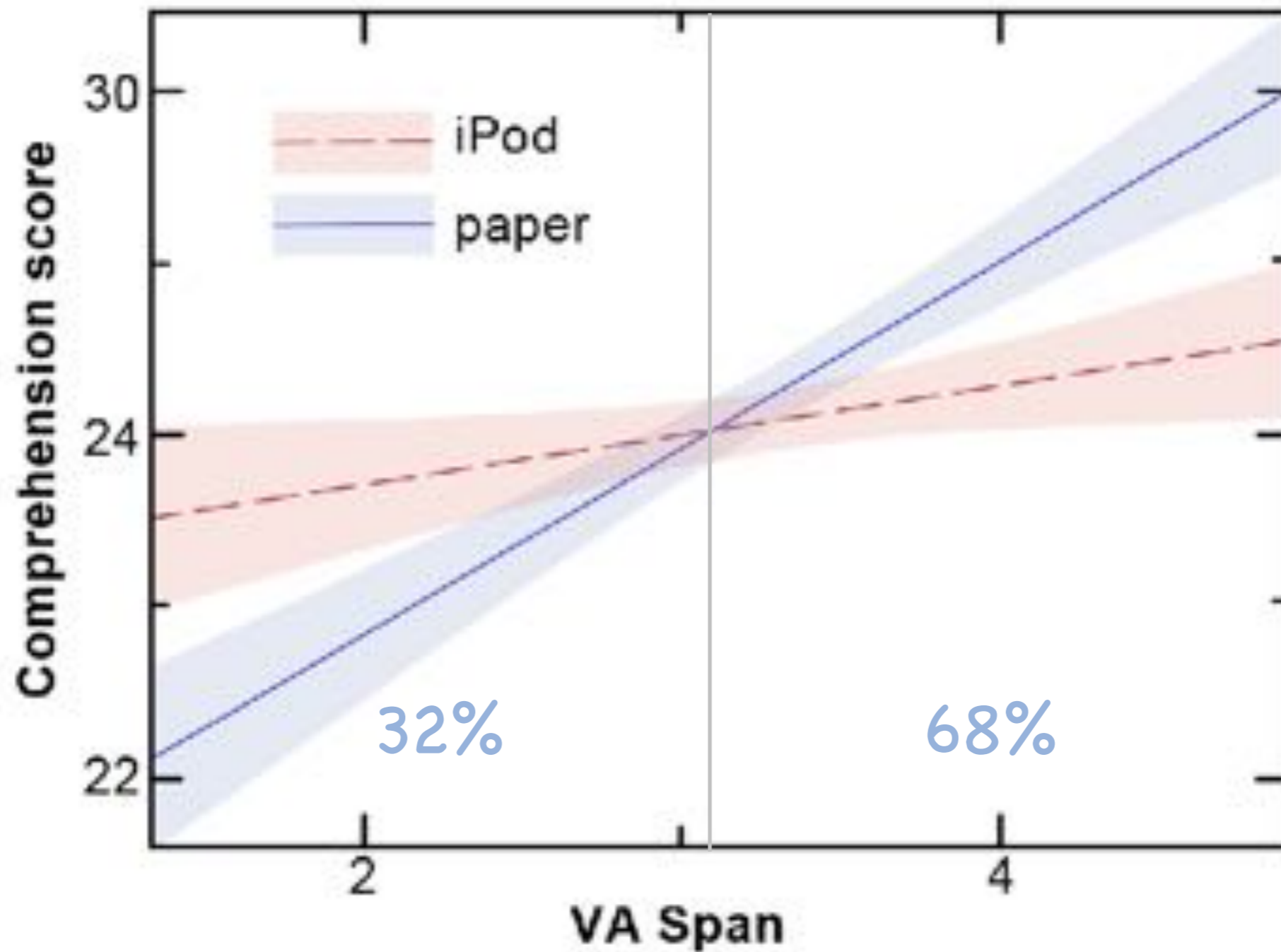
2-3. Staring at the bus, I observed the same thing.

