

Functional imaging of motor experience and expertise during action observation

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Background

- There is evidence that motor system influences perception and *vice versa*
- Studies in monkeys: "Mirror system" matches observed and executed actions*
- TMS and imaging studies show a similar action observation system in humans
- Previous studies: confined to simple grasping actions

Questions

Seeing what we can do:

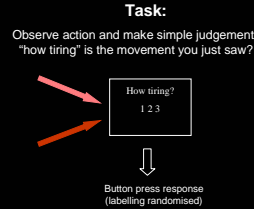
- What is the relationship between what you see and what you can do?
- Is there an influence of motor expertise on the visual system?
- Is the activity in the human action observation system (premotor cortex, parietal cortex and superior temporal sulcus) influenced by the motor repertoire of the observer?

Subjects

Subjects grouped according to motor expertise:
 • 10 expert ballet dancers
 • 9 expert Capoeira dancers
 • 10 non-expert controls
 male, age 18-27 years, right-handed, normal vision

Stimuli

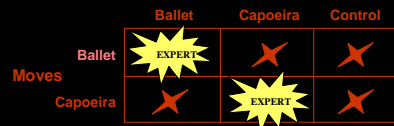
- 24 x 3 sec clips of classical ballet and Capoeira movements + null stimuli (black screen)
- Clips match for speed, body part, body localisation and movement direction (with aid of choreographer)
- Models matched for body shape and appearance
- Neutral chromable background
- Faces blurred



Design and Analysis

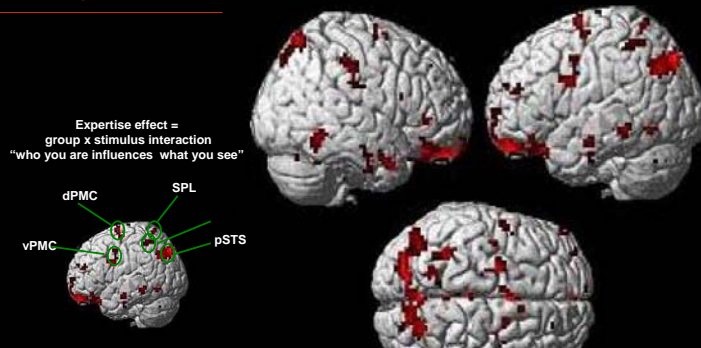
- 1.5T Magnetom VISION system (Siemens).
- 30 axial slices, 2.5 mm thickness, TR= 3.15 s, 280 scans per subject.
- SPM2 (Wellcome Department of Imaging Neuroscience) (www.fil.ion.ucl.ac.uk/spm)
- (SPM11) for each subject and stimulus conditions
- Mixed-effects analysis, 2x3 model: - Stimulus (ballet or capoeira)
 - Group (ballet dancer or capoeira dancer or control)
- F-test, for group by stimulus interaction
- Extent threshold 5 voxels

Subjects



Results I Activations in the expertise interaction

Brain regions	Talairach Coordinates	Z-score
L Dorsal precentral gyrus	-54 -6 72	4.05*
L Superior parietal lobe	-21 -57 69	3.70
R Superior parietal lobe	24 -66 63	3.88*
L Posterior intraparietal sulcus / Superior parietal lobe	-33 -54 57	3.37*
L Precentral gyrus	-15 -54 51	3.88
R Intraparietal sulcus / postcentral sulcus	33 -42 48	3.68*
R Supramarginal gyrus	57 -30 48	4.00
L Precentral gyrus	-54 0 45	3.66*
Retrosplenial gyrus	0 -33 36	4.08**
L Posterior Superior Temporal Sulcus	36 -39 -66	4.04*
L Ventral Precentral gyrus	-48 3 27	4.17
L Posterior cingulate gyrus	-3 -57 27	5.11**
R Cingulate gyrus	3 15 27	5.08**
R Parieto-occipital fissure	21 -60 27	3.79
R Caudate nucleus	15 -9 18	3.92
R Inferior frontal gyrus	54 36 3	3.57
R Head of caudate	9 12 -6	3.45
R Lateral occipital sulcus	63 -48 -9	3.97
R Lateral occipital sulcus	-51 -63 -9	3.82
L Occipital sulcus / Middle temporal gyrus	-60 -39 -9	4.14
Medial frontal gyrus	0 39 -15	4.75**
L Lateral orbital gyrus	33 36 -18	3.92
L Middle temporal gyrus	-60 -12 -18	3.56
R Parahippocampal gyrus	33 -18 -21	4.88**
L Lateral orbital gyrus	-27 24 -27	4.61
R Anterior middle temporal gyrus	54 6 30	4.46
R Anterior inferior temporal gyrus	51 12 -36	3.68

