100 - Numerical Cognition - 13
ewcn.bressanone 2023

Unveiling the neural substrate of number processing and grasping through functional near infrared spectroscopy (fNIRS)

Mariagrazia Ranzini [1]*, Sabrina Brigadoi [2]*, Yeliz Dinç[1], Pietro Scatturin[2], Antonino Vallesi[3], Carlo Semenza[3], Umberto Castiello[1], Marco Zorzi[1,4], Simone Cutini[2]

***These authors contributed equally to this work**

[1] Department of General Psychology (DPG), University of Padova, Italy
[2] Department of Developmental Psychology and Socialisation (DPSS), University of Padova, Italy
[3] Department of Neuroscience (DNS), University of Padova, Italy
[4] IRCCS San Camillo Hospital, Venice-Lido, Italy

mariagrazia.ranzini@unipd.it

Background

Behavioural studies suggest the existence of common cognitive mechanisms at play during the processing of numerical information and the execution of hand grasping [1-3]. This idea is in line with embodied and grounded cognition theories, claiming that knowledge is built upon sensorimotor experiences [1].
At the neural level, we have recently described neural areas involved in both number processing and grasping through a metanalysis of neuroimaging studies [4].

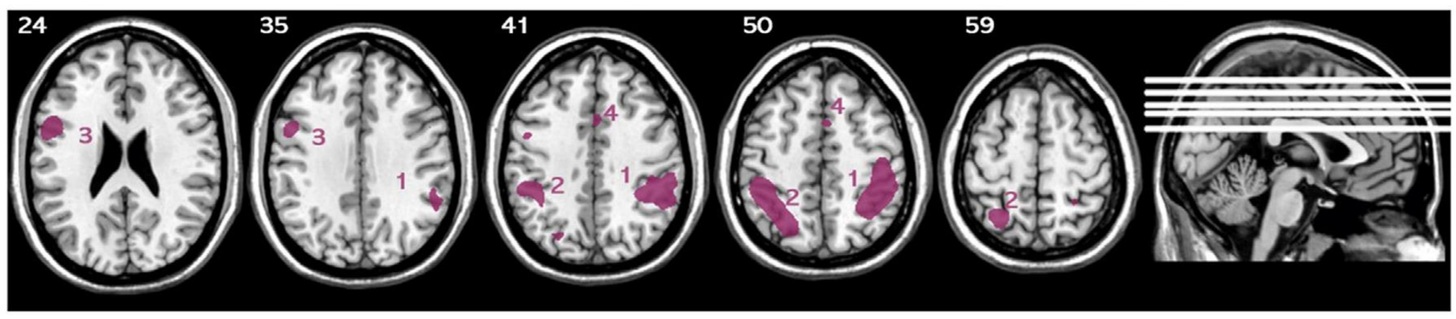


Fig.1 from [4]

Common areas were located in the inferior and posterior superior parietal lobules (IPL, PSPL), in the left precentral gyrus (PCG) and in the supplementary motor area (SMA) (Figure 1).

Aim of the Study

In this study we investigate the neural activity of these areas during the execution of hand motor and numerical tasks using functional near infrared spectroscopy (fNIRS).