- A. getting on the bus
- B. taking a break
- C. the bus was under construction



103
Landmark
HS students





about 1/3 of the participants w/dyslexia
comprehend better on iPod

format matters

A

ando la pera. La bambina asc
illo è magro. La quercia si tro
fiore è rosso. La bambina ave
ola. Il ragazzo non ha né capp
stanno saltando sopra il murc
no seduti e guardano verso la
terrazza potrebbero vedere tu
tetto della casa si vede anche
to, ma non il bicchiere. L'elef
o sul ramo dell'albero. La bar
i è verde. I ragazzi raccolgono

B

Il ragazzo che
lo è magro. La q
ella città. Non so
è rosso. La bam
stella, dentro cu
il ragazzo non ha

Zorzi, M., Barbiero, C., Facoetti, A., Lonciari, I., Carrozzi, M., Montico, M., et al. (2012). Extra-large letter spacing improves reading in dyslexia. *Proceedings of the National Academy of Sciences of the United States of America*, 109(28), 11455-11459.

format matters

For all those people who believe that Nessie isn't real
Perhaps you need to think again, she is the real deal.
Though far from being scary she is shy and rather small
So if you want to catch a peek you must be on the ball.
Nessie only pops her head up every now and then
And dives down to the darkest depths and huddles
in her den.

reduced crowding?

Marinus, E., Mostard, M., Segers, E., Schubert, T. M., Madelaine, A., & Wheldall, K. (2016). A Special Font for People with Dyslexia: Does it Work and, if so, why? *Dyslexia* (Chichester, England).

comments?