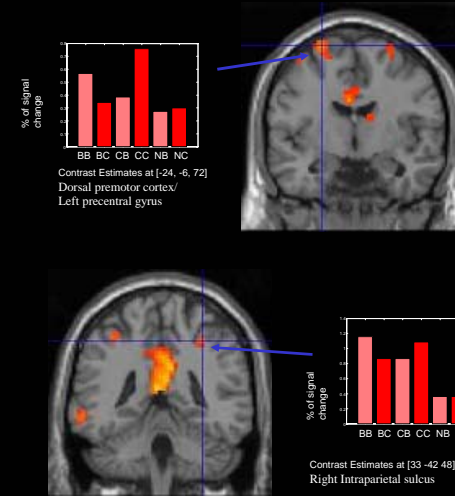


* Activations within the action observation system: Small Volume Correction (SVC) p < 0.05 (ref 2,3)
 ** Activations outside the action observation system: P < 0.05 corrected for multiple comparisons over whole brain

Results II

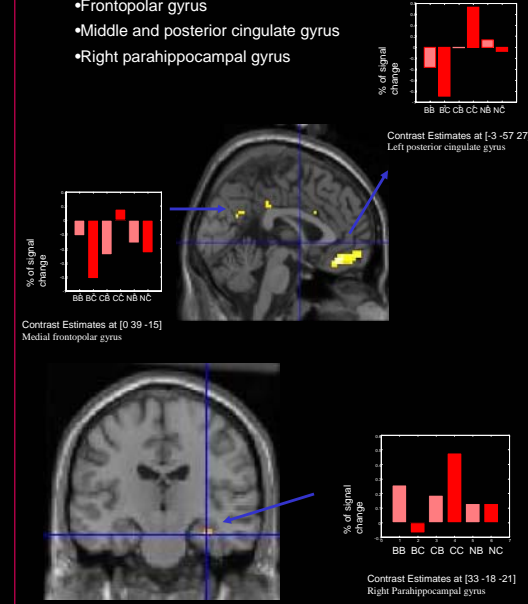
• Within the action observation system:

- Premotor cortex - dorsal (dPMC)
 - ventral (vPMC)
- Parietal cortex: - intraparietal sulcus (IPS)
 - superior parietal lobe (SPL)
- Superior temporal sulcus (STS)



• Outside the action observation system

- Frontopolar gyrus
- Middle and posterior cingulate gyrus
- Right parahippocampal gyrus



BB: Ballet dancers watching ballet CB: Capoeira dancers watching ballet NB: Non-experts controls watching ballet
 BC: Ballet dancers watching capoeira CC: Capoeira dancers watching capoeira NC: Non-experts control watching capoeira

Discussion

- We observe activations associated with the motor expertise of the observer in areas within and outside the action observation system
- These activations are greater for actions in the motor repertoire of the observer than for those that are not
- Within the action observation system:
 - Known somatotopy: dPMC proximal/leg, vPMC distal/hand
 - Consistent with two distinct parietal-premotor circuits:
 - SPL-dPMC
 - IPS-vPMC
 - pSTS: biological movement, intention analysis
- Outside the action observation system:
 - A separate activation in a fronto-medial circuit is produced by the motor expertise
 - Frontopolar gyrus (emotional engagement / action understanding)
 - Middle and posterior cingulate gyrus (episodic memory, familiarity)
 - Right parahippocampal gyrus (visuospatial memory)

Conclusion

- Motor expertise evokes activations within the action observation system
- Mirror activations not just kinematic or body part
- Familiarity / emotion engagement system is influenced by motor repertoire
- What you can do influences action observation
- Is there difference due to better perception or better prediction?

References

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