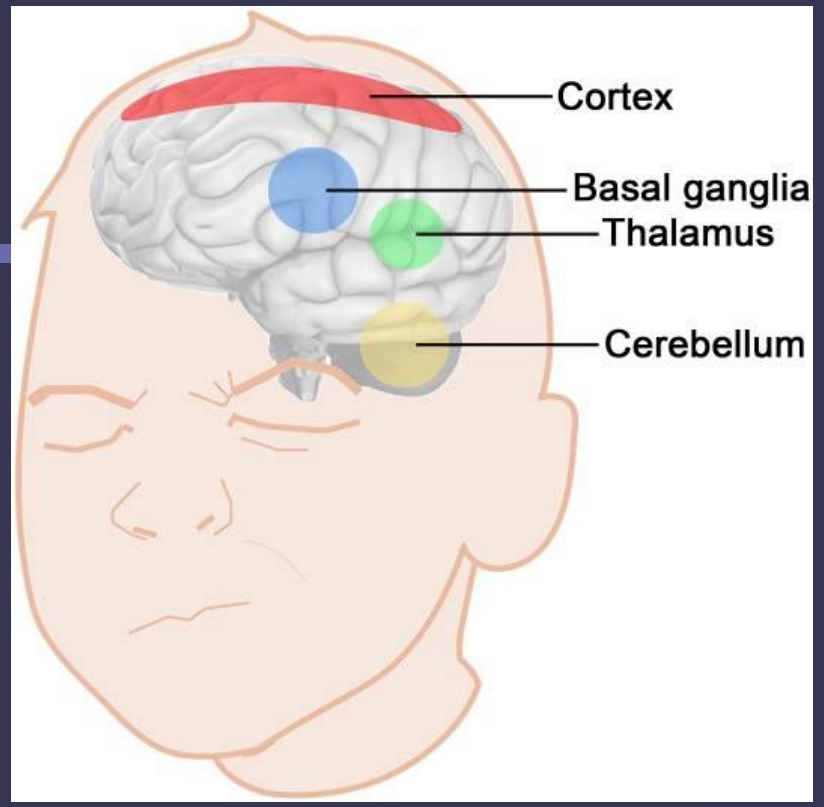


A Developmental Approach to Tics

Understanding & Addressing Their Root Cause

Brain Balance™
ACHIEVEMENT CENTERS

Here's how TICS can feel to a child...

Brain Balance™ ACHIEVEMENT CENTERS

Why Can't I Stop?

It's like an itch I need to scratch!!!!

If I try to hold it in, it's all I can think about.

It kinda wierds me out...

I'm just a normal kid!

I don't want to disturb anyone.

I don't want to be embarrassed any more.

Source: From the HBO documentary "I Have Tourette's But Tourette's Doesn't Have Me" (2005)

Patterns Classified as Tic "Disorders"

- Classification based on observed symptoms
  - Number of specific tics
  - Type of tics
  - Age of onset
  - Frequency
  - Duration of symptoms

Tourette Syndrome (TS)
- 2+ motor tics *and* 1+ vocal tic
- 1+ years duration, nearly every day
- Onset before age 18
- Tics not due to medication / condition

Persistent (Chronic) Tic Disorder
- 1+ motor or vocal tic(s), but *not* both.
- 1+ years, many times nearly every day
- Onset before age 18
- Tics not due to medication / condition

Provisional Tic Disorder
- 1+ motor or vocal tic(s)
- Under 12 months in a row
- Onset before age 18
- Tics not due to medication / condition
- No TS / persistent tic disorder diagnosis

Source: cdc.gov

What Are Tics?

- Tics: sudden twitches, movements, or sounds that people do repeatedly

  Motor tics — Simple tics

  Verbal tics — Complex tics

- Current scientific thinking about the source of tics
  - Genetic?
    "Tourette syndrome genetics research has been frustrating. Despite an apparent high heritability, association studies are largely barren."
  - Dopamine / neurochemistry?
    "There is little evidence of abnormalities of striatal dopaminergic innervation in Tourette syndrome."
  - Functional connectivity?
    *Increasing evidence of **circuitry problems** of the brain systems associated with social decision making (SDM), within the social behavior network (SBN)*

Source: cdc.gov, Roger L Albin, Tourette syndrome: a disorder of the social decision-making network, Brain, Volume 141, Issue 2, February 2018, Pages 332–347.

