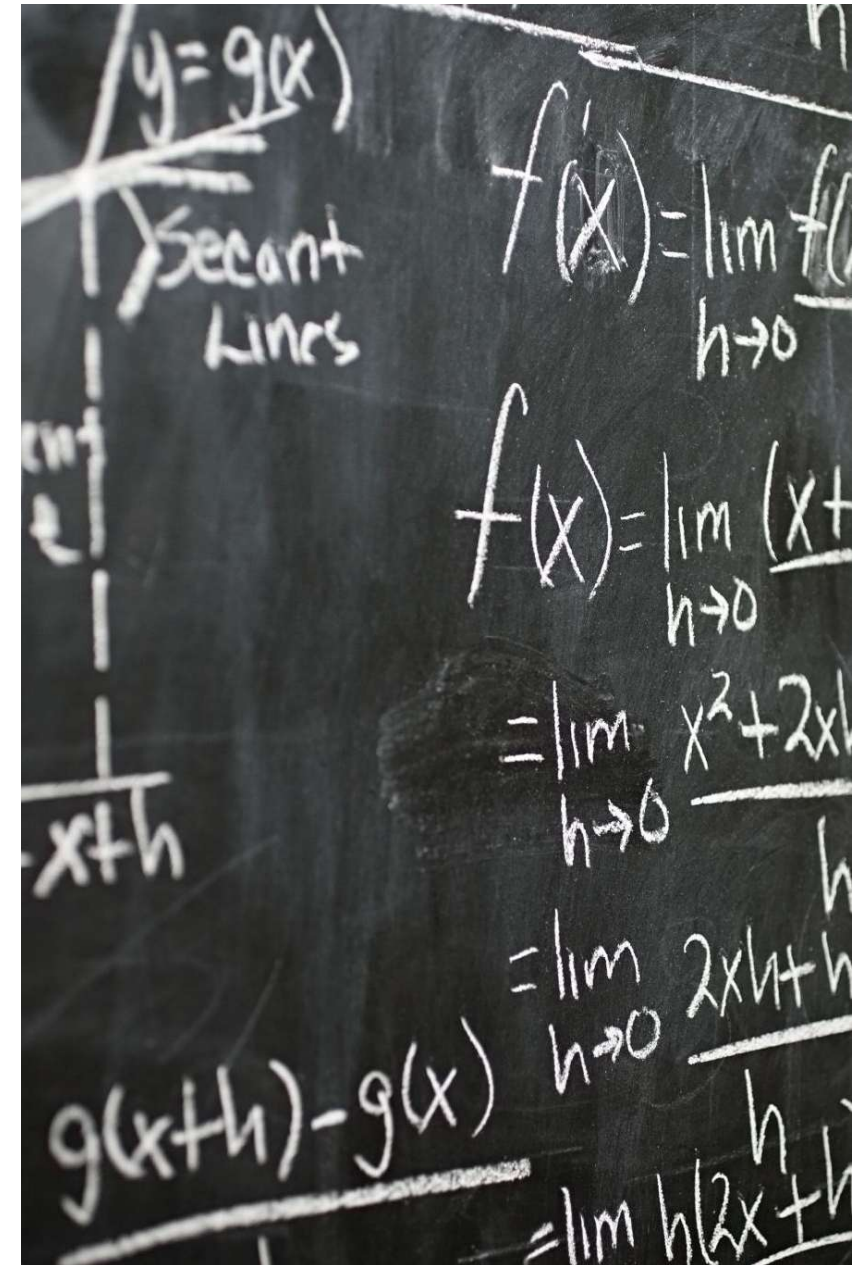


Basi neurali e processi cognitivi nella rappresentazione delle
grandezze nel sistema cognitivo

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

Sommario degli argomenti trattati

- Teoria della rappresentazione delle grandezze: metriche corticali comuni nella rappresentazione di tempo, spazio e numeri?
- Prove dell'esistenza di relazioni tra spazio e numeri nel sistema cognitivo umano.
- Prove dell'esistenza di relazioni tra tempo e spazio nel sistema cognitivo umano.
- Prove dell'esistenza di relazioni tra tempo e numeri nel sistema cognitivo umano.



The image shows a chalkboard with handwritten mathematical derivations. At the top left, the equation $y = g(x)$ is written. Below it, the words "Secant Lines" are written. To the right, the derivative is defined as $f'(x) = \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h}$. Below this, the function $f(x) = \lim_{h \rightarrow 0} (x^2 + 2xh)$ is written. This is followed by the simplification $= \lim_{h \rightarrow 0} (x^2 + 2xh)$. Then, the difference $g(x+h) - g(x)$ is written, and the final simplification $= \lim_{h \rightarrow 0} h(2x + h)$ is shown.

$$y = g(x)$$

Secant Lines

$$f'(x) = \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h}$$
$$f(x) = \lim_{h \rightarrow 0} (x^2 + 2xh)$$
$$= \lim_{h \rightarrow 0} (x^2 + 2xh)$$
$$g(x+h) - g(x)$$
$$= \lim_{h \rightarrow 0} h(2x + h)$$

Le origini...



