

Cognitive Neuroscience

A.A. 2025/2026

<https://carmelovicario.webnode.it/>

Goals

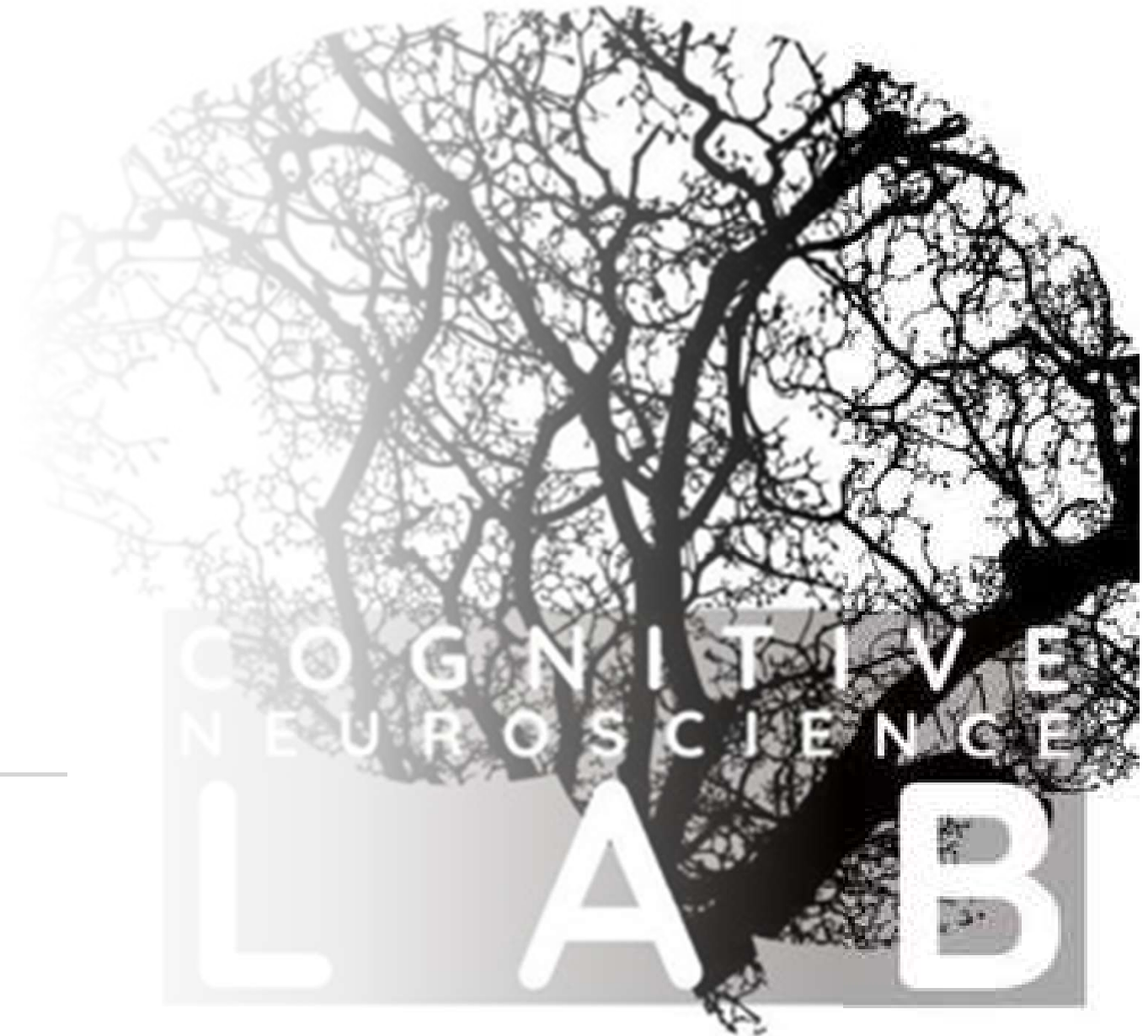
Providing an overview of the main research areas in the field of Cognitive Neuroscience.

Providing basic elements for the critical evaluation of a scientific article.

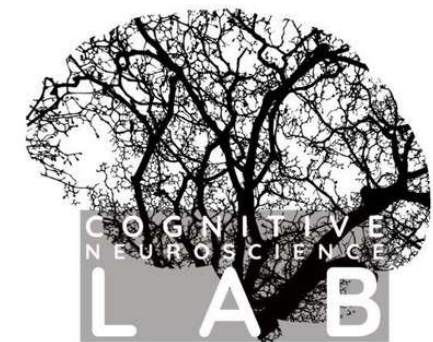
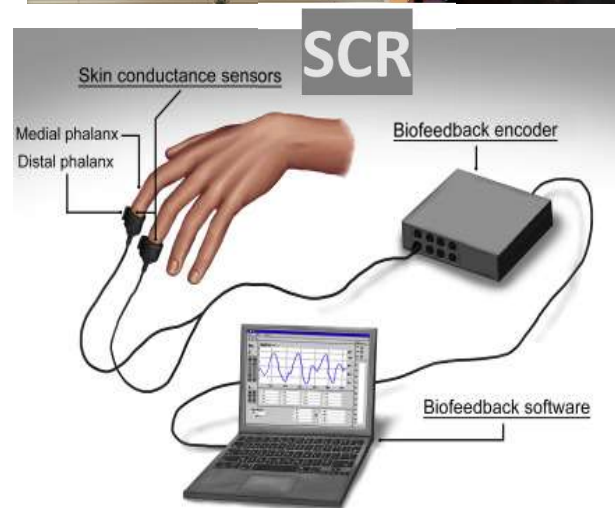
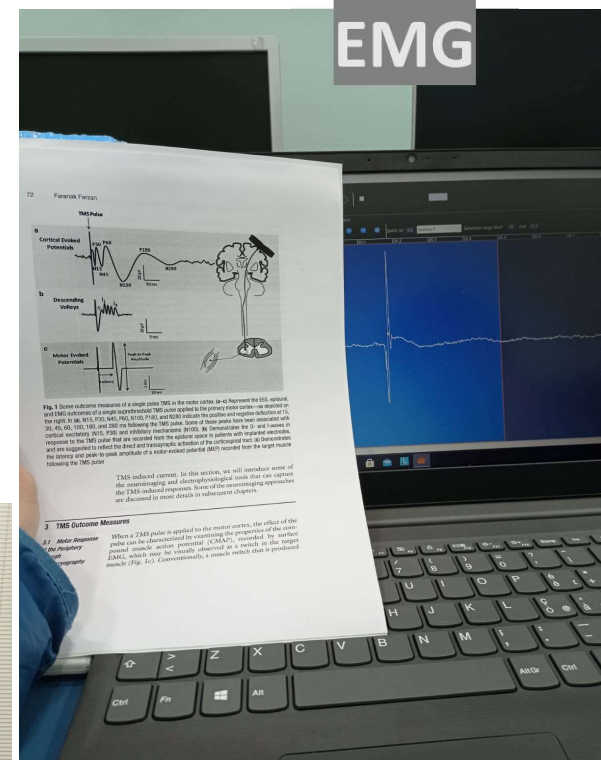
Providing basic elements for the design of scientific protocols.



