Difficulties Inherent in the Use of fMRI for Communication with Severely Brain-Injured Subjects

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Introduction

fMRI of mental imagery tasks has recently been successfully used to demonstrate functional communication in severely brain-injured patients (Monti et al, 2010).

ROI-based methods focusing on supp. motor area (SMA) have been primarily used to measure responses to commands and questions using motor imagery.

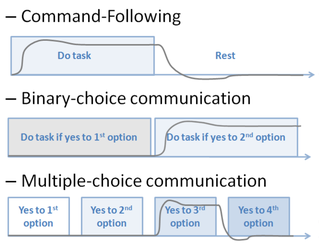
Little is known about the generalizability and variance of these methods.

We investigated potential differences in results obtained from ROI and whole-brain methods, as well as possible dissociations between behavioral and neuroimaging measures of volitional activity.

Methods

Three-part paradigm:

– Command-Following

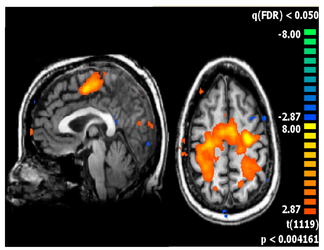


– Binary-choice communication

– Multiple-choice communication

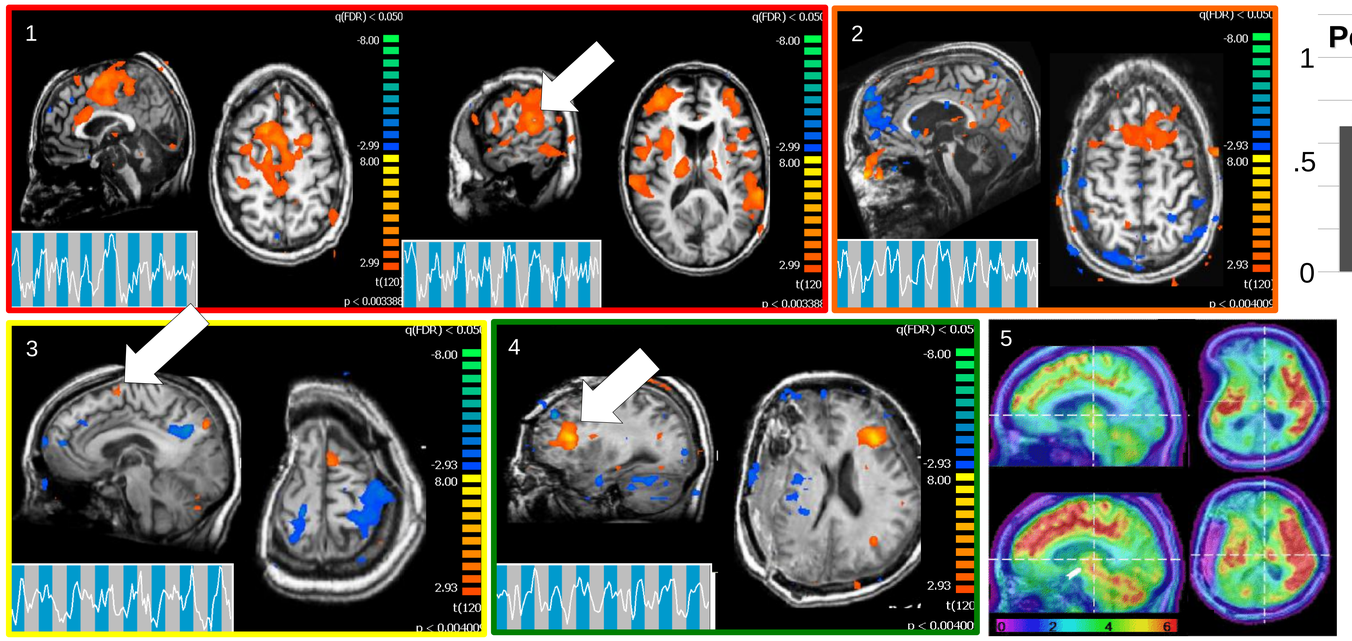
10 normal subjects and 6 brain-injured subjects were scanned (3 longitudinally). Etiology of injury, diagnosis, CRS-R scores, and fMRI results are shown in the table (bottom center). Both whole-brain and ROI analysis methods were used.