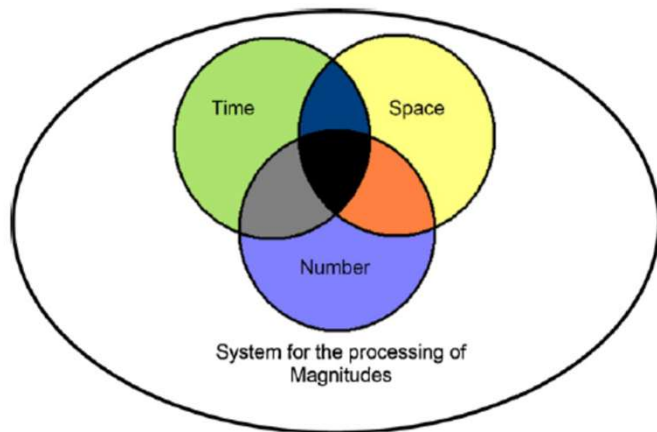
Opinion

TRENDS in Cognitive Sciences Vol.7 No.11 November 2003

483

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

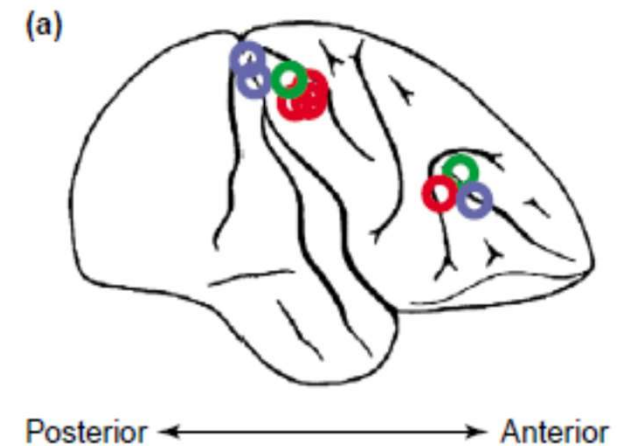
Vincent Walsh

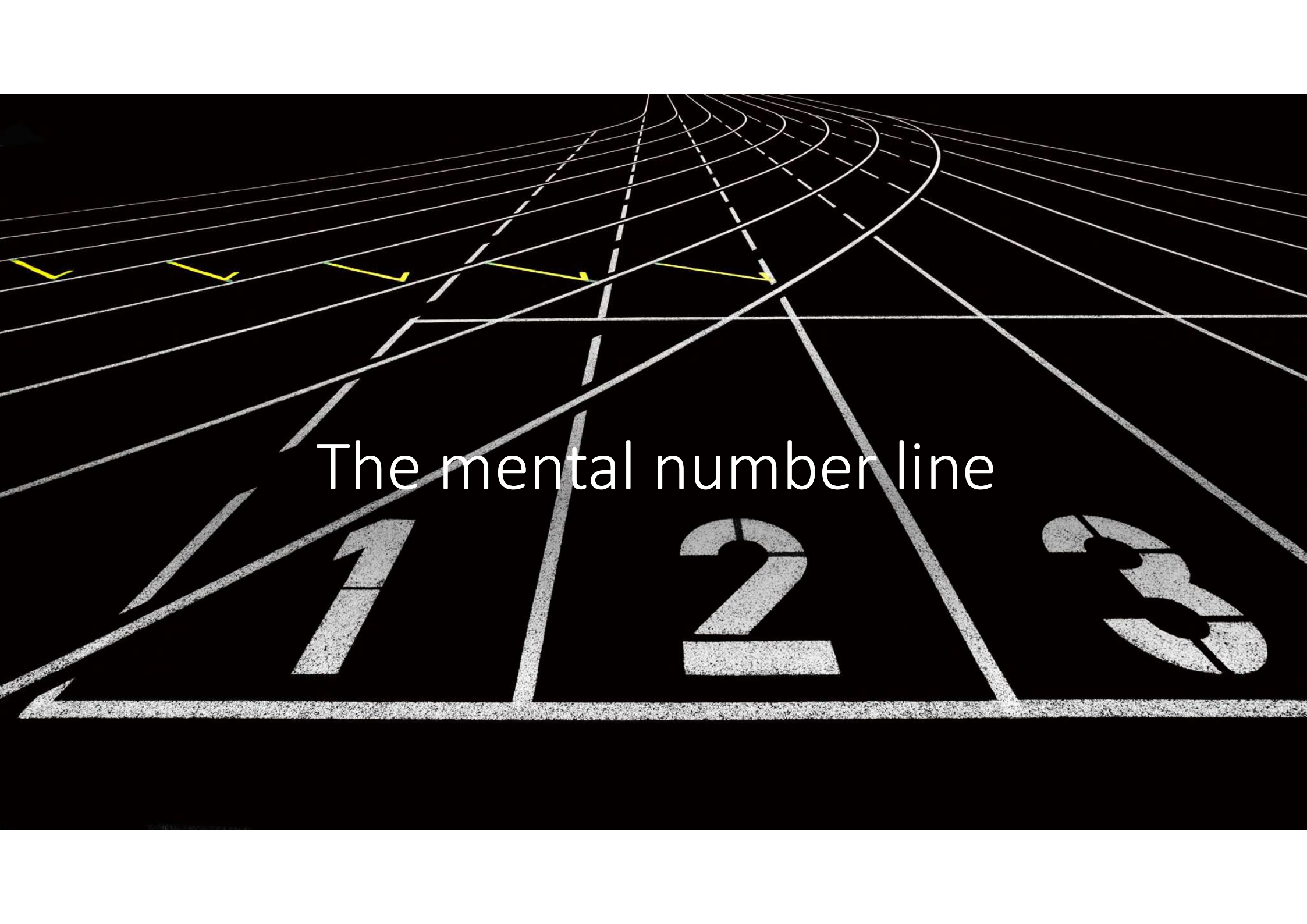


Prof
Vincent Walsh



ATOM predicts perceptual biases while
combining these 3 domains





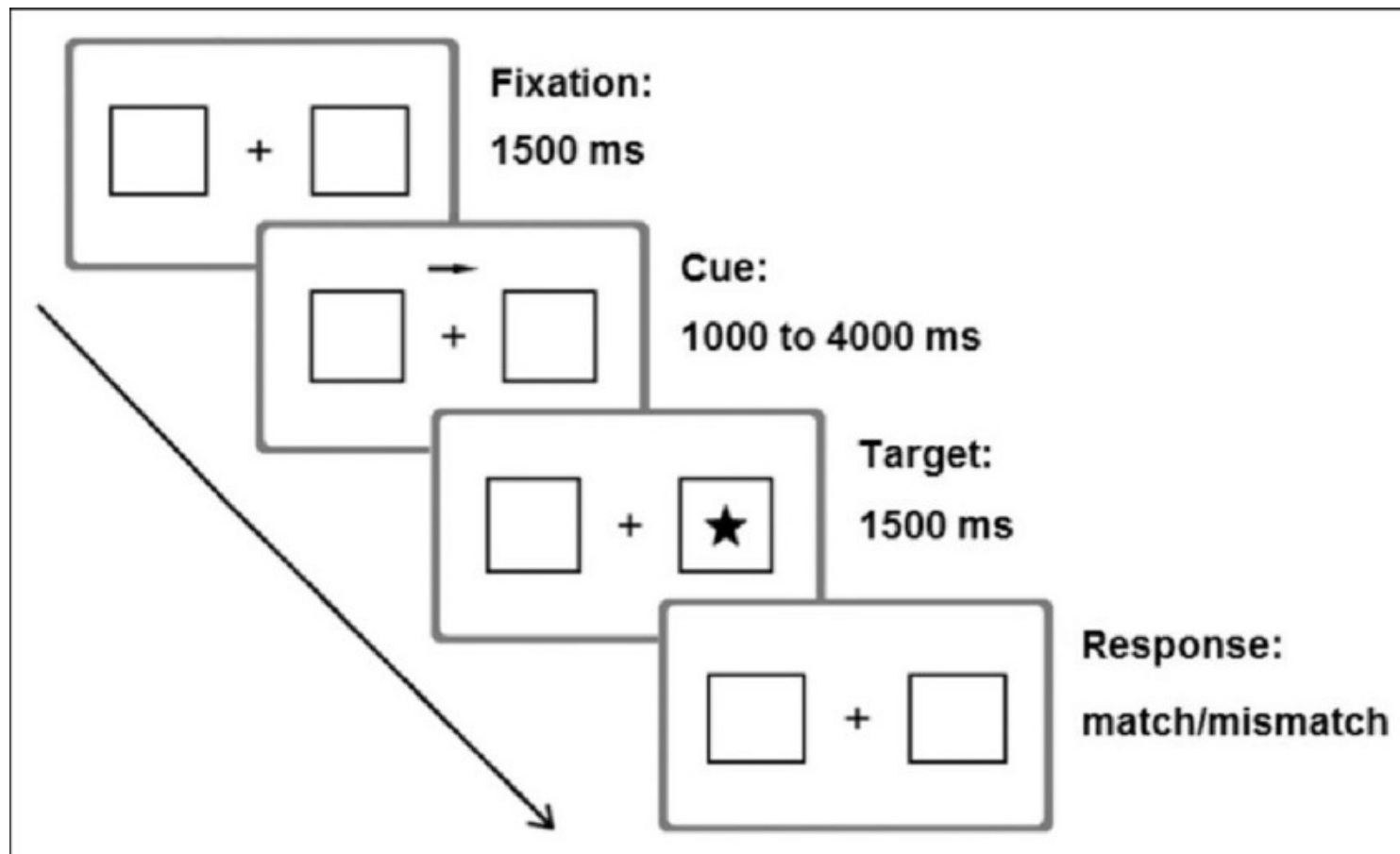
The mental number line

Evidenze a supporto dell'esistenza di una codifica spaziale del numero: studi comportamentali

c Line bisection effect

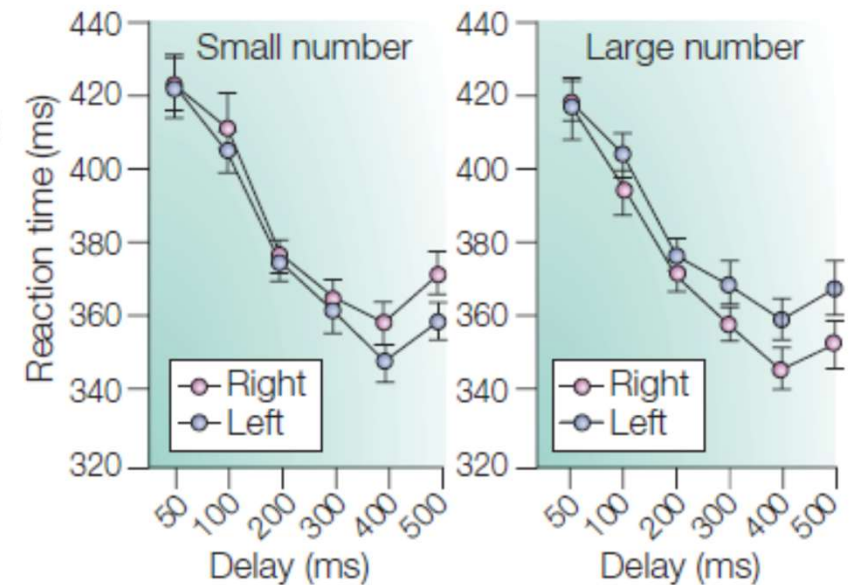
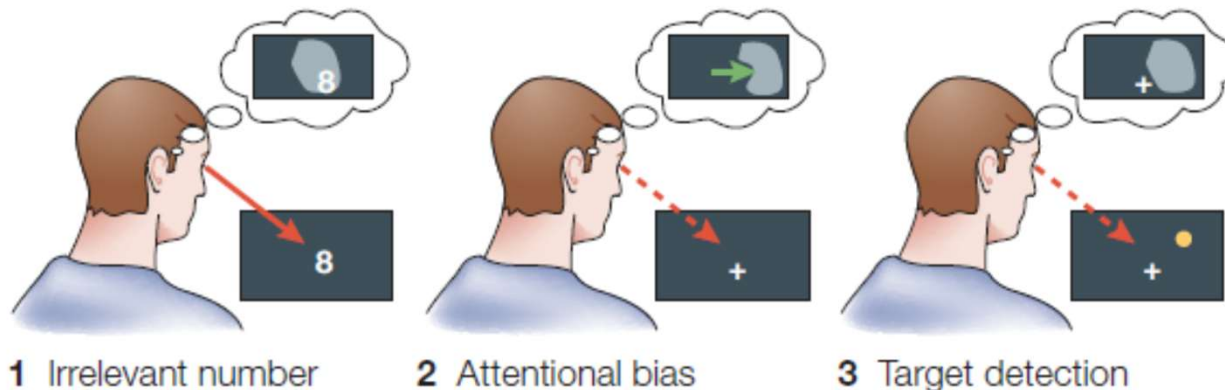


Attenzione spaziale nel paradigma di posner



Evidenze a supporto dell'esistenza di una codifica spaziale del numero: studi comportamentali

b Attention bias effect



Space, number and decision making

The Scientific World Journal
Volume 2012, Article ID 347068, 6 pages
doi:10.1100/2012/347068

TheScientificWorldJOURNAL

Clinical Study

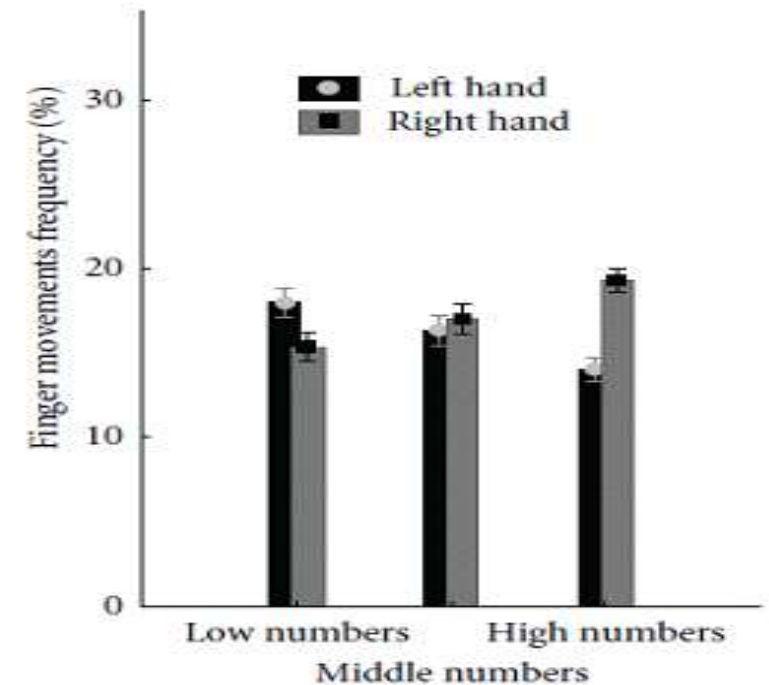
Perceiving Numbers Affects the Internal Random Movements Generator

Carmelo Mario Vicario

Correspondences

Head turns bias the brain's internal random generator

Tobias Loetscher, Urs Schwarz,



CORRESPONDENCE · Volume 20, Issue 6, PR264-R265, March 23, 2010 · [Open Archive](#)

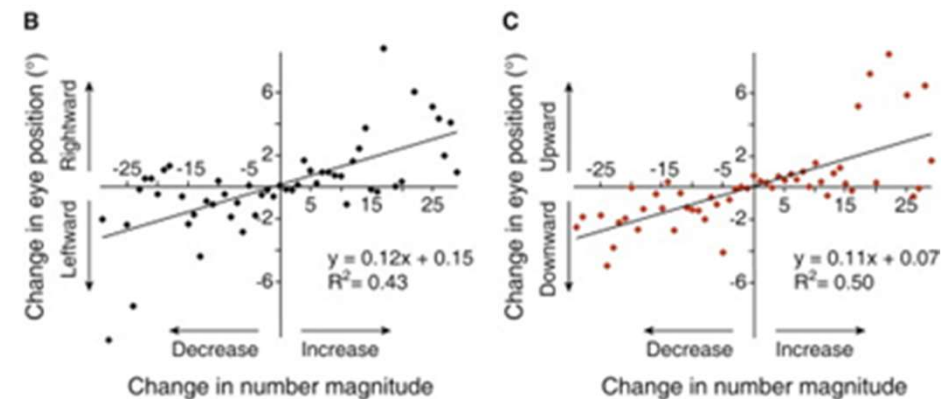
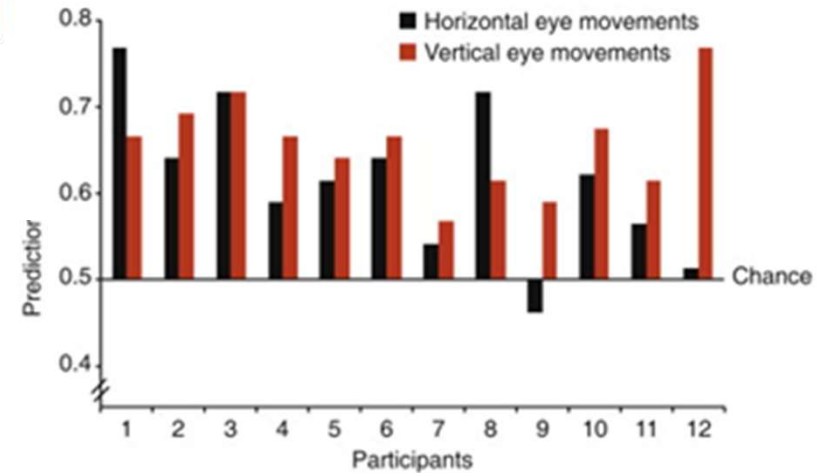
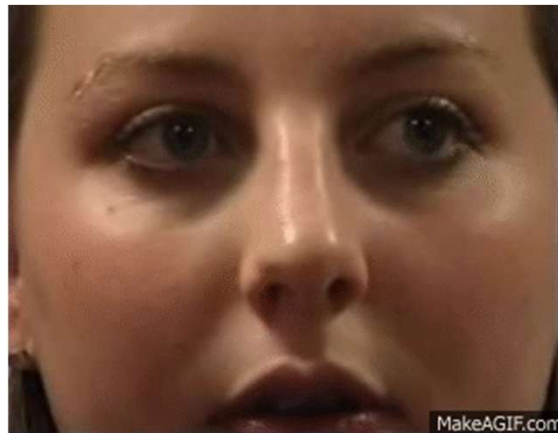
[Download Full Issue](#)