let's

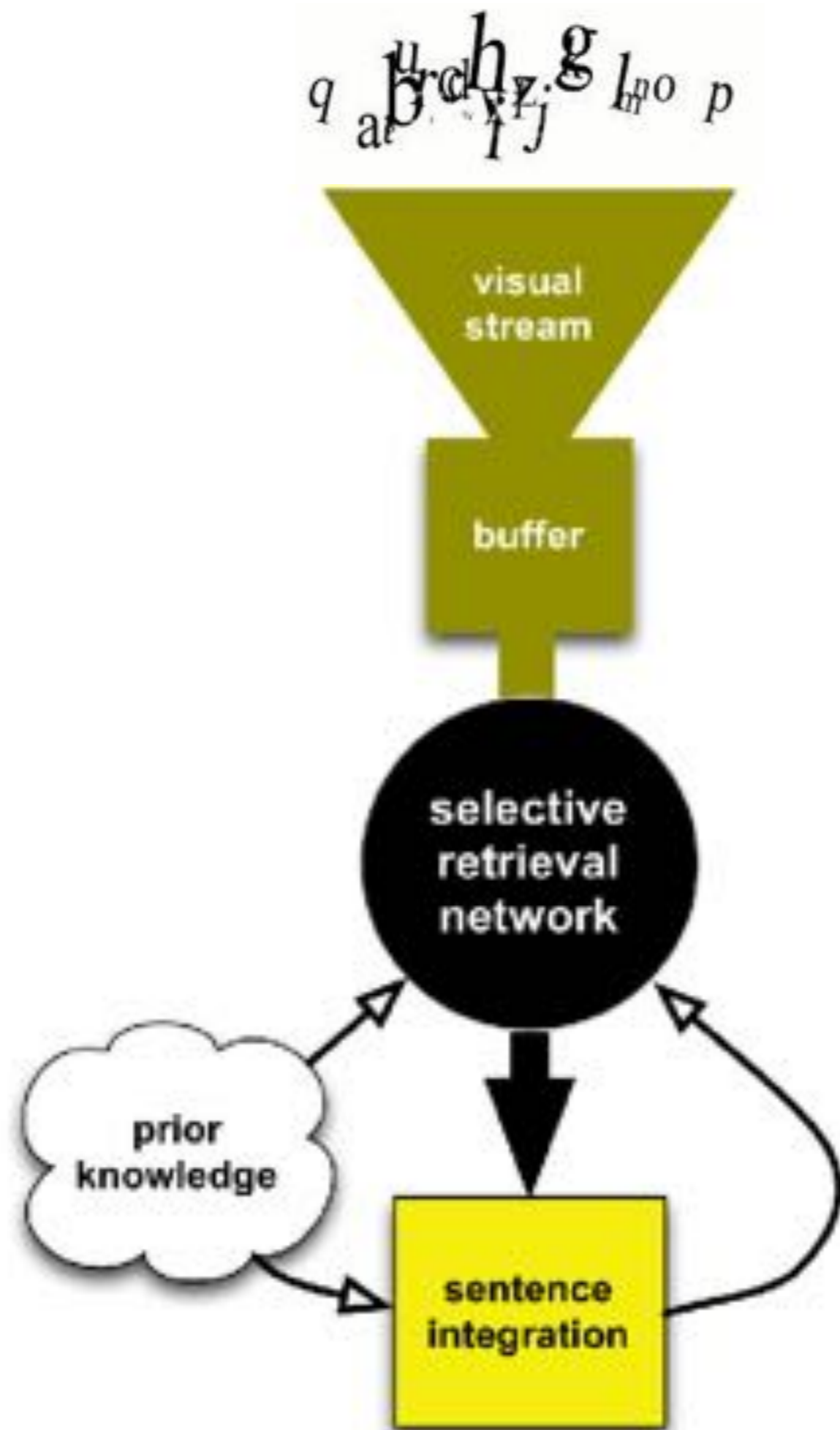
**improve the
efficiency of scanning**

