PATH to Reading

Training on PATH to Reading Significantly Improves Attention, Reading, and Working Memory

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Summary

PATH

- Validated program based on research in neurobiology
- Effectively improves reading
- Improves ability to attend, remember, and multitask
- Trains brain pathways to operate together
- Simple to administer

PATH to Reading

PATH to Reading?

- Computer program to improve brain's speed
- Rapid and effective
- Prevents reading and learning problems
- Remediates attention, reading, and memory

PATH to Reading

PATH to Reading Benefits All Students

- Only *PATH* training significantly improved:
  1) Attention
  2) Reading Speed 2-11 fold
  3) Reading Comprehension
  4) Pronunciation
  5) Working Memory.

- *PATH* improves academic skills regardless of reading level.
- Improvements are sustained over time.

PATH Training Improves Ability To:

- **Pay attention**
- **Read Fluently**
- **Understand**
- **Remember**
- **Multitask**
- **Navigate**

Much more easily !

When done 10-15 minutes 2-3 times/week

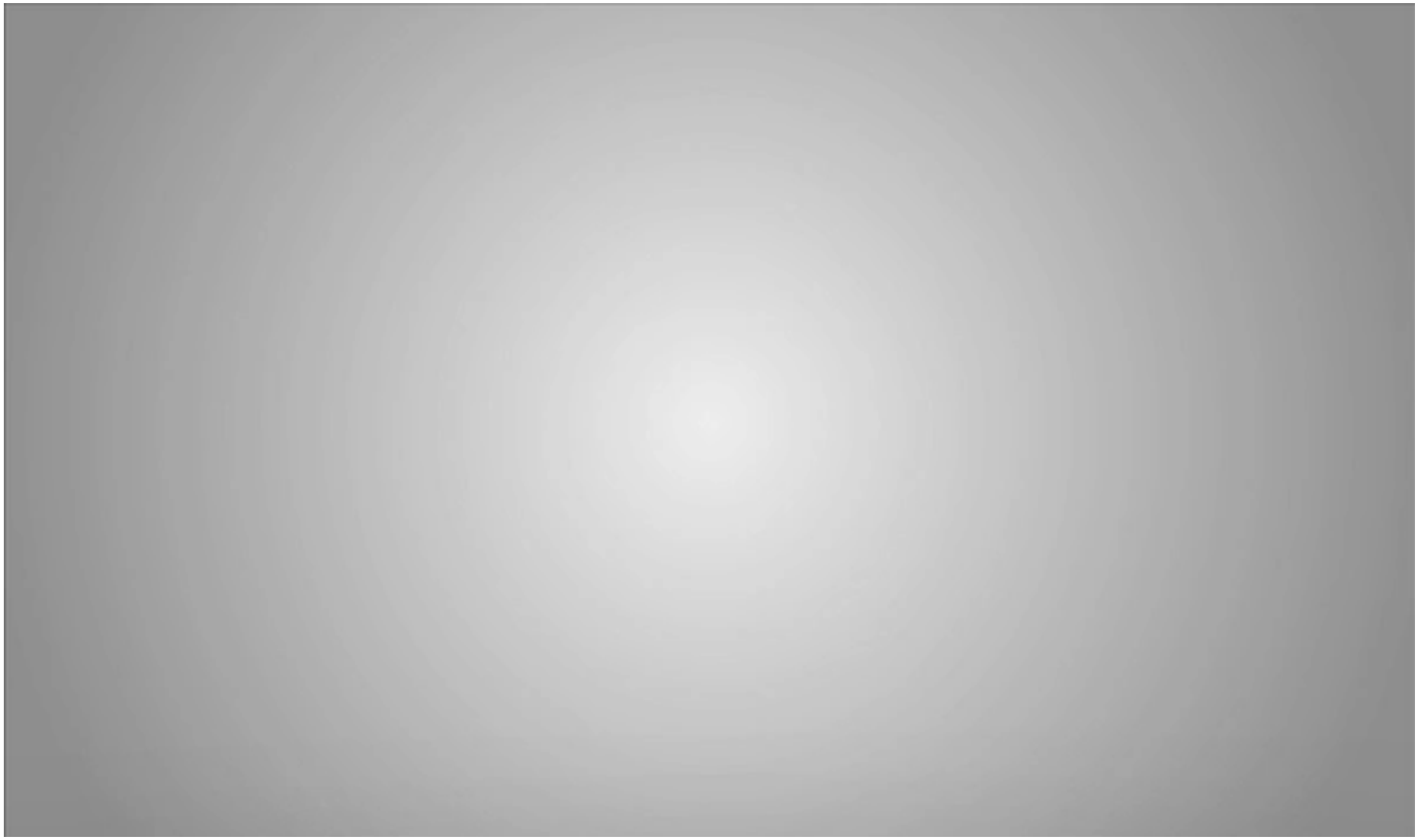
PATH to Reading

Improves Cognitive Skills

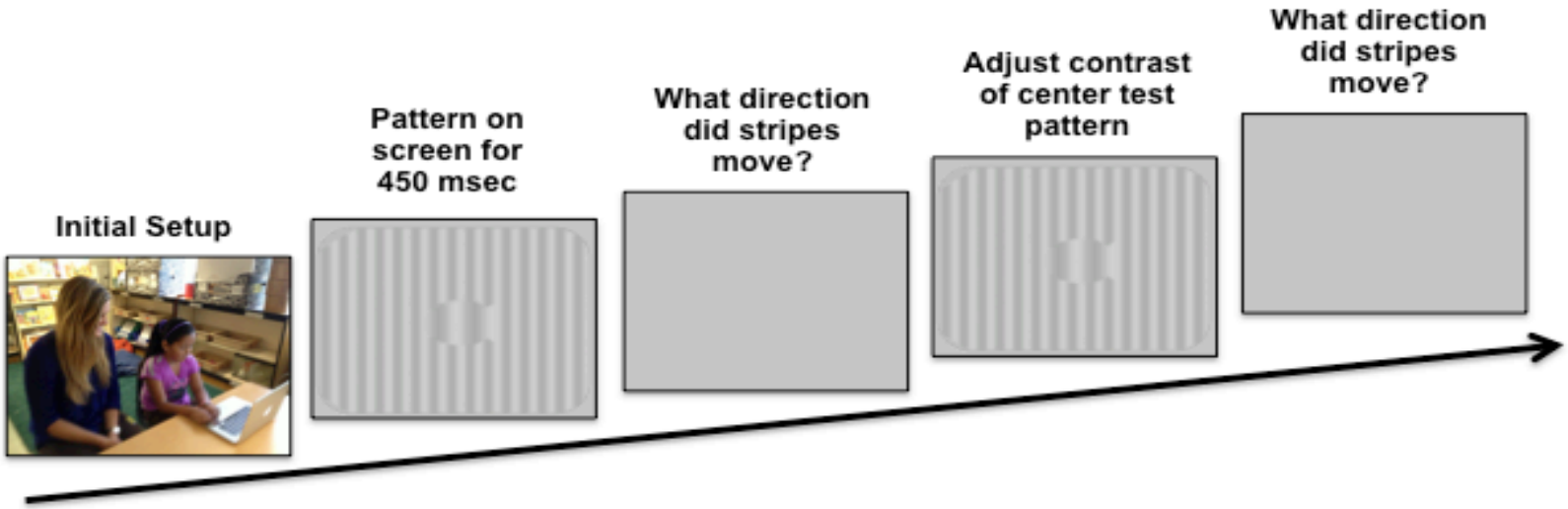
- Attention
- Processing speed
- Sequential processing
- Multi-tasking
- Cognitive fatigue
- Working Memory
- Useful Field of View

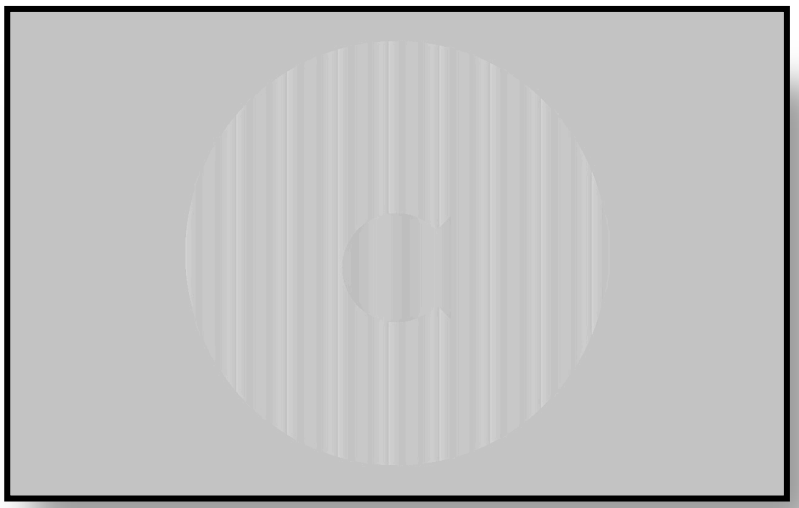
- Reading Fluency
- Comprehension
- Pronunciation
- Spelling
- Math
- Figure-Ground
- Navigation

Demonstration of PATH



PATH Program

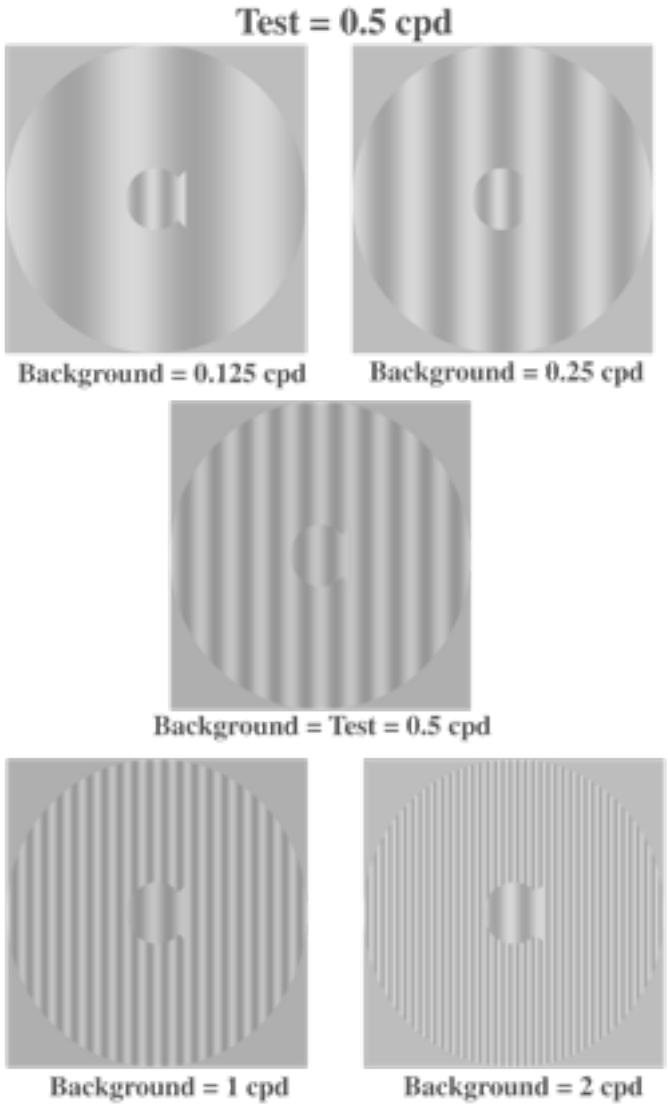




- Patterns gray scale and dim ➔ activates motion cells
- Improves sensitivity to movement
- Patterns train motion cells to improve relative to pattern cells (stationary background)

PATH Patterns

- Task: Discriminate direction center stripes moved.