Eye position predicts what number you have in mind

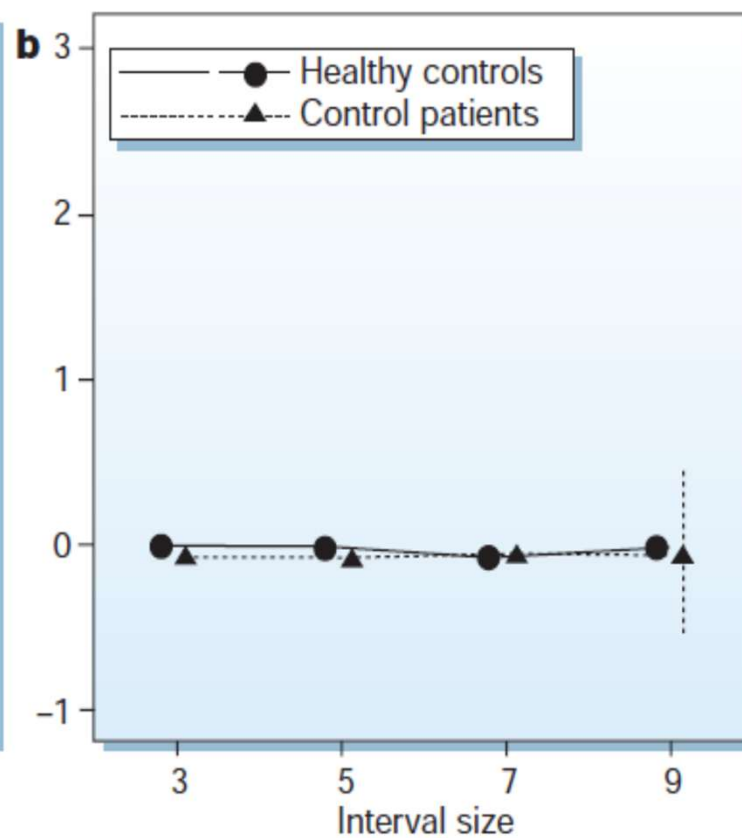
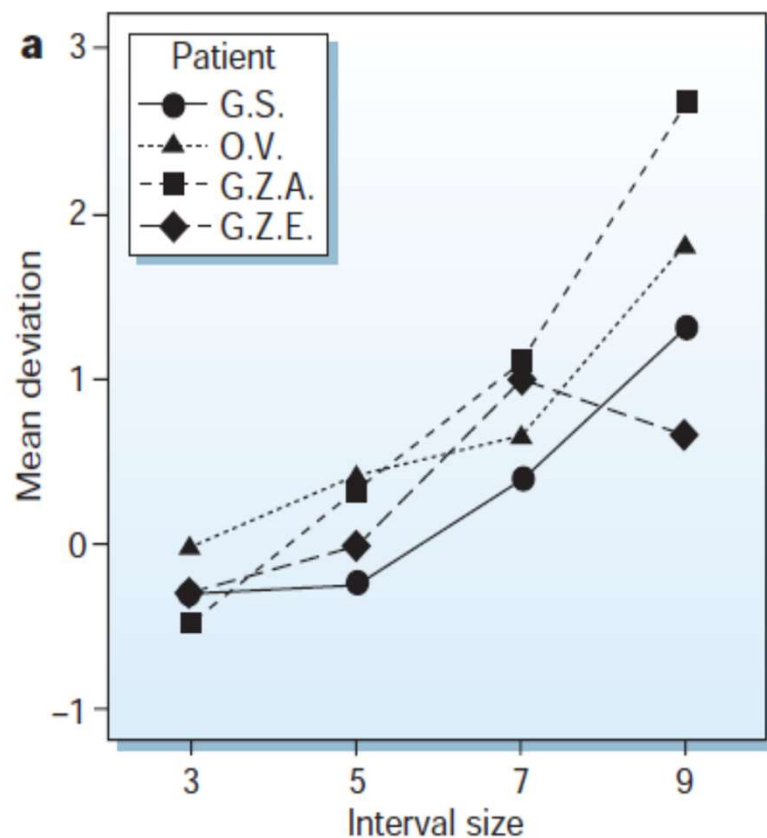
[Tobias Loetscher](#)^{1,2} · [Christopher J. Bockisch](#)^{2,3} · [Michael E.R. Nicholls](#)¹ · [Peter Brugger](#)² [✉](#)

[Affiliations & Notes](#) [Article Info](#)

eyes and their position
give an insight into the
nature of the systematic
choices made by the
brain's 'random number
generator'



Evidenze a supporto dell'esistenza di una codifica spaziale del numero: il caso dei pz con neglect per lo spazio sx

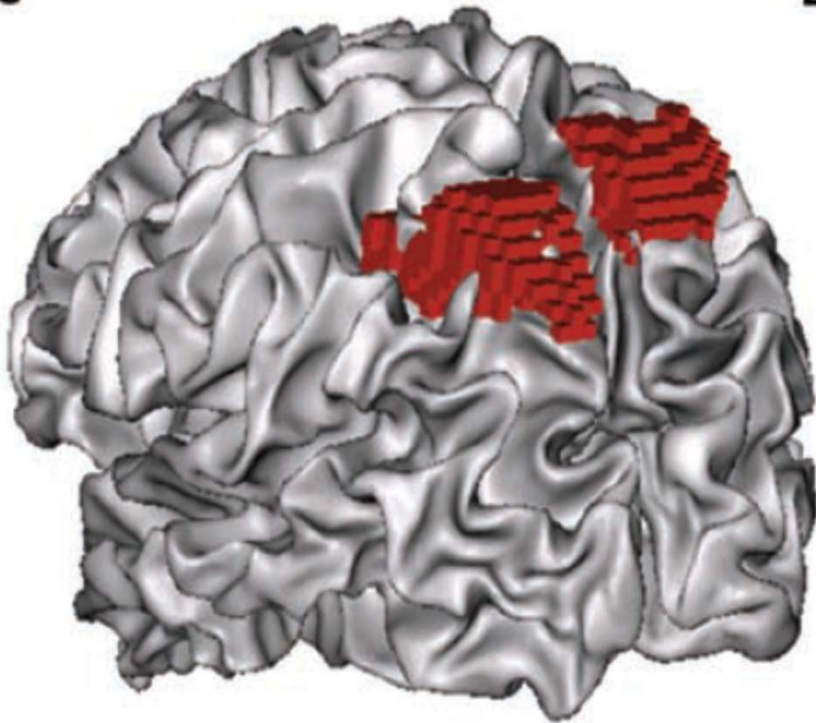


Performance di pazienti affetti da eminegligenza spaziale sx e controlli in un compito di identificazione del numero centrale rispetto a un intervallo numerico di riferimento.

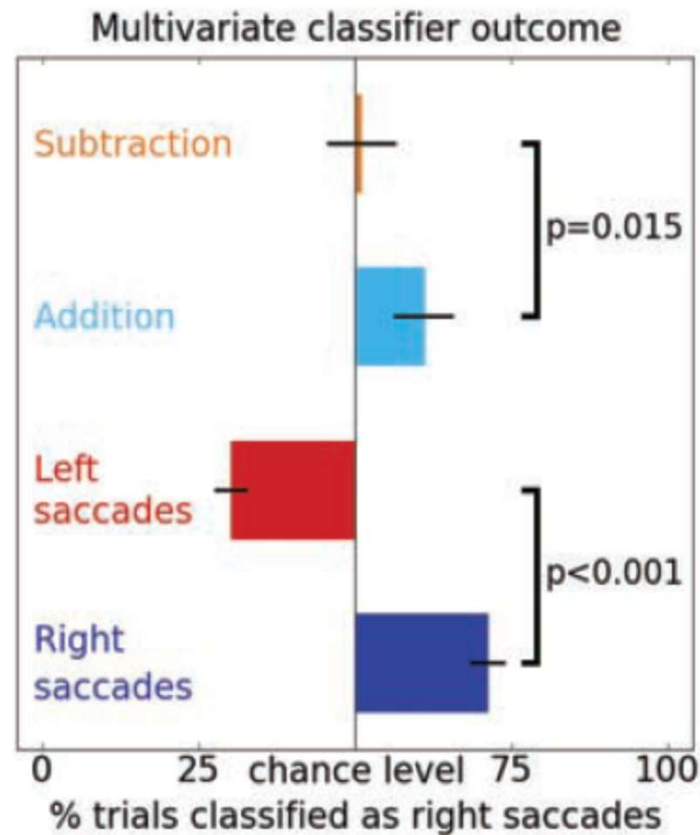
Positive values indicate **rightward shifts of the midpoint along the number line**; negative values represent leftward shifts

Evidenze a supporto dell'esistenza di una codifica spaziale del numero: studi di neuroimmagine

C



D



La **corteccia parietale superiore** e' probabilmente la base neurale comune per la rappresentazione dello spazio e dei numeri.

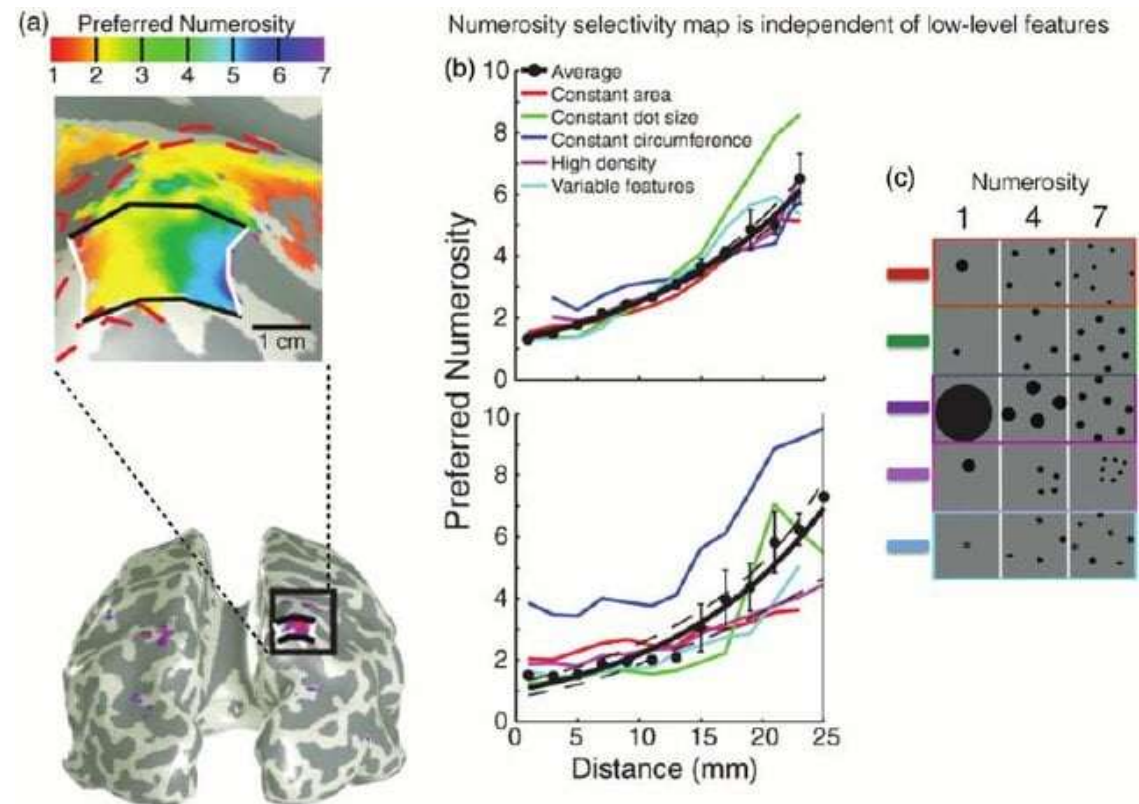
Number As a Primary Perceptual Attribute: A Review

[Giovanni Anobile](#), [Guido Marco Cicchini](#), and [David C. Burr](#)  [View all authors and affiliations](#)

[Volume 45, Issue 1-2](#) | <https://doi.org/10.1177/0301006615602599>

Nell'IPS esiste una **mappa topografica della numerosità**

Figure 4. Topographic representation of numerosity in human parietal cortex. (a) Spatially organized numerosity map for small numbers of elements (from 1 to 7) in **the parietal cortex**. Color code reflects brain regions preferentially activated by given numerosities. (b) Progression of numerosity selectivity (dots) as a function of distances from white lines in Figure 4(a). Different line colors refer to separate conditions where low-level features of stimuli were controlled for Figure 4(c). Adapted with permission from Harvey et al. (2013).