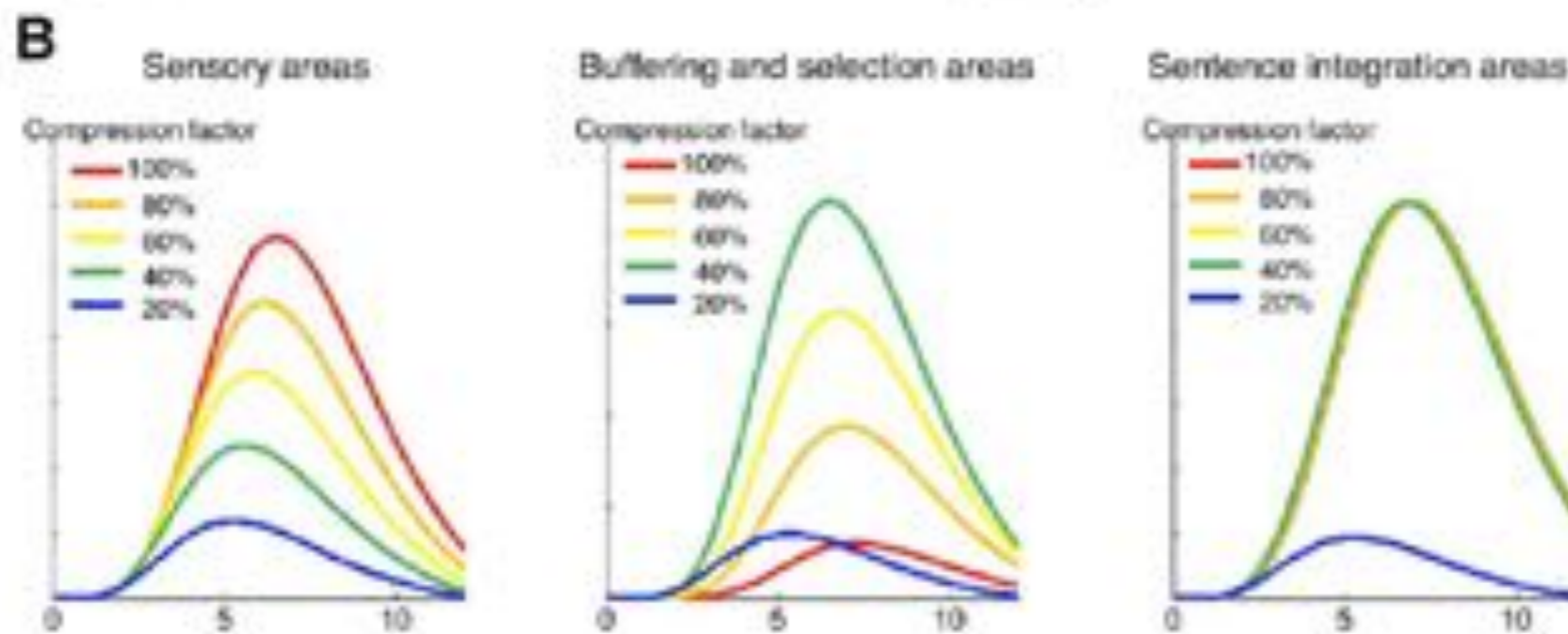
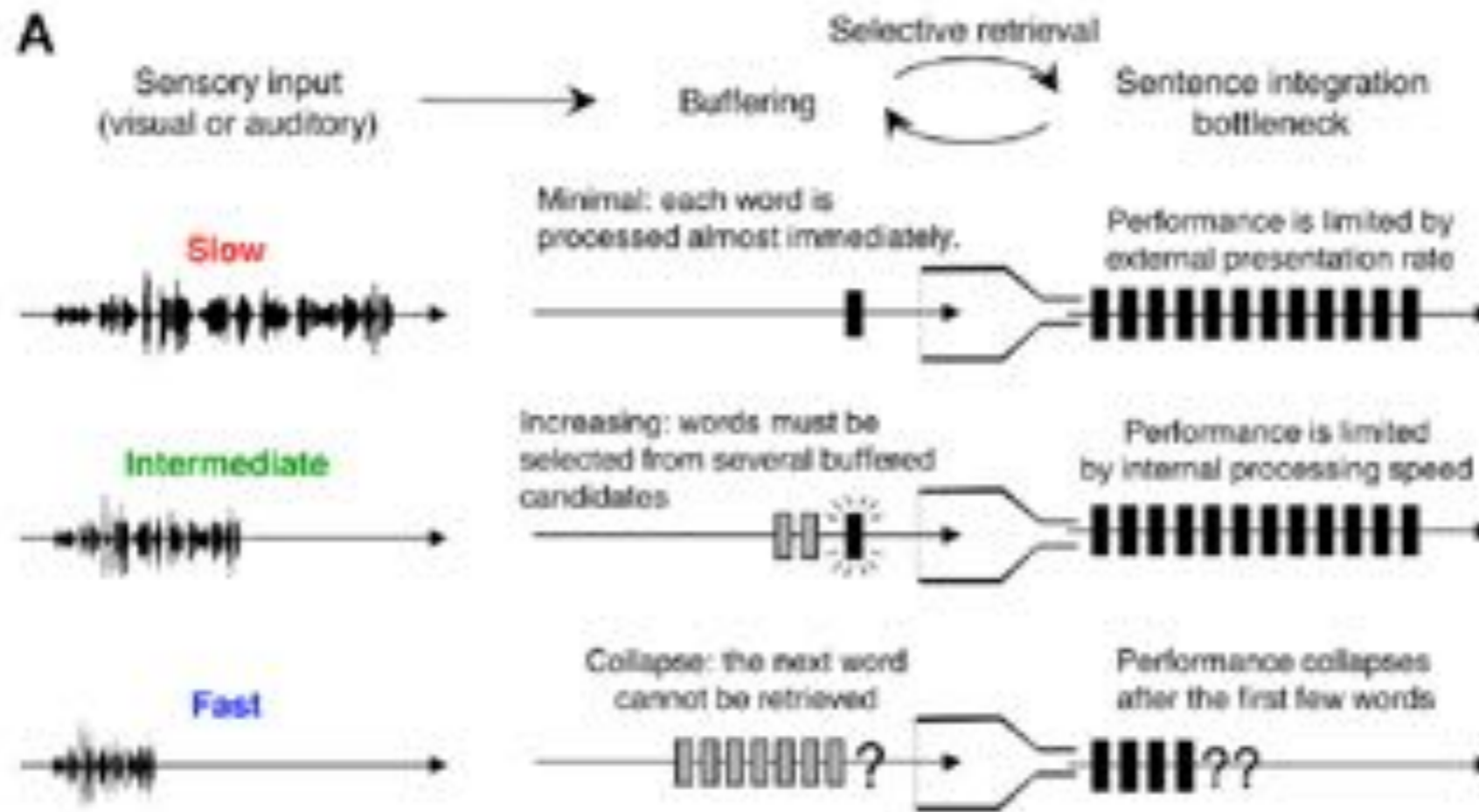
http://mollylab-1.mit.edu/lab/CSTM_Demo3.html

