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Leg-Specific Functional Activation in M1 Using Action Imagery During a Modified Attention Switching Task

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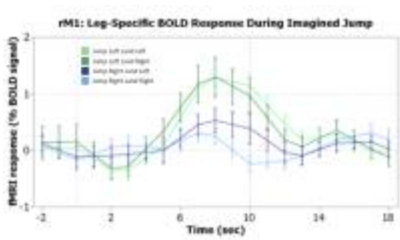
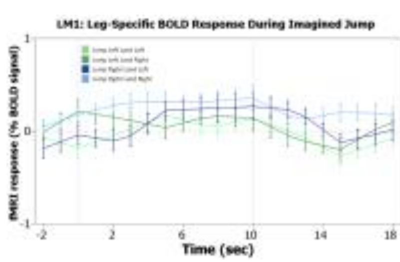
The magnetic resonance (MRI) environment imposes substantial constraints on the execution of behaviorally-relevant movements, especially when the lower limb(s) are involved. We developed a novel first person action-imagery paradigm to examine whether leg-specific functional activity could be produced in the primary motor representation of each leg during a modified attention switching task (AST). Nineteen healthy women aged between 18 and 32 participated after providing written informed consent. All participants completed an AST with 4 trials of 10 repetitions and 60-second intertrial intervals. The test required subjects to randomly jump (J) and land (L) with the right (R) or left (L) leg based on congruent or incongruent stimuli involving the direction and location of an arrow. To facilitate imagery, in an earlier test session, subjects wore a head-mounted camera to record the physical execution of the test from a first person perspective. During the functional test, subjects were instructed to watch the cues and imagine themselves performing the task while they watched themselves do so from their own perspective. Brain images were acquired with a three tesla (3T) Siemens Trio Tim MRI system with a 32 channel RF head coil. Stimulus presentation was achieved using Superlab, and imaging was synchronized to stimulus presentation using a Siemens TR trigger module. A three-dimensional magnetization-prepared rapid gradient-echo (MP-RAGE) sequence acquired whole-brain structural scans. Voxel size was set at $1.0mm^3$ for structural scans and $3.0mm^3$ for functional scans. Significant map clusters were included on the basis of a six-voxel cluster threshold, in addition to a false discovery rate (FDR) significance threshold set at $q=0.05$. Retained map clusters were then converted to voxels of interest (VOIs), and small cluster suppression was used to focus the analysis on the most active brain regions. To further analyze leg-specific hemodynamic responses, event-related averaging was performed based on jump and landing leg, with a baseline period (% signal change) of -4 to 1sec post-stimulus, and a resolution of -4 to 18sec post-stimulus. Compared to resting conditions, we observed generalized increases in activity in the dorsal and ventral streams, in addition to the supplementary, premotor, and dorsolateral prefrontal cortices ($q \leq 0.01$). Significant hemodynamic responses were observed in each primary motor (M1) leg representation ($q \leq 0.05$), with less activity during the imagined use of the dominant (right) leg. In each M1 representation, the peak event-related BOLD response amplitude corresponded with the degree of imagined leg involvement (rM1: JR/LR = 0.31%; JR/LL = 0.52%; JL/LL and JL/LR = 1.28%; LM1: JR/LR = 0.36%; JR/LL = 0.27%; JL/LL and JL/LR = 0.16%). Thus, leg-specific functional activity can be elicited through imagined behavioral use with first person visual representation.





In the right primary motor (M1) leg representation, event related hemodynamic activity increases with the imagined use of the left leg. The largest BOLD responses were observed when participants imagined jumping with the left leg. A smaller and delayed hemodynamic response was produced with a left leg landing. When the right leg was used to jump and land, little to no hemodynamic response was observed.

Similar to rM1, event-related functional activity increased in the left M1 leg area when participants imagined using the right leg. Hemodynamic responses were generally smaller, but still corresponded with the degree of imagined leg use.

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