Circuitry Problems

"The emergence of involuntary movements, vocalizations and subsequent natural history of Tourette syndrome follows a predictable pattern in the first 2 to 3 decades of life, suggesting that Tourette syndrome results from altered brain development trajectories."

Source: L Albin, Tourette syndrome: a disorder of the social decision-making network, Brain, Volume 141, Issue 2, February 2018, Pages 332–347.

Additional "Truisms" Regarding Tics

- Age of onset is typically middle childhood (6-10 yo), more frequent in boys than girls
- Symptoms are intermittent (i.e. appear, disappear, reappear)
- Tics can seriously impede daily function, interfering with school, work, or social life, and can
  - Generate feelings of embarrassment and stress
  - Tire and distract during the activity of suppression
  - Cause pain or injury
- Co-morbid w/ other NEURODEVELOPMENTAL issues (ADHD, anxiety, OCD, ASD, LDs, SPD, etc.)
- Medication / behavioral treatments have limited effectiveness, but there's no cure
- Tics most often decrease during adolescence & early adulthood, often disappearing entirely
  - Compensatory neuroplastic changes in the brain allow the individual's brain to "catch up"

Source: cdc.gov, Compensatory neural reorganization in Tourette syndrome, Stephen R Jackson et al. Curr Biol. 2011.

Wait...What?

Wait...What?

Neuroplastic changes

in brain structure & connectivity

control tics

over time, helping the brain onto a more typical

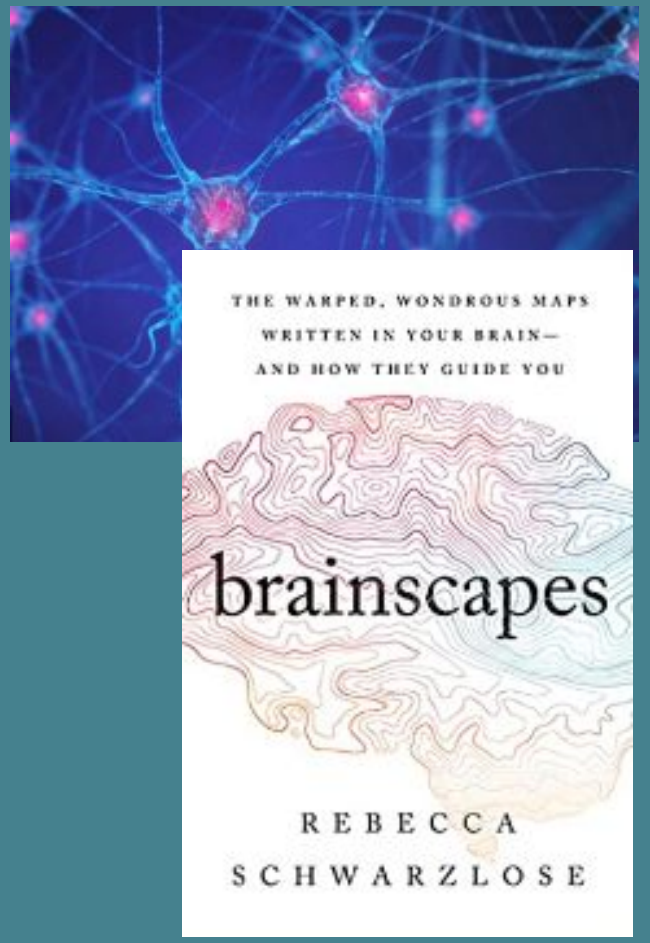
developmental trajectory.

Neuroplastic Change? What's that?