Lab topics



Lab Facilities



Research topics

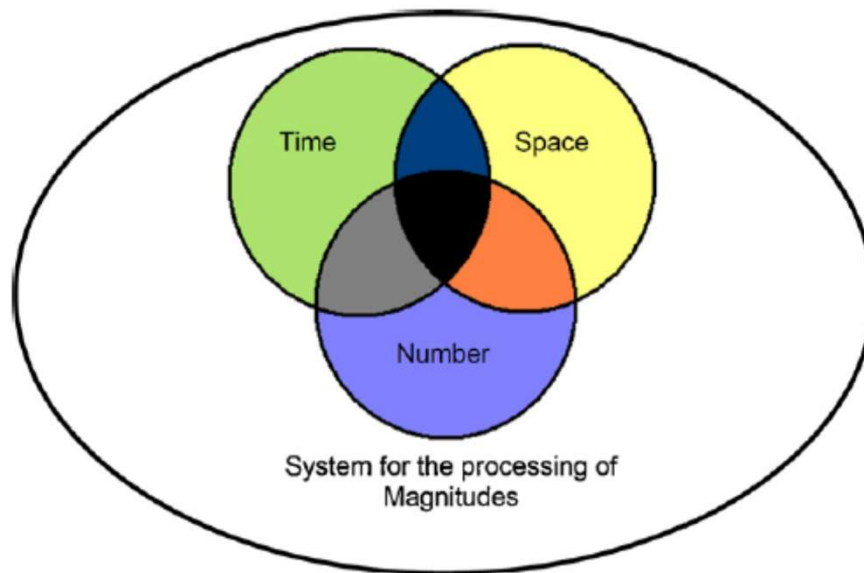


Prof
Vincent Walsh

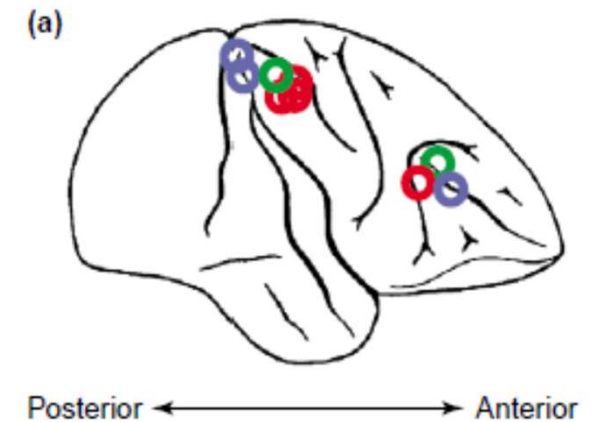


A theory of magnitude: common cortical metrics of time, space and quantity

Vincent Walsh

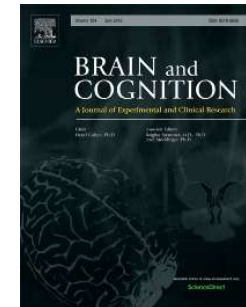


ATOM predicts perceptual biases while
combining these 3 domains



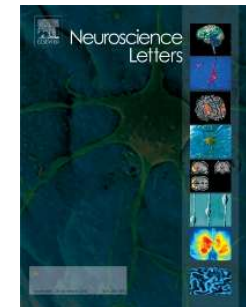
Optokinetic stimulation affects temporal estimation in healthy humans.

Vicario CM et al. Brain Cogn. 2007 Jun;64(1):68-73



Perceiving numbers alters time perception.

Oliveri M, **Vicario CM**, et al. Neurosci Lett. 2008 Jun 27;438(3):308-11



Relativistic compression and expansion of experiential time in the left and right space.

Vicario CM, et al., PLoS One. 2008 Mar 5;3(3):e1716.



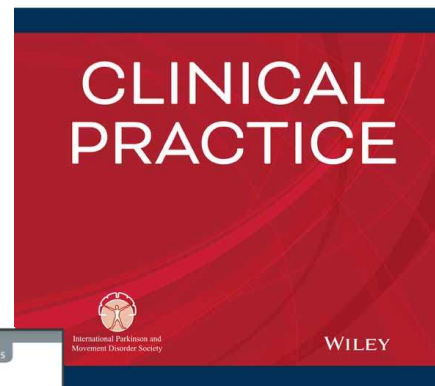



**KEEP
CALM
AND
TRACK
YOUR TIME**



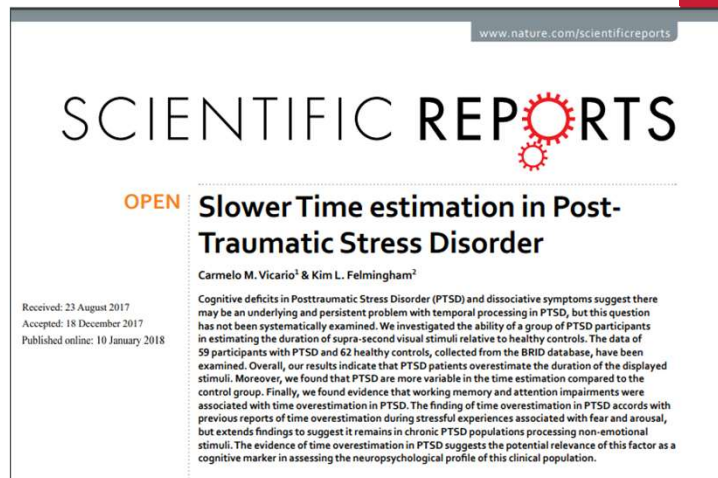
Neurophysiological mechanisms of time estimation and time keeping

Movement Disorders



Vicario CM et al. Temporal accuracy and variability in the left and right posterior parietal cortex. **Neuroscience.** 2013 Aug 15;245:121-8.

Vicario CM, et al., Delay Reward Discounting in Adolescents With Tourette's Syndrome. **Mov Disord.** 2020 Jul;35(7):1279-1280.



Motor Coordination and the Motor Cortex

Motor coordination is not confined to a single region of the brain, but is associated with activity in a range of areas.

The motor cortex is the part of the brain most commonly associated with movement.



It consists of several distinct parts, namely: the primary motor cortex, the premotor cortex, the supplementary motor area, the primary somatosensory cortex, and the posterior parietal cortex.



The primary motor cortex is arguably the most important since this region is responsible for initiating voluntary motion and is distinguished histologically by its containing many large pyramidal neurons known as Betz cells.



The premotor cortex is assumed to play a part in motor control since its projections to the spinal cord are similar to those of the primary motor cortex.



The posterior parietal cortex seems specifically tied to hand-eye coordination and assists with learning new motor tasks.



The supplementary motor area (SMA) is a small region located in front of the part of the primary motor cortex responsible for controlling the legs.



It performs specialized functions such as various kinds of coordination such as coordinating movement on the two sides of the body and organizing actions across time as well as initiating particular kinds of movements and controlling posture.



The somatosensory cortex sits behind the primary motor cortex and is the main part of the brain concerned with the reception and localization of tactile signals.



It also deals with proprioception, the internal feeling of the limbs that allows them to be oriented without constantly looking at them.

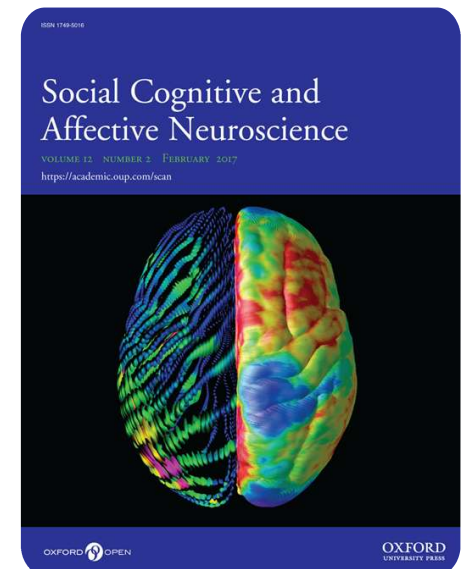
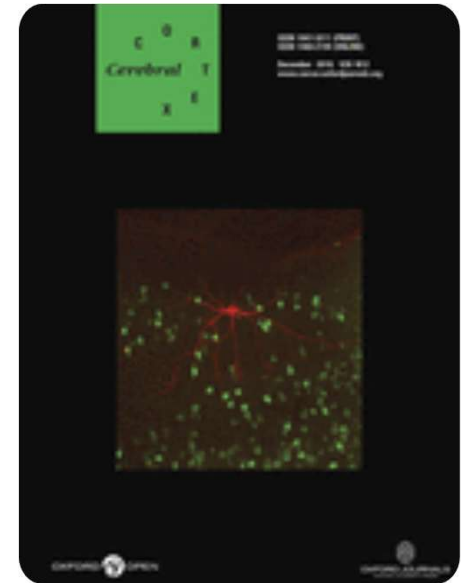
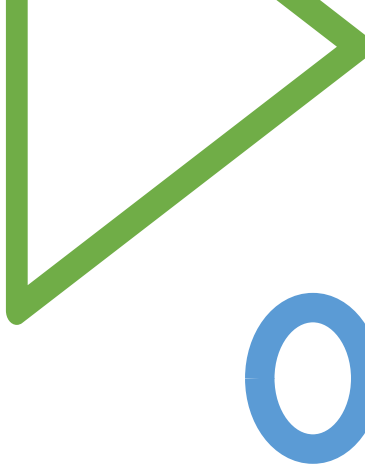


Cognition, emotion and motor system

Competing mechanisms for mapping action-related categorical knowledge and observed actions. Candidi M, **Vicario CM**, et al. Cereb **Cortex**. 2010 Dec;20(12):2832-41.

