Functional ultrasound imaging of movement intentions in the posterior parietal cortex

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Background, Motivation and Objective

Functional ultrasound imaging (fUS) provides a unique combination of spatial coverage, spatiotemporal resolution (100 µm, 25 ms), and compatibility with freely moving animals. However, fUS monitoring of subtle preparatory actions in larger brains has been relatively unexplored to date. Here, we tested the ability of fUS to decode movement intentions in the posterior parietal cortex (PPC) of behaving non-human primates (NHPs), a brain region involved in the preparation of eye saccades and reach movements. In addition, we aimed to show that fUS is a viable imaging method for brain-machine interfacing.

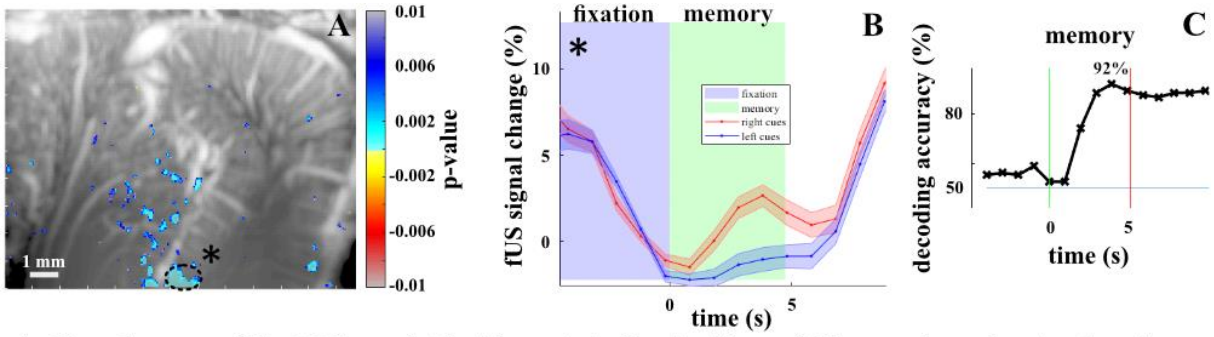
Statement of Contribution/Methods

Two NHPs were trained to perform memory-guided saccades and joystick reaches. In each trial, we presented a target in the peripheral visual field for 300 ms, the animal memorized the location of the target for 5 s while maintaining eye fixation and finally performed a movement to the remembered target location. During the task, we acquired fUS images at 15 MHz (750 Hz coherent compounded framerate, 1 Hz fUS framerate) in PPC to capture brain areas associated with movement planning and execution. In addition, we implemented several decoding methods to predict impending left vs. right movements on a single trial basis in the context of brain-machine interfacing.

Results/Discussion

Consistent with fMRI studies [1], we detected fUS signal changes (< 5%) during the memory-period that were higher for contralateral than for ipsilateral cues (Fig 1B). The high spatial resolution of fUS imaging (Fig 1A) revealed functional areas that have been documented by fMRI studies, but also medial functional areas that were undocumented. In addition, we successfully predicted left vs. right movements using fUS activity from the memory-delay period on a single trial basis (accuracy > 90%) (Figure 1C). Together, these results suggest that fUS is capable of imaging subtle cortical activity in behaving NHPs and may also be a viable imaging method for single-trial BMI control.

[1] Wilke M, Kagan I, Andersen RA. Functional imaging reveals rapid reorganization of cortical activity after parietal inactivation in monkeys. PNAS. 2012 May 22; 109(21):8274-9.



A. Vascular map of the PPC overlaid with statistically significant fUS contralateral activations in a reach movement trial. **B.** fUS signal in the circled location. Right trials in red, and left trials in blue. Memory delay in green. **C.** Accuracy of a linear single trial decoding approach.