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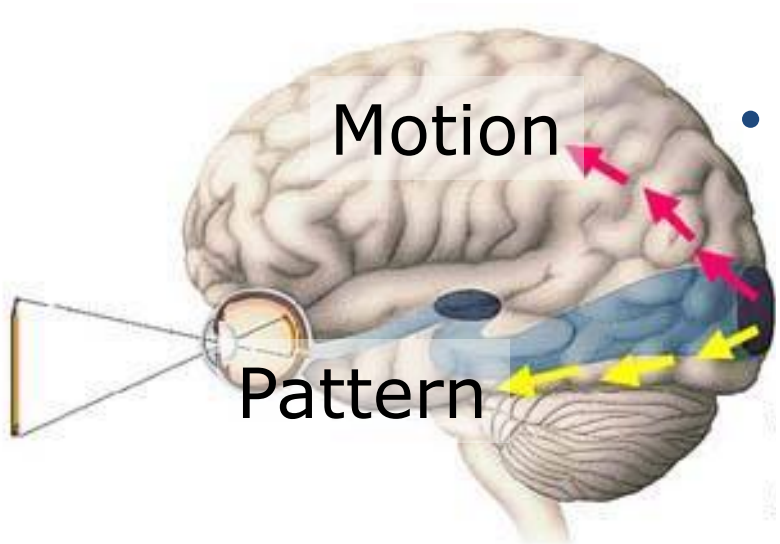
Dyslexia Problem



- Child's brain **not** working **efficiently**
- 2 brain pathways **not** working together

Motion (fast) ⇐⇒ Pattern (slow)

- Motion cells $\frac{1}{10}$ sec **too slow**

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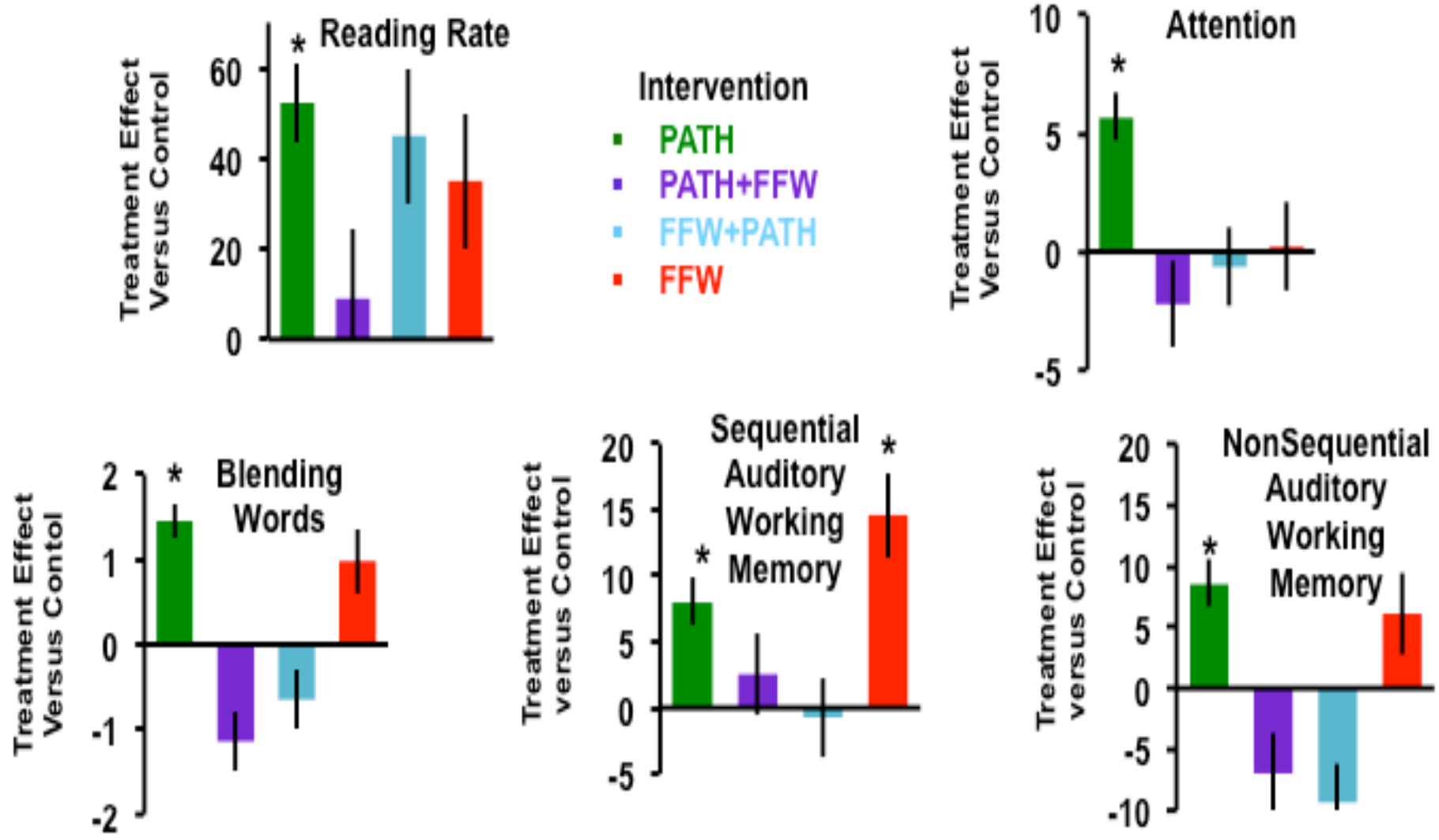
Results of PATH Training

Results 2012-2013



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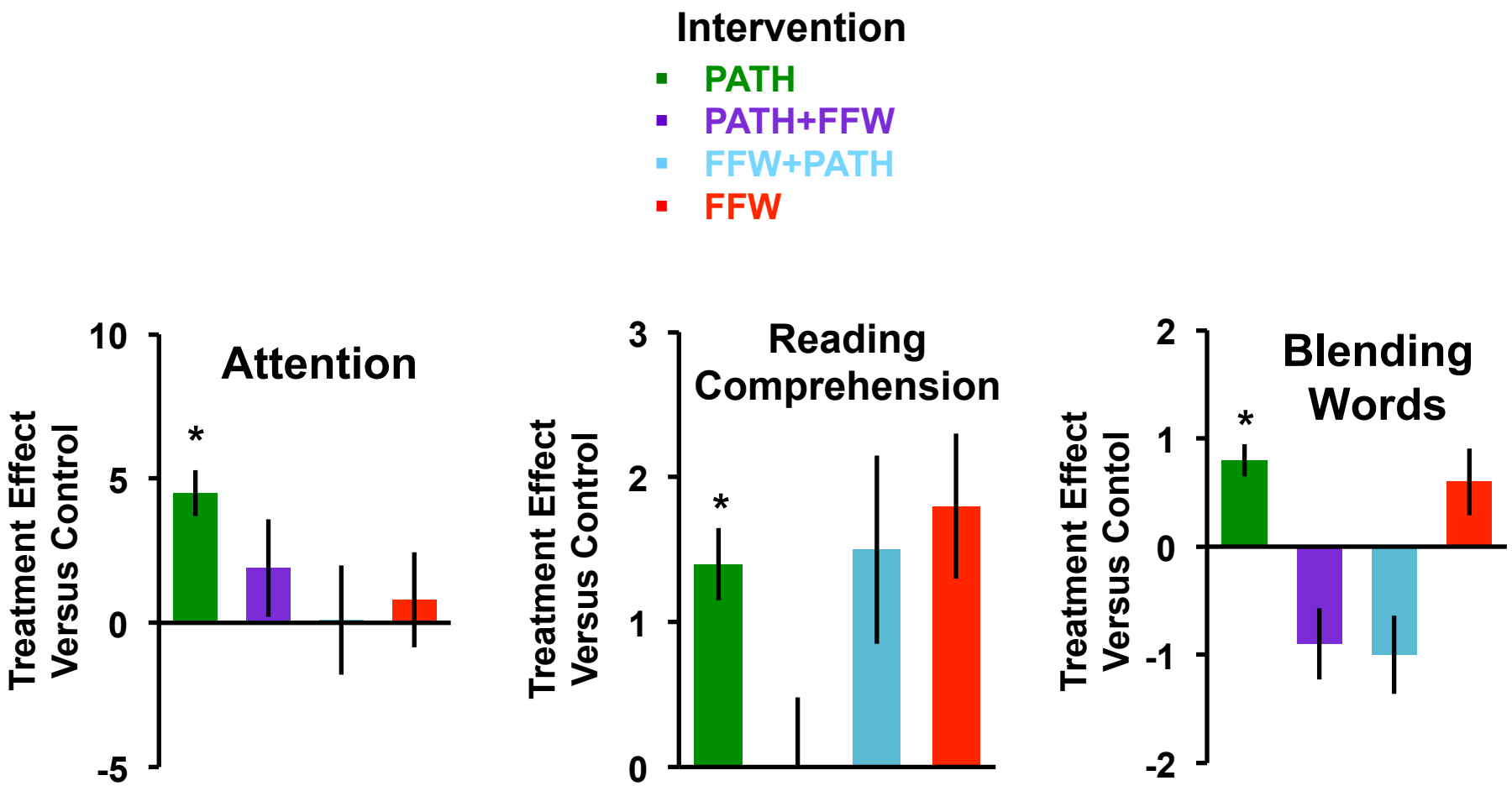
Results 2012 - 2014



In 2013-2014, intervention training done before school, instead of before guided reading as done in 2012-2013, resulting in smaller improvements than found the previous year when training interventions done immediately before guided reading.