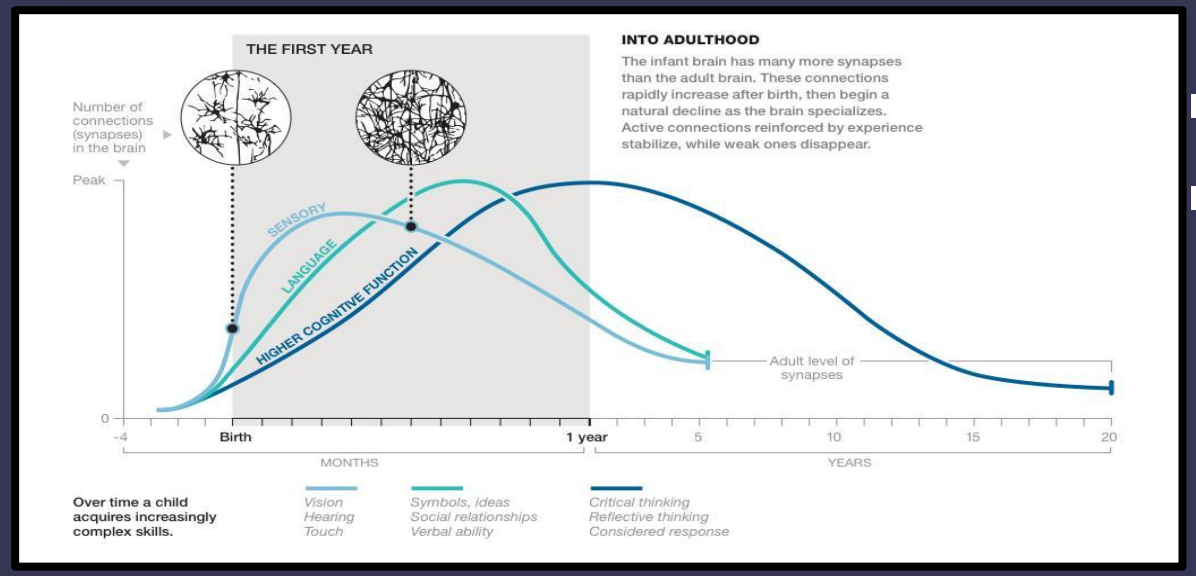
Brain Balance™ ACHIEVEMENT CENTERS

The Human Brain: An Organ of "Surreal Complexity"

- The most complicated organ known in nature
  - ~ 100 billion neurons (brain cells) form ~ 100 trillion connections
  - "Neurons that fire together, wire together"
  - Functional connections in the brain are the basis of learning
- Typical wiring ("functional connectivity") = the "Human Connectome"
  - Enables typical self-regulation, skill mastery, etc.
- Disorders involve **predictable** differences in functional connectivity
  - Wiring differences are **detectable** ahead of symptoms
- The brain can change. It remains neuroplastic throughout our lives



Building The Human Connectome



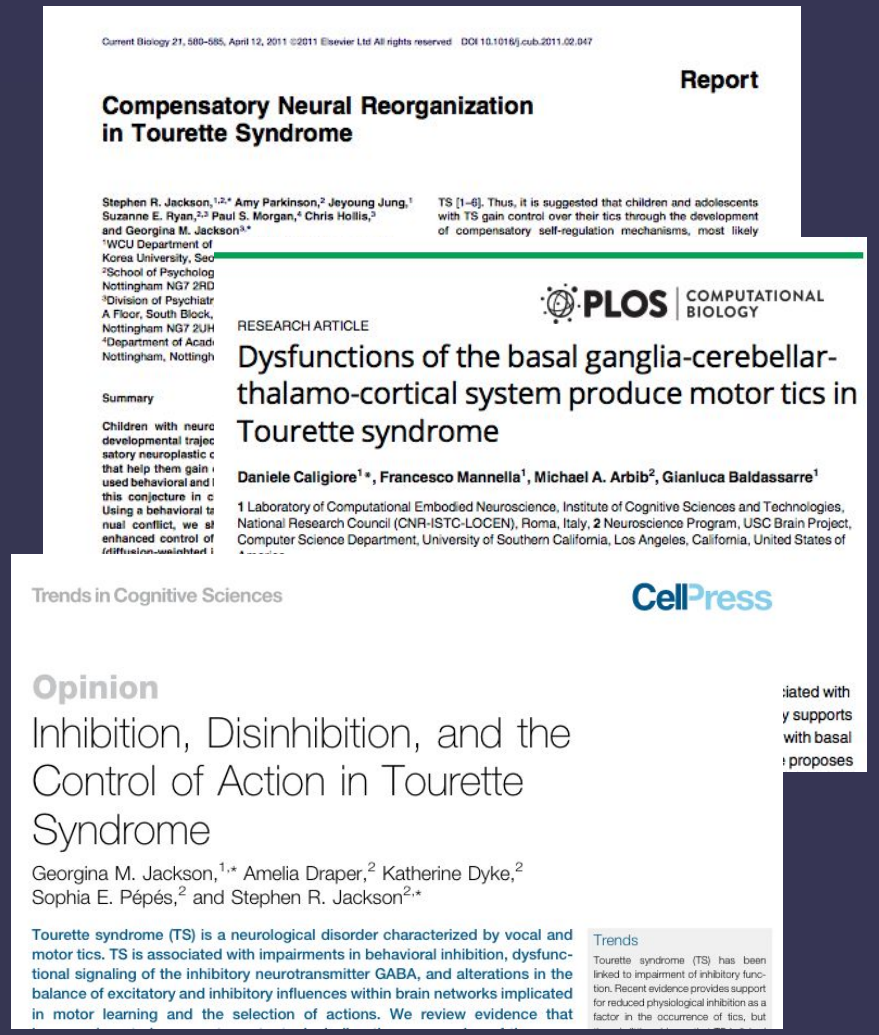
- Brain wiring depends heavily on environmental input
  - Being born with the right "equipment" is not enough
  - Experiences & stimulation drive development
- "Lightning pace of development" in the first few years
  - Different stimuli / tasks establish different networks
  - Repeated activation strengthens / refines circuits
- Dysfunction is observable when brain wiring is not typical
- Appropriate intervention exists and is highly effective
  - Strengthens existing connections
  - Builds connections not previously formed
  - Improves self-regulation, learning, skill mastery, etc.

