Using specific brain areas to understand domain-general computations

We thank Y. Li and K. Krishnamurthy for their insightful comments on our study, as well as their synthesis of the extensive supporting literature. We wish to clarify our perspective on the broad hypothesis that Li and Krishnamurthy emphasize, concerning a general role that LIP might play in perceptual decision-making. We do not believe that our study (Lafuente et al, 2015) implies that LIP is a general decision maker. The finding that another area, MIP, is capable of supporting similar computations suggests that the computations and neural mechanisms that support them are general, whereas LIP itself presumably comes into play when an eye movement is involved, even if only provisionally. Those general mechanisms exploit persistent neural activity to represent quantities of use in a variety of operations that extend in time beyond evanescent sensory events and the real-time demands of motor control. They include planning, reasoning, deliberating, and other operations that can be studied in the setting of perceptual and value-based decision making, but similar mechanisms are likely to support other cognitive functions as well (e.g., exploration, prioritizing, parsing, strategizing and remembering).

Indeed the importance of this line of research is not to identify the area that makes a certain type of decision. Rather, it is to expose neural mechanisms whose operation in normal brains support normal cognition—what it is about a normal brain that makes us “not confused”. Indeed, it is the breakdown of such operations that are likely to hold the key to disorders of cognition, that is, the link from genes, toxins, trauma and ischemia to the pathophysiology of disordered thought. This is just a working hypothesis, but the search for general mechanisms, which runs almost antithetical to the search for *the area that does X*, is the more important goal of the line of research summarized so nicely by Li and Krishnamurthy.

Thus, our focus is on the similarity of processing by MIP and LIP neurons, and on the potential implications of two areas that are representing a decision variable at the same time. This type of parallel processing, by parietal areas whose projections associate them with different motor intentions (Andersen and Cui, 2009; Snyder et al., 1997), has implications that are far more important than general-purpose decision making. For example, the presence of multiple representations of evidence complicates the interpretation of inactivation studies and, in a similar vein, guides strategies to promote recovery from focal ischemic (or other) insult to the association cortex. Parallel processing raises the possibility that different decision circuits could apply different termination rules and cost functions to proceed from deliberation to action. Multiplicity also raises the possibility of conflicting representations of belief, perhaps explaining vacillation and change of mind (Resulaj et al., 2009). These considerations do not negate the important points raised by Li and Krishnamurthy, but we would invite these authors and readers to consider generalization of computation and mechanism even as we continue to expand our understanding of each area’s repertoire.

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References

Andersen RA, Cui H (2009) Intention, action planning, and decision making in parietal-frontal circuits. Neuron 63:568–583.

de Lafuente V, Jazayeri M, Shadlen MN (2015) Representation of Accumulating Evidence for a Decision in Two Parietal Areas. Journal of Neuroscience 35:4306–4318.

Resulaj A, Kiani R, Wolpert DM, Shadlen MN (2009) Changes of mind in decision-making. Nature 461:263–266.

Snyder LH, Batista AP, Andersen RA (1997) Coding of intention in the posterior parietal cortex. Nature 386:167–170.