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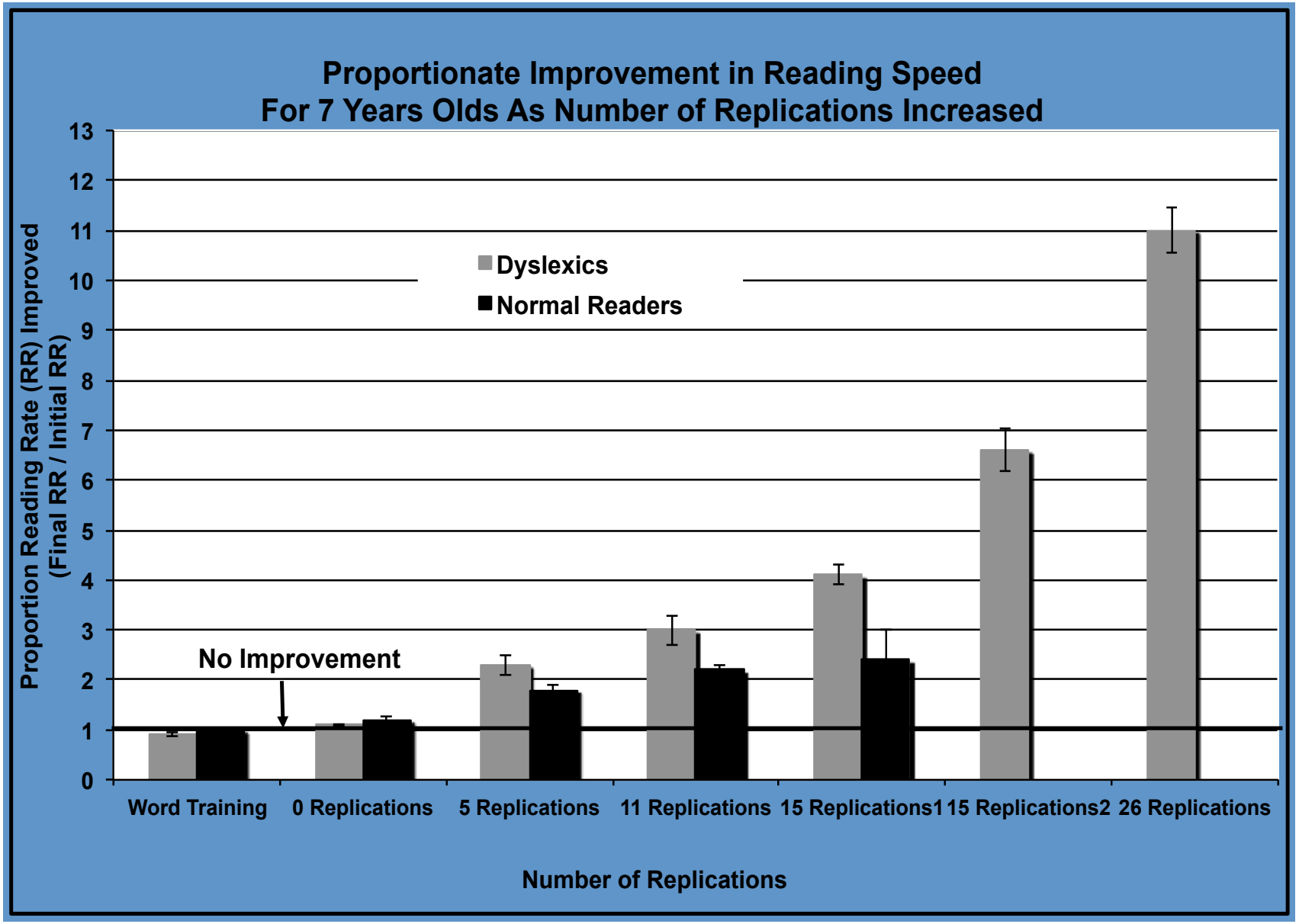
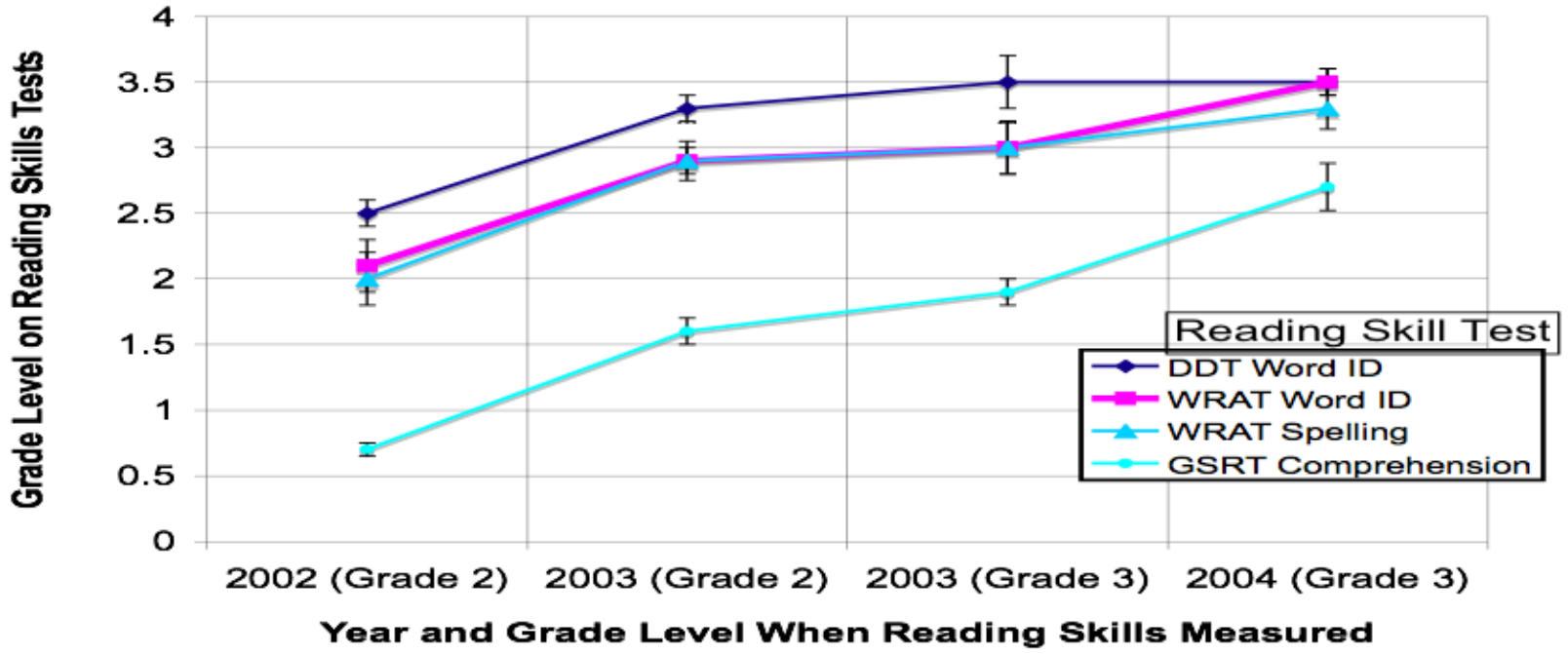
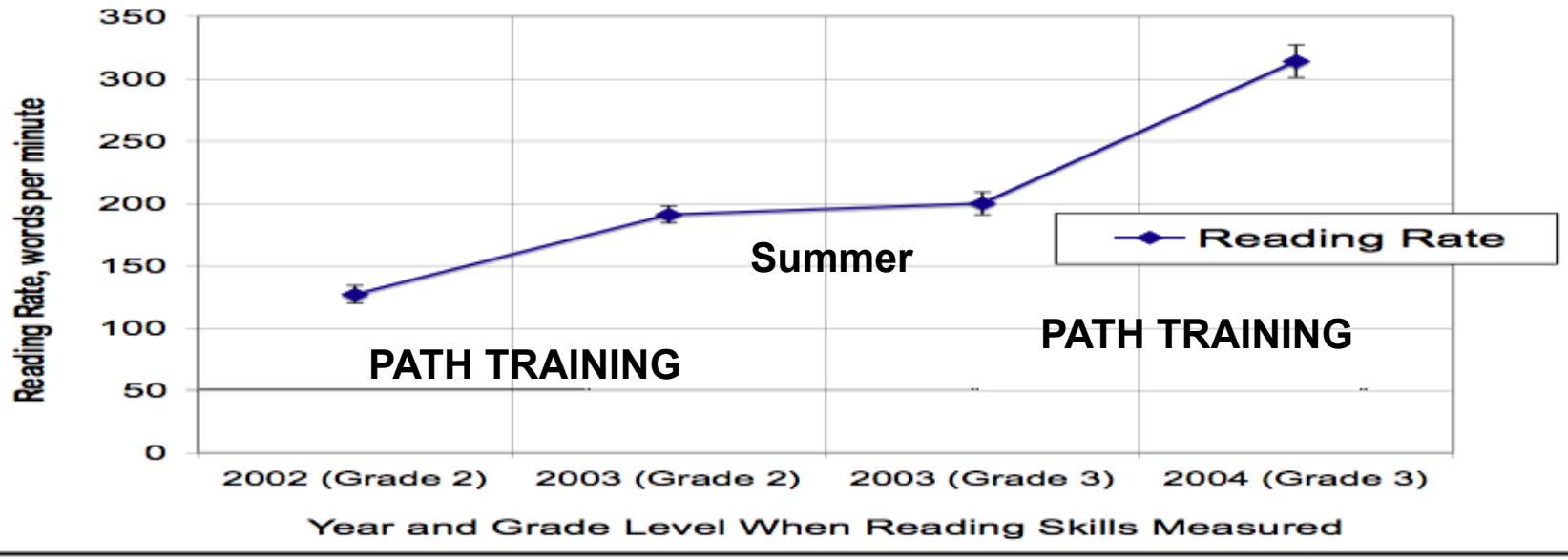
More motion training = faster reading speeds



Improvements are Sustained Over Time





PATH: Attention and Reading Improved Significantly

- Students improvement > controls
  - Attention ($p < 0.007$)
  - Reading Comprehension ($p < 0.006$)
  - Reading Speed ($p < 0.004$)
  - Blending Words ($p < 0.001$)
  - Auditory Working Memory ($p < 0.03$)

- *FFW* improved only sequential auditory WM ($p < 0.03$)

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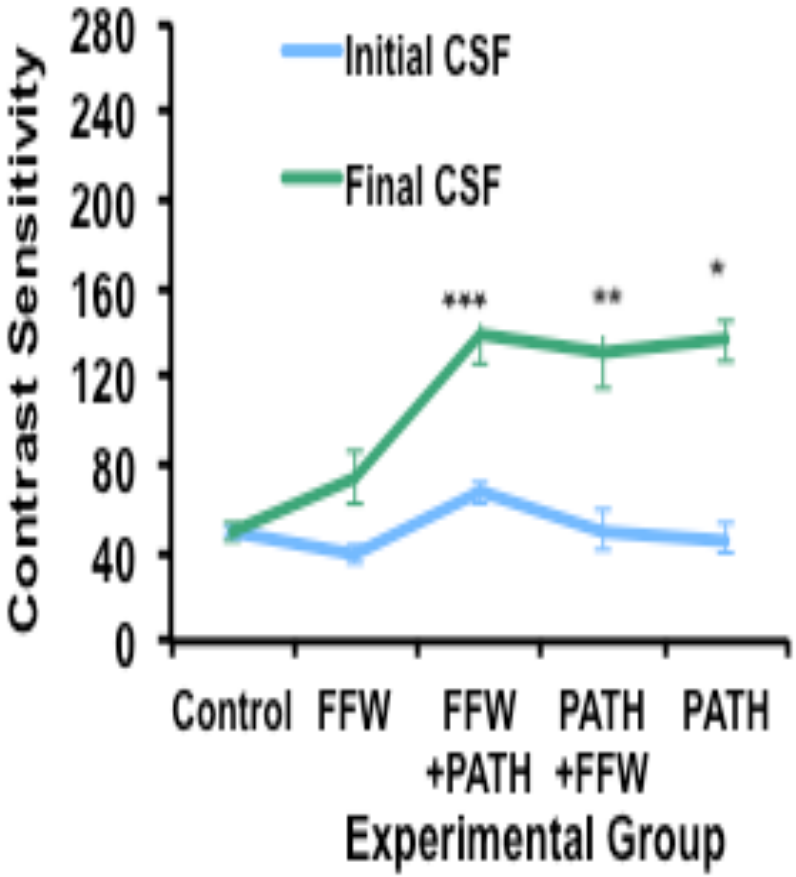
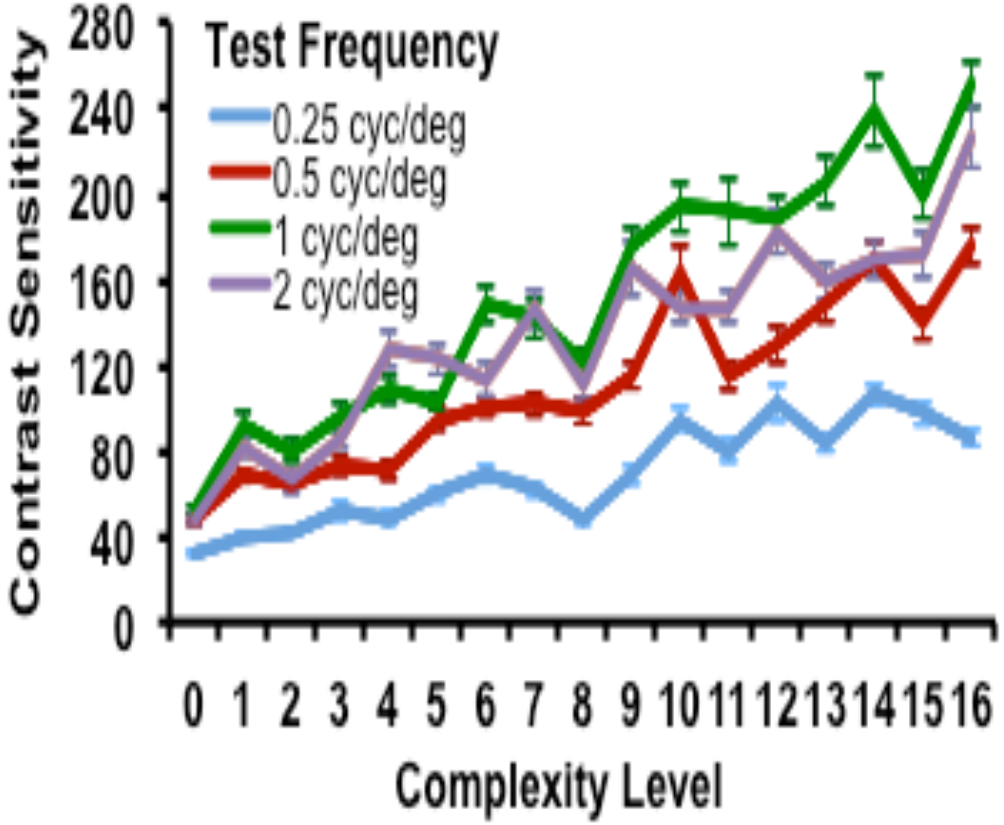
Movement Discrimination Contrast Sensitivity Increased Significantly