Source: Bhattacharjee, Yudhijit, "The First Year", *National Geographic*, January 2015.

Neuroplasticity's Role in Overcoming Tics

- Increasingly, TS research is focused on the functional connectivity within a system of brain regions
- These regions "learn" to work together in the way we consider "typical" over time
- Suppression of tics is a part of typical human development, much like social and emotional learning, academic learning, physical coordination, etc.

"Increased control over motor outputs, including suppression of tics, may develop during adolescence in TS and be accompanied by compensatory, neuromodulatory, alterations in brain structure & function."



Current Biology 21, 580–585, April 12, 2011 ©2011 Elsevier Ltd All rights reserved DOI 10.1016/j.cub.2011.02.047

Report

Compensatory Neural Reorganization in Tourette Syndrome

Stephen R. Jackson,[1,2,*] Amy Parkinson,[2] Jeyoung Jung,[1] Suzanne E. Ryan,[2,3] Paul S. Morgan,[4] Chris Hollis,[3] and Georgina M. Jackson[3,*]

TS [1–6]. Thus, it is suggested that children and adolescents with TS gain control over their tics through the development of compensatory self-regulation mechanisms, most likely

PLOS | COMPUTATIONAL BIOLOGY

RESEARCH ARTICLE

Dysfunctions of the basal ganglia-cerebellar-thalamo-cortical system produce motor tics in Tourette syndrome

Daniele Caligiore[1]*, Francesco Mannella[1], Michael A. Arbib[2], Gianluca Baldassarre[1]

1 Laboratory of Computational Embodied Neuroscience, Institute of Cognitive Sciences and Technologies, National Research Council (CNR-ISTC-LOCEN), Roma, Italy, 2 Neuroscience Program, USC Brain Project, Computer Science Department, University of Southern California, Los Angeles, California, United States of

Summary

Children with neuro
developmental trajec
satory neuroplastic c
that help them gain
used behavioral and
this conjecture in c
Using a behavioral ta
nual conflict, we sh
enhanced control of

Trends in Cognitive Sciences

CellPress

Opinion

Inhibition, Disinhibition, and the Control of Action in Tourette Syndrome

Georgina M. Jackson,[1,*] Amelia Draper,[2] Katherine Dyke,[2] Sophia E. Pépés,[2] and Stephen R. Jackson[2,*]

Tourette syndrome (TS) is a neurological disorder characterized by vocal and motor tics. TS is associated with impairments in behavioral inhibition, dysfunctional signaling of the inhibitory neurotransmitter GABA, and alterations in the balance of excitatory and inhibitory influences within brain networks implicated in motor learning and the selection of actions. We review evidence that

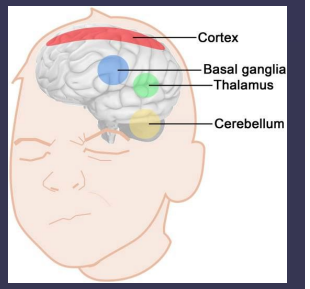
Trends

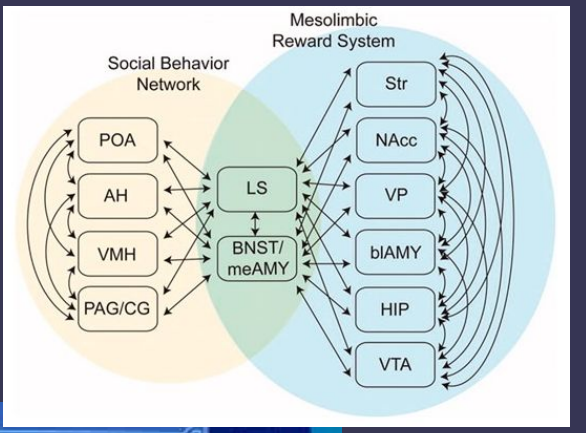
Tourette syndrome (TS) has been linked to impairment of inhibitory function. Recent evidence provides support for reduced physiological inhibition as a factor in the occurrence of tics, but

iated with
y supports
with basal
proposes

A "System Perspective"