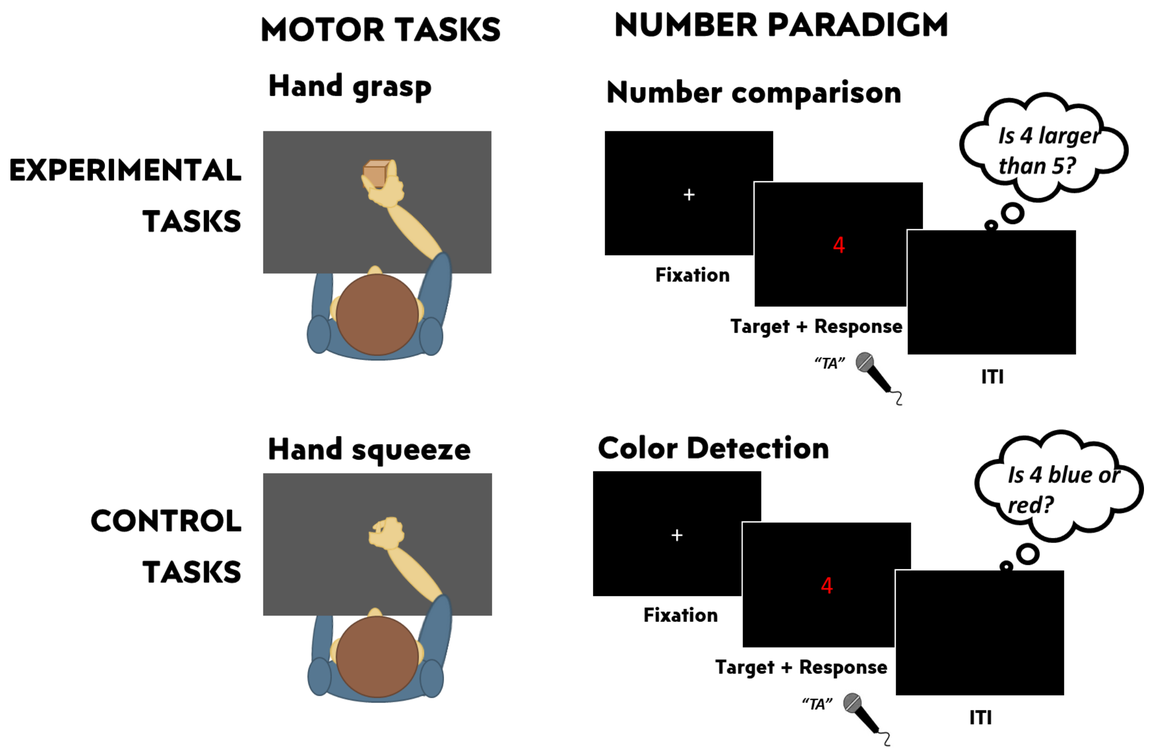
Method

Participants: Thirty healthy adults, mean age=23y/o; 20 female participants.

Materials and procedure: four tasks were executed during the recording of cerebral activity through fNIRS. Those tasks were administered in a single session and in the same order for all participants: hand grasping (n. trials =32), hand squeezing (n. trials =32), number magnitude comparison (n. trials =64), and digit colour detection (n. trials =32). Experimental and control tasks were matched for visual and response modalities.

Maths abilities were assessed at the end of the session without fNIRS recording arithmetic facts retrieval (48 trials: addition, subtraction, multiplication, division) and mental calculation (24 trials: addition, subtraction).

fNIRS acquisition: optodes were arranged in a customized array, covering frontoparietal cortical areas involved both in number processing and in the hand grasping [1] (Nirscout - NIRx; 106 channels + 8 short-separation (SS) channels). Preprocessing: motion correction, band-pass filtering, GLM with SS channels regression).



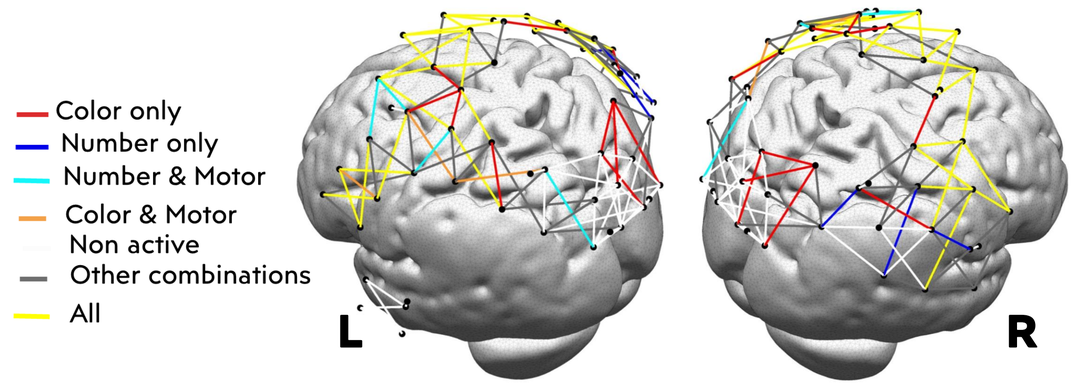
Results

Accuracy: >95% in both number comparison and color detection.