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PATH prevents reading & learning problems

- **Improves motion discrimination**
  1) Timing
  2) Sensitivity
- **Motion & pattern pathways work together.**
- **Improves academic skills:**
  1) Attention
  2) Reading Speed and Comprehension
  3) Working Memory

Novel Training Improves Visual Motion Timing and Sensitivity

- Sluggish magno cells ➔ cause dyslexia and attention deficits, preventing attention network from developing
- Movement discrimination training activating magno relative to parvo cells **remediates wide range of cognitive deficits**
- More *PATH* training = faster reading speeds
- *PATH* training faster than any other interventions
- *PATH* can be administered to entire class of students

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Symptoms Remediated By PATH Training

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Symptoms of Inefficient Cognitive Processing

- **Trouble focusing attention.**
- Inability to quickly and accurately process sequential information, e.g. trouble reading.
- Trouble remembering ideas and events.
- Slow processing of information.
- A tendency to lose place when thinking or reading.
- Headaches when multi-tasking.
- Thinking requires too much effort.
- Math, spelling and/or writing problems.
- Difficulty remembering lists of instructions.

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PATH Is My Research

- Visual psychophysics
- Vision Research ➔ 40 years
- Validation studies ➔ 30 years
- Patented technology ➔ ages 5 to 90

Symptoms of Typical Child Helped by PATH training

- Confusing **b**'s and **d**'s, **p**'s and **q**'s, '**saw**' and '**was**'
- Not seeing small words, like '**a**', '**the**', '**on**' correctly, but seeing larger words correctly
- Needing a pointer to guide reading
- Difficulty judging the direction and speed of moving objects.
- Spelling and creative writing problems
- Difficulty remembering lists of instructions

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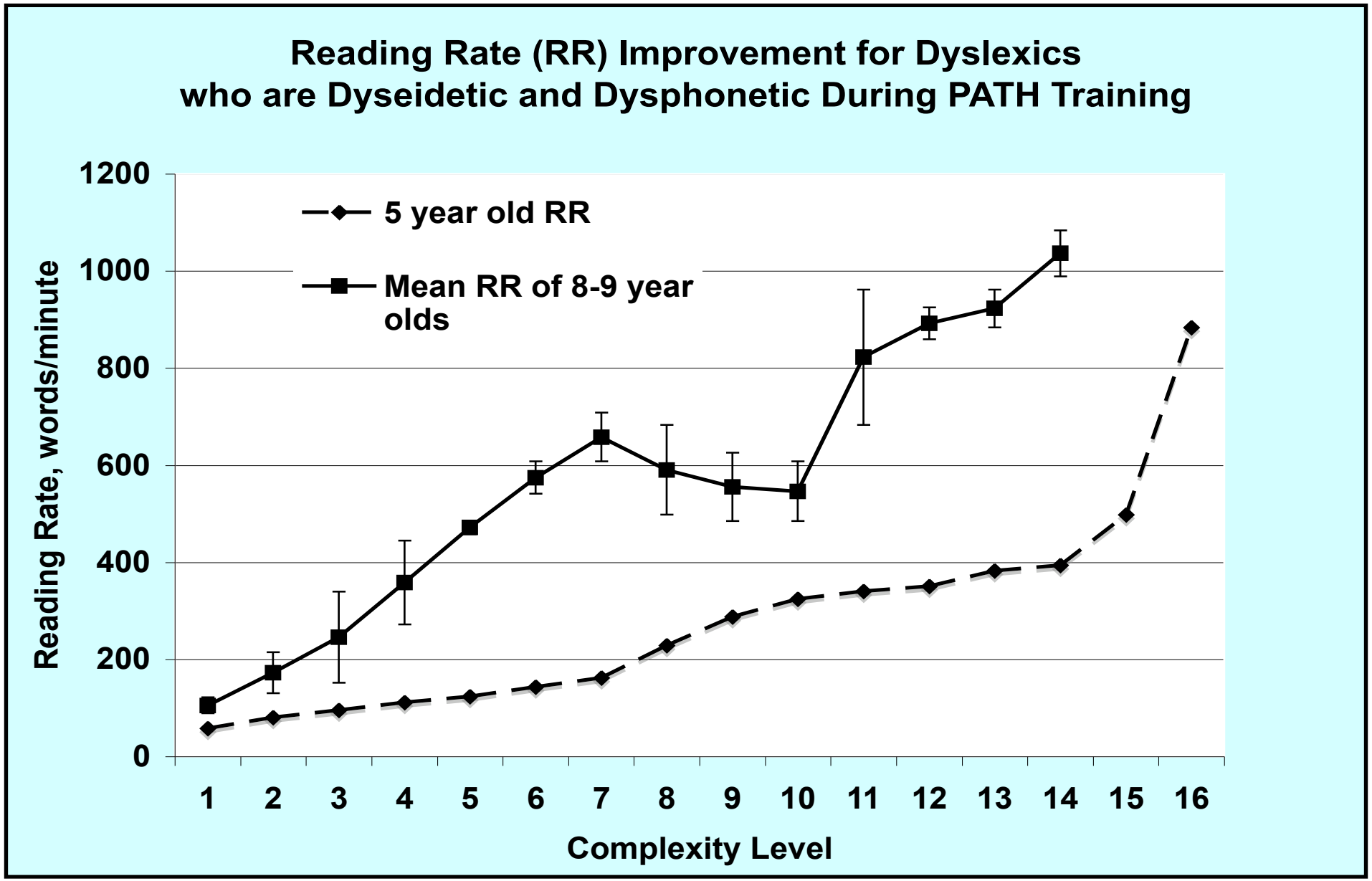

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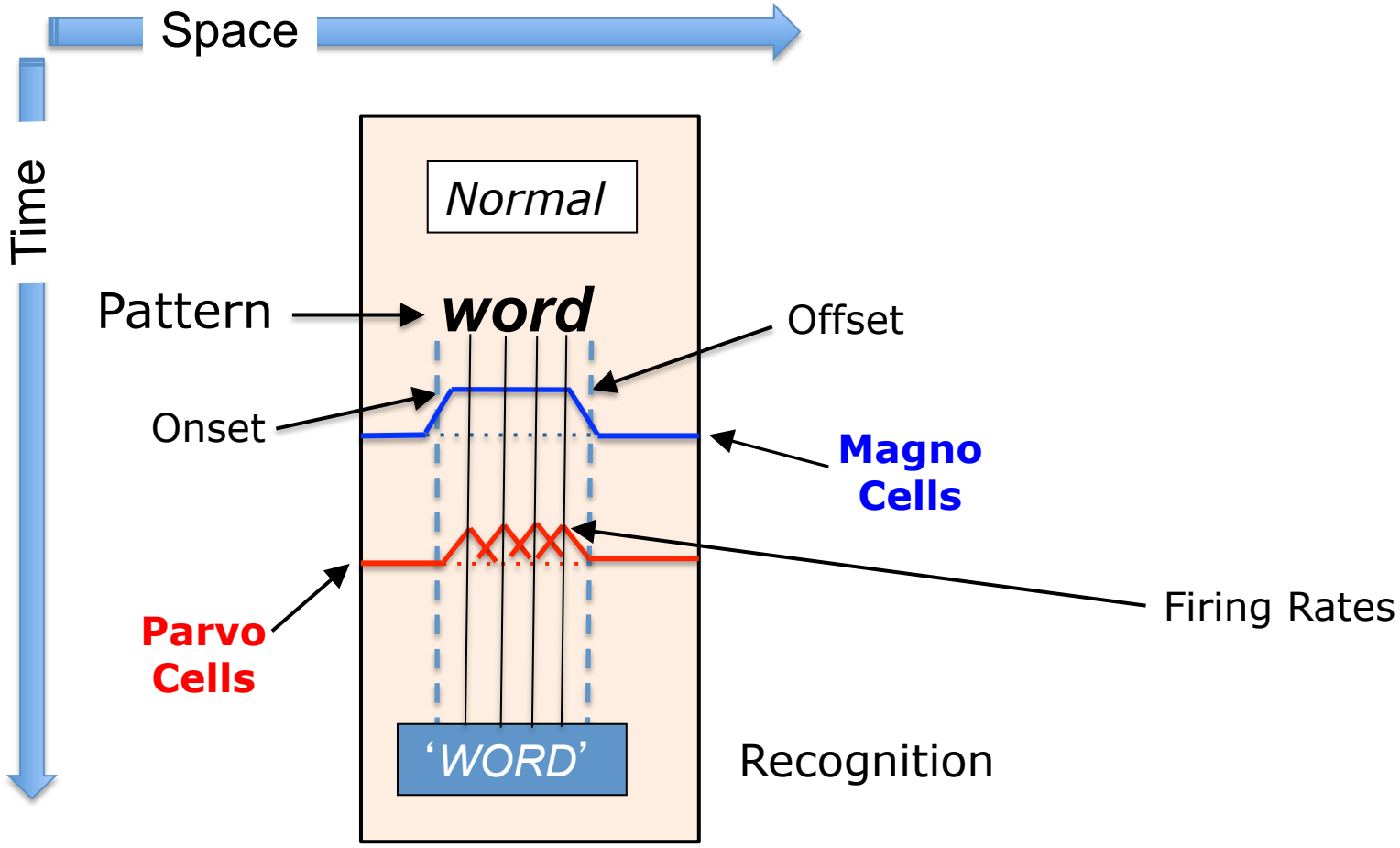
Neuroscience Behind Why PATH Training Works Rapidly To Improve Ease of Learning

