Cognition in Motion: Cognitive and Movement Training for Healthy Ageing

Federico Gori
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In the second half of the 20\textsuperscript{th} Century, the view that plasticity was limited to the first years of life was ascendant in medical neurology, psychiatry, and education.

Nothing could be further from the truth!
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Like your physical body, **YOUR BRAIN NEEDS EXERCISE**

- to grow and to sustain high function
- to sustain your organic health
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Michael Merzenich

Michael M. Merzenich
Merz,[1] the Good Doctor, the Brain Guy[2]

Born 1942
Lebanon, Oregon, USA

Education University of Portland (BD),
Johns Hopkins Medical School
(PhD in Physiology), University of
Wisconsin (postdoctoral studies)

Known for Brain plasticity research[3]
Medical career

Profession Professor emeritus neuroscientist

Institutions University of California, San
Francisco

Research Basic and clinical sciences of
hearing

Notable prizes National Academy of Sciences,
Institute of Medicine, Ipsen Prize,
Zülch Prize of the Max-Planck
Institute, Thomas A. Edison
Patent Award, the Purkinje
Medal, and Karl Spencer Lashley
Award
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• Mike Merzenich has been one of the first neuroscientists discovering and proving the brain plasticity.
• Mike’s good news is that our brain can be physically modified with training. The consequences of this specific and generalized training are:
  • Modification of the degenerative process of aging
  • Modification of the «brain cognitive functions» for normal people (schools, elderly population...)
  • Modification of the «brain cognitive functions» for elite people (athletes, military...)
1. Myelination
2. Response power
3. Response coordination (functional reliability)
4. PV inhibitory neuron numbers, morphologies
5. SS inhibitory neuron numbers, morphologies
6. Pyramidal cell dendritic branching
7. Cortico-thalamic axonal arbor branching
8. Astroglial and microglial cell branching, metabolism
9. Young-brain chemistry
10. Brain speed
11. Representational orderliness
12. Minicolumn size
13. Complex feature selective responding
14. BDNF expression
12. Cortical process “noise” (“chatter”)
13. Distractor suppression power
14. Sequential processing accuracy
15. Cortical system ‘prediction’
16. Distractor suppression
17. Reactive hyperemia
18. Blood brain barrier integrity
20. Brain system connectivity
21. Intrinsic immune response
22. Neurotransmitter transporters
23. NE & SE expression
24. ACh expression
25. DA expression

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How do you turn an old (or impaired) brain into a (physically and functionally) more capable ('younger') one?

HOW DO YOU KEEP IT SAFER?

YOU TRAIN IT

Of course neurological rejuvenation will only be achieved with particular forms of training.
How do you turn a brain in the prime of life into an old one?

JUST ADD NOISE
What is noise in everyday life?
What’s the ‘negative’ side of plasticity all about? Why did nature endow us with this peculiar property?

1. Our reversible plasticity assures that we sustain overall neurobehavioral CONTROL. **It’s all about “getting the answer right”!**

2. Getting that answer right is a key to (historic) human survival.

3. If we’re consistently “correct”, our machinery advances its powers.

4. If we begin to fail, our machinery adjusts to take longer, as it looks ‘more carefully’, to be more certain that it’s not making a mistake.

5. Older individuals sustain basic control of their operations (lives)—even while their BRAIN is usually slowly losing its youthful high-speed, high-accuracy prowess!

6. Again, **WE HAVE THE POWER OF CONTROL** over whether a brain shall advance, or retreat.
We can throw the “plasticity switch” in a “blastic” or “clastic” direction, at will.

Coordinated positive, performance enhancing, organic brain health strengthening changes.

Blastic = GROWTH

Clastic = DEGENERATION

Coordinated negative, performance degrading, organic brain health compromising changes.
‘Speed of processing’ is one of a series of important higher-performance/rejuvenation targets of BrainHQ training.