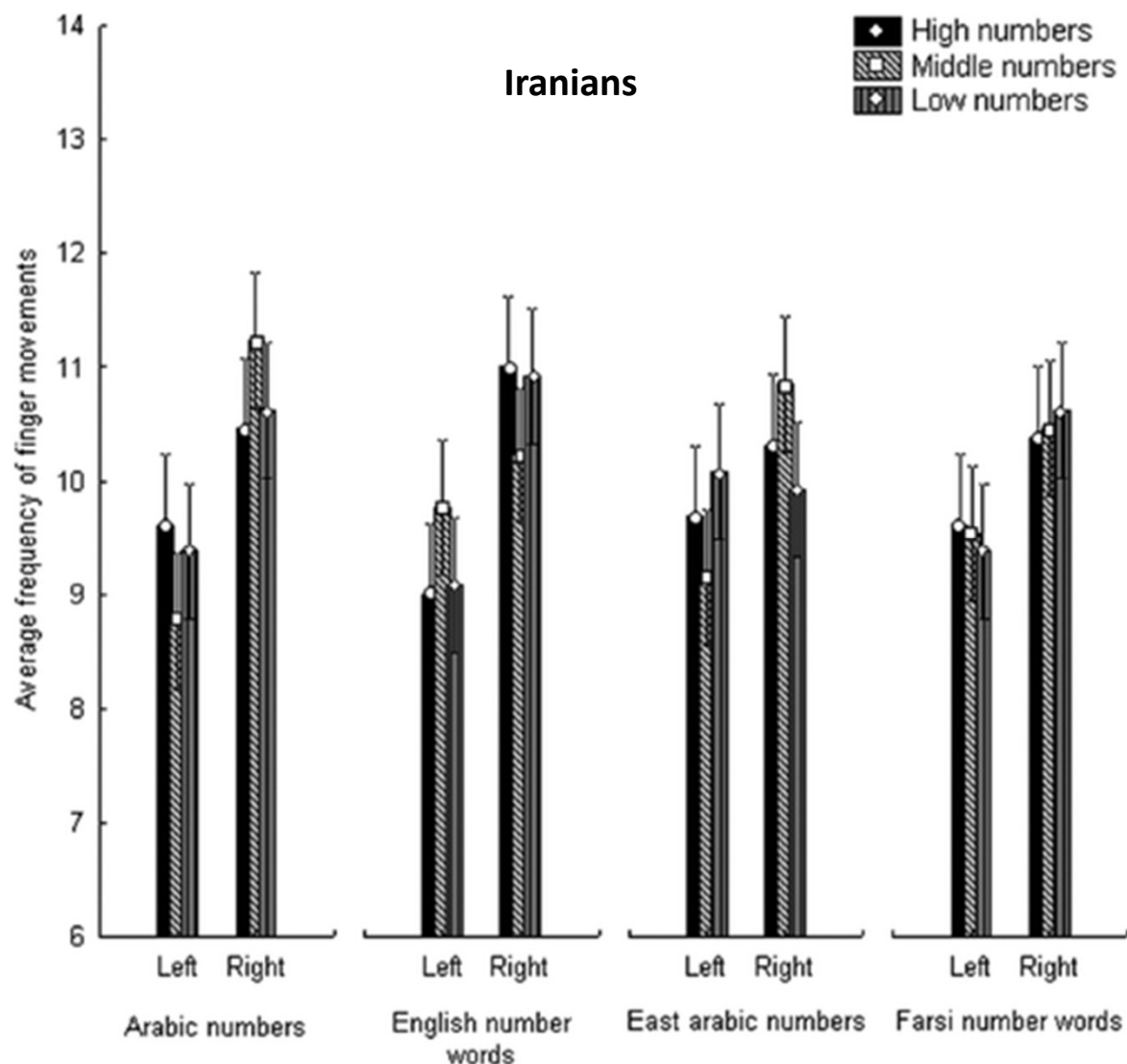


Ruolo dello stile di scrittura/lettura nella codifica spaziale della quantità

L'interazione spazio-quantità potrebbe essere stata progressivamente plasmata da convenzioni culturali, come l'orientamento della scrittura.

NUMERICAL CODES

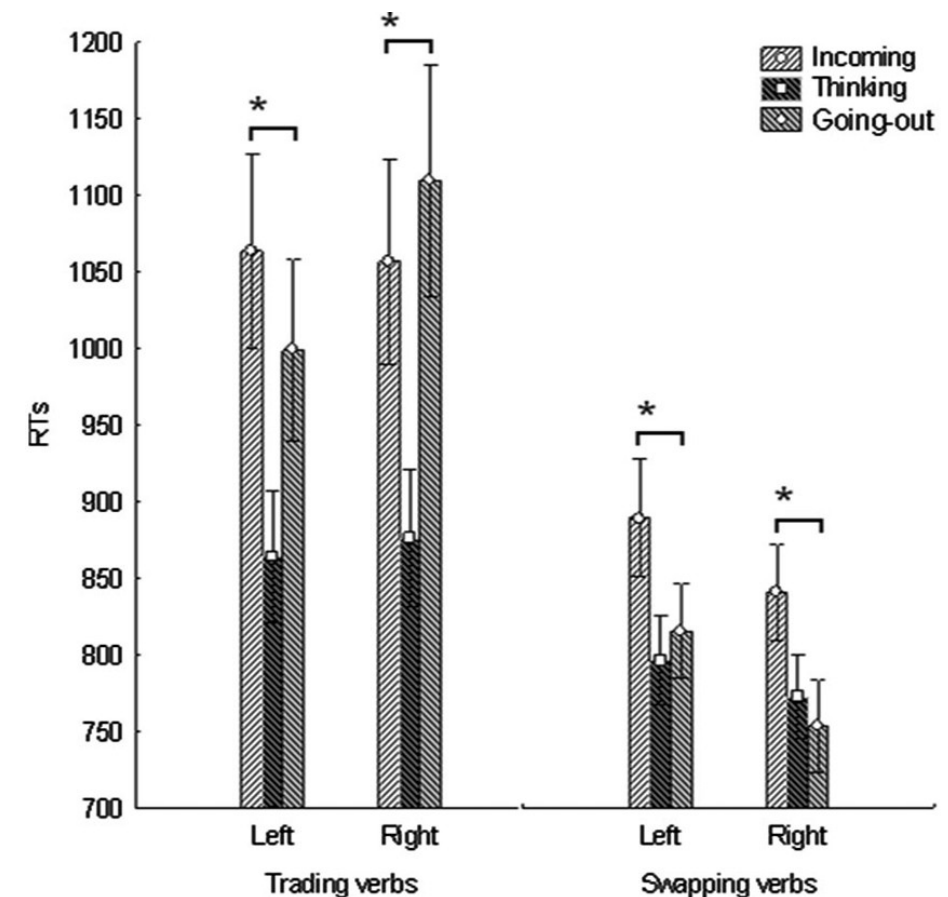
Arabic	East Arabic	English numerical words	Farsi numerical words
1	١	One	یک
2	٢	Two	دو
4	٤	Four	چهار
6	٦	Six	شش
8	٨	Eight	هشت
9	٩	nine	نه



left-right compatibility with trading verbs

Trading	Gain verbs	Incassare (To cash)	Riscuotere (To cash)	Ricavare (To derive)	Guadagnare (To gain)	Intascare (To rake in)	Arricchire (To enrich)
	Loss verbs	Pagare (To pay)	Risarcire (To compensate)	Indennizzare (To indemnify)	Perdere (To lose)	Saldare (To pay)	Impoverire (To impoverish)
Swapping	Receiving verbs	Ricevere (to receive)	Ereditare (to inherit)	Accettare (to accept)	Accogliere (to welcome)	Rilevare (to take)	Acquisire (to acquire)
	Giving verbs	Regalare (to give)	Donare (to donate)	Offrire (to offer)	Devolvere (to devolute)	Consegnare (to deliver)	Porgere (to hand)
Thinking Verbs		Ritenere (to consider)	Credere (to believe)	Supporre (to suppose)	Pensare (to think)	Immaginare (to imagine)	Sperare (to hope)

The corsive items refer to the verbs (written in Italian) originally used in the task. In the parenthesis it is proposed the English translation.



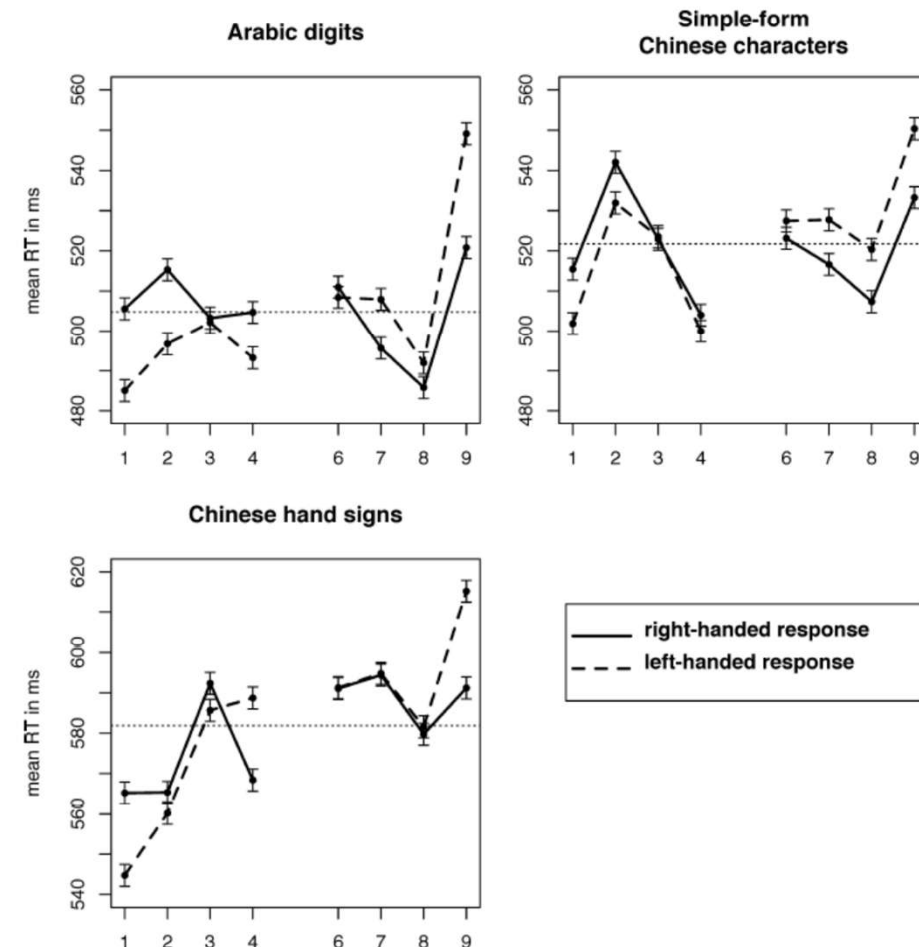
RESEARCH ARTICLE

The SNARC Effect in Chinese Numerals: Do Visual Properties of Characters and Hand Signs Influence Number Processing?