PATH to Reading

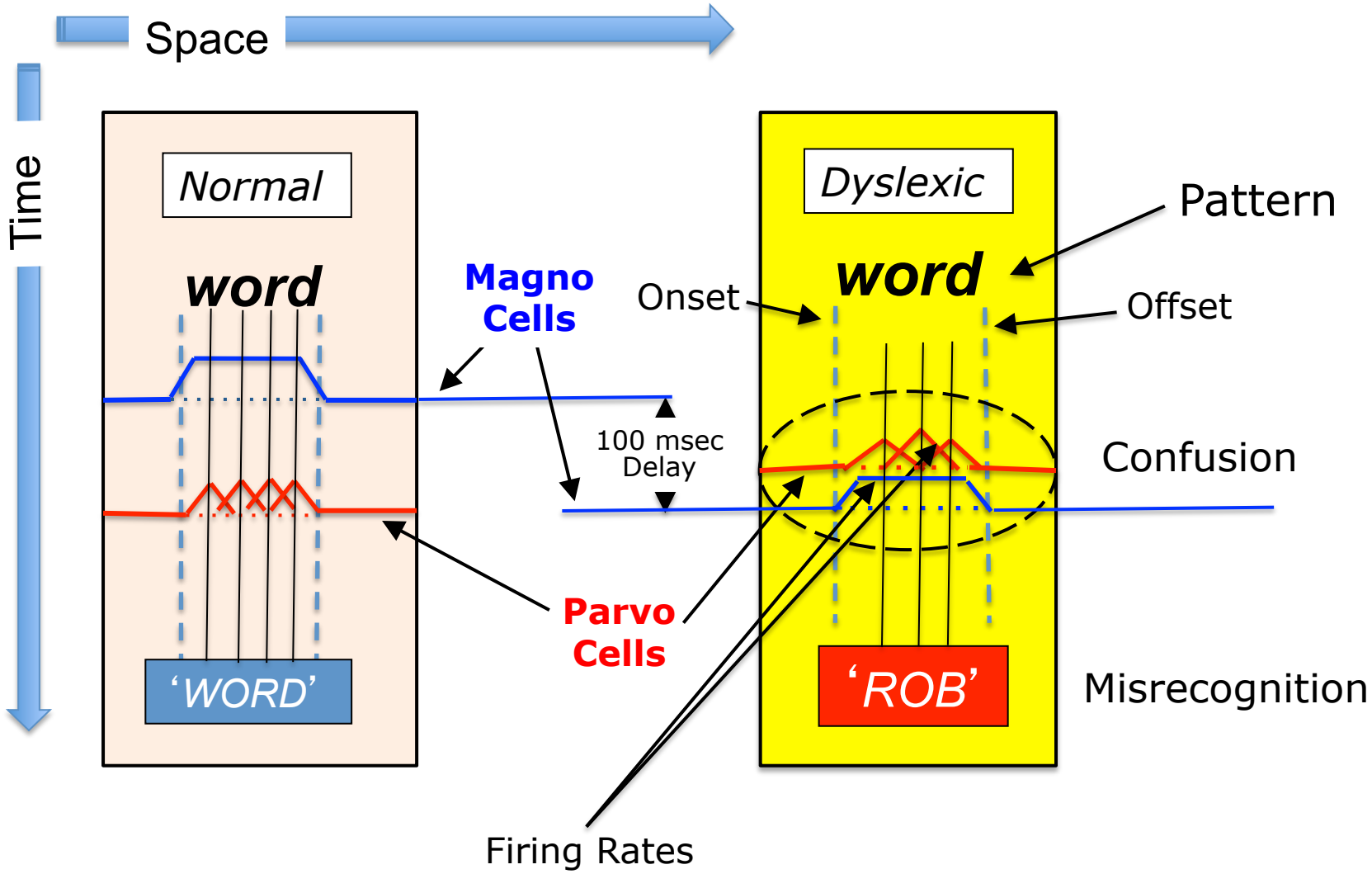
Why Is Learning So Difficult for Some People?

- *It's not a matter of* a matter of bad teachers, inadequate schools, old textbooks or student motivation.
- It is a matter of neural timing deficits that *can be corrected.*
- Traditional strategies will not work unless this timing issue is addressed.
- ***Tuning the brain's timing*** unlocks a person's ability to think in a focused manner, using multi-tasking that relies on working memory and sequential processing.

Word Distortions for Normal Magno



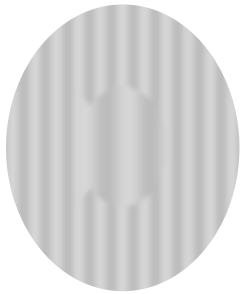
Word Distortions for Sluggish Magno



Motion Pathways

Motion pathway
= 'where' (fast)

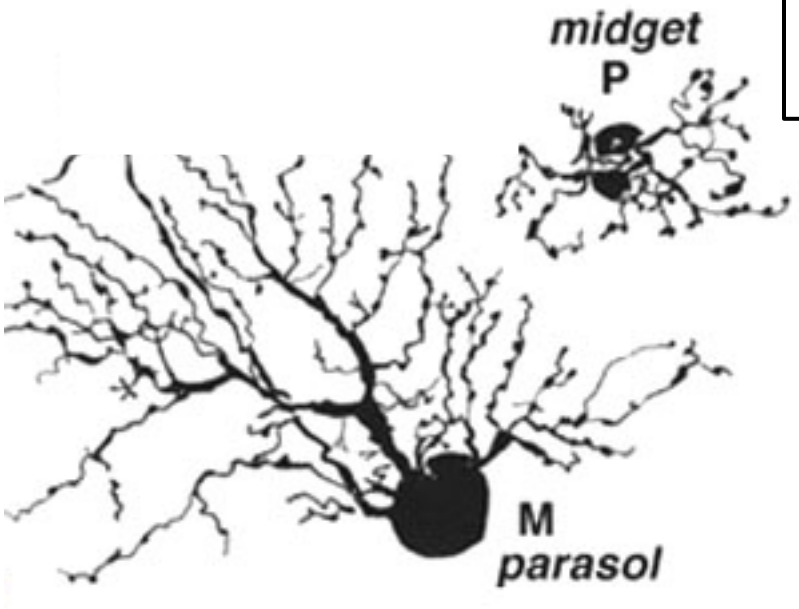
Where ➔➔ What



Pattern pathway
= 'what' (slow)

- Cognitive processing problems ➔
  'where' ✚ *'what'* activated at same time,
- *'what'* does not know '*where*' to look.

PATH Alleviates Temporal Deficits



Reading difficulties = Dyslexia

- Data: Dyslexics ➔

  Sluggish magno cells (dorsal)

  Normal parvo cells (ventral)

- Hypothesis: Dyslexics

Sluggish magno ➔ Timing deficits ***between magno & parvo***

PATH Alleviates Temporal Deficits

- Data: Dyslexics ➔

  Sluggish magno cells (dorsal)

  Normal parvo cells (ventral)

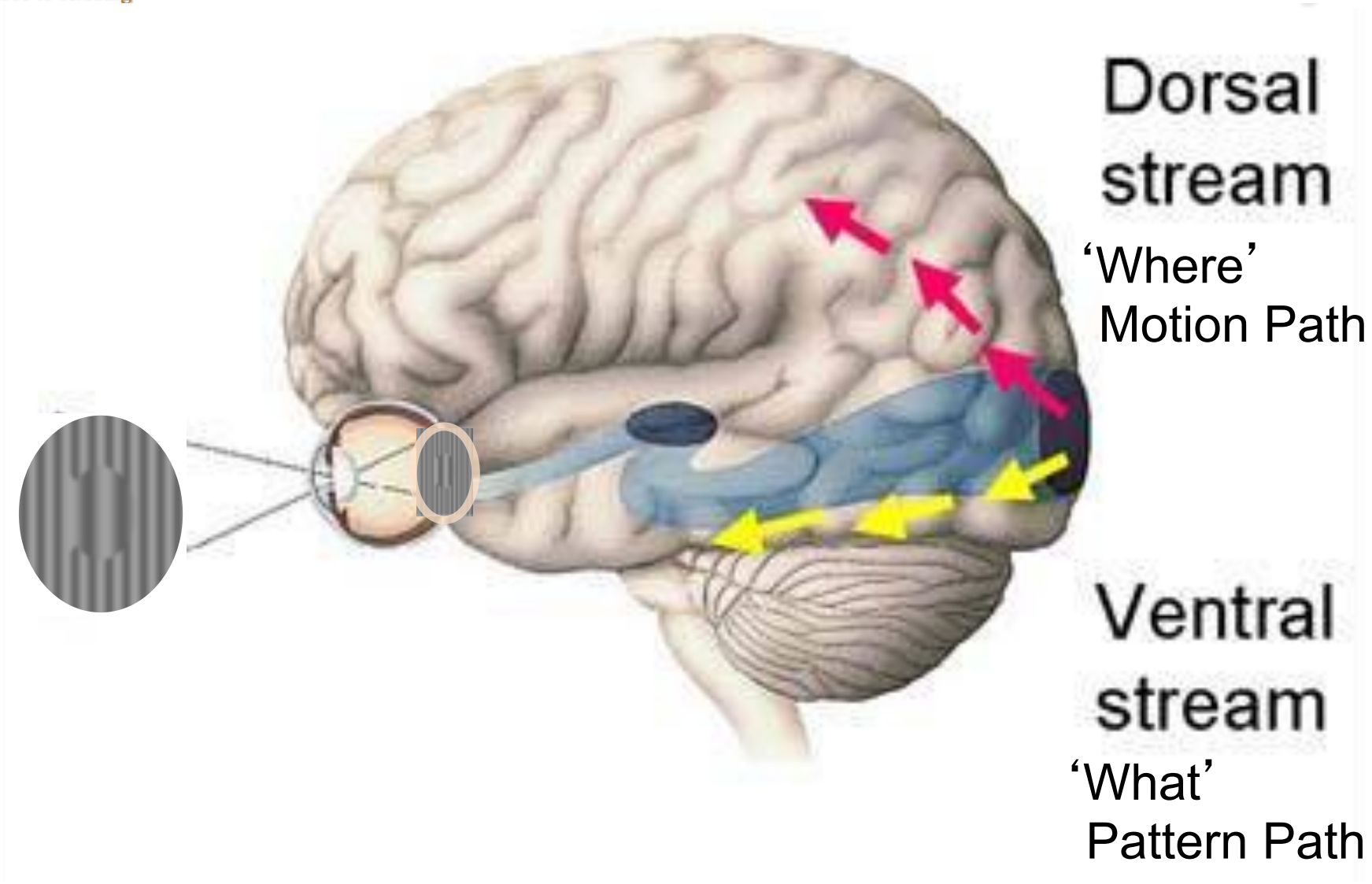
- Hypothesis: Dyslexics

  Sluggish magno ➔ Timing deficits *between magno & parvo*

  – Magnocells: global word form shape and location (low contrast, low spatial frequency)

  – Parvocells: local details ➔ letters in word deciphered (high contrast, high spatial frequency)