Normal Subject Results



All normal subjects tested showed task-related BOLD activity in the SMA during the command-following, binary-choice, and multiple-choice tasks when analyzed with both ROI and whole-brain methods (example shown above, ROI results shown at top right in bar graph).

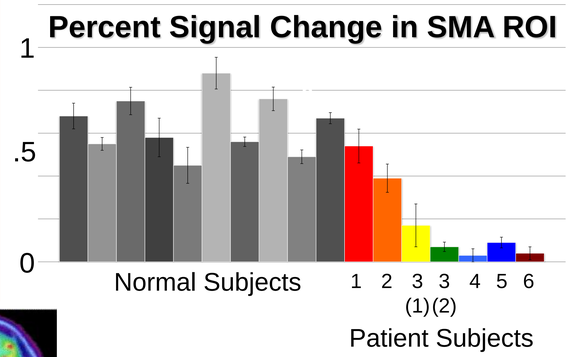
ROI vs. Whole-Brain Analysis Results for Command-Following Task



Arrows indicate significant clusters of task-related activity not captured by the SMA ROI.

For S1 and S3, whole-brain analysis shows task-related statistically significant clusters of activity not captured by the ROI analysis (see arrows).

S3 demonstrated significant changes in brain metabolism and structure following a cranioplasty that occurred between visit #1 and visit #2 (see figure 5, PET image; Voss et al, 2010).



Above: Bar graph of percent signal change in SMA ROI for normal and severely brain-injured subjects with standard error. S1 and S2 show results in the normal range.

Left(1-4): Results from whole-brain statistical mapping during the command-following task ("imagine swimming") (z>2.3, p<.05) for S1, S2, and S3 (visits 1 and 2). Colored rectangles around each figure match to the bars in the SMA ROI figure. S4, S5 and S6 showed no statistically-significant results.

Left(5): PET Images of S3 from before (top) and after (bottom) a cranioplasty.

Evidence of Dissociation Between Behavioral and fMRI Results

Table of Results

						Behavior		Imaging	
Subject #	Age/Gender	Etiology of Injury	TE	CRS-R	Diagnosis	CF	Comm	CF	Comm
1 (Test 1)	25/F	CVA	29	7	MCS	NO	NO	NO	NO
1 (Test 2)	25/F	CVA	29	10	MCS	YES	NO	YES	+/-
2	25/M	TBI	23	NT	LIS	YES	YES	YES	NO
3 (Test 1)	18/F	TBI	6	14	MCS	YES	NO	YES	NT
3 (Test 2)	18/F	TBI	10	19	MCS	YES	NO	YES	NO
4 (Test 1)	58/F	HIE	20	16-19	MCS	YES	NO	NO	NO
4 (Test 2)	60/F	HIE	32	23	EMCS	YES	YES	NO	NO
5	39/M	TBI	60	10-13	MCS	NO	NO	NO	NT
6	40/M	TBI	62	14	MCS	NO	NO	NO	NT

Highlighted rows show clear dissociations between behavioral and fMRI results.

S2 can follow commands and communicate outside of the scanner using head movements, but was unable to communicate using mental imagery in the scanner.

S4 was able to follow commands outside of the scanner on visit 1 and follow commands and communicate outside of the scanner on visit 2 using spoken language, but was unable to follow commands or communicate using mental imagery in the scanner on either visit.

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Conclusions

1. While an ROI-based approach captures responses for all normal subjects, significant variation in the activity patterns of some severely-brain injured subjects suggests that a whole brain analysis may be preferable.

2. Dissociations between the ability to perform basic command following and communication tasks outside of the scanner and the ability to perform these mental imagery tasks may significantly complicate the ability to interpret negative or intermediate results from fMRI measurements.

3. At present, these methods are not optimized to capture the true cognitive abilities of the severely brain-injured population.