Counterfactual thinking affects the excitability of the motor cortex. **Vicario CM**, et al. Cortex. 2015 Apr;65:139-48

Pictures of disgusting foods and disgusted facial expressions suppress the tongue motor cortex. **Vicario CM**, et al. Soc Cogn Affect Neurosci. 2017 Feb 1;12(2):352-362.





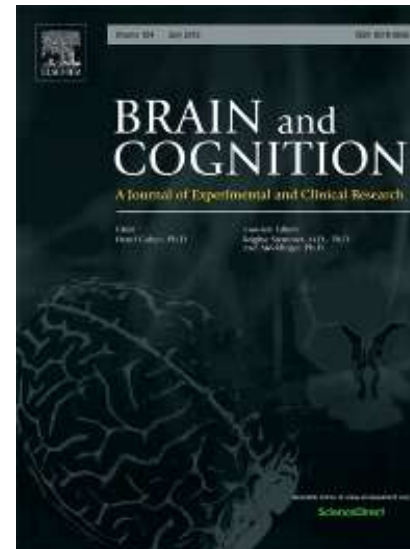
How individual variables shape morality

Moral judgment and individual variables

Vicario, C.M. and Rafal, R. D. Relationship between body mass index and moral disapproval rating for ethical violations. *Personality and Individual Differences* 104 (2017) 8–11

Vicario CM, et al. The effect of hunger and satiety in the judgment of ethical violations. *Brain Cogn.* **2018** Aug;125:32-36.

Lucifora et al. (2021) How self-control predicts moral decision making: an exploratory study. *International Journal of Environmental Research and Public Health.* 18(7):3840.



International Journal of
*Environmental Research
and Public Health*



Fear extinction
memory and Anxiety
recovery

Noninvasive brain stimulation to boost fear extinction learning and promote anxiety recovery



A systematic review on the therapeutic effectiveness of non-invasive brain stimulation for the treatment of anxiety disorders

C.M. Vicario^{a,b,f,*}, Mohammad Ali Salehinejad^{b,c}, K. Felmingham^d, G. Martino^a, M.A. Nitsche^{b,e}

^a Dipartimento di Scienze Cognitive, Psicologiche, Pedagogiche e degli studi culturali, Università di Messina, Messina, Italy

^b Dept. Psychology and Neurosciences, Leibniz Research Centre for Working Environment and Human Factors, Dortmund, Germany

^c International Graduate School of Neuroscience, Ruhr University Bochum, Bochum, Germany

^d School of Psychological Sciences, University of Melbourne, Australia

^e Dept. Neurology, University Medical Hospital Bergmannsheil, Bochum, Germany

^f School of Psychology, University of Tasmania, Hobart, TAS, Australia

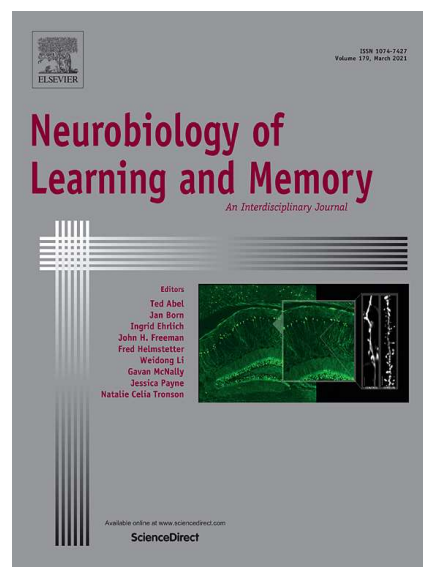
ARTICLE INFO

Keywords:

Non-invasive brain stimulation
rTMS
tDCS
Specific phobias
Social anxiety disorder
Panic disorder
Agoraphobia
Generalized anxiety disorder

ABSTRACT

The interest in the use of non-invasive brain stimulation for enhancing neural functions and reducing symptoms in anxiety disorders is growing. Based on the DSM-V classification for anxiety disorders, we examined all available research using repetitive transcranial magnetic stimulation (rTMS) and transcranial direct current stimulation (tDCS) for the treatment of specific phobias, social anxiety disorder, panic disorder, agoraphobia, and generalized anxiety disorder. A systematic literature search conducted in PubMed and Google Scholar databases provided 26 results: 12 sham-controlled studies and 15 non-sham-controlled studies. With regard to the latter sub-group of studies, 9 were case reports, and 6 open label studies. Overall, our work provides preliminary evidence that both, excitatory stimulation of the left prefrontal cortex and inhibitory stimulation of the right prefrontal cortex can reduce symptom severity in anxiety disorders. The current results are discussed in the light of a model for the treatment of anxiety disorders via non-invasive brain stimulation, which is based on up-/downregulation mechanisms and might serve as guide for future systematic investigations in the field.



Ney LJ, Vicario CM, Nitsche MA, Felmingham KL. [Timing matters: Transcranial direct current stimulation after extinction learning impairs subsequent fear extinction retention.](#) Neurobiol Learn Mem. 2021 Jan;177:107356.

Vicario CM, Nitsche MA, Hoysted I, Yavari F, Avenanti A, Salehinejad MA, Felmingham KL. [Anodal transcranial direct current stimulation over the ventromedial prefrontal cortex enhances fear extinction in healthy humans: A single blind sham-controlled study.](#) Brain Stimul. 2020 Mar-Apr;13(2):489-491.



frontiers
in Human Neuroscience

SYSTEMATIC REVIEW
published: 22 March 2021
doi: 10.3389/fnhum.2021.655947

A Systematic Review on the Effect of Transcranial Direct Current and Magnetic Stimulation on Fear Memory and Extinction

Vuk Marković^{1,2}, Carmelo M. Vicario^{3,4}, Fatemeh Yavari¹, Mohammad A. Salehinejad¹ and Michael A. Nitsche^{1,4*}

¹ Department of Psychology and Neurosciences, Leibniz Research Centre for Working Environment and Human Factors, Dortmund, Germany; ² International Graduate School of Neuroscience, Ruhr-University Bochum, Bochum, Germany; ³ Department of Cognitive Science, University of Messina, Messina, Italy; ⁴ Department of Neurology, University Medical Hospital Bergmannsheil, Bochum, Germany

OPEN ACCESS

Edited by:

Ken-ichiro Taniuchi,
Tokoh University, Japan

Reviewed by:

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Unilever, Brazil
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University Medical Center
Schleswig-Holstein, Germany

*Correspondence:

Carmelo M. Vicario
cvcario@unime.it

[†]These authors have contributed
equally to this work

Specialty section:

This article was submitted to
Brain Imaging and Stimulation,
a section of the journal
Frontiers in Human Neuroscience

Received: 19 January 2021

Accepted: 25 February 2021

Anxiety disorders are among the most prevalent mental disorders. Present treatments such as cognitive behavior therapy and pharmacological treatments show only moderate success, which emphasizes the importance for the development of new treatment protocols. Non-invasive brain stimulation methods such as repetitive transcranial magnetic stimulation (rTMS) and transcranial direct current stimulation (tDCS) have been probed as therapeutic option for anxiety disorders in recent years. Mechanistic information about their mode of action, and most efficient protocols is however limited. Here the fear extinction model can serve as a model of exposure therapies for studying therapeutic mechanisms, and development of appropriate intervention protocols. We systematically reviewed 30 research articles that investigated the impact of rTMS and tDCS on fear memory and extinction in animal models and humans, in clinical and healthy populations. The results of these studies suggest that tDCS and rTMS can be efficient methods to modulate fear memory and extinction. Furthermore, excitability-enhancing stimulation applied over the vmPFC showed the strongest potential to enhance fear extinction. We further discuss factors that determine the efficacy of rTMS and tDCS in the context of the fear extinction model and provide future directions to optimize parameters and protocols of stimulation for research and treatment.

