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Comparisons and Calculations in the Human Posterior Parietal Cortex

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Introduction: The parietal cortex is centrally involved in sensorimotor transformations for motor outputs such as reaches, saccades, and grasps [1]. These actions require computations on quantifiable variables such as distance and size. This fundamental link between sensorimotor planning and execution and numerical processing may explain why, in both animal electrophysiology and human neural imaging studies, the parietal cortex has been implicated in quantity representation during arithmetic, comparison, and other number manipulations [2, 3].

Material, Methods and Results: We investigated numerical representation in the posterior parietal cortex (PPC) using intracortical recordings from a human with tetraplegia [4]. From two 96-channel microelectrode arrays, we identified neurons in the anterior intraparietal area and Brodmann's area 5 whose firing rates modulated during mental arithmetic calculations and quantity comparisons. These neural activities reflected numerical value, arithmetic and comparison operators (i.e. plus or minus, greater than or less than), and spatial location of answers.

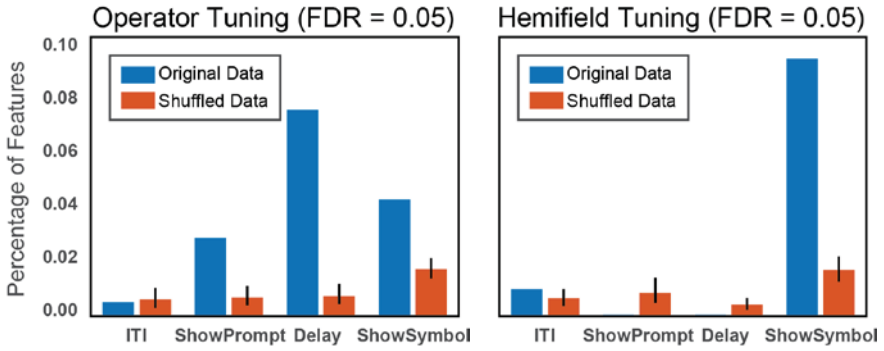

Figure 1. *Percentage of neurons tuned to arithmetic operator (i.e. plus vs. minus) and answer hemifield (i.e. left vs. right) in an arithmetic calculation task. Tuning percentages were compared to shuffled data at a false discovery rate of 0.05.*

In an arithmetic calculation task, about 11% of the neuronal population (25/218) exhibited tuning with respect to the arithmetic operator (i.e. plus or minus), and about 10% of the population (21/218) modulated with respect to the answer hemifield (i.e. left or right) (Fig. 1). Similar trends were observed in a quantity comparison task, where 45% of neurons (45/97) could distinguish the answer hemifield and 12% of neurons (12/97) represented the comparison operator (i.e. less than or greater than) when comparing the size of two circles.

Discussion: Although arithmetic and comparison operations are distinct from movement, the neural circuitry required to perform movement-related sensorimotor transformations is likely well suited to involvement in the processing required to compare and calculate quantities. This aspect of the parietal cortex could provide insights into how to best use PPC for neural interfaces, both to avoid interference as well as to optimize control.

Significance: These data provide the first evidence from intracortical electrophysiological recordings made in human for the involvement of PPC in quantity comparisons and calculations. The involvement of the parietal cortex in numerical processing confirms an important function of this versatile brain area, and points toward potential applications in neural prosthetics.

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