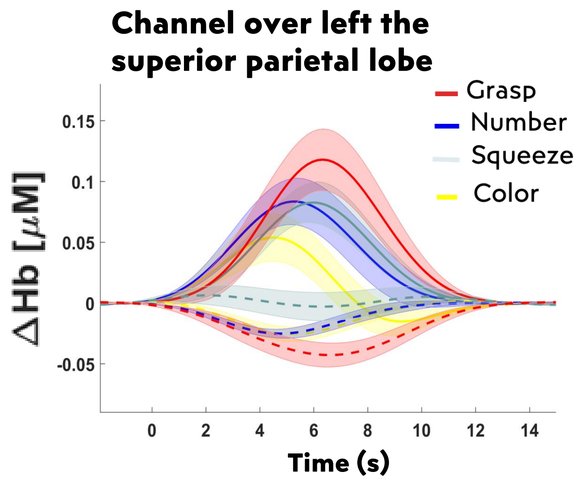
Response times (RTs): RTs in color detection (M=613ms) than RTs in number comparison (M=661ms, p<.02).

Maths tasks:

	Arithmetic Fact Retrieval	Mental Calculation
	% Correct Responses (Mean and SD)	
Total	85 (9)	73 (13)
Addition	91 (8)	78 (12)
Subtraction	96 (5)	67 (17)
Multiplication	77 (15)	
Division	76 (18)	



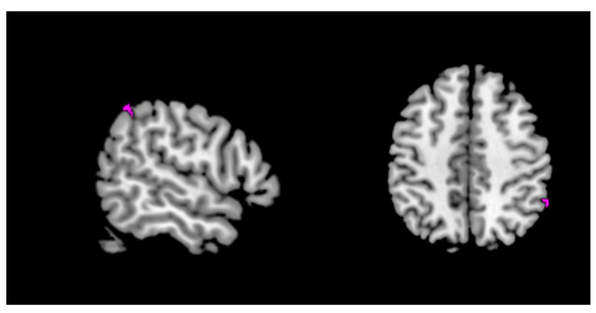
Channels over left SPL and PCG were significantly active during both number comparison and motor tasks, while channels active only during number comparison were located over the right parietal cortex (t-test vs. 0 corrected for multiple comparisons).

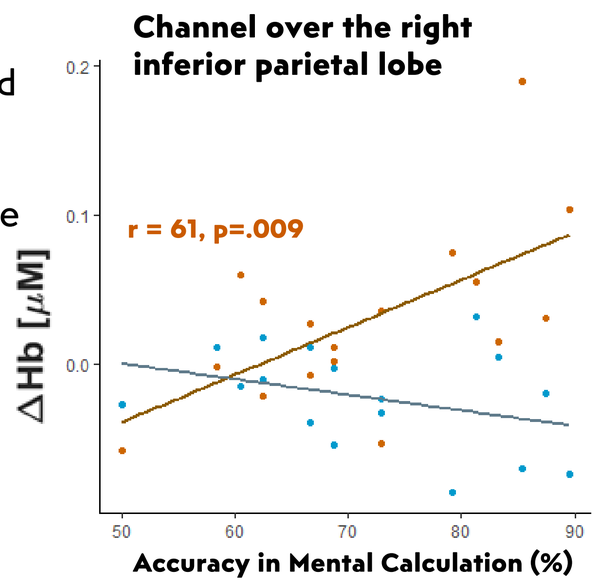


One channel over the left SPL was active during the experimental tasks and not during the control tasks.

Correlations between cerebral activity and behavioural performance in mental calculation

HbO mean amplitude during number comparison was significantly correlated with the performance in mental calculation (percentage of accuracy) in one "number-specific" channel over the right inferior parietal lobe (p<.01).





Conclusions

The spatial overlap between active channels during number comparison and motor tasks confirms the results of our metanalysis [4], it and supports the idea of common mechanisms involved in number processing and hand actions.

Some channels in the right parietal lobe showed activity only during number comparison as compared to the other conditions.

Interestingly, this number-specific activity was correlated with performance in mental calculation in one channel over the right inferior parietal lobe. This finding is in line with the claim that the role of the right hemisphere in the processing of numbers should be reconsidered [5].

References. **[1]** Fischer, M. H. (2012). *Cognitive processing, 13(1),* 161-164. **[2]** Andres, M., et al. (2008). *Cortex, 44(4),* 414-419. **[3]** Ranzini, M., et al. (2022). *PLOS ONE, 17(6),* e0269557. **[4]** Ranzini, M., et al. (2022). Cortex, 148, 31-67. **[5]** Semenza, C., & Benavides-Varela, S. (2018). *Philosophical Transactions of the Royal Society B: Biological Sciences, 373.*

GRINP
Grasping and Reaching in Number Processing