Liu Y, Yttri EA, & Snyder LH. Reversible inactivation reveals that LIPv subserves general attention while LIPd subserves saccadic intention.

The role of the lateral intraparietal area, LIP, in visuospatial processing has been debated for several decades. Strong evidence has supported an involvement in the sensorimotor transformation for saccade movement planning, while other strong evidence has supported a more general role in registering salient spatial locations. A promising technique to resolve this discrepancy is reversible inactivation by micro-injection of pharmacological agents. An oculomotor role for LIP was supported by the study of Li & Andersen (1999), who found that reversible inactivation of LIP with muscimol led to delayed reaction times for visually- and memory-guided saccades. However, a non-specific role was supported by studies of Wardak and colleagues (2002, 2004), who found normal reaction times for single targets, but pronounced delays when visual targets were presented among distractors. In both studies, the injections were aimed at the lateral bank of the IPS in the region in which delay activity was found in an oculomotor delayed saccade task. However, LIP is likely to consist of two separate regions, LIPd and LIPv (Lewis & Van Essen, 2000), raising the possibility that the two studies may have inadvertently targeted different cortical areas.

In order to address this possibility, we performed similar reversible inactivation experiments by co-injecting manganese (Mn), a MRI-lucent contrast agent, with muscimol, a GABA-a agonist. The inclusion of Mn allowed us to directly visualize our injection sites using anatomical magnetic resonance imaging (Fig. 1). We found both oculomotor deficits and search deficits following LIP inactivations. More importantly, our imaging data showed that the injection sites underlying saccadic and search effects were anatomically dissociable. The reaction times (RT) for contralateral

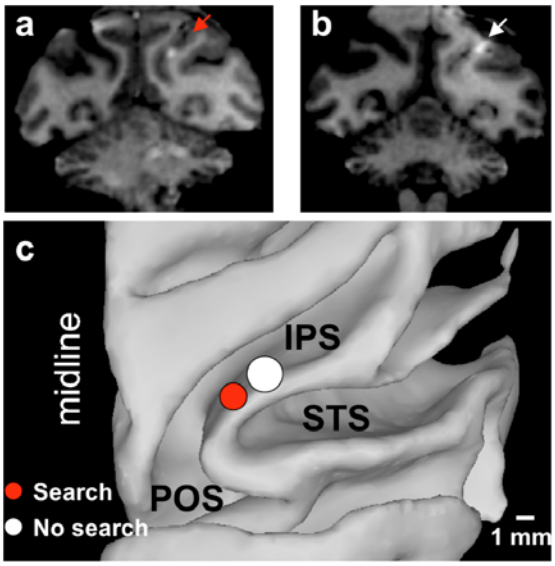

Figure 1 | MRIs of LIP injections. Injection sites were visible as bright halos representing the manganese-induced T1 signal increase on the coronal sections. a. A single ventral LIP injection (1.0 uL). b. A double dorsal LIP injections (1.0 x 2 uL). c. Two injection halo outlines superimposed on the fiducial surface of the monkey's brain. Red: sites that showed a search effect. White: sites that did not show a search effect. IPS, intraparietal sulcus; POS, parieto-occipital sulcus; STS, superior temporal sulcus.

memory saccades were prolonged after inactivation of both the dorsal (superficial, < 5.0 mm below the gyral surface, Fig. 1b) and ventral (deep, >= 5.0 mm, Fig. 1a) portions of the lateral bank of the IPS . In contrast, search errors significantly increased after inactivations of the ventral or deep portion of the lateral bank (Fig. 1a). This is consistent with a parcellation of function in this region. Our results are consistent with LIP actually consisting of two functionally and anatomically separable regions, one (LIPd) performing saccade-specific functions and the other (LIPv) playing an effector-independent role in visual search. Our muscimol-Mn-MRI technique offers a promising tool for examining regions affected by the injected material and delineating the functionality of the corresponding cortical areas.