Fig 1. The stimuli used in our experiments. (a) Arabic digits, (b) simple-form Chinese characters, (c) Chinese hand signs as used in Chinese Sign Language. Stimuli in each column represent identical numbers. Note that the

Lettura da sinistra a dx oltre che dall'altro al basso



No Innate Number Line in the Human Brain

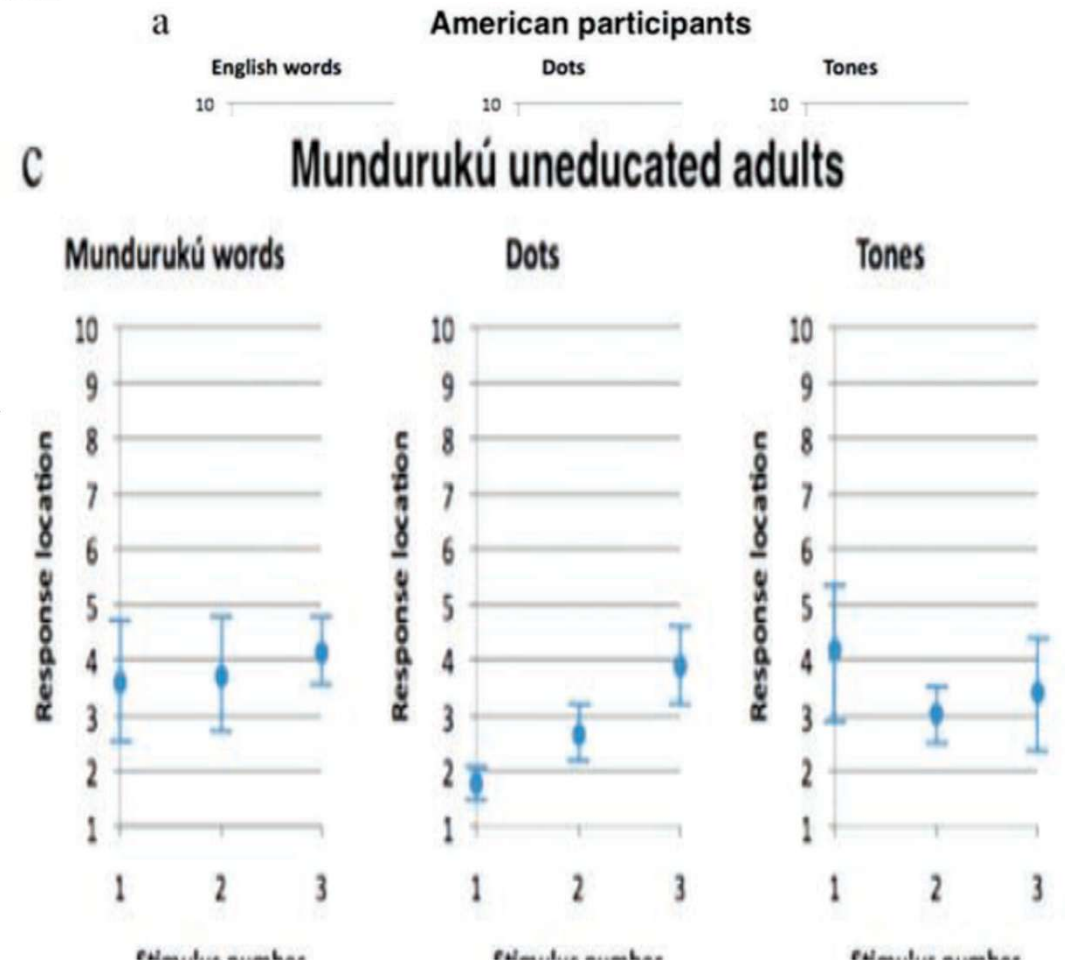
Rafael E. Núñez¹

Mundurukú participants, systematically failed to establish this fundamental number-space mapping

Figure S1. Response mode in Mundurucu participants (photo from experiment ran in Muiussu (first mission, 2006) ; copyright Pierre Pica/UMR 7023).



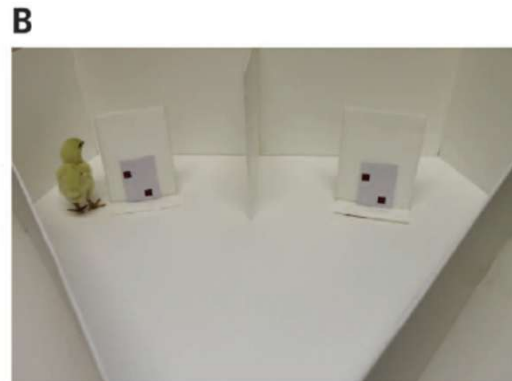
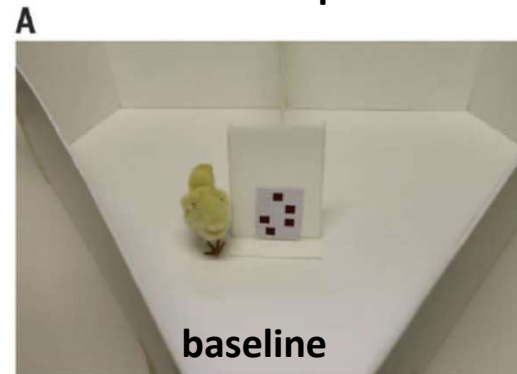
Journal of Cross-Cultural Psychology
42(4) 651–668
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DOI: 10.1177/0022022111406097
jccp.sagepub.com



Prove dell'esistenza dello SNARC in modelli animali: evidenze per una **codifica innata** del legame spazio-quantità?

Questi risultati indicano che la tendenza a mappare le grandezze numeriche da sinistra-a-destra- esiste indipendentemente da fattori culturali e può essere osservata in animali con esperienza numerica non simbolica molto limitata, supportando un **fondamento innato** di tale codifica spaziale della quantità'.

compito di circumnavigazione di un target in cambio di una ricompensa



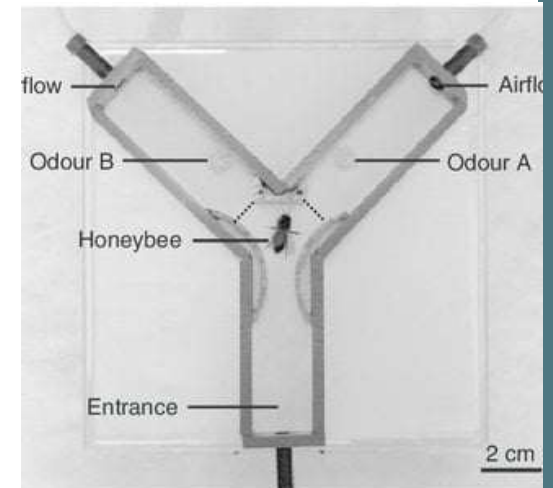
RESEARCH ARTICLE | NEUROSCIENCE | 

An insect brain organizes numbers on a left-to-right mental number line

Martin Giurfa , Claire Marcout , Peter Hilpert , , and Rosa Rugani  [Authors Info & Affiliations](#)

Edited by Gene Robinson, University of Illinois at Urbana-Champaign Institute for Genomic Biology, Urbana, IL; received February 28, 2022; accepted September 12, 2022

October 17, 2022 | 119 (44) e2203584119 | <https://doi.org/10.1073/pnas.2203584119>



Anche un cervello di ~1 milione di neuroni organizza i numeri spazialmente in modo **astratto e relativo**

- L'ape entra in un **labirinto a Y**
- Alla fine trova **due pannelli: sinistra vs destra**
- Ogni pannello contiene **un numero di elementi** (es. 2 vs 4)

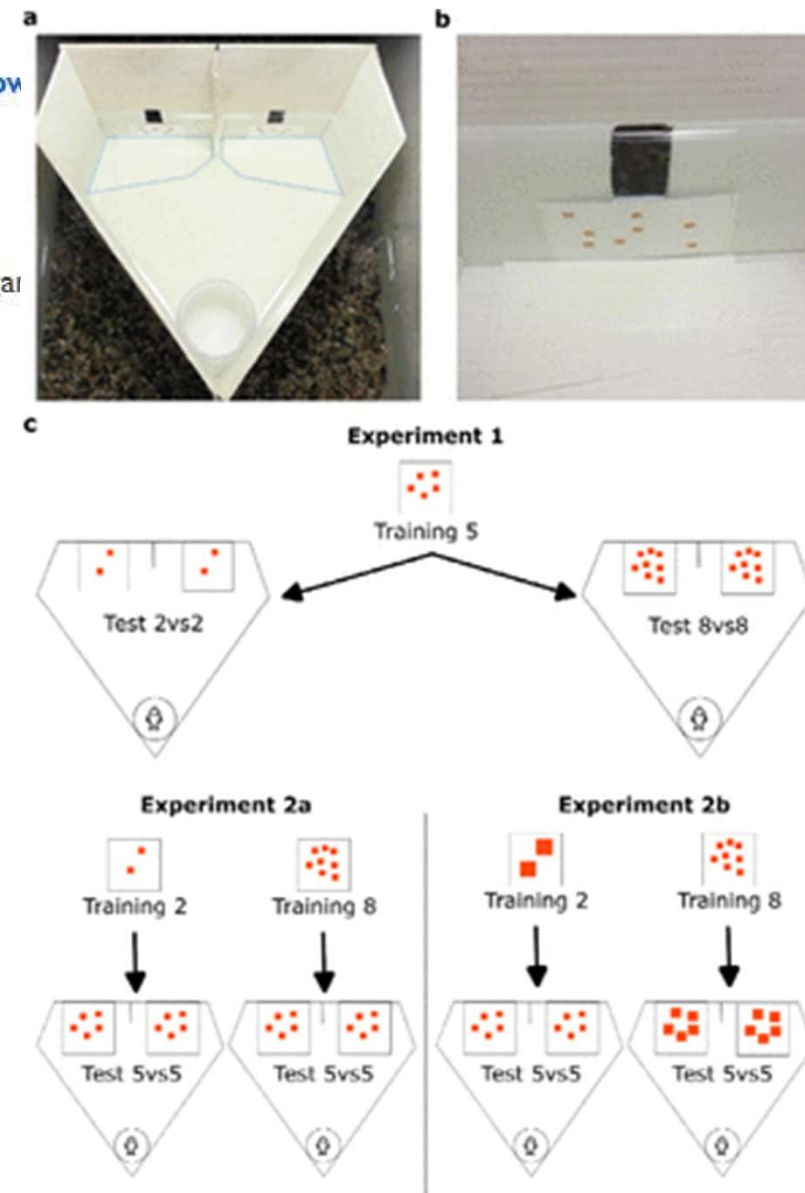
New Results

Space-number association in zebrafish

 Davide Potrich,  Mirko Zanon,  Rosa Rugani,  Valeria Anna Sovrano,  Giorgio Vallortigari