Keywords: non-invasive brain stimulation, fear memory, dorsolateral prefrontal cortex, ventromedial prefrontal cortex, repetitive transcranial magnetic stimulation, fear extinction

Noninvasive brain stimulation to boost addiction recovery



Types of Behavior Addictions



BRAIN STIMULATION

Basic, Translational, and Clinical Research in Neuromodulation

Noninvasive brain stimulation to boost addiction recovery

Vicario CM, Salehinejad MA, Mosayebi-Samani M, Maezawa H, Avenanti A, Nitsche MA. [Transcranial direct current stimulation over the tongue motor cortex reduces appetite in healthy humans](#). Brain Stimul. 2020 Jul-Aug;13(4):1121-1123

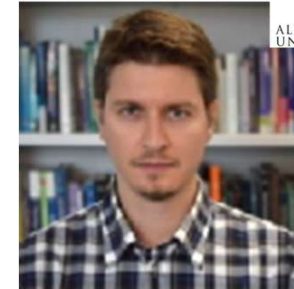
Alizadehgoradel J, Nejati V, Sadeghi Movahed F, Imani S, Taherifard M, Mosayebi-Samani M, **Vicario CM**, Nitsche MA, Salehinejad MA. [Repeated stimulation of the dorsolateral-prefrontal cortex improves executive dysfunctions and craving in drug addiction: A randomized, double-blind, parallel-group study](#). Brain Stimul. 2020 May-Jun;13(3):582-593.



Worldwide collaboration network



ALMA MATER STUDIORUM
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Università
degli Studi di
Messina



LEIBNIZ RESEARCH CENTRE
FOR WORKING ENVIRONMENT
AND HUMAN FACTORS



UNIVERSITY OF
CALGARY



**Psychophysiological correlates
of Ideological extremism**

Aging Brain

Diet and aging

Microplastics and aging

Topics for the
master thesis

The program

- 16 Marzo:** 09:00/16:00 – Microplastics and mental health
- 01 April:** 09:00-12:00 – Seminario su neural correlates of Dementia
- 02 April:** 09:00-12:00 – Intro to Cognitive Neuroscience and ATOM
- 07 April:** 09:00-12:00 – How to program a research protocol and analyze my data
- 08 April:** 09:00-12:00 - Continuation
- 09 April:** 10:00-13:00 – Autismo neural basis of (Prof. Pennisi)
- 10 April:** 09:00-12:00: Research Methods in Cognitive Neuroscience (NIBS)
- 11 April:** 09:00-12:00:– 3h EEG and applications in the Cognitive Neuroscience field (Dr Ferraioli).
- 13 April:** 09:00-12:00: Ted talks + articoli (asincrona)
- 14 April:** 09:00-12:00 : Ted Talks + articoli (asincrona)
- 5 Maggio:** 16:00-19:00: Prova in itinere + Neural and cognitive bases of Time perception
- 29 Maggio:** 09:00- 19:00: SINP 8 h
- 30 Maggio:** 09:00-13:00: SINP 4 h

What to study

Materials:

1) Pdf of lectures

2) TED talks:

[Sarah Dudas: Microplastics are everywhere -- but we can do something about them | TED Talk](#)

[Mia Nacamulli: How the food you eat affects your brain | TED Talk](#)

[Heribert Watzke: The brain in your gut | TED Talk](#)

[The fight against Alzheimer's and dementia | TED Talks](#)

3) Scientific articles:

[Association between microplastics exposure and depressive symptoms in college students – ScienceDirect](#)

[A theory of magnitude: common cortical metrics of time, space and quantity – ScienceDirect](#)

[\(PDF\) Number As a Primary Perceptual Attribute: A Review](#)

Useful websites

www.sciencedirect.com

PubMed

<http://www.ncbi.nlm.nih.gov/sites/entrez>

Google Scholar

<https://www.researchgate.net>

End of the
millennium:
tangible
changes

The term **Cognitive Neuroscience** first appeared in the 1970s and has grown rapidly, thanks to technological advances that have made brain measurements cheaper and more powerful than ever, and to the recognition that neural and physiological information are critical to understanding how we perceive and interact with the world around us.

WHAT IS COGNITIVE NEUROSCIENCE?

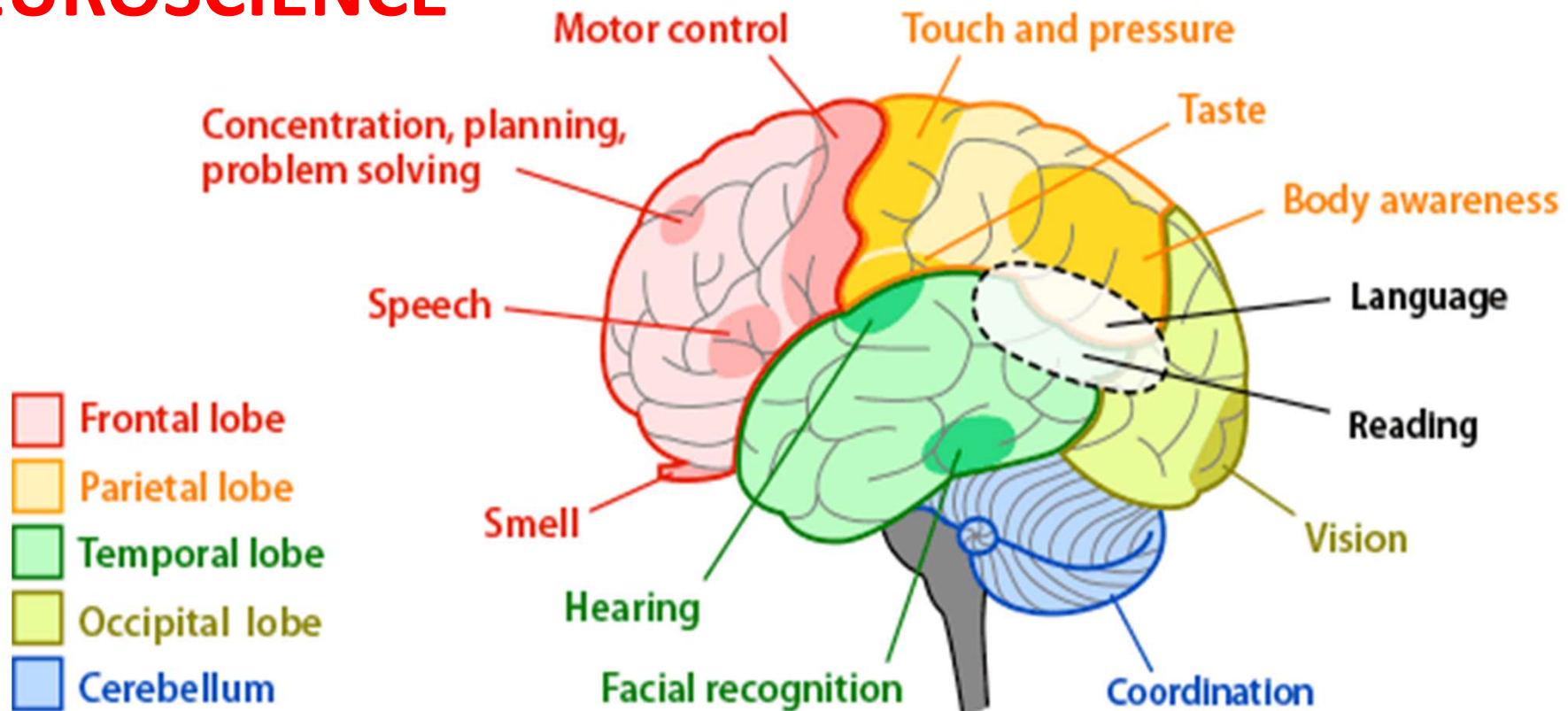
- An interdisciplinary field that combines methodologies and approaches from neuroscience and cognitive psychology to better understand the biological correlates that underlie cognitive processes



WHAT IS COGNITION?

