

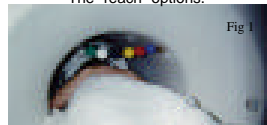
Distributed Functional Neuroanatomy of Human Visually Guided Reach: an Event-Related fMRI Study

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Purpose: Visual information serves a central role for hand-eye coordinated movements (Batista, *et al.*, 1999). However, the neural components that integrate these hand and eye functions have not been determined in humans. In this study we employ fMRI to isolate a neural pathway that drives volitional visually-guided reach actions.

Methods: Contiguous axial images of the entire brain (21 slices) for 8 subjects were acquired on a 1.5T GE scanner with a standard echoplanar sequence. Reaches were performed with right and left hands in response to both visual and auditory instructions targeting one of six colored styrofoam balls suspended horizontally in front of the scanner bore and visible to the subject via the slanted mirror mounted in the head coil. (Fig 1.)

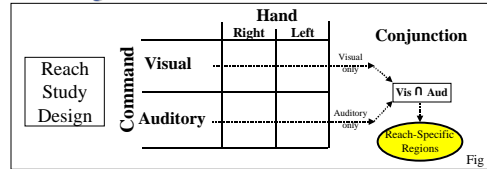
Two experimental paradigms were employed: Event-related and block design. In the case of event-related design, the command and reach tasks were separated in time (Fig 2a). In the case of the block design the command and reach epochs were presented sequentially (Fig 2b).



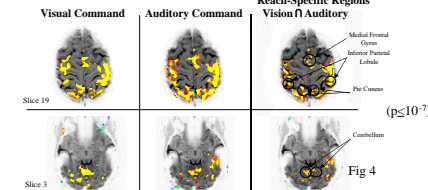
In order to isolate the set of regions associated with the coordination of both visual and motor systems a technique was developed to target all brain areas active in all conditions. This technique (conjunction) biases the results against inclusion of input sensory activity (visual or auditory) and motor execution (right hand or left hand), and towards brain regions that are associated with functions that include both visual and motor-related signals. (Fig 3)

Experimental Design and Analysis Techniques

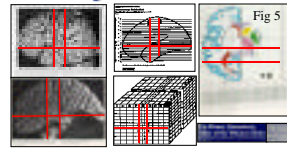
1. Conjunction of Visual and Auditory Commands and Right and Left Hand Reaches



Examples of Conjunction Analyses



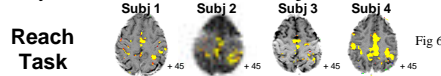
2. Labelling of all active areas



All brain regions that meet the conjunction criteria are labelled by comparison with the human brain Atlas. (Fig 5)

3. Conservation of Active Areas

The conservation technique was developed to isolate activity observed in all subjects excluding the effects of individual differences. Fig 6 illustrates the individual patterns of responses for 4 subjects on a comparable slice of brain. Final Results include only activity conserved across all 8 subjects.



The visual-motor pathway was represented by all areas conserved across all subjects.

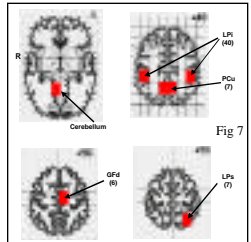
Results: In addition to the primary visual and sensory/motor systems which were computationally extracted for this analysis, the functional anatomy for this simple task included: medial frontal gyrus (BA 6); 3 Parietal Lobe structures, inferior parietal lobule (BA 40), precuneus (BA 7), and superior parietal lobule (BA 7); and the Cerebellum. The average activity centroids are listed in Table 1.

Table 1.

Conserved Reach-Specific Regions

Anatomical Labels	BA	Average Coordinates n=8					
		Left Hemisphere			Right Hemisphere		
		x	y	z	x	y	z
Cerebellum							
Inf. Parietal Lobule (LPI)	40	+37.2	-37.8	+38.2	-35.5	-40.3	+36.1
Pre-Cuneus (PCu)	7	+11.7	-57.3	+40	-13.9	-52.5	+37.8
Medial Frontal Gyrus (GFD)	6	+18.7	-5.5	+52.5			
Sup. Parietal Lobule (LPIs)	7	+25.5	-54.83	+55			

Reach Specific Regions n=8



The location of the average centroids are indicated on the axial standard Human Atlas templates. (Fig 7) Image left is brain right.

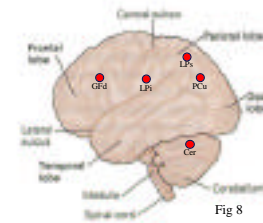


Fig 8 shows a sagittal view of the centroids (collapsed over the x axis) to illustrate the hand-eye coordination Reach-Network.

Conclusions: These results suggest a specific pathway for visually guided motor tasks that incorporates inputs from the Frontal and Parietal Lobes, as well as from the Cerebellum. This pathway provides a foundation for future models of visual integration within motor control systems.

* Batista, A.P., Buneo, C.A., Snyder, L.H., Anderson, R.A. *Science*, 285, 257-260, 1999.