PATH to Reading



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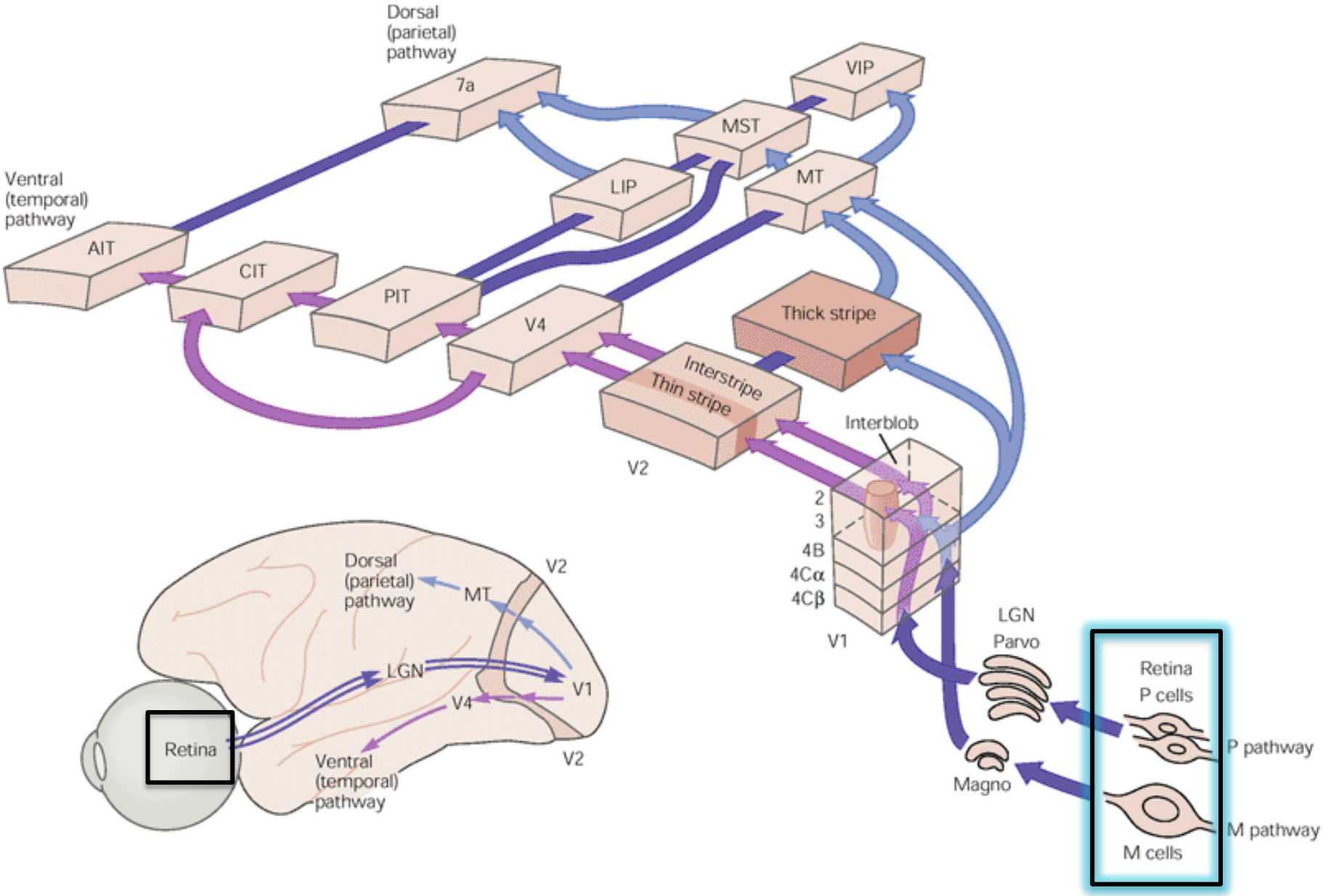
Magno and Parvo Pathways



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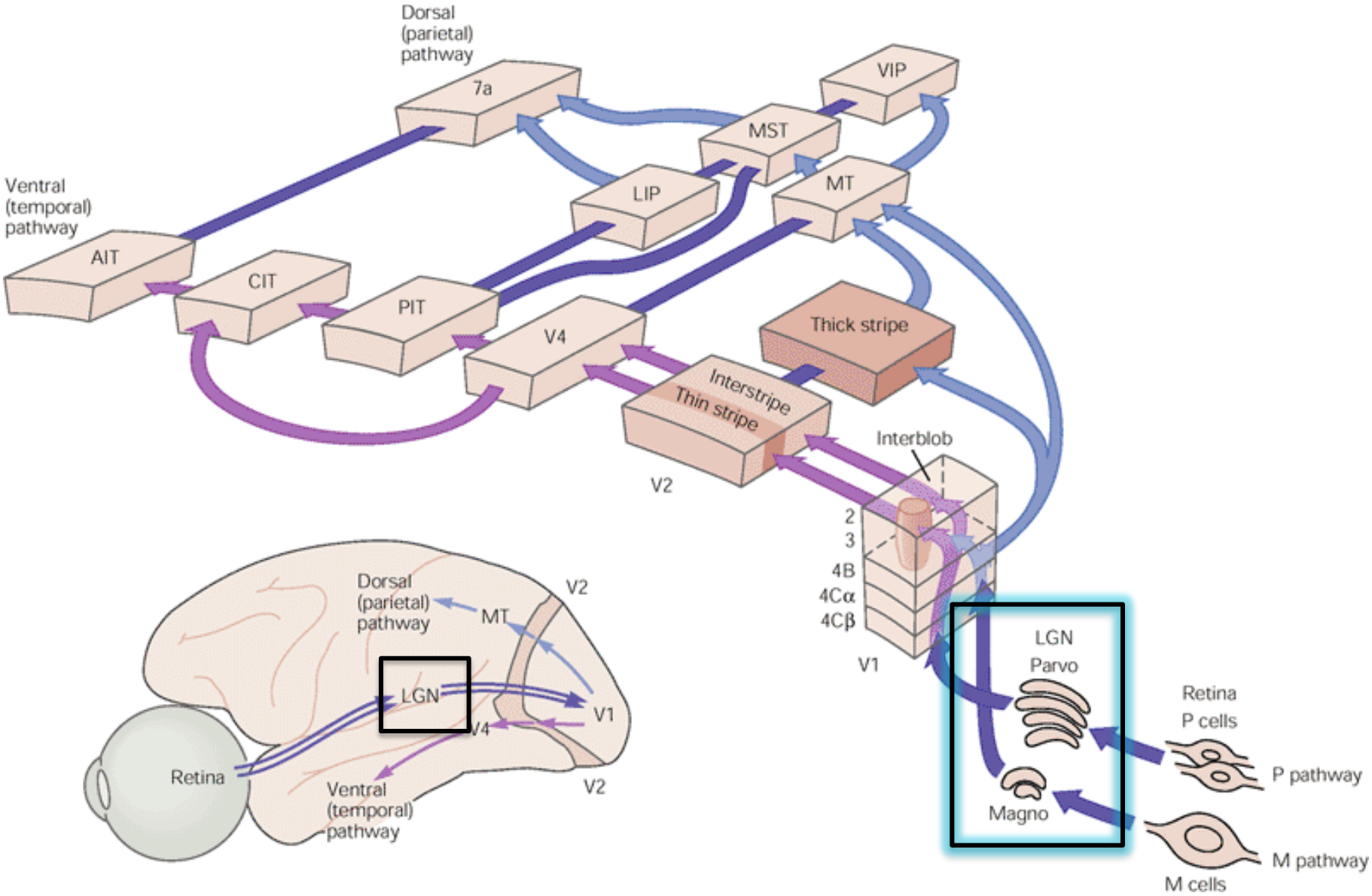
Magno and Parvo Pathways



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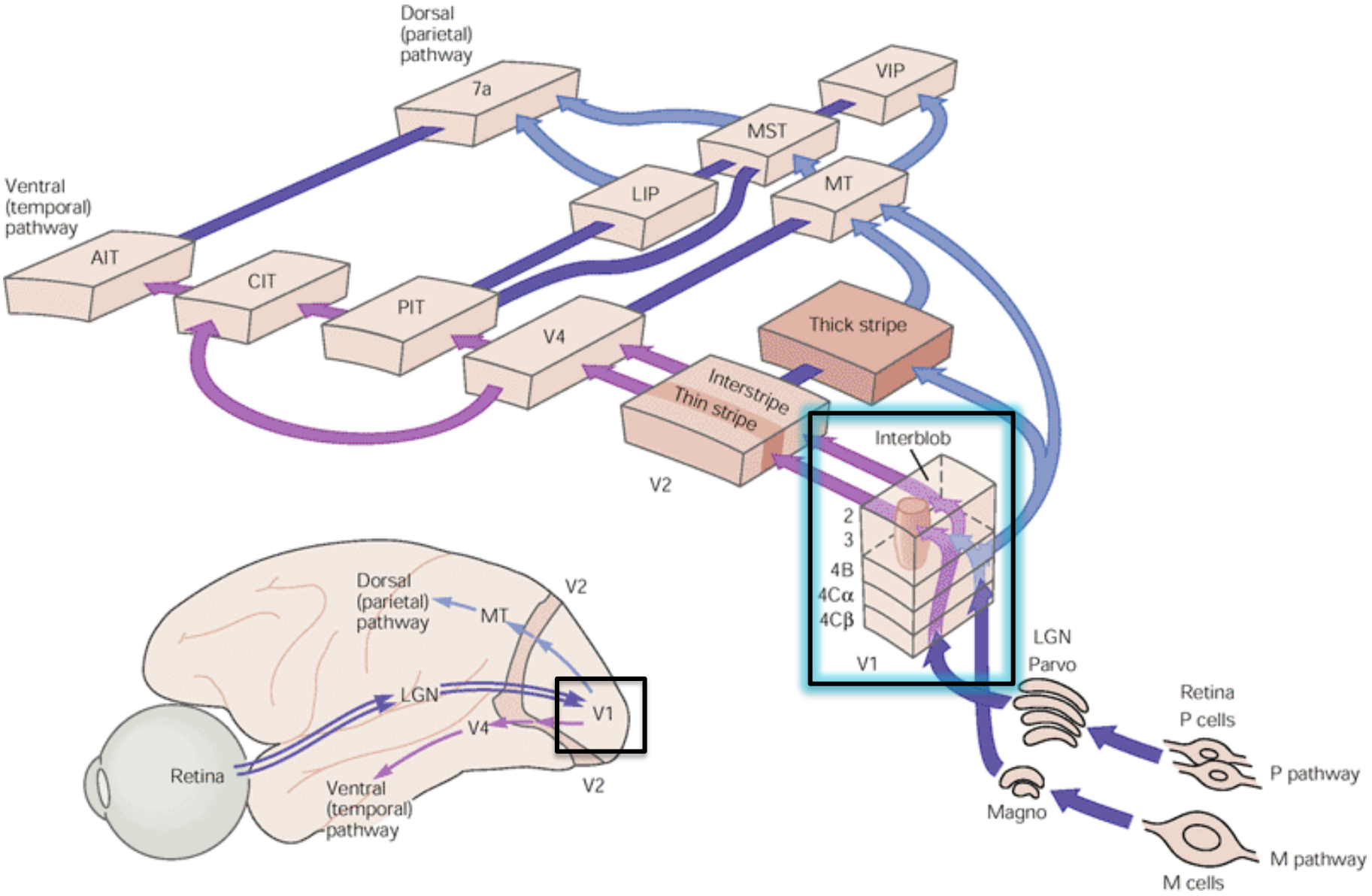
Magno and Parvo Pathways