All mental abilities and processes related to attention, memory, language, problem solving, social cognition ect

COGNITIVE NEUROSCIENCE



Classical topics



ATTENTION



MEMORY AND
LEARNING



LANGUAGE



EXECUTIVE
FUNCTIONS



EMOTIONS



DECISION
MAKING



SOCIAL
COGNITION

*Scienze cliniche
neurologiche*

Neurofisiologia

Neurochimica

Neuroanatomia

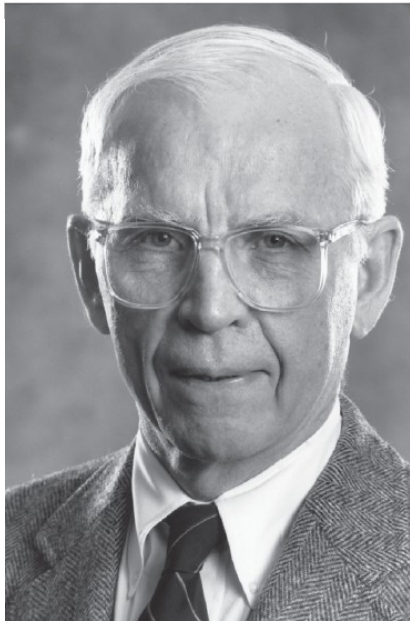
Neuropsicologia

*Scienze cliniche
psichiatriche*

Psicofisica

COGNITIVE NEUROSCIENCE

Neurofarmacologia



*Neuroscienze
computazionali*

neurogenetica

Psicologia sperimentale

Scienze cognitive

Neurobiologia

Neuroscience Sociali

**Vernon Mountcastle
(1918-2015)**

Neuroscienze cognitive



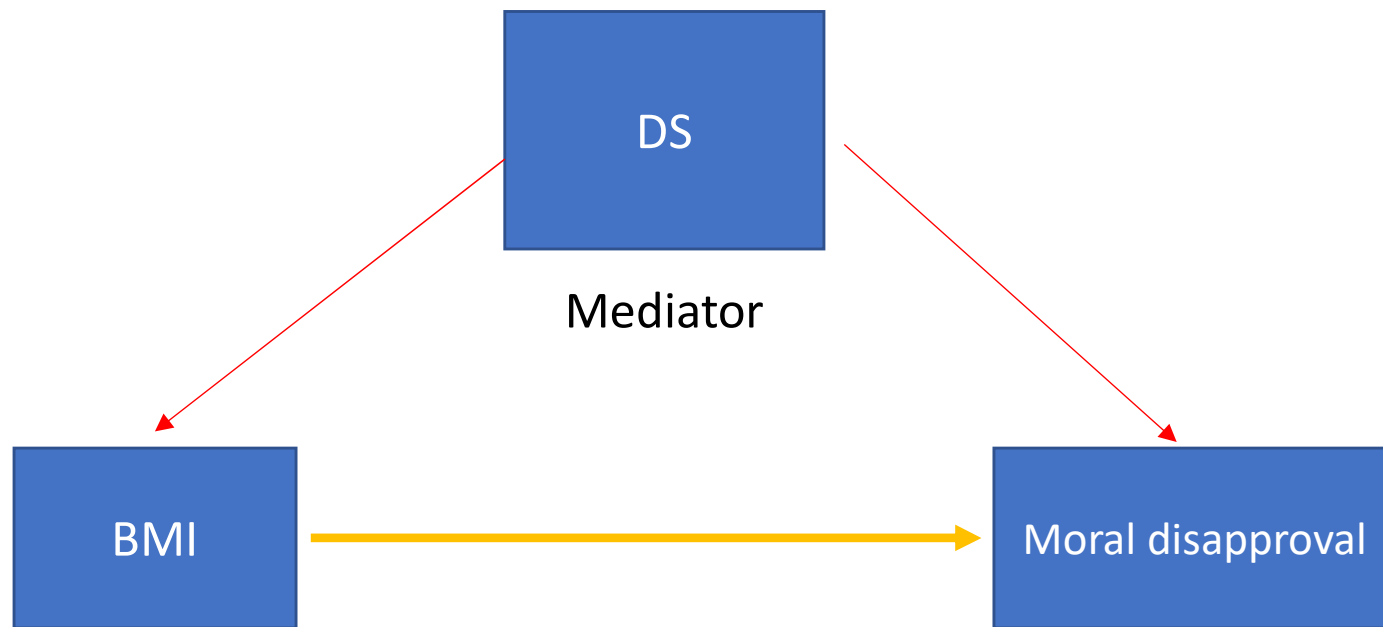
The hub of cognitive neuroscience: The scientific Research

The main mission of cognitive neuroscience is to explain how perception and behavior rise from the neural activity.

Metodo della correlazione

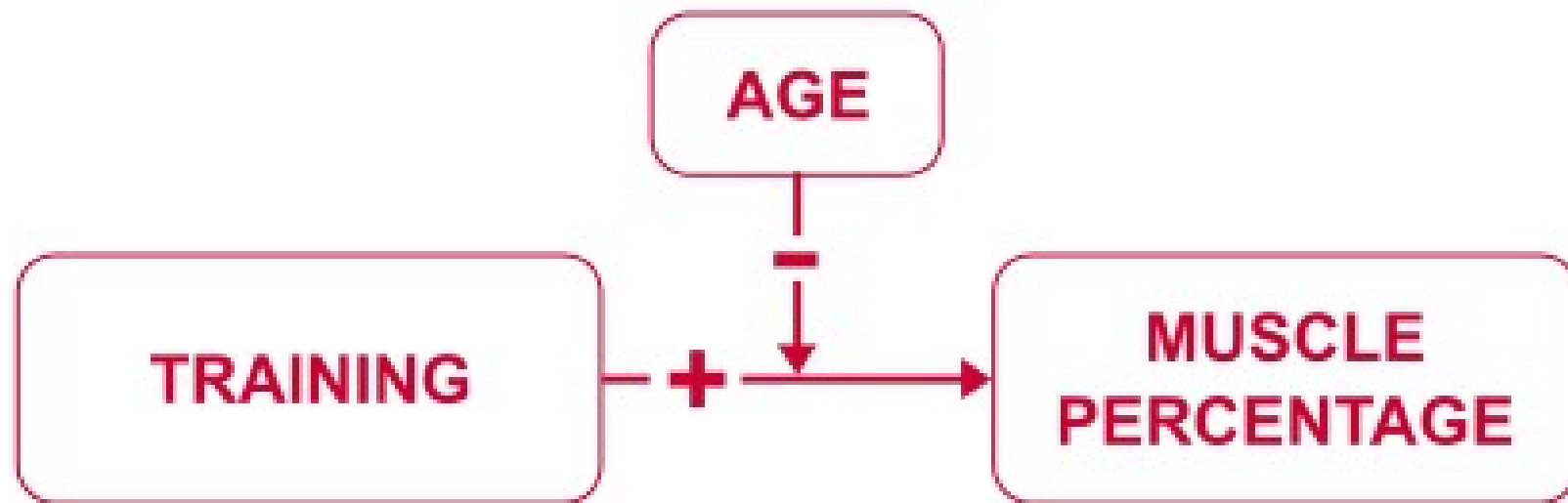
- Permette di verificare se esiste una relazione tra due o più variabili
- Non permette di stabilire relazioni causa-effetto per due motivi:
 - **Direzionalità** ➡ la correlazione dice che due variabili covariano, ma non se una è la causa dell'altra o viceversa
 - **Terza variabile** ➡ la correlazione potrebbe essere dovuta ad una terza variabile non considerata