- Neuro-anatomical system
  - Basal ganglia work together with the cortex and cerebellum
  - Selection and maintenance of appropriate responses
    - ➢ Generate behaviors of various complexity
    - ➢ Inhibit inappropriate responses
- Systemic differences in Tourette's Syndrome
  - Related brain structures are immature
  - Atypical interactions/functional connectivity between regions
- Same "dysfunction" is also implicated in OCD and ADHD



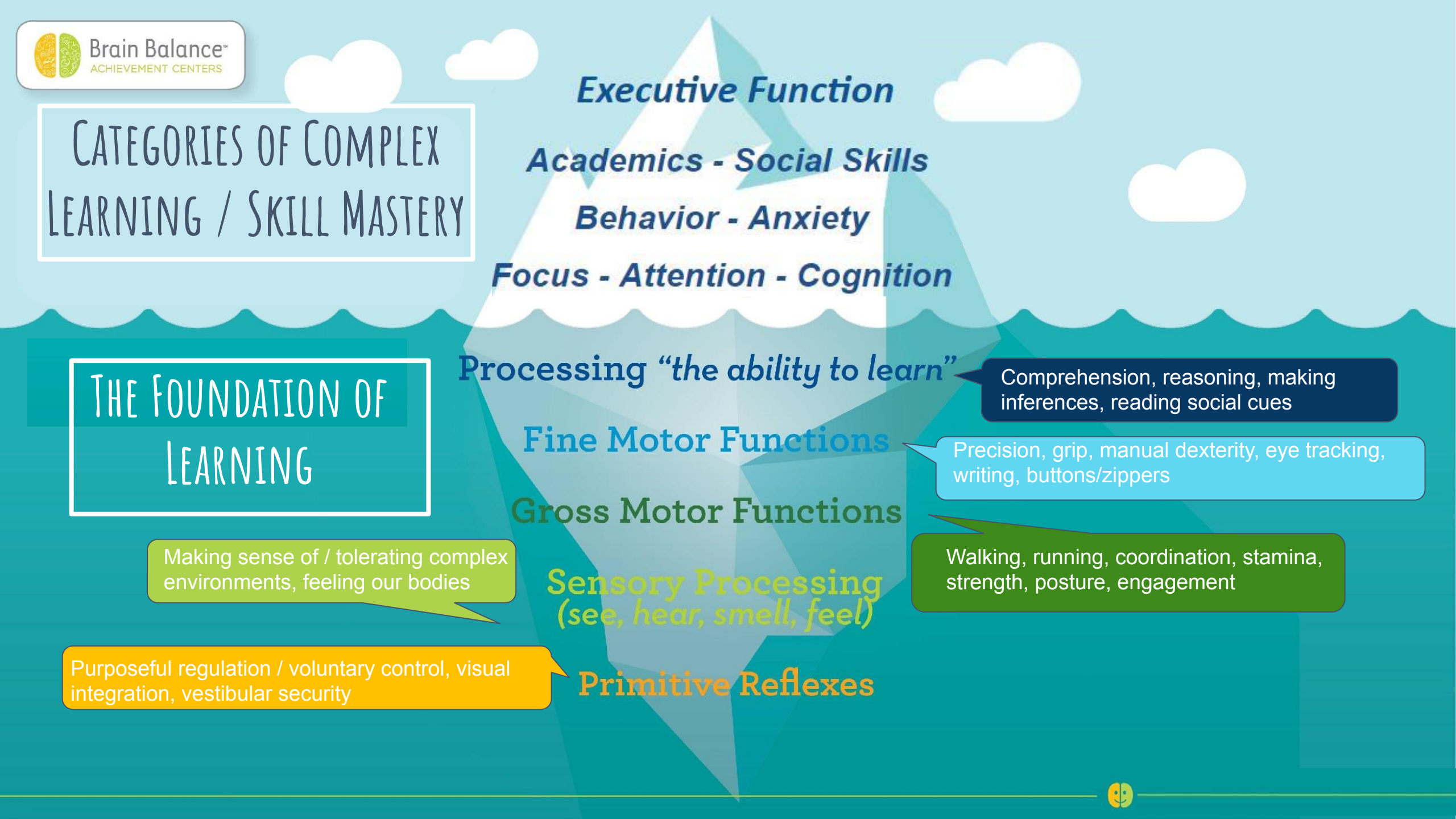


"ADHD is common in TS, as are anxiety disorders [and] obsessive compulsive behaviours, often arising to the level of OCD. It is plausible to view simple tics and complex obsessions as opposite poles of a spectrum with compulsive behaviours occupying the middle of the spectrum"

Source: Roger L Albin, Tourette syndrome: a disorder of the social decision-making network, Brain, Volume 141, Issue 2, February 2018, Pages 332–347.

Brain Balance™
ACHIEVEMENT CENTERS

Categories of Complex Learning / Skill Mastery



The Foundation of Learning

Comprehension, reasoning, making inferences, reading social cues

Precision, grip, manual dexterity, eye tracking, writing, buttons/zippers