Prof. Molly Potter MIT

RSVP

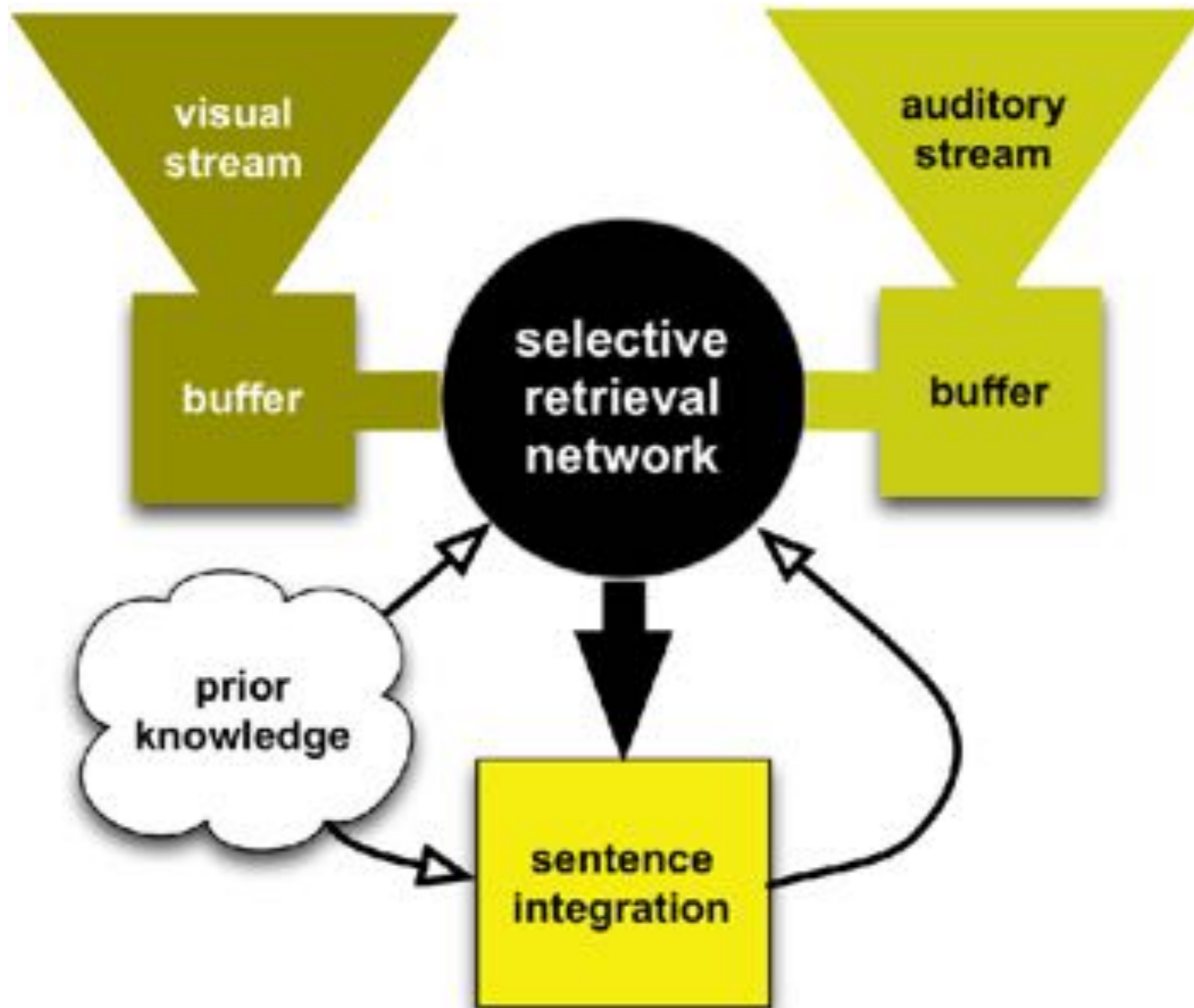
**commercial RSVP app for reading:
Flash Reader**





Vagharchakian, L., Dehaene-Lambertz, G., Pallier, C., & Dehaene, S. (2012). A temporal bottleneck in the language comprehension network. *Journal of Neuroscience*, 32(26), 9089–9102.

vdr experiment



This is to invite
your
collaboration in
an experiment to
investigate new
e-reader
technologies for
reading. We are