SOP typically undergoes dramatic decline with age.

All of these declining abilities can be improved or rejuvenated, AT ANY AGE, by BrainHQ training.

Adapted from studies conducted by University of Virginia professor Timothy Salthouse.
“Processing speed” measures provide an important indicator of both the brain’s performance abilities, AND its organic health status.

One example of processing speed recovery resulting from BrainHQ training.

Before training

After training

TRAINING on BrainHQ.com’s "Double Decision" exercise.
Randomly assigned controlled trials have demonstrated the important consequences of driving training-driven improvements in processing speed. One example is the ACTIVE Trial.

Subjects were trained using BrainHQ’s “Double Decision” task.

Adapted from Edwards et al., 2017
Speed of Processing gains on this divided-attention visual task resulted in many “real-world” benefits:

Half as many traffic accidents  
(Ball, et al., 2010)

Far safer driving  
(Roenker et al., 2004)

Reliably sustained driving mobility  
(Edwards, Myers et al., 2009; Edwards, Delahunt et al., 2009; Ross et al., 2014; Ross et al. in press)

More confident, effective driving  
(Edwards, et al., 2009)
More speed of processing training gains “transferred” to real-world benefits.....

- **Improvements in everyday performance abilities**  
  (Edwards et al., 2001; 2005; Ball et al., 2002; Lin et al., 2016)

- **Protection against senior depression**  
  (Wolinsky et al., 2009)

- **Better sustained independence, better health, better QOL**  
  (Wolinsky et al., 2006, 2009, 2010)

- **Less everyday functional difficulty across >10 years**  
  (Rebok et al., 2014)

- **48% reduction in dementia incidence**  
  (Edwards et al., submitted for publication)
It’s not just about delaying the loss of independence or the onset dementia in aging. The same strategies are also being applied to:

1. Delay the onset of Parkinsons disease.
2. Delay the onset of the full expressions of Huntingtons (and other) inherited neurological disorders.
3. Treat depression; grow resilience against depression onset.
4. Treat schizophrenia (and other psychotic) illnesses; delay/prevent their onsets In at-risk individuals
5. Overcome neurological distortions attributed to severe childhood abuse, neglect, high stress, deprivation.
6. Treat individuals with physically wounded (stroke, TBI, concussions, et alia), poisoned, and chronically-infected brains.
7. Restore blood-brain barrier integrity and cognitive status, in MS; surgical trauma; heart failure; concussion; et alia.
8. Ameliorate the expressions of autism and other inherited disorders.
9. Among other targets.
Create and validate cognitive exercises and assessments to measure, rebuild, refine and improve every major system of the brain:

- **Movement** (balance, gait, fine motor)
- **Auditory-language** (speed, accuracy, memory)
- **Visual-spatial** (speed, accuracy, memory)
- **Executive function** (planning, reasoning, decision-making)
- **Memory** (immediate, delayed, working)
L’approccio è di tipo bottom-up

- Fine tunes perceptual systems, the elemental building block of cognition
- Engages neuro-modulatory systems to enhance mood, plasticity and learning
- Moves upward to attention, working memory, other types of memory, problem-solving, planning, reasoning, decision-making
- Better cognitive function improves multiple measures of quality of life

SPEED + ACCURACY + NEUROMODULATION = GAINS
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Cognitive Training Applicability

- **Cognitive**
  - Speed
  - Attention
  - Memory
  - Executive Function
  - Social Cognition

- **Behavioral**
  - Mood
  - Confidence
  - Stress Management
  - Impulse Control

- **Functional**
  - Speech & Language
  - Visual-Spatial
  - Visual-Motor/Movement

Progressive Training Can Fundamentally Change Performance
Thinking, Walking, Talking: Integratory Motor and Cognitive Brain Function