Walking, running, coordination, stamina, strength, posture, engagement

Making sense of / tolerating complex environments, feeling our bodies

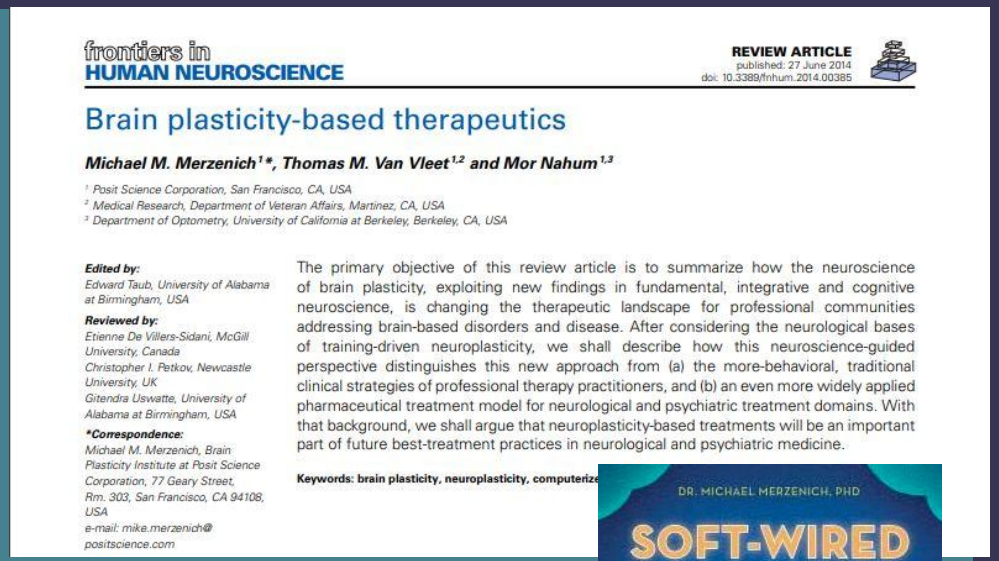
Purposeful regulation / voluntary control, visual integration, vestibular security

The Promise of Plasticity-Based Interventions

Dr. Michael Merzenich, Neuroscientist & Author:

"Brain plasticity-based therapeutics can be expected to drive fundamental re-normalizing corrections for distorted brain systems."

- Neurodevelopmental disorders: "failure modes of the **self-organizing** brain"
- We have clear insight into brain-changing processes
  - In the degrading, aging, distorting direction
  - In the strengthening, rejuvenating, corrective direction
- Brain "remodeling" can be induced
  - On a large scale
  - At any age



frontiers in HUMAN NEUROSCIENCE

REVIEW ARTICLE
published: 27 June 2014
doi: 10.3389/fnhum.2014.00385

Brain plasticity-based therapeutics

Michael M. Merzenich[1]*, Thomas M. Van Vleet[1,2] and Mor Nahum[1,3]

[1] Posit Science Corporation, San Francisco, CA, USA
[2] Medical Research, Department of Veteran Affairs, Martinez, CA, USA
[3] Department of Optometry, University of California at Berkeley, Berkeley, CA, USA