doi: <https://doi.org/10.64898/2026.03.04.709503>

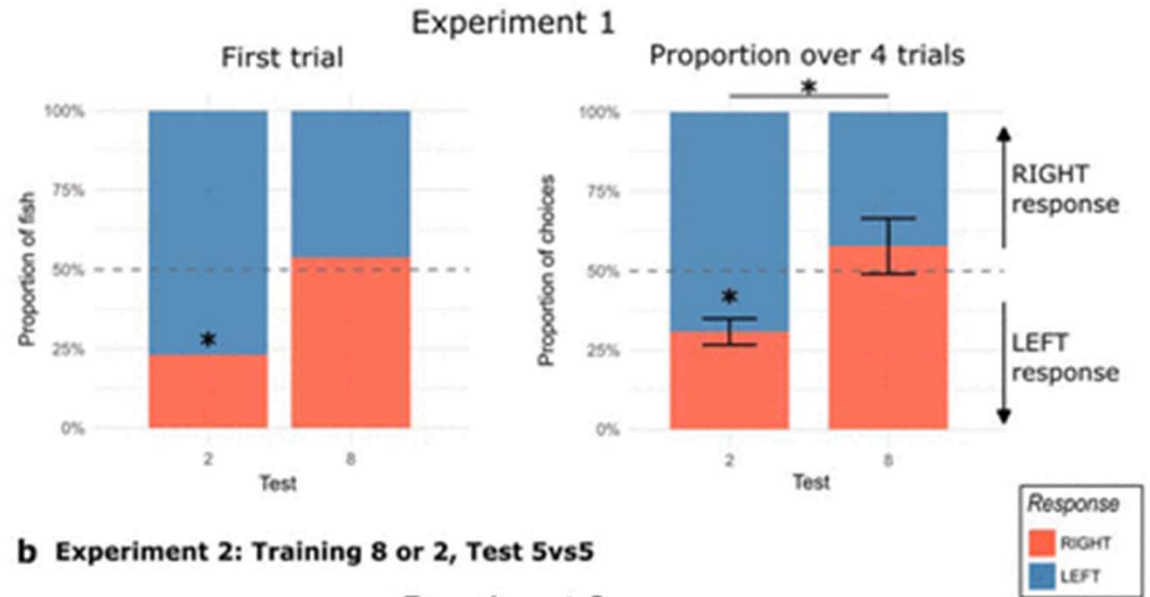
 Follow



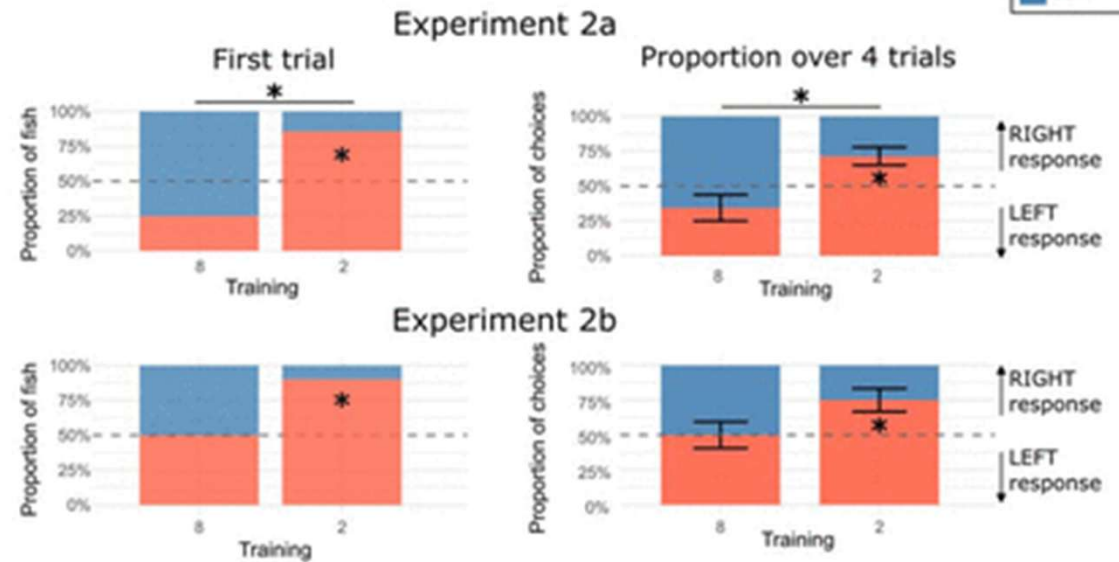
Results

- Vertebrato **molto basale**
- cervello senza corteccia sviluppata (niente IPS umano-like)

a Training 5, Test 2vs2 and 8vs8



b Experiment 2: Training 8 or 2, Test 5vs5



Work In progress

Perché MNL nei platelminti?

- 1) sistema nervoso **bilateriano e minimamente centralizzato**,
- 2) una sensibilità visiva ben documentata con **fototassi negativa** e gradienti di risposta alla luce;
- 3) una letteratura che supporta **apprendimento associativo** e perfino abilità di orientamento/direzione in maze.

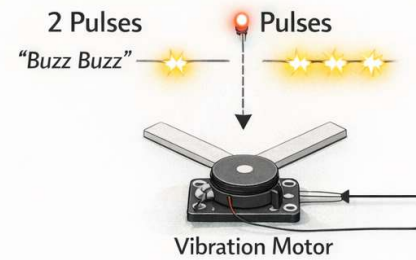
MNL emerge da **dinamiche di rete minime**, non da moduli specializzati?

Bilateri molto primitivi

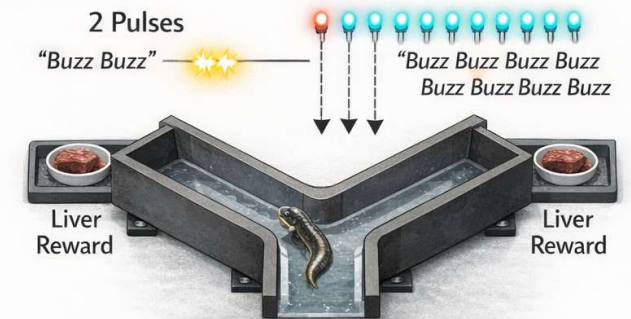


Stimolazione tattile

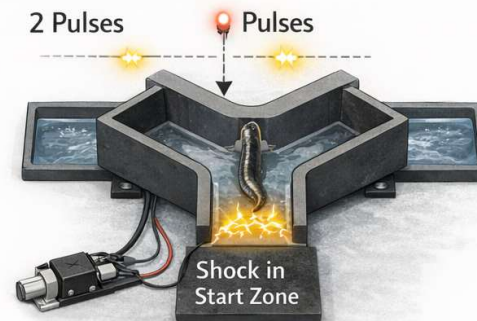
A Vibration Stimuli



B Reward Paradigm



C Avoidance Paradigm

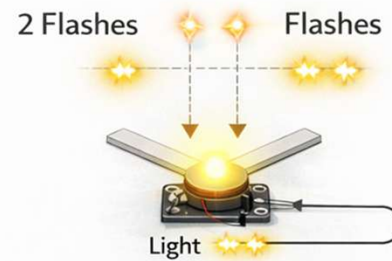


D Vibration Stimuli

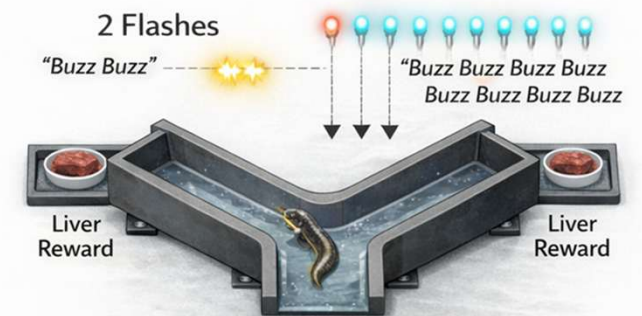


Stimolazione visiva

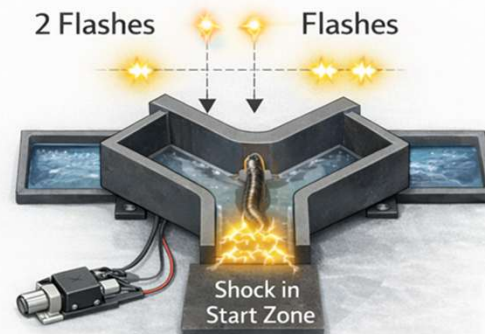
A Luminous Stimuli



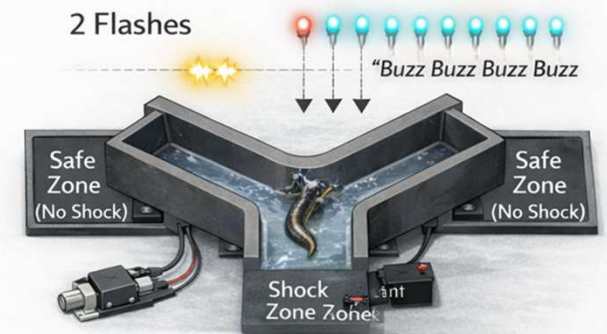
B Reward Paradigm



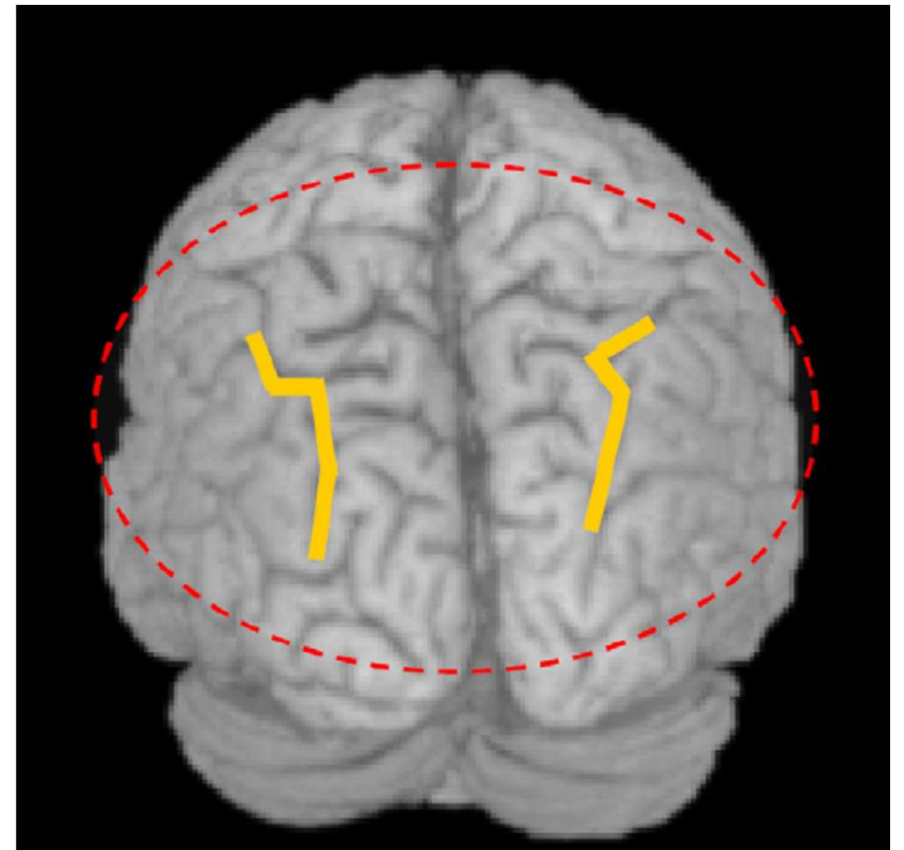
C Avoidance Paradigm



D Luminous Stimuli



The bilateral IPS is thought to be the neural substrate of the MNL



Prove dell'esistenza di una codifica spaziale del tempo

OPEN ACCESS Freely available online



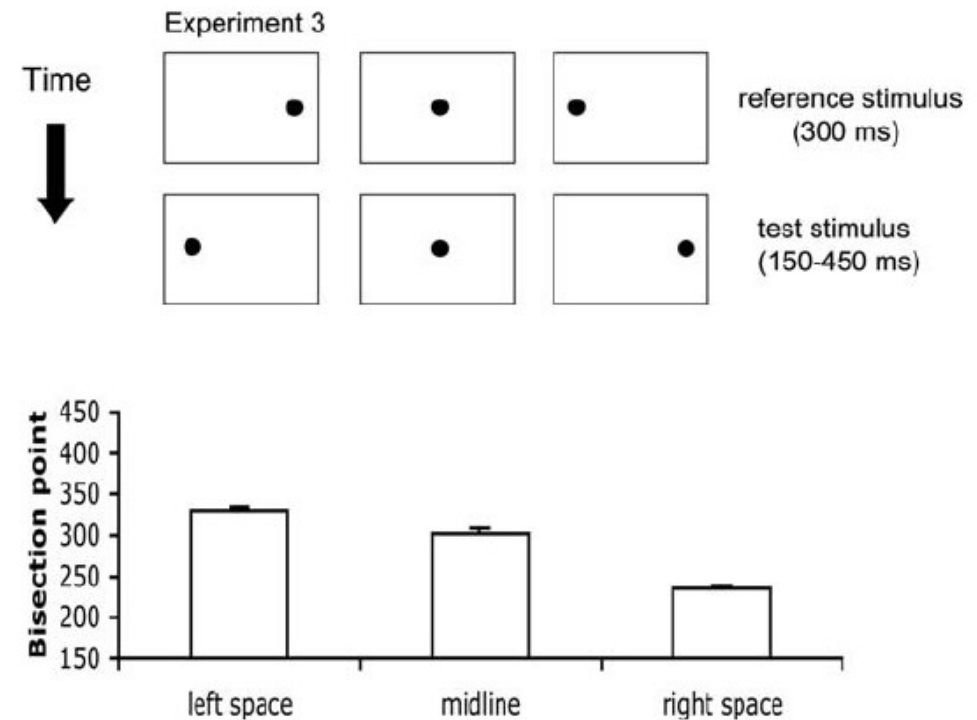
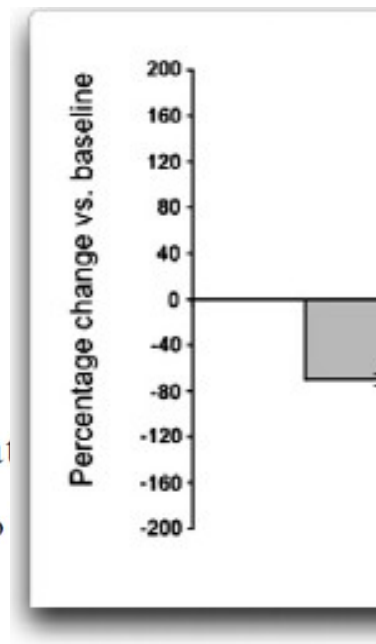
Relativistic Compression and Expansion of Experiential Time in the Left and Right Space

