The Role of the Lateral Premotor Cortex in Conditional and Imitated Praxis

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Summary

• Study designed to test the hypothesis that the lateral premotor cortex has a specific role in conditional selection of actions on the basis of abstract cues
• PET study compared local cerebral blood flow during an abstract conditional task to blood flow during imitation
• The abstract conditional task was very well learnt before scanning
• There was no detectable activation of premotor cortex during the imitation or abstract conditional task
• It is possible that the role of premotor cortex is specific to the early phase of motor conditional learning
The role of the lateral premotor cortex (LPM C) in man is still not clear. LPM C may be important when action selection is conditional on abstract cues from the environment.

- Monkeys with LPM C lesions are unable to relearn a task which requires them to select one of two movements on a lever depending on a nearby colour cue [1]
- Patients with focal LPM C strokes may be unable to learn to associate abstract stimuli with motor acts [2]
• In less abstract tasks, LPMC lesions do not impair relearning
  – LPMC lesioned monkeys can relearn to select one of two actions on a lever according to a colour cue if the cue is on the lever itself (rather than nearby) [3]
• Apraxic patients also have difficulty with abstract conditional motor tasks
  – Many patients with apraxia cannot mime a gesture to command, but find imitation and tool use easier [4]
• This study is designed to test the hypothesis that abstract conditional tasks activate premotor cortex more than less abstract tasks such as imitation
Subjects learnt two related tasks: Imitation (I) and Abstract Conditional (AC) (see next panel).

Each task involved the cued right-handed performance of four hand gestures which were unfamiliar to our (English) subjects, but differed in the cue that signalled which action to perform.

In the AC task, subjects saw a ready signal, followed by one of four abstract cues which signalled which gesture to perform (right). They then saw a video of the gesture, which they ignored. This cycle repeated every 12 seconds.

In the I task, subjects saw a ready signal, a video of one of the gestures, which they imitated, then the associated abstract stimulus, which they ignored, again repeated every 12 seconds.
Abstract Conditional

Ready → Stimulus signals correct gesture → (Performance by subject) → Ignored video → Ready →...

Imitation

Ready → Video to imitate → (Performance by subject) → Ignored Stimulus → Ready →...

Ready Video to imitate

Ignored Stimulus signals

(Performance by subject)

Ready

Imitation

(Performance by subject)
Subjects and Methods

• 9 normal right handed volunteers
  – aged 37-57 (4 male, 5 female).

• Study protocol
  – 90 minutes training before scanning (45 minutes per task)
  – Scans were 5 I, 5 AC, 2 rest, random order
    • Rest was same visual input, but without performance.
  – bolus injection of O\textsuperscript{15} H\textsubscript{2}O in a CTI 953B PET scanner

• Analysis
  – Scans realigned with SPM96, normalised to the Talairach template with SPM95, smoothed to 16mm. Statistical analysis used standard (default) settings in SPM96.
  – All SPMs thresholded to p<0.001 uncorrected
Results - Overview

• All subjects learned stimulus/gesture association
  – No errors during scanning

• Activation of SMA but not LPMC during AC and I compared to rest
  – No differences in LPMC at any threshold

• Very little difference between AC and I
  – No area surviving correction for multiple comparisons

• Lack of LPMC activation compared to rest was unlikely to be due to LPMC activation during rest scans
  – Comparison of rest scans in this study with those of another study with eyes closed found trend for SMA activation in this study, but not for premotor cortex
Results: Imitation vs Rest

SMA / Cingulate 24
L Thalamus
L M1, S1, 5, 40, (7)
Visual 18
R M1
R S1 / 40
Results: Conditional vs Rest

- SMA / Cingulate 24
- L Thalamus
- L M1, S1, 5, 40, (7)
- Visual 18
- R M1
- R 40 / ?7
Results: Conditional vs Imitation

AC minus I

I minus AC

Body of R HC

L BA 8 (FEF)

L cingulate 23
Conclusions

- No support for hypothesis that LPMC is involved in abstract conditional action selection
- No activation of LPMC by performance of complex hand gestures in either task
- Marked activation of thalamus, SMA / cingulate in both tasks
- LPMC may be involved in selection tasks early in learning, but not when task is well learnt, regardless of the mode of action selection
References

1) Halsband, U. and Passingham, R. E. (1985) Premotor cortex and the conditions for movement in monkeys (Macaca fascicularis), Behav Brain Res 18, 269-77

2) Passingham, R. E. (1986) Cues for movement in monkeys (Macaca mulatta) with lesions in premotor cortex, Behav Neurosci 100, 695-703
