Dyslexia:

“Asynchrony” of Brain Systems
• **Underlying assumptions:**

• **Reading** is a cognitive skill and based on decoding, comprehension, and fluency skills.

• Each skill is derived from differential cerebral systems.
Information processing System

• **Input**

• **Attention** (selective, focus- distracters)

• **Perception** (visual auditory integration)

• **Processing** (Working memory >> Long Term Memory)

• **Output** : Retrieval – Response
The Problem:

The ability to read is not part of our evolutionary heritage.

For 60,000/5000 years, no cerebral system was devoted specifically to reading.

Consequently, the reading activity must be adapted to cerebral systems usually devoted to other aims.
The Brain Systems:


- a different biological structure
- a different cerebral location
- a different mode of processing (holistic / sequential)
- a different rate of entering the “GATE” Thalamus
- a different rate of processing:
A natural GAP exists among regular readers

P1
Auditory cortex: 30-40 ms (Schmolesky et al., 1998)
Visual cortex: 50-70 ms (Heil et al., 1999)

N170
Auditory association area 140(+- 10) Visual association area (170 +- 20)

P2- Sensory association

P3 WM
Auditory: 320 (+-10) ms
Visual: 380 (+-10) ms
64=EEG Bio semi

WFA
P3 Auditory / Visual linguistic oddball Ba/Pa - Pz electrode
Unimpaired readers the 50 ms phenomenon (Breznitz & Misra, 2003)
However:

Accurate reading requires exact synchronization and integration in content \((G/P-)\) and time of the systems activated during reading.

This complexity poses a major challenge for the human brain, and often fails = 25% learning disabilities and 70% of them suffer from reading disorders.
-Definition of Dyslexia- Reading impairment

“Dyslexia is evident when accurate and fluent word reading and/or spelling develops very incompletely –or with great difficulty.”

-1.5.S.D.

Results: impaired comprehension

(Fletcher, 2008 ; BDA 2011).
Inaccuracy:

- **Decoding Errors** Primary source = a phonological core deficit (see Share 1994 for review, Share et al., 2004; 2008).
- Orthography (Bernniger et al, 2008) or both (Boder 1999).
- Morphology (Berninger 2005).
- Working Memory Capacity (Swanson 2009)

Lack of fluency: (Katzir, Shaul et al., 2004)

- Slow reading rate (Torgesen, 2002)
- Slow prosody (Levy, 2001)
- SOP (Wolf 2005; Breznitz 2003)

- consequence – poor reading comprehension
Shaywitz 2003

- Broca’s area
- Inferior frontal gyrus (articulation/word analysis)
- Parieto-temporal (word analysis)
- Occipito-temporal (word form)

Nonimpaired

- Dyslexic
- Broca’s area
- Inferior frontal gyrus (articulation/word analysis)
Among Dyslexics: Disruption in G/P correspondent was found to appear at the early stages of the perception of linguistic input in the Fusiform brain area (McCandliss, 2008; Breznitz and Korinth, 2010).
S Loretta at N170 ERP component During Lexical Decision Task

Regular

Dyslexics
A-V  Wider Gap among “Dyslexics”

A gap of 100-170 ms

A slower then v= Young (Breznitz 2006)
Visual slower then A = adults (Breznitz 2003 ;Sela 2010)

Clear that a wider gap cannot be tolerated by the information processing system (STM/WM limitation) for G/P exact to occur
“The Asynchrony Theory”
as a possible explanation for dyslexia
(Breznitz, 2002-2008)

Suggests that the speed at which information arriving from brain systems activated in word decoding process is not synchronized
The central question is:

Is it possible to improve synchronization between the brain systems (modalities?) thereby affecting the quality of word decoding?
The Idea: “Lazy” brain that likes familiar routines --
→ Need to be challenged

There is a need to “force” the brain to make an effort beyond its routine activity.

The principles:

• Force and maintain the activity

• How? The Acceleration Phenomenon (1997)

• A gap between ability and performance

• If forced, beyond self paced processing > the brain can do better
The Acceleration Program


• Incorporate the three reading skills (decoding, comprehension, fluency)

• Train (manipulate) the subject to read faster over multiple sessions

• Challenging but at the same time within the demonstrated capacity of each trainee (Complexity? Optimal level of training?)
The RAP Brain-Challenging Principles

- Find the individual’s “optimal level of training,” not too easy, not too difficult (in both content and presentation time)
- Adapt to reading abilities of the trainee
- Train via computer (silent reading)
- Train under accelerated (staircase) time constraint manipulation.
- Adapt individually to the training outcome of each training session
- Intensive: 3 times per week for 8 weeks, 24 sessions of about 20 minutes each.
Training Research Program:
Dyslexics (80) and skilled readers (80) in each group
Each training program had a total of 24 sessions, 3 times a week for 8 weeks