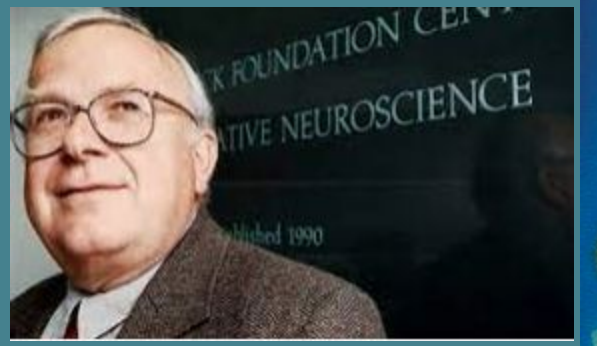
Edited by:
Edward Taub, University of Alabama at Birmingham, USA

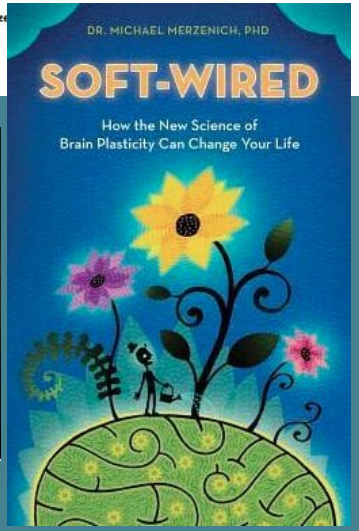
Reviewed by:
Etienne De Villers-Sidani, McGill University, Canada
Christopher I. Petkov, Newcastle University, UK
Gitendra Uswatte, University of Alabama at Birmingham, USA

*Correspondence:
Michael M. Merzenich, Brain Plasticity Institute at Posit Science Corporation, 77 Geary Street, Rm. 303, San Francisco, CA 94108, USA
e-mail: mike.merzenich@positscience.com

The primary objective of this review article is to summarize how the neuroscience of brain plasticity, exploiting new findings in fundamental, integrative and cognitive neuroscience, is changing the therapeutic landscape for professional communities addressing brain-based disorders and disease. After considering the neurological bases of training-driven neuroplasticity, we shall describe how this neuroscience-guided perspective distinguishes this new approach from (a) the more-behavioral, traditional clinical strategies of professional therapy practitioners, and (b) an even more widely applied pharmaceutical treatment model for neurological and psychiatric treatment domains. With that background, we shall argue that neuroplasticity-based treatments will be an important part of future best-treatment practices in neurological and psychiatric medicine.

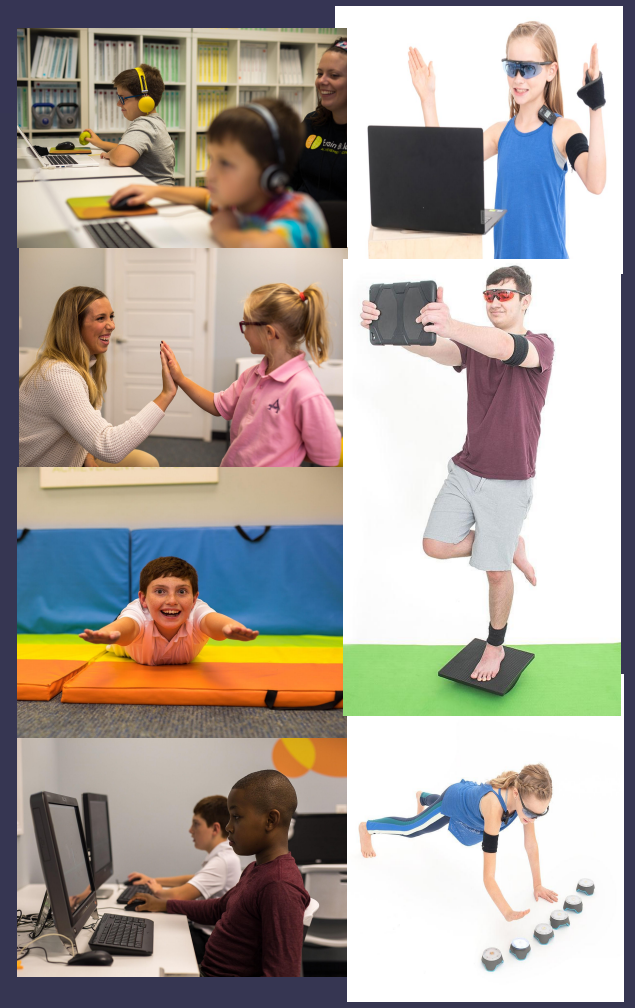
Keywords: brain plasticity, neuroplasticity, computerize





Leveraging Brain Plasticity

- Intensive, integrated, targeted, strengthening exercise
  - Sensory engagement
  - Physical exercise
  - Academic / cognitive activities
- Progressively challenging, purposeful
- Must reflect complexity of real world to change brain
- Improves speed & efficiency of neural pathways
  - Key networks in the brain fire, then wire, together
  - Drives synchronization of skills
- Brain connections become more typical
- Leads to more typical function
  - Self-regulation
  - Information processing
  - Learning



How Do We Know The Approach Works?