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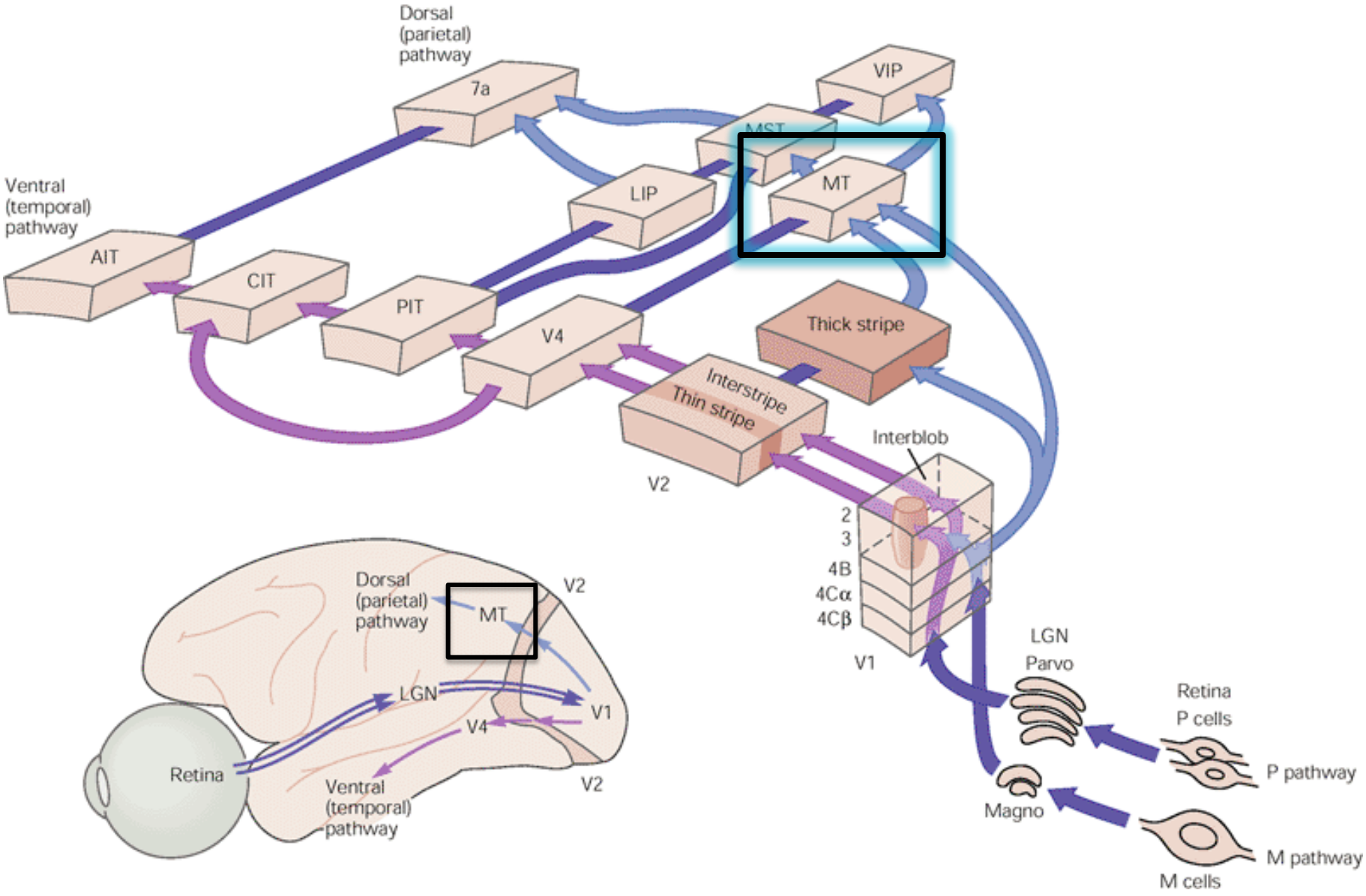
Magno and Parvo Pathways



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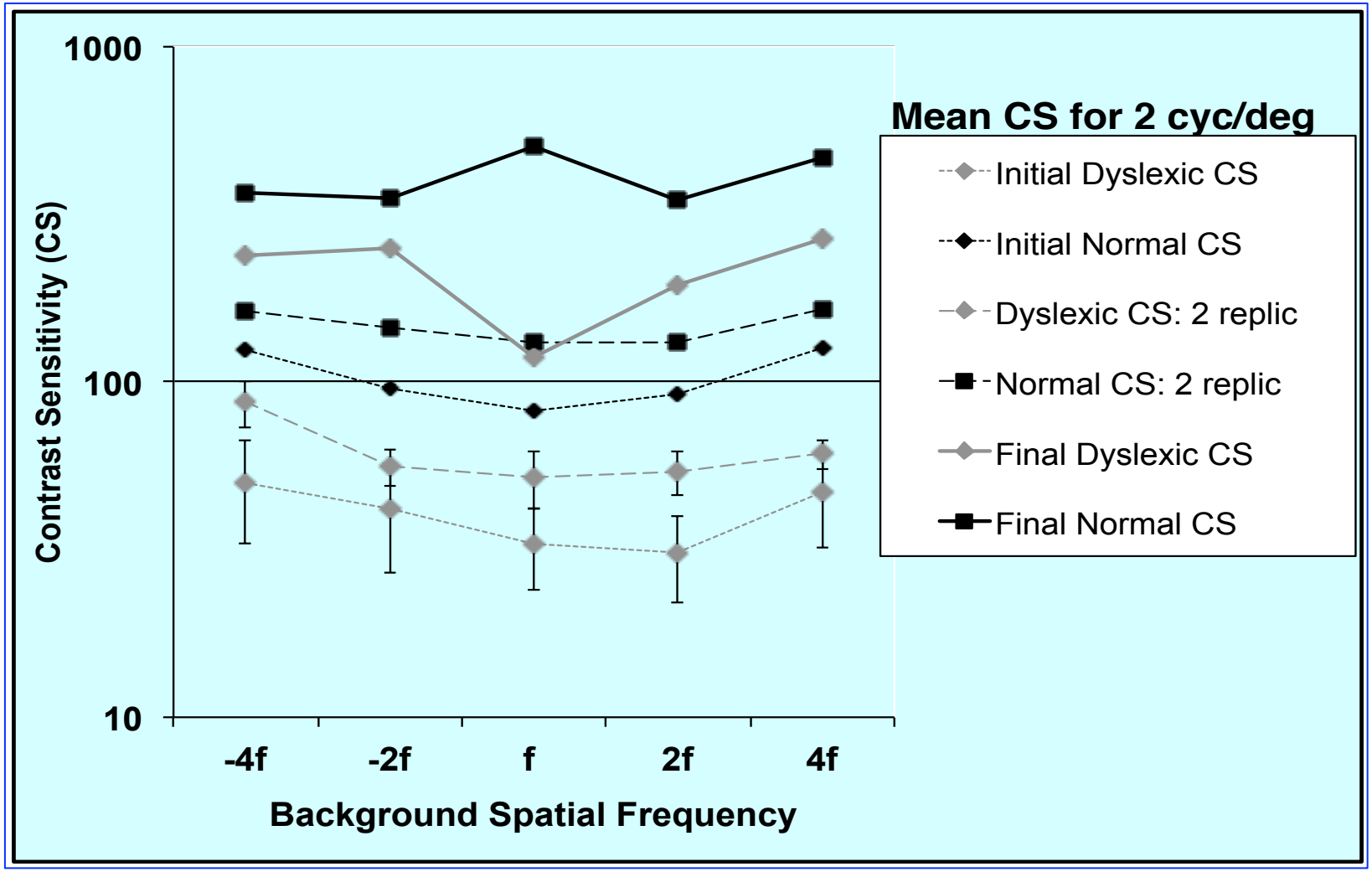
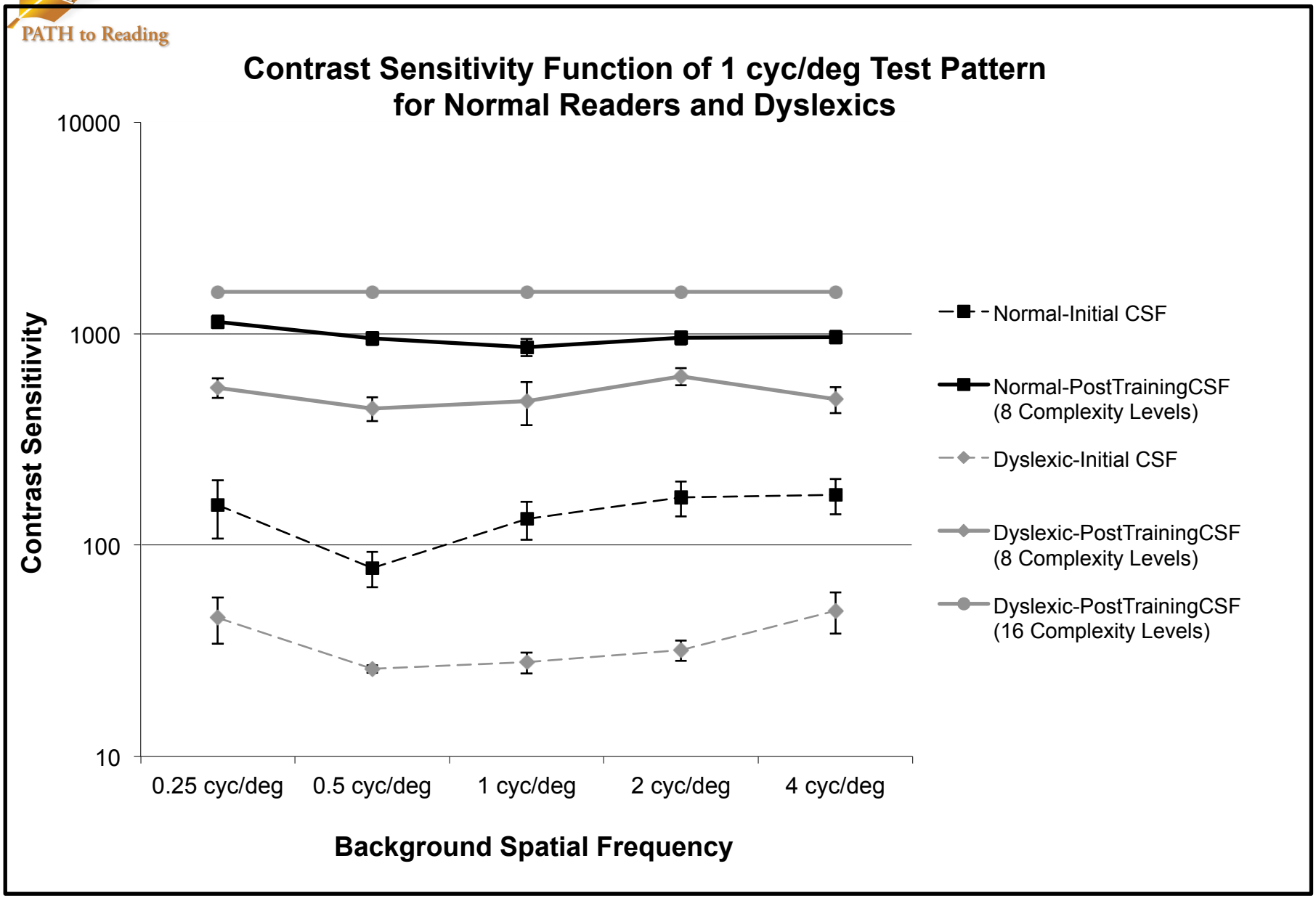
Contrast Sensitivity Function for 2 cpd Test Pattern on Different Backgrounds.



