FMRI Reveals that Peak Activated Regions in the Primary Sensorimotor Cortex and Premotor Regions are the same for Multiple Sclerosis Patients and Controls During Complex Finger Tapping

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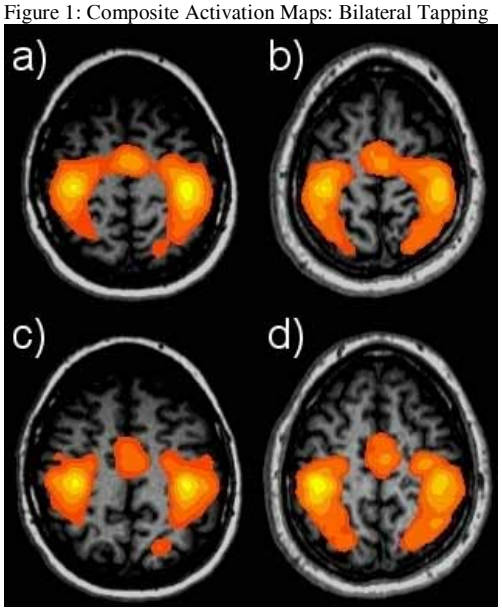
Abstract

Twenty-two right handed multiple sclerosis (MS) patients and 16 controls performed a bilateral complex finger tapping task. FMRI activation within predefined sensory and cortical ROIs was indentified. Comparisons were made of the spatial location of the maximally activated voxel within the primary sensorimotor cortex (SMC), dorsal premotor (PMd) and ventral premotor (PMv) cortex, supplemental motor area (SMA), superior parietal lobule (SPL) and inferior parietal lobule (IPL). Contrary to prior reports, we found no significant differences in the location of the maximally activated voxel for any of the sensory or motor ROIs in MS patients relative to healthy controls

Figure 1: Composite Activation Maps: Bilateral Tapping



a,c) Healthy controls and b,d) MS patients. False color overlay is thresholded at the same significance level for all maps ($p<10^{8}$)

Introduction

Previous fMRI studies in multiple sclerosis (MS) have reported increased cortical sensory and motor activation following performance of hand motor tasks[1-3]. However, there is no clear consensus whether the activation in MS patients is shifted with respect to controls. We have previously demonstrated that, compared to controls, MS patients have significantly more head motion during fMRI scans that must be controlled for when comparing group differences.[4] To determine if the sensory and motor activations are shifted in MS patients relative to controls, after carefully controlling for head motion, we examined the spatial location of the maximally activated voxel within the SMC, PMd, PMv, SMA, SPL and IPL.

Materials & Methods

Prospectively motion-corrected[5] gradient echo EPI fMRI exams at 3T were performed on 21 MS patients and 15 approximately age and gender matched controls. All subjects were right handed as assessed by the Edingburgh handedness inventory. The multiple sclerosis functional composite (MSFC) examination was administered to all subjects prior to MR scanning. One hundred-sixty volumes of 31-4mm thick axial slices (TE/TR/flip=29ms/2000m/90°, matrix=64x64, 256mm x 256mm FOV, receive bandwidth=125KHz) were acquired. Subjects performed a bilateral finger tapping task in a standard block paradigm. Fingers were tapped sequentially in the following order: thumb, middle, pinky, index and ring finger. Subjects were instructed to repeat the sequence as fast as possible without making mistakes. Task performance was recorded with a data glove (Fifth Dimension Technologies, Irvine, CA) and analyzed for tapping rate, error rate and mirror movements. Head motion was monitored using parameters output from the prospective motion correction methodology[6]. Subject data was discarded if motion corruption was present upon visual inspection. Remaining fMRI timeseries data were spatially filtered with a Hamming filter[7] and analyzed for activation by least-squares fitting the timeseries for each pixel to a boxcar reference function plus a slope[8]. The resulting student t maps were overlaid onto high resolution T1-weighted images. For each subject, anatomic ROIs were drawn bilaterally around the SMC, SMA, PMv, PMd, SPL and IPL. Student's t maps and ROIs for each subject were transformed into Talairach space. Talairach transformed Student's t maps were averaged voxel-by-voxel to generate composite maps for each group (Fig 1). In each individual subject, the xyz coordinates (in Talairach space) of the maximally activated voxel were determined for every ROI.