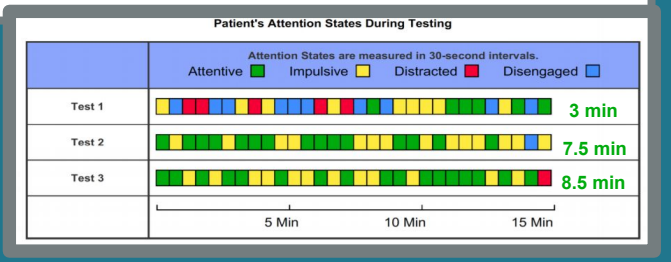
Harvard/McLean Findings

- "Profound effects" in terms of
  - Symptom improvement
  - Measured attention
  - Functional brain connections
- Multiple assessments
  - Pre-study (Test 1)
  - Immediately after 16 weeks of participation (Test 2)
  - ½ year post-study (Test 3)
- Persistence of benefits due to true neuroplastic change

Martin H. Teicher, M.D., Ph.D
Director, Developmental Biopsychiatry Research Program
Chief, Laboratory of Developmental Psychopharmacology
McLean Hospital
115 Mill Street
Belmont, MA 02478-9106

Harvard Medical School
Department of Psychiatry
Associate Professor
Phone: 617-855-2970
Fax: 617-855-3712
Email:
martin_teicher@hms.harvard.edu

White Paper: Profound Effects of Brain Balance Exercises and Interactive Metronome and on a Subset of Children with Attention Deficit Hyperactivity Disorder



Replicable Results / Parent-Reported Success Stories

"LIFE CHANGING in the most positive way" "It's just absolutely amazing what he's accomplished."

"He's been on the school news here 6 or 7 times already doing weather reports, news reports, things like that."

"1.5 years later...99% better...occasionally make a snorting noise...interacts with friends...a normal social life."

In Summary:

By promoting beneficial neuroplastic change,

we can help people

control tics sooner.

Any Questions?

Contact Information

908-517-1101

summit@brainbalance.com

bstoeber@brainbalance.com

brainbalance.com

Resources

Aala, B., Kent, E.G., Morris, D. & Nevins, S. (Producers). Kent, E.G. (Director). (2005). I Have Tourette's But Tourette's Doesn't Have Me [documentary]. United States: Home Box Office.

Albin, R. L. (2018). Tourette syndrome: a disorder of the social decision-making network. Brain, 141(2), 332-347.

Bhattacharjee, Y. (2015). The first year. National Geographic, 227(1), 58-77.

Caligiore, D., Mannella, F., Arbib, M. A., & Baldassarre, G. (2017). Dysfunctions of the basal ganglia-cerebellar-thalamo-cortical system produce motor tics in Tourette syndrome. PLoS Computational Biology, 13(3), e1005395.

Centers for Disease Control and Prevention (2020, May 13). Risk factors and causes for Tourette syndrome. https://www.cdc.gov/ncbddd/tourette/riskfactors.html

Jackson, G. M., Draper, A., Dyke, K., Pépés, S. E., & Jackson, S. R. (2015). Inhibition, disinhibition, and the control of action in Tourette syndrome. Trends in Cognitive Sciences, 19(11), 655-665.

Jackson, S. R., Parkinson, A., Jung, J., Ryan, S. E., Morgan, P. S., Hollis, C., & Jackson, G. M. (2011). Compensatory neural reorganization in Tourette syndrome. Current Biology, 21(7), 580-585.

Merzenich, M. M., Van Vleet, T. M., & Nahum, M. (2014). Brain plasticity-based therapeutics. Frontiers in Human Neuroscience, 8, 385.

Merzenich, M. M. (2013). Soft-Wired: How the New Science of Brain Plasticity Can Change Your Life. Parnassus.

Schwarzlose, R. (2021). Brainscapes: An Atlas of Your Life on Earth. Profile Books.