Carmelo Mario Vicario², Patrizia Pecoraro¹, Patrizia Turriziani¹, Giacomo Koch³, Carlo Caltagirone³,
Massimiliano Oliveri^{1,3*}



Optokinetic stimulation

Carmelo Mario



LATERAL HEAD TURNING AFFECTS TEMPORAL MEMORY¹

6

C. M. VICARIO, *ET AL.*

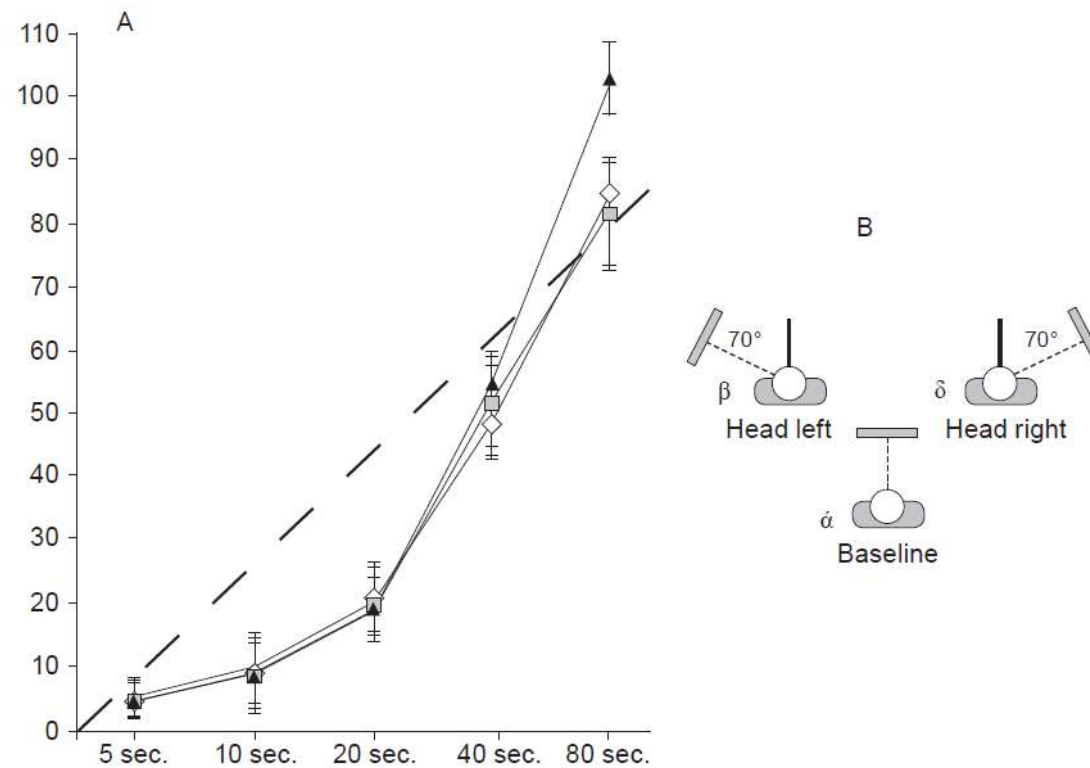


FIG. 1. A. Mean of temporal estimation for all conditions. Left ($\diamond$); Baseline ($\square$); Right ($\blacktriangle$). B. Typical trial sequence (α) Baseline condition; (β) lateral head turning to the left side of space; (δ) lateral head turning to the right side of space.

Motor and Linguistic Linking of Space and Time in the Cerebellum

Massimiliano Oliveri^{1,2*}, Sonia Bonni², Patrizia Turriziani¹, Giacomo Koch^{2,3}, Emanuele Lo Gerfo², Sara Torriero^{1,2}, Carmelo Mario Vicario⁴, Laura Petrosini⁴, Carlo Caltagirone^{2,3}

¹ Dipartimento di Psicologia, Università degli Studi di Palermo, Palermo, Italy, ² Fondazione Santa Lucia IRCCS, Roma, Italy, ³ Clinica Neurologica, Università di Roma Tor Vergata, Rome, Italy, ⁴ Dipartimento di Psicologia, Università degli Studi di Roma La Sapienza, Rome, Italy

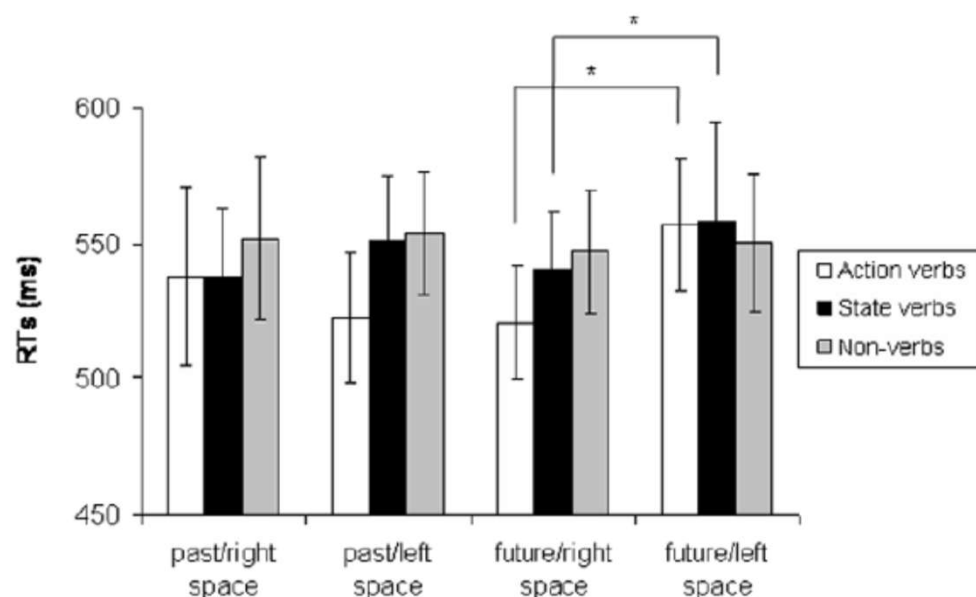


Figure 2. Average RTs to past tense and future tense of action verbs, state verbs and non-verbs in the left vs. right space. Asterisks indicate statistically significant differences.

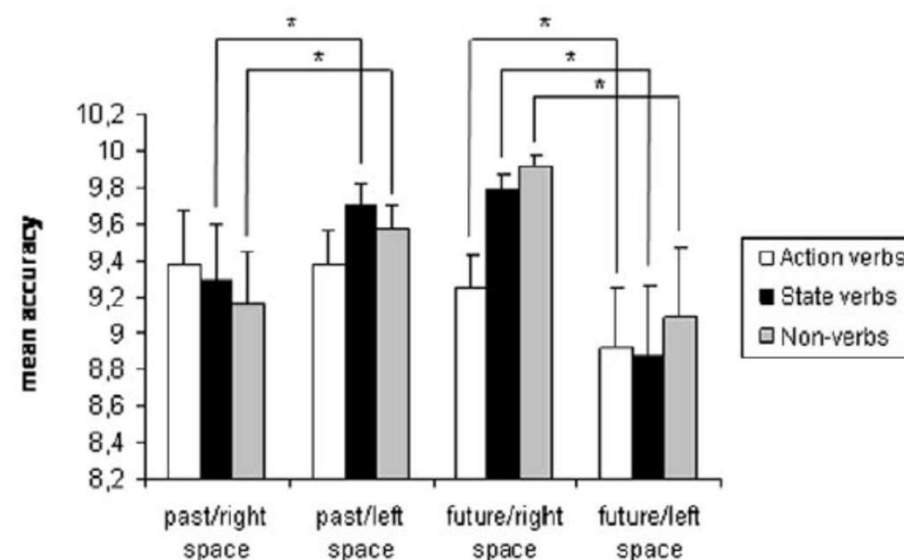
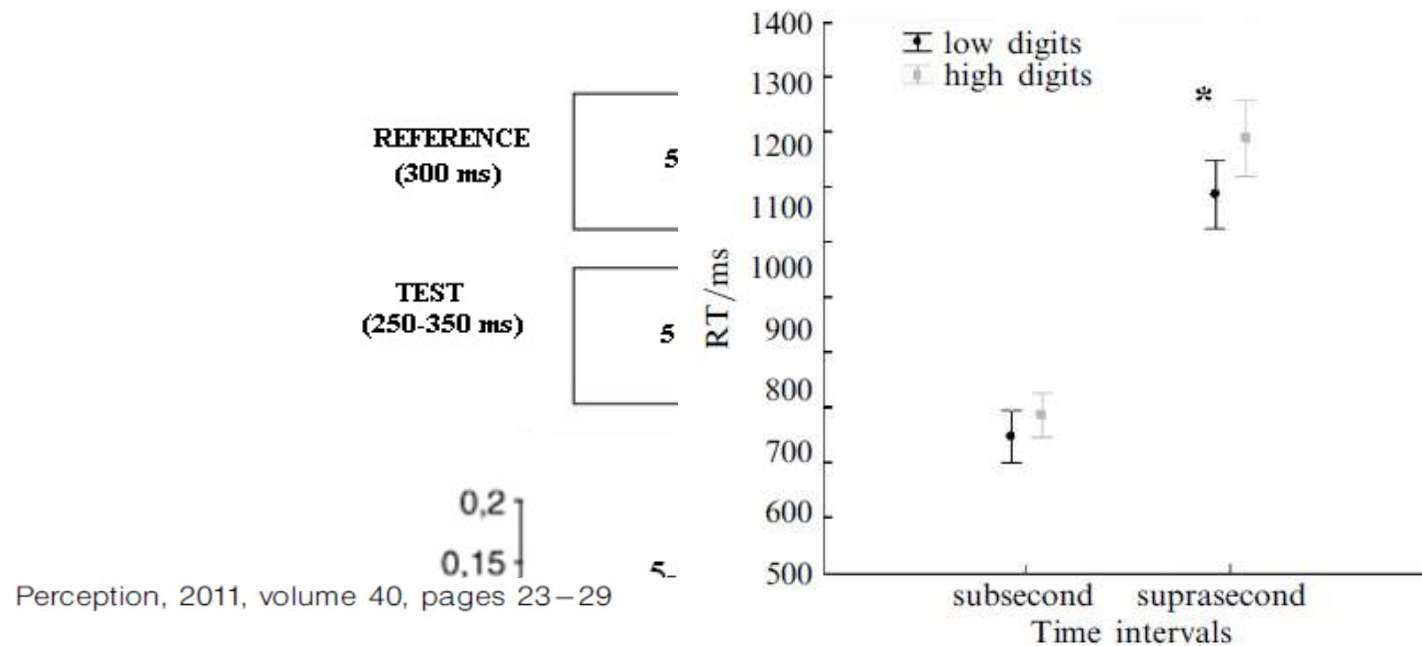


Figure 3. Average accuracy of responses to past tense and future tense of action verbs, state verbs and non-verbs in the left vs. right space. Asterisks indicate statistically significant differences.
doi:10.1371/journal.pone.0007933.g003

Evidenze circa l'esistenza di una relazione tra tempo e quantita'



Perception, 2011, volume 40, pages 23–29

doi:10.1068/p6800

Perceiving numbers affects the subjective temporal midpoint

Carmelo Mario Vicario

Time and developmental dyscalculia

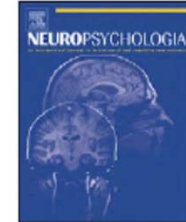
Neuropsychologia 48 (2010) 2861–2868



Contents lists available at ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia



A disassociation between physical and mental number bisection in developmental dyscalculia

Sarit Ashkenazi*, Avishai Henik

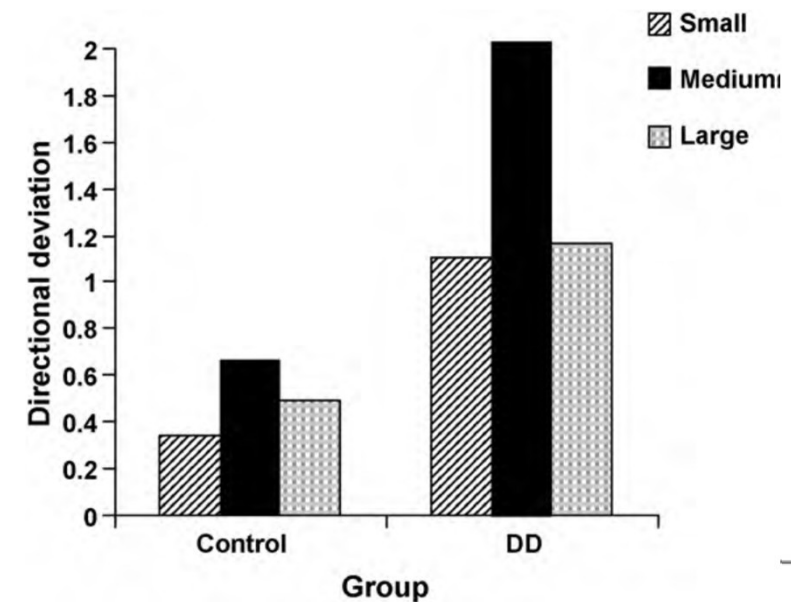


Fig. 2. Mean deviation as a function of group and range. A positive deviation means a leftward tendency.