Table 1. Student's t and xyz coordinates of the maximally activated voxel in each ROI for MS patients and controls.

ROI		Controls: Left Hem.				MS Patients: Left Hem.				Controls: Right Hem.				MS Patients: Right Hem.			
		maxT	X	Y	Z	maxT	X	Y	Z	maxT	X	Y	Z	maxT	X	Y	Z
PMd	Mean	1433.0	-31.3	-13.5	59.4	1454.9	-32.7	-16.6	60.0	1432.0	29.3	-17.0	59.6	1384.0	33.8	-16.8	57.6
	Std	456.3	7.5	4.2	4.3	454.3	6.1	4.7	4.1	531.9	7.5	4.9	4.7	448.7	4.0	5.6	5.1
PMv	Mean	1095.2	-55.3	-4.3	30.0	1243.7	-52.9	-7.2	37.9	1119.6	48.8	-1.0	30.5	1254.2	49.9	-6.3	37.6
	Std	400.5	3.5	4.6	14.0	353.3	7.6	7.2	13.7	309.6	6.6	13.7	18.0	448.1	7.8	4.9	11.2
SMC	Mean	1727.5	-37.1	-24.4	51.8	1808.6	-36.2	-27.3	54.3	1942.8	35.6	-24.4	52.1	1776.1	36.1	-26.3	54.4
	Std	525.6	4.8	5.0	4.5	470.8	4.4	6.2	5.6	462.1	3.9	5.7	5.2	482.5	3.8	5.7	6.7
IPL	Mean	1599.2	-39.1	-39.4	50.6	1712.6	-40.6	-37.7	51.5	1650.2	38.6	-34.0	47.9	1528.1	42.5	-32.9	47.3
	Std	325.1	7.9	10.6	7.5	544.2	8.4	10.1	8.5	276.6	4.1	6.7	3.5	476.1	9.6	10.7	12.9
SPL	Mean	1317.2	-25.3	-55.4	51.6	1056.8	-20.2	-63.8	54.0	1062.8	23.9	-58.5	50.0	1003.0	20.7	-58.1	51.9
	Std	289.6	4.8	4.3	8.0	539.9	6.5	6.0	4.0	179.5	4.2	6.3	4.4	473.4	8.6	8.2	13.6
SMA	Mean	1512.4	-6.3	-10.0	54.1	1437.4	-4.3	-7.8	54.6	1394.4	1.5	-10.5	54.5	1421.3	3.6	-8.9	54.1
	Std	440.3	2.8	7.2	4.2	420.9	3.7	5.7	5.2	429.0	3.7	5.7	4.6	429.5	2.4	4.3	6.0

Results

10 healthy controls and 8 MS patients had motion free studies. MSFC scores were 0.46 +/- 0.32 for patients and 0.65 +/- 0.29 for controls. Mean age was 41.1 +/- 9.6 (3 males) for MS patients and 40.5 +/- 8.4 (3 males) for controls. All subjects performed the task well and there was no difference in finger tapping or error rates between MS patients and controls. No mirror movements were detected in any studies. MS and control activation volumes were not statistically different for the SMC, PMv, PMd, SMA, IPL or SPL. Student's t and xyz coordinates of the maximally activated voxel are listed for every ROI (Table 1). The mean displacement between controls and patients are as follows (LH-left hemisphere, RH-right hemisphere): PMd: 3.5+/- 7.0 mm(LH), 5.0+/-8.3 mm (RH) PMv: 8.8+/-18.1 mm (LH), 8.9+/-19.0 mm (RH) SMC: 4.0+/-7.6 mm (LH), 3.0+/-8.3 mm (RH) IPL: 2.4+/-13.1 mm (LH), 4.1+/-10.7 mm (RH) SPL: 10.1+/-7.6 mm (LH), 3.7+/-11.0 mm (RH) SMA: 3.0+/-7.5 mm (LH), 2.7+/-5.6 mm (RH). None of the mean displacements between MS patients and controls represented a significant difference.

Conclusion

After carefully controlling for differences in head motion between MS patients and controls, the Student's t and the xyz coordinates of the maximally activated voxel in the SMC, PMv, PMd, SMA, IPL and SPL during bilateral complex finger tapping were not significantly different. Intrasubject differences in location of peak amplitude were much larger than the observed displacement between controls and MS patients.

References

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