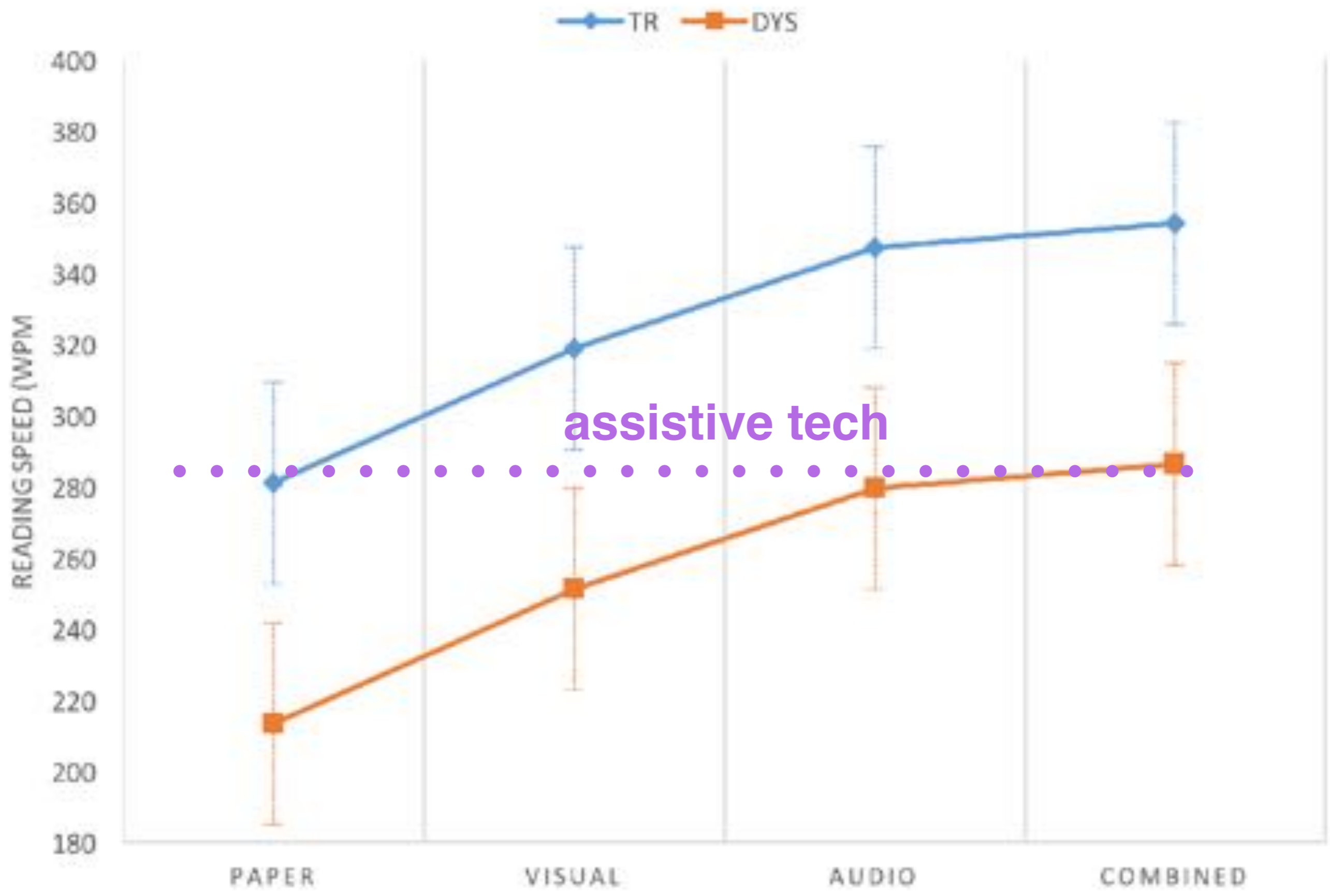
demonstration of
VDR
experiment

Winston Chen



Voice Dream Reader

www.voicedream.com



spelling

- MS Word
- Online Dictionaries
- Dragon
- Google Search

writing

- Scrivener
- Mind Mapping Software

Notetaking

- Apps (Notes, Pearnote...)
- Livescribe Pen

memory

- Phone and computer reminders

Focus

- Noise cancelling headphones
- FM lecture mic systems
- Screen blockers (e.g., MS Word)

thinking and planning

- Mind Mapping software (e.g. iThoughtsX, Presentation)



Thanks!

**Boon
Philanthropy**



- ¹ University of Massachusetts Boston
- ² Harvard Graduate School of Education
- ³ Harvard-Smithsonian Center for Astrophysics
- ⁴ University of Sheffield
- ⁵ Landmark College

numerous faculty and students of
Landmark School, Landmark College, Harvard, Wheeler High School,
scientists from around the world who participated

Matthew H. Schneps^{1,3}, Marc Pomplun¹, L. Todd Rose², Chen Chen², Gerhard
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Banerjee⁵, Lincoln Greenhill³.



Marc
Pomplun



Chen
Chen



Jenny
Thomson



Gerhard
Sonnert



Amanda
Heffner-Wong



Jiahui
Wang



Kevin
Kent



Ann
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END

mschneps @ me.com