Neglect spaziale unilaterale e stima del tempo

Neuropsychology
2011, Vol. 25, No. 2, 193–200

I pazienti con **N+** hanno ottenuto **punteggi significativamente peggiori (minore accuratezza)** rispetto a quelli con N- e HC.

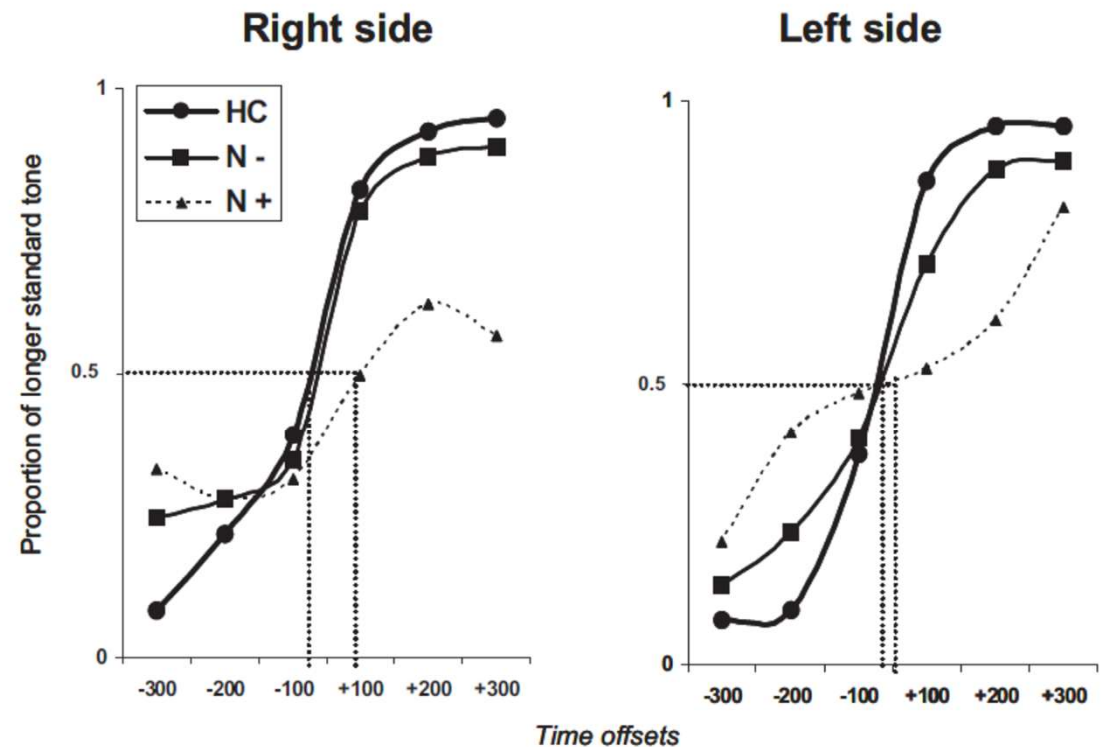
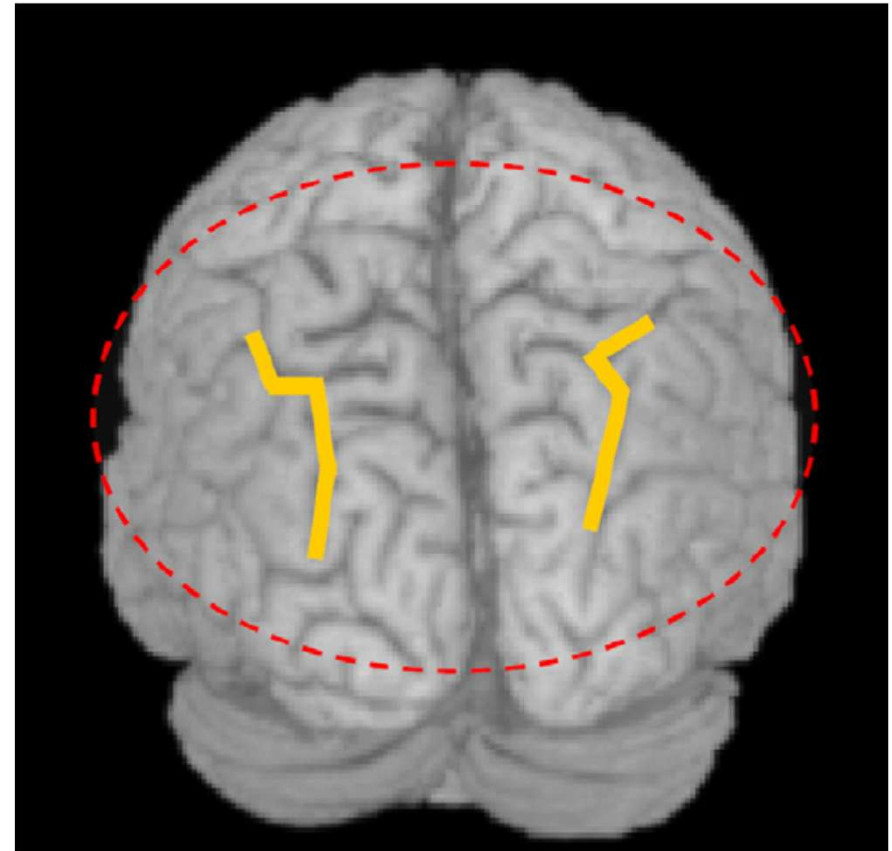
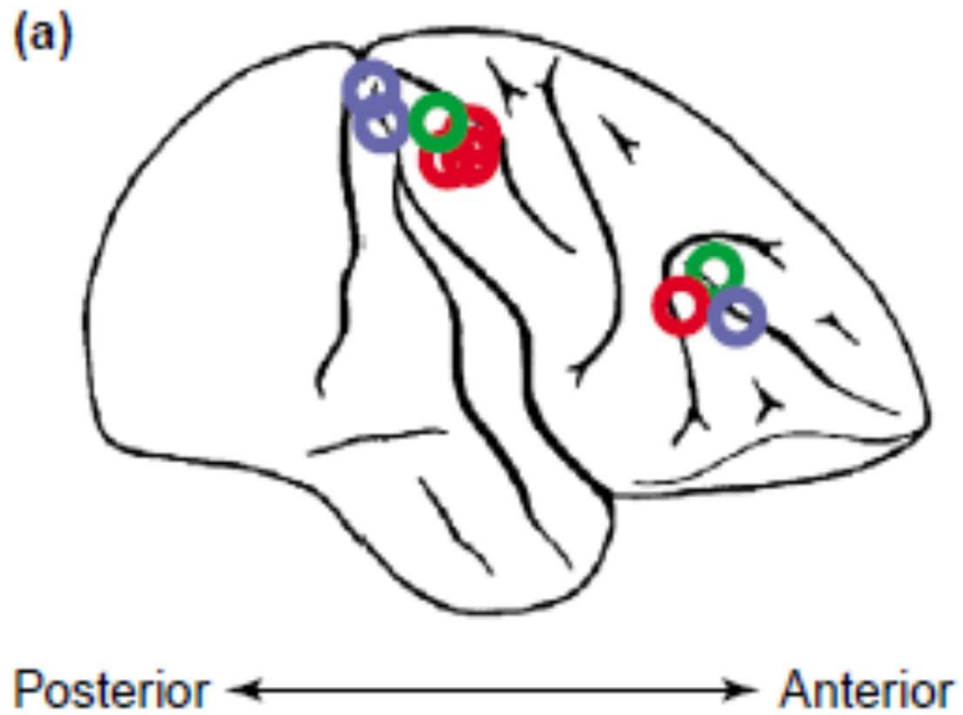
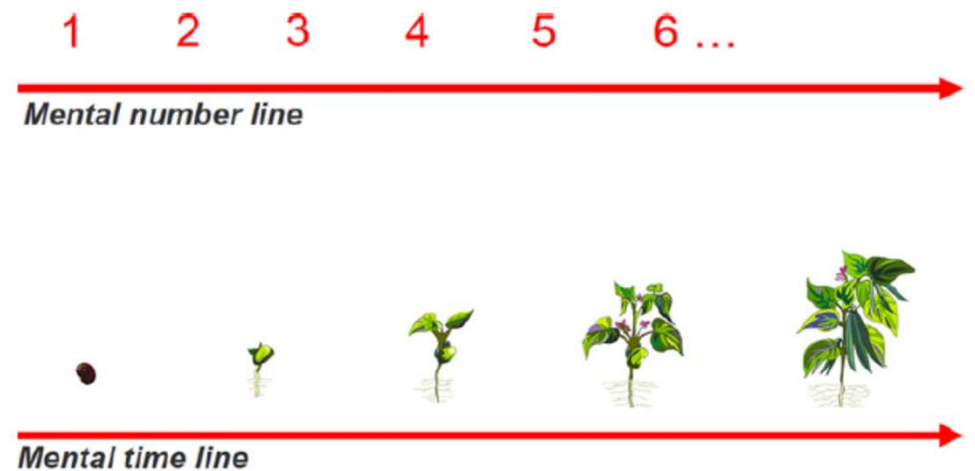
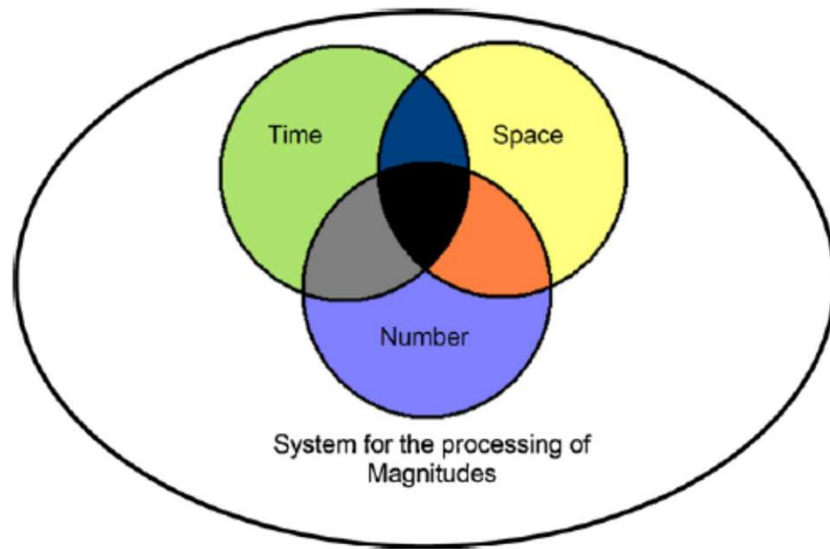


Figure 2. PSE for each group in the time discrimination task, as a function of the side of test tone presentation. N+ = patients with spatial neglect ($n = 6$); N- = patients without spatial neglect ($n = 8$); HC = healthy controls ($n = 8$).

Correlati neurali per la mental time line



Conclusioni



Left, low, short

Right, high, long



The mental time/number line is spatially encoded