The relationship between two variables can be **mediated**



The relationship between two variables
can be **moderated**

MODERATION EFFECT IN REGRESSION

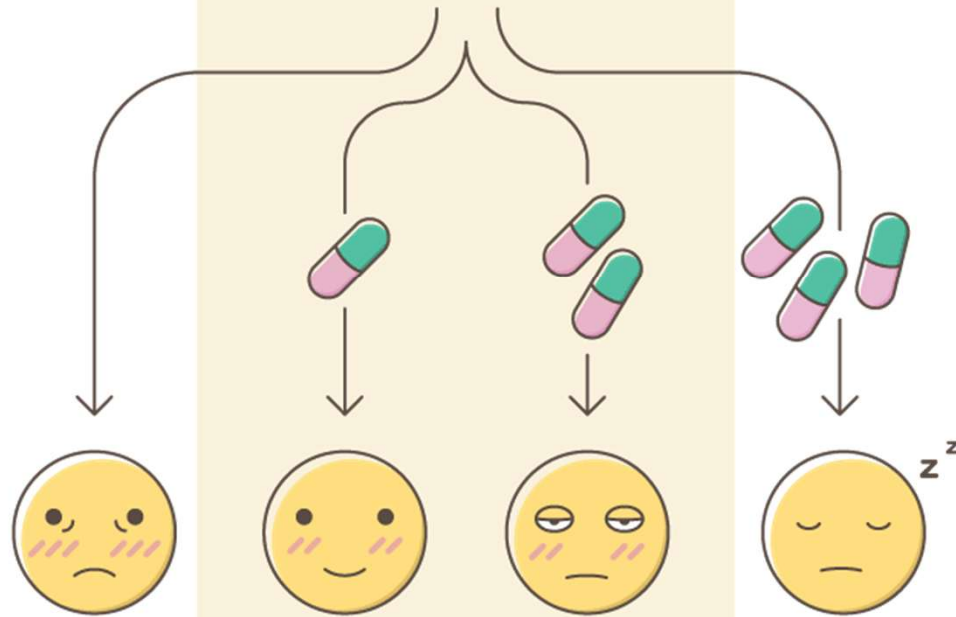


**Does the *effect* of training on muscle
percentage decline with age?**

Metodo sperimentale

- Permette di stabilire relazioni di causa-effetto tra variabili
- Comporta la manipolazione di variabili indipendenti e la misura degli effetti sulla variabile dipendente

**VARIABLE IS MANIPULATED
(INDEPENDENT VARIABLE)**



Effect: Histamine level
Level of drowsiness

**VARIABLE IS MEASURED
(DEPENDENT VARIABLE)**

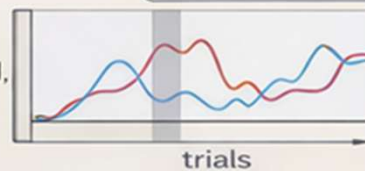
Statistical Methods in Cognitive Neuroscience

General Linear Models (GLMs)

- ANOVA (Activations)
- Regression
- t-tests



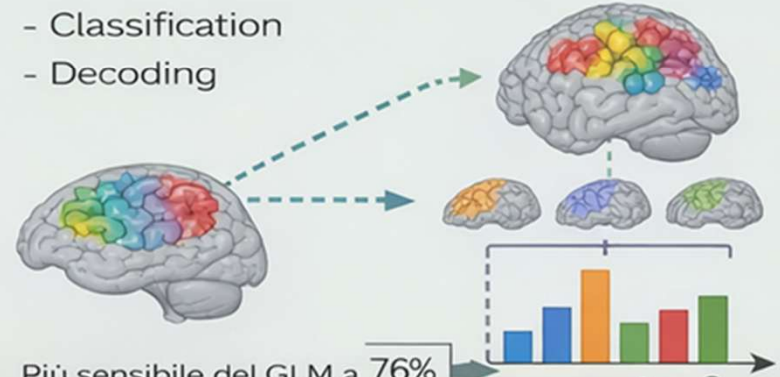
Testano effetti medi (attivazioni) voxel-wise o ROI-based, modellando il segnale in funzione del disegno sperimentale.



Approccio univariato robusto, ma poco sensibile a pattern distribuiti complessi.

Multivariate Pattern Analysis (MVPA)

- Classification
- Decoding



Più sensibile del GLM a 76% pattern sottili, ma richiede validazione rigorosa (cross-validation, overfitting).

Functional Connectivity

- Correlation
- Covariance
- Granger causality
- Dynamic Causal Modeling



Misura correlazioni temporali tra regioni, identificando reti funzionali (resting-state o task-based).

Effective Connectivity (DCM, Granger)

- Network Metrics $\beta \gamma$
- Covariance Σ
- Granger causality $A \rightarrow B$
- Influence Path Diagrams $A \diamond B$

$$B \Rightarrow A \leftrightarrow B$$

Granger causality

Influence Path Diagrams

$$A \leftrightarrow C$$

Stima direzionalità e influenza causale tra regioni cerebrali, modellando interazioni dinamiche. Più informativo ma anche più revisione costante.

HOW SCN IS STUDIED?

- **PSYCHOPHYSIOLOGY;**
- **ELECTROENCEPHALOGRAPHY (EEG)**
- **NEUROIMAGING;**
- **NON-INVASIVE BRAIN STIMULATION**
- **PATIENTS**
- **PHARMACOLOGICAL MANIPULATIONS**
- **ANIMAL MODELS**

PSYCHOPHYSIOLOGY

1) It measures the physiological consequences of cognition and emotion;

2) Only **indirect** measures;