Gerry Leisman, Ahmed A. Moustafa, and Tal Shafir

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Abstract

In this article, we argue that motor and cognitive processes are functionally related and most likely share a similar evolutionary history. This is supported by clinical and neural data showing that some brain regions integrate both motor and cognitive functions. In addition, we also argue that cognitive processes coincide with complex motor output. Further, we also review data that support the converse notion that motor processes can contribute to cognitive function, as found by many rehabilitation and aerobic exercise training programs. Support is provided for motor and cognitive processes possessing dynamic bidirectional influences on each other.
Cognitive Functions of the Cerebellar Hemispheres

The cerebellar hemispheres project mainly to the lateral cerebellar nuclei (also called dentate), and the dentate nuclei send prominent projections to a surprisingly large number of areas in the frontal lobes of the cerebral cortex. The frontal lobes have long been viewed as the brain regions where higher cognitive functions reside. Therefore, the prominent projection from the cerebellum to these areas implicates the cerebellum in higher cognitive function. The availability of brain imaging for research on human subjects has generated an impressive amount of data showing that the lateral cerebellum becomes active when a person participates in cognitive tasks or engages in the solution of difficult problems. Even some language operations, such as the generation of appropriate verbs from a list of nouns, give rise to activity in the lateral cerebellum.
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Research Article

Effects of Physical-Cognitive Dual Task Training on Executive Function and Gait Performance in Older Adults: A Randomized Controlled Trial

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Abstract

Physical and cognitive training seem to counteract age-related decline in physical and mental function. Recently, the possibility of integrating cognitive demands into physical training has attracted attention. The purpose of this study was to evaluate the effects of twelve weeks of designed physical-cognitive training on executive cognitive function and gait performance in older adults. Thirty-six healthy, active individuals aged 72.30 ± 5.84 years were assigned to two types of physical training with major focus on physical single task (ST) training (n = 16) and physical-cognitive dual task (DT) training (n = 20), respectively. They were tested before and after the intervention for executive function (Inhibition, working memory) through Random Number Generation and for gait (walking with/without negotiating hurdles) under both single and dual task (ST, DT) conditions. Gait performance improved in both groups, while inhibitory performance decreased after exercise training with ST focus but tended to increase after training with physical-cognitive DT focus. Changes in inhibition performance were correlated with changes in DT walking performance with group differences as a function of motor task complexity (with/without hurdles). The study supports the effectiveness of group exercise classes for older individuals to improve gait performance, with physical-cognitive DT training selectively counteracting the age-related decline in a core executive function essential for daily living.

Cognitive Resources Necessary for Motor Control in Older Adults Are Reduced by Walking and Coordination Training

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We examined if physical exercise interventions were effective to reduce cognitive brain resources recruited while performing motor control tasks in older adults. Forty-three older adults (63-79 years of age) participated in either a walking (n = 17) or a motor coordination (n = 13) intervention (1 year, 3 times per week) or were assigned to a control group (n = 11) doing relaxation and stretching exercises. Pre and post the intervention period, we applied functional MRI to assess brain activation during imagery of forward and backward walking and during counting backwards from 100 as control task. In both experimental groups, activation in the right dorsolateral prefrontal cortex (DLPFC) during imagery of forward walking decreased from pre-to post-test (Effect size: -1.35 and -1.26 for coordination and walking training, respectively, Cohen’s d). Regression analysis revealed a significant positive association between initial motor status and activation change in the right DLPFC (R² = 0.242, F(3,29) = 4.18, p = 0.012). Participants with lowest motor status at pretest profited most from the interventions. Data suggest that physical training in older adults is effective to free up cognitive resources otherwise needed for the control of locomotion. Training benefits may become particularly apparent in so-called dual-task situations where subjects must perform motor and cognitive tasks concurrently.
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For the first time Microgate and Posit Science started working together on the idea to combine Cognitive Load and movement exercises with the determination of the mutual interactions.
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Whatever you can think or dream, begin it.

Boldness has genius, power, and magic in it.

J.W. Goethe