PATH to Reading



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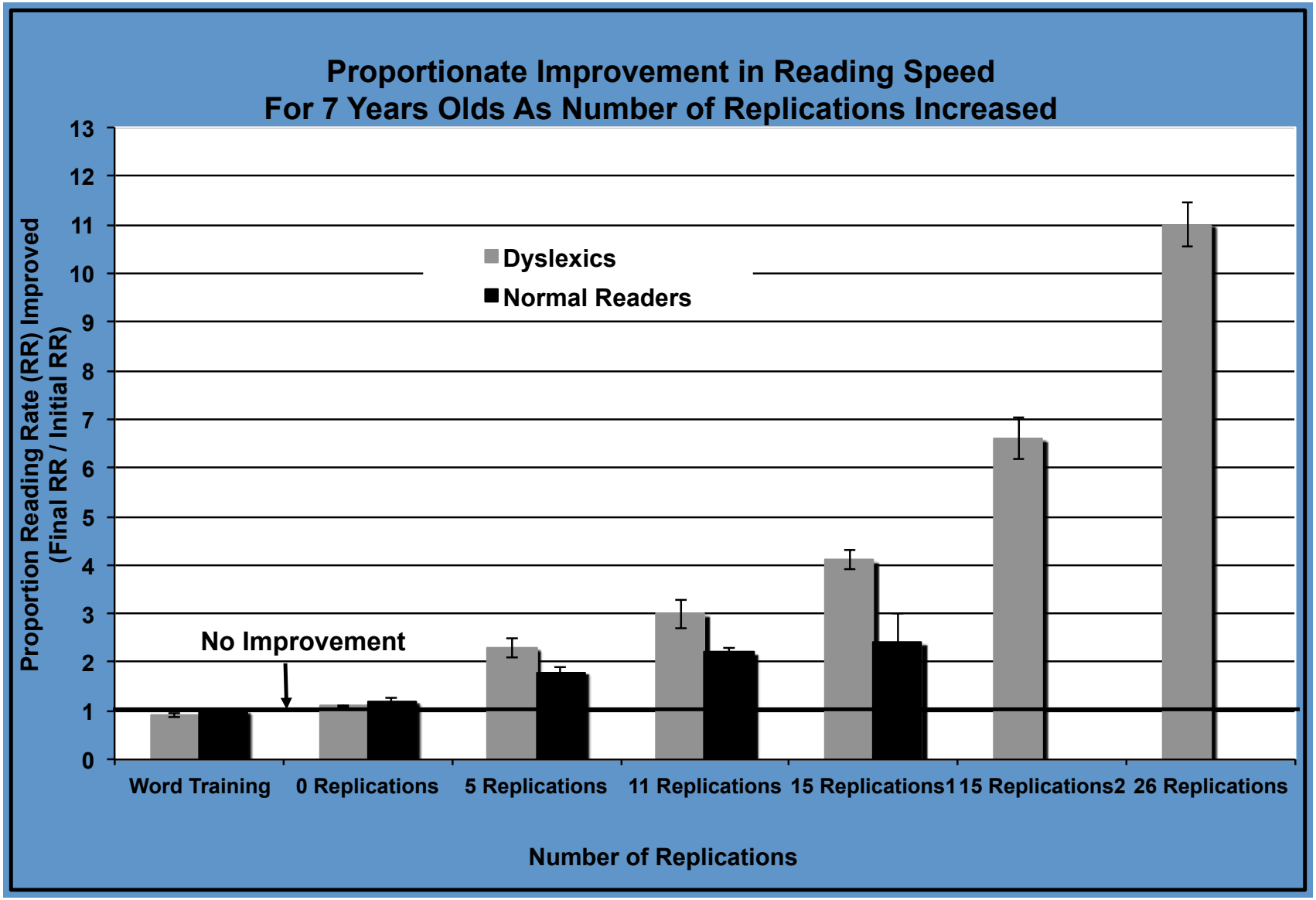
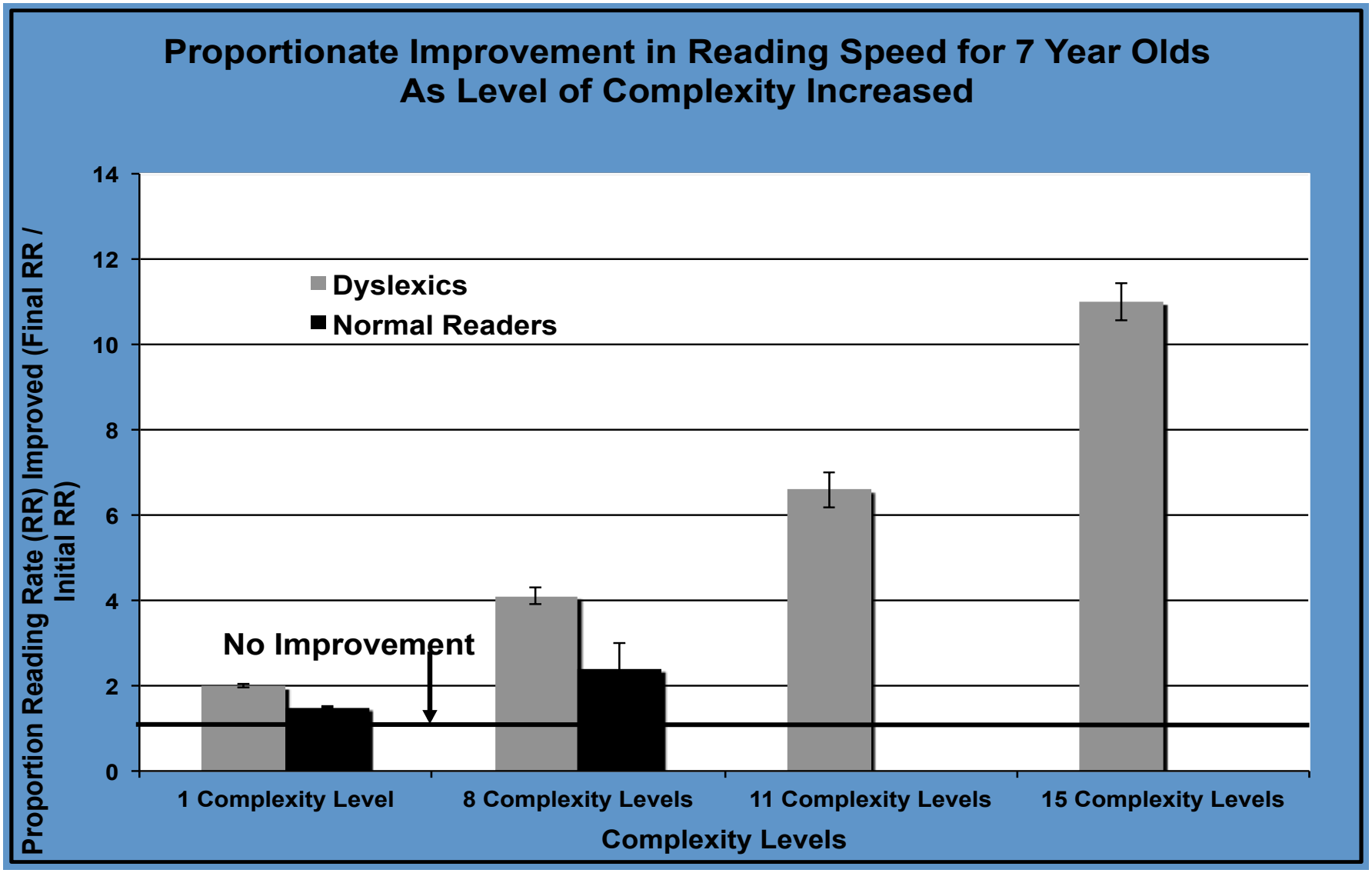
More PATH Therapy Used
More Reading Rates Improved



PATH to Reading

The More Levels of Complexity Used The More Reading Rates Improved



PATH to Reading

Background

- **Dyslexic's Timing deficits:**

  1) ***auditory*** → phonemic awareness

  2) ***visual*** → patterns moving relative to background

- Impaired focus of attention

⇩

- Targeting timing deficits improves reading performance.

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Stimulus Needed To Detect Dyslexia

- When direction of motion discriminated *relative to stationary background* dyslexics exhibit impaired magno cell function.

Found for all types of Dyslexics

PATH to Reading

A good reader?

- Reads effortlessly
- Auditory and visual processing in synchrony
- Skills need to be developed for dyslexics

Validation Study 2012-2013

1) ***Auditory*** → *FastForWord (FFW)*

   Visual → *PATH to Reading (PATH)*

2) Timing targeting magno pathways improves reading + attention + working memory?

3) *FFW* + *PATH* improves reading skills more?

PATH to Reading

Standardized Tests

- **Decoding-Encoding Screener for Dyslexia (DESD)**
- **Computer-based reading speed**
- **Gray Oral Reading Test (GORT)** measures comprehension and reading speed
- **Comprehensive Test of Phonological Processing (CTOPP)**: *Blending Words* measures phonological awareness
- **Cognitive Assessment Systems (CAS)** Attention Scale: Stroop and Number Detection
- **Test of Information Processing Skills (TIPS)** measures visual and auditory working memory

PATH Complexity Levels

- Complexity level increases:
  1) Background Sinewave components (1 - 3)
  2) Background contrast 5% - 20%
  3) Pattern's speed 6.7 - 13.3 Hz

- Students trained on 16 complexity levels
  - 1 motion direction (left or right),
  - 2 motion directions

- Repeated measures ANCOVAS were used to compare matched samples, controlling for age, sex, ethnicity, school attended, and English as a second language.

PATH to Reading

FastForWord (FFW)

- *FFW* improves phonological processing ➔ lengthen phonemes until perceived accurately
- *FFW* builds ***auditory*** processing and oral language skills
- 7 computer-based auditory exercises train subjects
- Exercises progressively require:
  - longer attention periods
  - more working memory
  - better reading comprehension

PATH to Reading

Validation Methods

- Randomized trial on dyslexic 2nd graders in SDUSD
- Subjects from wide ethnic distribution of low SES
- 7 year-olds in mid-developmental period
- **Data collection: Standardized Tests & Training**
  - 5 elementary schools
  - 40 trained UCSD undergraduates

Experimental Design

- **Groups:**
  1) Controls: *Learning Upgrade*
  2) *PATH to Reading (PATH)* Training
  3) *FastForWord (FFW) Training*
  4) *FFW + PATH*
  5) *PATH + FFW*

- **Visual and Auditory Timing interventions:**
  1) Early in morning before guided reading
  2) 30 minutes for 20 weeks, either
     - **3 days/week** for ***PATH***, (30 hours training)
     - **5 days/week** for ***FFW*** (50 hours training)
  3) Controls ➔ *Learning Upgrade* in classroom

PATH Results

- Movement discrimination contrast thresholds
  - Dyslexics (2.9%±0.2)
  - Typically-developing (1.35%±0.3)
  - Significantly different ($p < 0.0001$)
- Movement discrimination contrast sensitivity improved significantly, $p < 0.0001$, for each test spatial frequency.
- Movement discrimination timing reduced significantly, $p < 0.004$.
- More movement discrimination training = faster reading speeds.
- Improvements are sustained over time.

PATH to Reading

Contrast Sensitivity Increases

Test Frequency	Mean Increase per Complexity Level	Standard Error	$t_{(22)}$ value	p value
0.25 cyc/deg	4.19%	0.59%	7.11	< 0.0001
0.5 cyc/deg	7.29%	0.85%	8.56	< 0.0001
1 cyc/deg	11.22%	1.54%	7.26	< 0.0001
2 cyc/deg	7.83%	1.35%	5.79	< 0.0001

Results Summary

- ***PATH* improved:**
  - Motion discrimination timing
  - Motion discrimination contrast sensitivity
  - Magno relative to parvo cell functioning
  - Academic skills (Reading, Attention, Memory)

- **Improvements are sustained over time**

Basis of Timing Deficiencies

- Undeveloped direction-selectivity network ➔ V1 and MT.
- Low level deficits (V1-MT) prevent attention networks (PPC, DLPFC) from developing properly.
- Multifrequency backgrounds ➔ frame of reference.
- MT's center-surround organization enhances figure/ ground discrimination.
- Motion training modifies V1-MT feedforward and feedback pathways between magno relative to parvo cells.
- Motion training improves anterior dorsal stream (PPC) where there is convergence of auditory & visual inputs.

PATH to Reading

Low Level Deficits in Dorsal Stream Disrupt Processing at Higher Levels

Disrupted PPC, DLPFC: Central Executive Network

Disrupted MST, LIP, FEF

Disrupted MT

Disrupted magno timing in V1

PATH Improves Central Executive Network (CEN)

CEN:

- Strong activation in cognitively challenging tasks.
- Critical for:
  - Active maintenance and manipulation of information in working memory.
  - Judgment and decision-making in the context of goal directed behavior.
  - Acquisition of school subjects like literacy and math, and effortful control related to social development.
- Involves planning or decision-making, cognitive flexibility, abstract thinking, error detection, novel or not well-learned responses, Initiating appropriate behavior and inhibiting inappropriate behavior, learning rules, overcoming habitual actions, and picking out relevant information from what is perceived.

PATH Training Improves Cognitive Deficits in Older Adults

- Older adults must expend more effort to retrieve information from working memory for tasks like multi-tasking, sequential processing, and navigation.
- Recent fMRI and PET studies indicate that older adults have more prefrontal activation from recruiting additional brain areas to complete tasks.
- Prefrontal activity was increased similarly by both aging and a divided attention task.
- Processing speed and attention deficits found to explain a large part of age-related memory loss.
- Mental slowing can lead to superficial processing and inefficient strategies where elaboration is required.