<table>
<thead>
<tr>
<th>Group 1 25/25</th>
<th>Assessment</th>
<th>RAP Training</th>
<th>Assessment immediately after completing training</th>
<th>CPC Training</th>
<th>Assessment immediately after completing training</th>
<th>Assessment after 6 months</th>
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<tr>
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<td>CPC Training</td>
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<td>RAP Training</td>
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<td>Group 3 15/15</td>
<td>Assessment</td>
<td>NAP training</td>
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<td>Assessment after 6 months</td>
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<td>Group 4 15/15</td>
<td>Assessment</td>
<td>No training</td>
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<td>No training</td>
<td>Assessment</td>
<td>Assessment after 6 months</td>
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Controls

• Cognitive Personal Training Program, CPC (CogniFit 2004, non-alphabetic computer-based training program)
• Non-accelerated reading program (NAP)
• No training
The Acceleration Program

• Assesses basic reading ability
• Accelerates the reading pace and monitors comprehension
• Individualized feedback for the student
• Exactly matches the child’s abilities
CogniFit (2007) Personal Coach Program (CPC)

- Assesses and trains basic learning skills (attention, memory, pace, spatial perception)
- Training through games
- Individualized feedback showing the child’s progress
- Adapts itself to the child’s ability level
Spatial Memory Task
Aural Memory Task
Divided Attention Task
Acceleration Training

Mean reading rate (in ms) & SE; Days 1-24
Acceleration Training

Acceleration No Acceleration trainings
% correct answers and SE: days 1-24

[Graph showing mean comprehension accuracy (% correct) over training days 1-24 for different groups: Dyslexics r-acc, Dyslexics no-acc, Typical readers r-acc, Typical readers no-acc.]
Rate over 48 sessions: RAP training

Rate Over The Course of 48 Sessions

ms per letter

RAP_dys
Rap_reg

session
Decoding: Number of Correct Words per Minute

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<tr>
<th></th>
<th>D.Mf</th>
<th>D.Acc</th>
<th>D.No Acc</th>
<th>D.No Train</th>
<th>R.Mf</th>
<th>R.Acc</th>
<th>R. No Acc</th>
<th>R.No Train</th>
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Fluency: Reading Rate in Seconds

Reading Time

Test 1 Test 2 Test 3 Test 4

D.Mf D.Acc D.No Acc D.No Train
R.Mf R.Acc R. No Acc R.No Train
Reading Comprehension: Number of Correct Answers

Comprehension

Test 1  Test 2  Test 3  Test 4

D.Mf  D.Acc  D.No Acc  D.No Train
R.Mf  R.Acc  R.No Acc  R.No Train
Brain Activity at the Perception Stage Before Training and After Training with Acceleration RAP and Cognitive Training CPC
fMRI Results
(With Avi Karni, Yossi Arzouan and David Manore)

After training: (22 dyslexic readers)

Semantic task (yes/no):
Sentences: Last word congruent / non-congruent
Threshold = 0.05 and kCluster = 25
Semantic Task
fMRI Study (adults) : Fusiform Gyrus
Arzouan, Karni, Breznitz (2012)

Dyslexics After>Before

Brain activity (VWFA) before and after training CPC + RAP
Summary

• Q: Can the brain of a reading disabled person be trained to read better?
• A: Definitely Yes!

• How (effectiveness)?- Training basic cognitive skills and then language training

There still remains the basic question as to what brings about the change?
• Change- Correction, improves the deficiencies?
• Creating other activities (bypassing)- that activate the dormant brain cells (no stable patterns in the work environment)?
• New cells created and activated?
• Compensation of the systems that are not deficient?
Research Assumptions - Based on:
The flexibility of the brain to change at any age

By:

• *Increasing* neuronal *connections*: connections at any age
  – Possible with development, learning, repetition, practice

• Renewal: stem cells in the hippocampus (area for memory and information consolidation)

• Migration: of stem cells to the affected region
Reading Acceleration Phenomenon and Intervention Program (RAP) Running in Different Languages

**Hebrew** – Haifa University, Breznitz & Karni: Behavioral, EEG, fMRI (Adults, children)

**Arabic** – (Israeli Palestine Dr. Dagani children)

**English** – University of Seattle, Prof. Berninger: Behavioral University of Cincinnati Dr. Holland and Dr. Kruse (Children) Drexel University fNIRS Dr. M. Kurtulish (Adults)

**German** – Humboldt University of Berlin, Sommer & Kornith: Behavioral, ERP, eye movements (Adults). Dr. Hassehoren (children)

**Dutch** – University of Amsterdam, Dr. Snelling: Behavioral (JLD 2009) (Children)

**Finland** – Dr Aro, Dr. Lyytennen (Children)
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