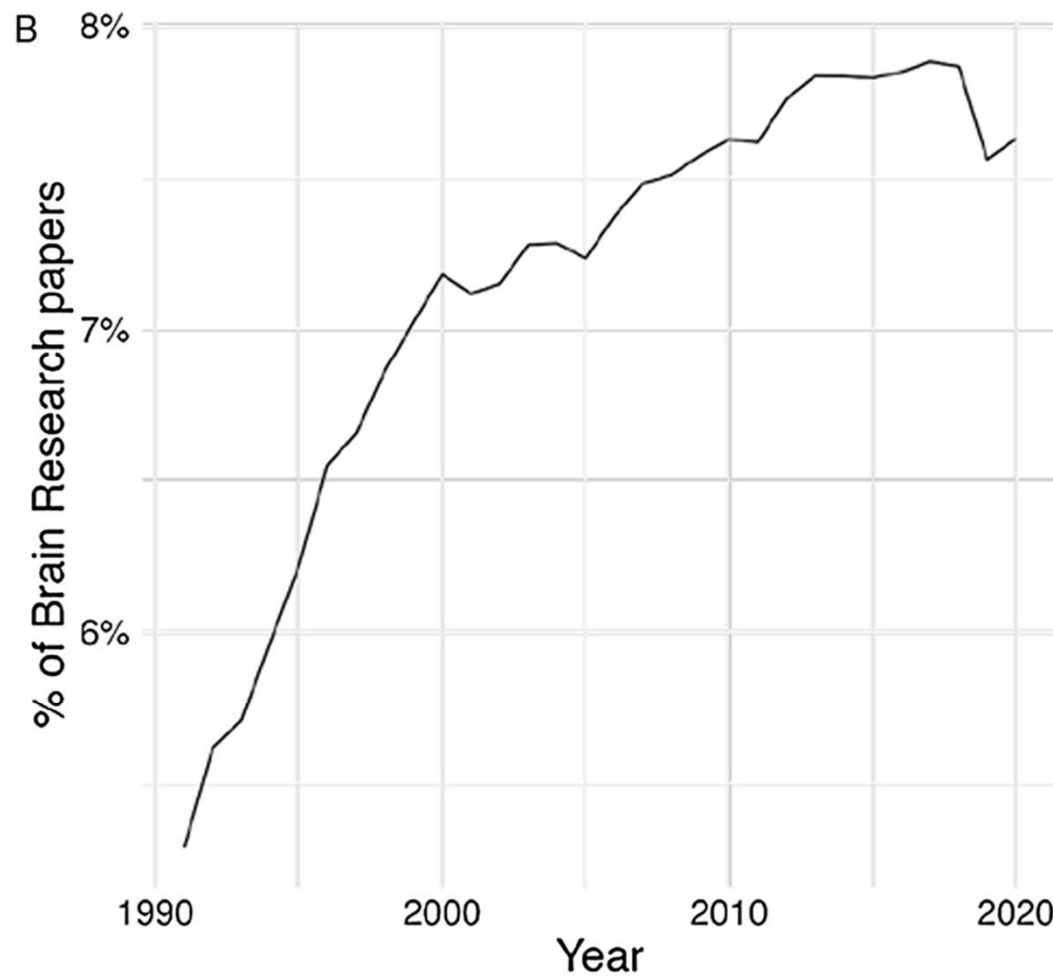
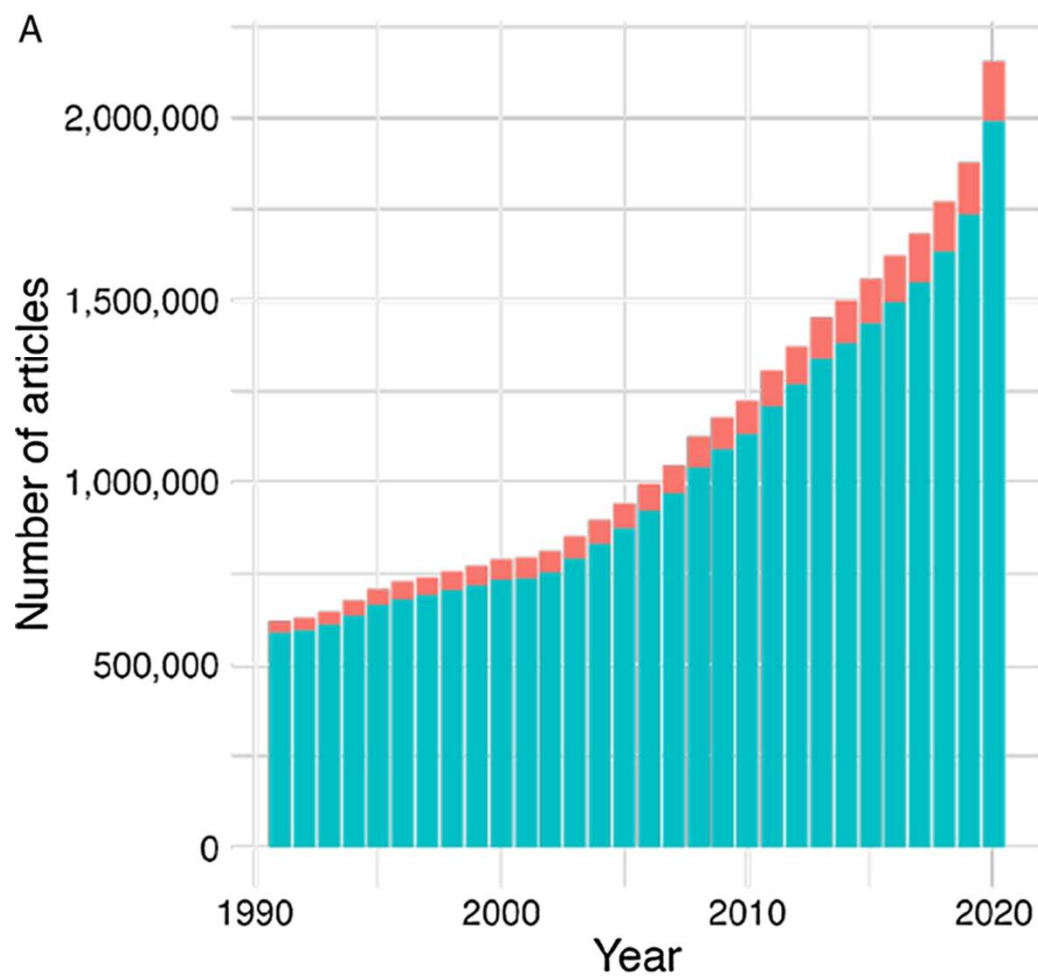
It includes:

elettrocardiogramma (ECG),

elettromiogramma (EMG)

attività elettrodermica (EDA).

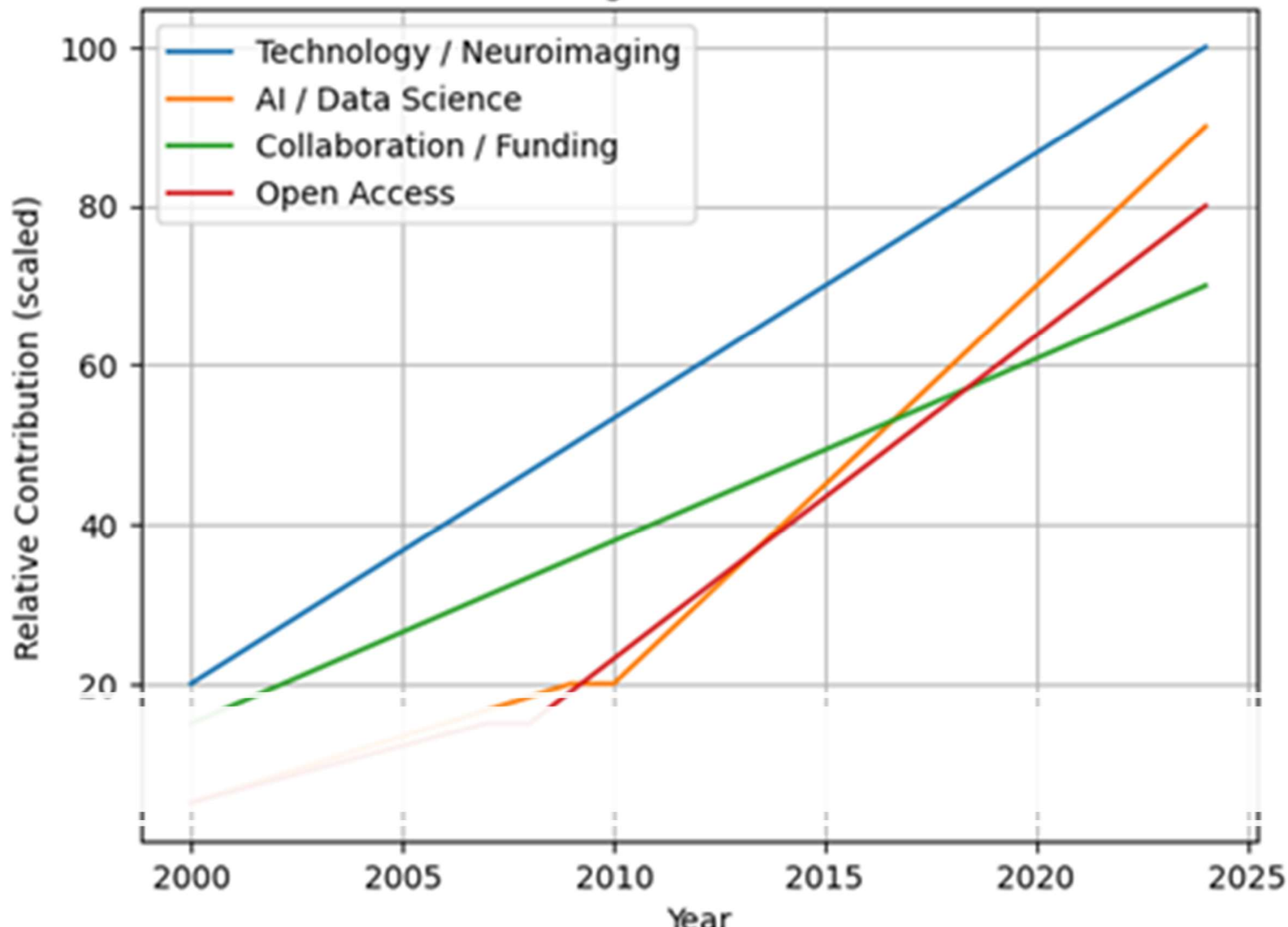
Cognitive Neuroscience in the scientific community



