DESIGNING EFFECTIVE INTERVENTIONS TO ENHANCE COGNITION

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JULY 5, 2015
LEARNING DISABILITIES ASSOCIATION OF NEW ZEALAND CONFERENCE
WHANGAREI
Electrical and chemical signals
Neuronal loss throughout the lifespan
Some reasons to remain optimistic

- Recent evidence shows that we lose neurons throughout adulthood **overall**, but create **new neurons locally** (e.g. hippocampus)

- **Synaptic plasticity** (creation/deletion of connections between neurons) remains throughout the lifespan
Impact on learning

- The Brain's Ability to Change in Response to Experiences
- Amount of Effort Such Change Requires

AGE

Birth 2 4 6 8 10 20 30 40 50 60 70
Plasticity matters

$$r = .67$$
Some reasons to be cautious

• Just because the brain is plastic does not mean that any training regimen can lead to meaningful improvements

• Many popular brain training games are not supported by scientific evidence, even though their rationale sounds “sciencey”

• Transfer (i.e. improvements on tasks or domains that were not part of the training regimen) remains the exception rather than the norm, especially in non-clinical populations
Rationale for a novel approach

- Physical exercise helps to create new neurons (i.e. neurogenesis)
- Need to be integrated within existing neural networks (i.e. synaptogenesis)
- How? Learning!
- Computerized means to enhance cognition
- Our approach: bridge these trends of literature into specifically-designed training programs
Comparing approaches

Physical exercise (AE)

Cognitive training (WM)

Integrated approach (DS)
Design

- **Randomized-controlled experiment** (AE, WM, DS)
- Training 1hr, 3x/week, 24 sessions
- Active control conditions:
  - Working Memory training
  - Aerobic Exercise
- Designed Sport Included:
  - Perceptive problems
  - Motor problems
  - Cognitive problems
- Targets **cognitive and physiological** gains
Spatial Ability

Working Memory

Score (% correct)

Session

Pre Post

Score (% correct)

Session

Pre Post

DS
WM
AE
Underlying mechanisms

- Physical exercise primes the brain for learning
- Cognitive training provides the material for growth
- Either approach alone is suboptimal
- An integrated approach appears to be more efficient: larger gains in less time
How does this apply to cognitive remediation?

- **Cognitive remediation** is a different problem than **cognitive training**: in the former approach, some abilities are deficient and induce debilitating disorders.

- Meaning of cognitive enhancement can be argued in cognitive training, **cognitive remediation offers a clear goal**: targeting deficient abilities to allow individuals to function normally.

- But: knowledge gained from cognitive training studies can inform remediation.
Tackling dyslexia

SO, A DYSLEXIC MAN WALKS INTO A BRA...

- Developmental learning disorders affect many children, impairing their experience in the classroom and hindering many aspects of their life.

- Once a bleak sentence associated with life-long difficulties, dyslexia can now benefit from promising interventions.

- Questions remain regarding the influence of changes in neural networks after an intervention.
An example:
Ritalin and ADHD
An example: Ritalin and ADHD

The dopamine transporter normally moves unbound dopamine from the synapse into the sending neuron.

Ritalin and cocaine both block the dopamine transporter, causing dopamine to build up in the synapse.

- Synapse
- Dopamine
- Dopamine receptor
Physical exercise and ADHD

- Physical exercise acts as a **natural enhancer of neurotransmitter release**, through increases in BDNF

- **Numerous benefits:**
  - No disruption of chemical imbalance
  - Positive side-effects (general health, weight, self-esteem)
  - Complex motor coordination induces cognitive gains
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- Too few individuals have access to the cognitive remediation programs they need (financial costs, limited evidence)
- Designing, implementing and testing a scientifically-supported training program free of charge
- Using state-of-the-art neuroscience techniques
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**Physical component:**

- High Intensity Training (HIT)
- Two core mechanisms:
  - *Arousal:*
    - **Prime children** for learning
    - **More attention-focused** (particularly useful in ADHD)
  - *Neurophysiological:*
    - Known effects on **dopamine** and **BDNF**
    - Preliminary evidence of **High Intensity Training effect on cognition**
- How? Video-based exercise
  - No need for special equipment or facilities
  - Standardized, so no need to train instructors
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Cognitive component:

- How to target different learning disorders with a **single program**?

- Key-idea: **adaptive training**
  
  - Software adapts to core deficits by allocating more time to tasks where performance is lower
  
  - Allows combining **domain-general training** (needed for everyone) and **domain-specific** (impaired in a particular learning disorder)
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Behavioural Interventions to Remediate Learning Disorders: A Technical Report

23 March 2015

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I Introduction ..............................................................................................................
II Audited Programmes ..............................................................................................
  A Arrowsmith Programme ......................................................................................
  B Brain Gym ..........................................................................................................  
  C Cellfield ............................................................................................................
  D Cogmed Working Memory Training ...................................................................
  E Coloured Overlays and Lenses (including those from Irlen and The Institute Optometry) ..............................................................................................................
  F Danks Davis Dyslexia Tutoring .........................................................................
  G Davis Dyslexia ....................................................................................................
  H Dore Programme ..................................................................................................  
  I Fast ForWord .......................................................................................................  
  J Lexia Reading ........................................................................................................
  K Lumosity ............................................................................................................
  L Orton-Gillingham .................................................................................................
  M The Slingerland Approach, as used in New Zealand by The Learning Key .......
  N Steps ...................................................................................................................
  O The Tomatis Method for Auditory Retraining ....................................................
III Omitted Programmes ............................................................................................
IV Conclusion ............................................................................................................
Applications in the classroom

- **Be skeptical** of quick fixes promising large effects

  - What justifies the change?

  - E.g. cutting down PE in response to disappointing academic achievement

- Encourage the **addition of passive or active motor features** (more sensory systems involved = better learning)

  - E.g. observation, gestures

- **Structured plays combining cognitive challenges and physical motion** are key to success

  - E.g. why not work together across subjects? (PE with maths/physics/biology)
Applications in the classroom

- Children do not pay attention to boring things
  - Novelty and diversity are key
  - E.g. preferential looking paradigm in infants
- Transfer, or the generalization of knowledge, emerges given sufficient encounters with new content
  - Multiple explanations of the same ideas are often needed
  - E.g. rules can be extracted from presentation of the same principle in different situations (different subjects, or different situation within subjects)
- Every brain is different
  - Does not mean every single learning situation must be individualized, but worth keeping in mind when children face learning difficulties
  - E.g. research on the benefits of spatial depiction of numerical concepts
Reading the evidence

- Observational or experimental
- Random assignment
- Sample size
- Type of control group
- Attrition rate
- Dependent variables
- Conflicts of interest
Conclusion and future directions

• Latest neuroscientific evidence shows that meaningful cognitive changes are possible throughout the lifespan

• But a one-size-fits-all approach is not realistic: Each individual is different in their response to training

• Significant changes take time and effort

• By combining successful approaches, we can maximize our chances to propose an effective training program with meaningful gains