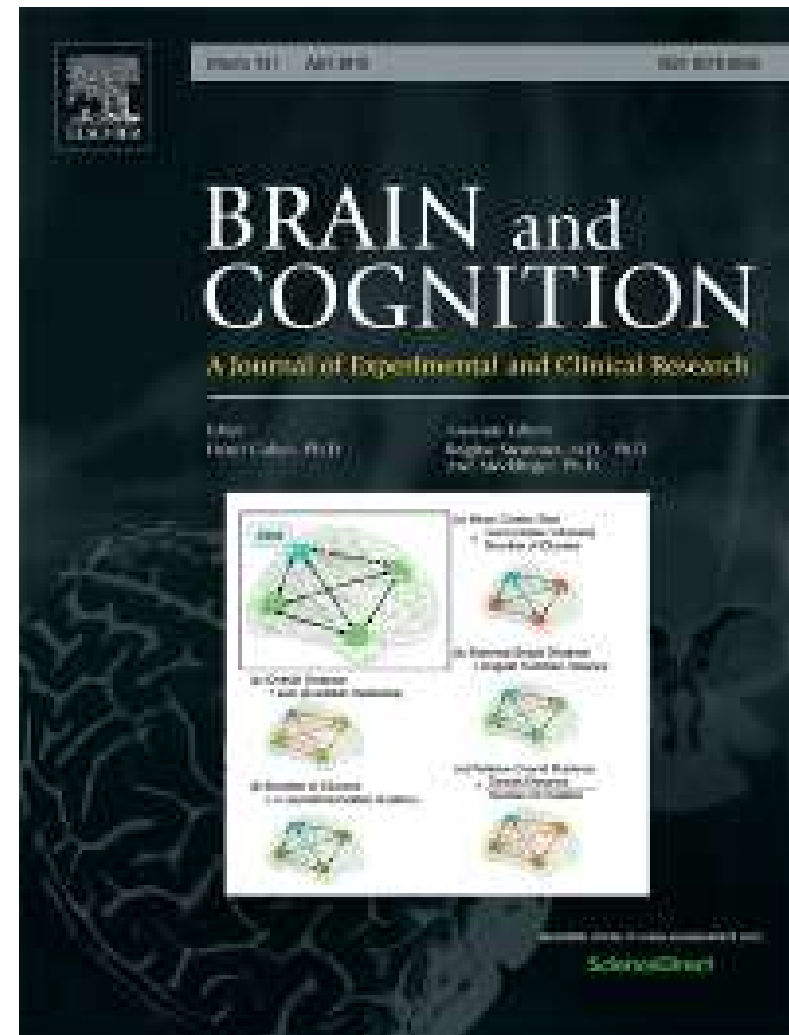
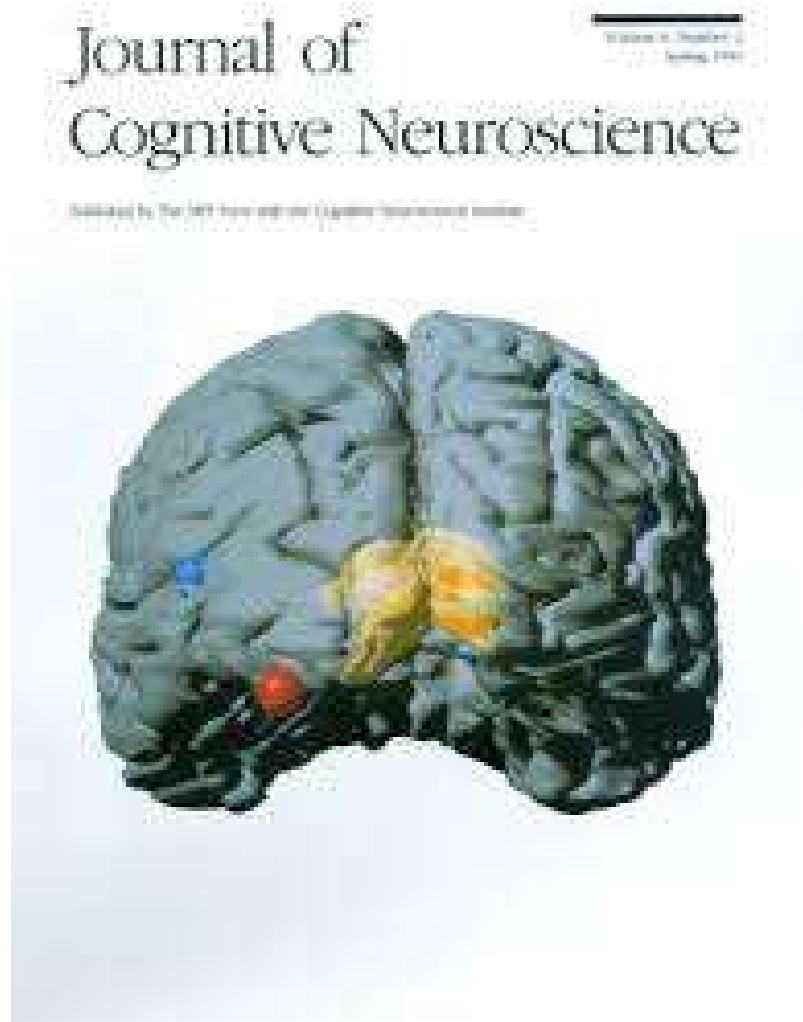
Brain research Other research

sciences/article/worldwide-trends-in-brain-research-a-bibliometric-analysis/749E041FC41D7C3504F7C4F753A5F8E4

Drivers of Growth in Cognitive Neuroscience Publications



Dedicated journals



MARCH 7 – 10, 2026

[CNS Account](#)

CNS
2026
VANCOUVER

CNS 2026 ANNUAL MEETING - MARCH 7 - 10, 2026

We invite you to join us at the Cognitive Neuroscience Society (CNS) 2026 Annual Meeting, March 7 - 10, 2026 in Vancouver, BC, Canada at the **JW Marriott Parq Vancouver Hotel**, located located at **39 Smithe St, Vancouver, BC V6B 0R3, Canada**. We will have a full schedule of events slated for this year's meeting that will include Invited Symposia, Symposia, Several Poster Sessions, a Keynote Address as well as our Annual George A. Miller Award Lecture, Distinguished Career Contributions Award Lecture and Young Investigators Award Lecture. #CNS2026

General Information	+
Program	+
Attendee Resources	+
Hotel	+

Dedicated Annual Meetings and Society

Cognitive Neuroscience: Topics and Approaches

- SOCIAL COGNITIVE NEUROSCIENCE

