Novel insular cortex and claustrum activation observed during a visuomotor adaptation task using a viewing window paradigm.

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Introduction

The present study describes the use of a viewing window paradigm[1] to examine the neural correlates of a visuomotor adaptation task.

Previous research has reported a wide range of recruited brain areas when participants perform a visuomotor adaptation task[2]. However, traditional tasks suffer from a sparse visual environment that does not map well onto conditions in which a visuomotor transformation would normally be required.

To further clarify these neuronal underpinnings, a functional magnetic resonance imaging (fMRI) study utilizing a viewing window paradigm was performed.

Experiment 1

Purpose

To examine the neural substrates of a complex, visually rich, visuomotor adaptation task.

Method

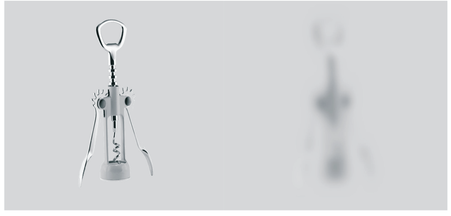
Participants

Twelve (5 male, mean age = 27) individuals participated. All subjects were right handed, and had normal or corrected-to-normal vision.

Stimuli

Digital images were modified using a Gaussian blur algorithm. This procedure resulted in two distinct images of each object.

Example Images

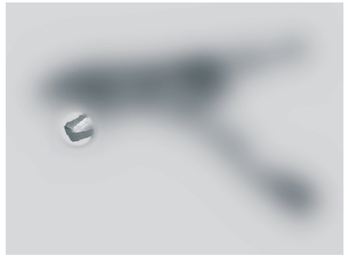


Clear Image Blurred Image

The Viewing Window

The "window" is a circular region, controlled by a touchscreen monitor, which allows participants to move the window via a stylus held in their dominant hand.

Viewing Window Example

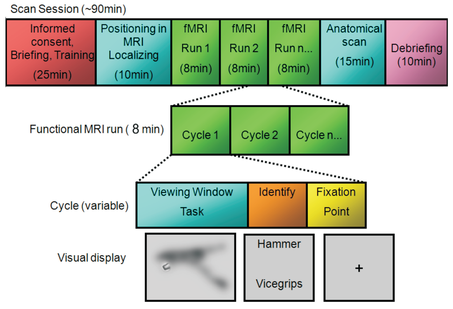


Procedure

Two visuomotor "flip" conditions were created for the identification task by varying how the participant's body movements affected the onscreen movement of the viewing window.

Movement Type	X-Axis Body Movement	Y-Axis Body Movement
Normal	Remains Veridical	Remains Veridical
Flip in X-Axis	Results in opposite on-screen movement	Remains Veridical
Flip in Y-Axis	Remains Veridical	Results in opposite on-screen movement

Each functional scan was 8 minutes in duration and was run 4 times (with 16 objects per run, 64 total objects). Participants were given up to a maximum of 20s to explore the object, and 5s to make a response. Any remaining time was added to the fixation period.



Results

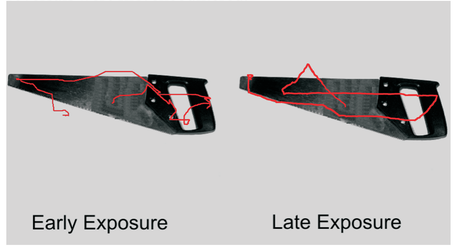
One participant was excluded from the analysis due to excessive head movement, and one participant was released from the experiment early due to experimenter concern of claustrophobia. Data analyses were performed on the remaining 9 participants.

The first functional run from each participant was discarded as practice. All functional scans had a signal to noise ratio of .50 or greater.

Behavioual Data

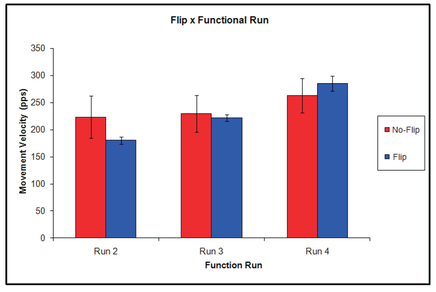
Sample Scan Paths

Participants showed more natural and directed movements during later exposure to a reversal condition than to when reversals were first encountered.



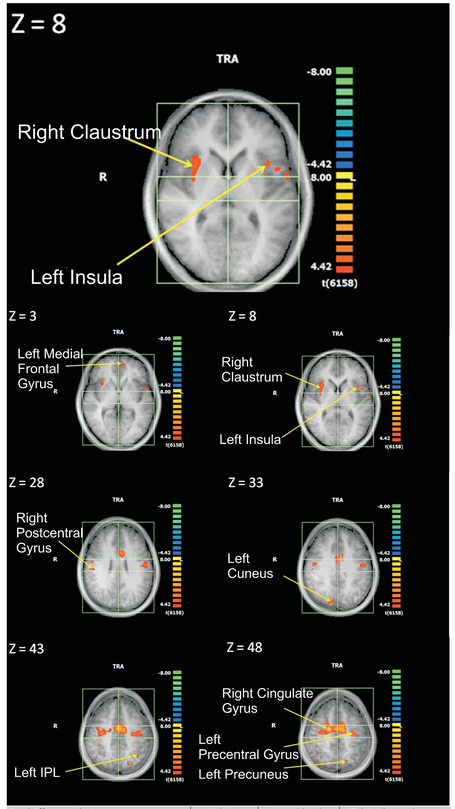
Movement Velocity

Participants moved the viewing window faster in later runs when compared to earlier runs. A significant Run x Flip interaction was observed, with the viewing window being moved at a lower velocity when a visuomotor reversal was introduced in Run 2 ($p < .05$), but at par with the no flip condition by Run 4 ($p > .05$). That is, a participant's velocity was not affected by a reversal in later runs.



Functional Data

Following standard pre-processing, a multi-scan fixed-effects GLM analysis with four predictors (fixation, response, normal movement, and flip in movememnt) was used to determine areas that were activated significantly more during a flip in the x-axis or flip in the y-axis when compared to the normal condition.



Fixed-Effects Analysis Anatomical location of Peak Voxel	Volume (voxel)	Voxel-level (T)	Talairach coordinates (x, y, z)
Right Post-Central Gyrus	260	5.034	48, -19, 28
Right Cingulate Gyrus	16080	6.889	-3,-4,43
Right Claustrum	882	5.401	33,-1,7
Right Cuneus	266	4.767	15,-82,34
Left Medial Frontal Gyrus	169	5.095	-12,50,4
Left Precuneus	438	5.135	-18,-67,49
Left Precentral Gyrus	4889	6.489	-30,-16,49
Left Inferior Parietal Lobule	140	4.918	-36,-58,44
Left Insula	96	4.867	-39,14,10

Conclusions

In addition to the areas of activity typically observed during visuomotor adaptation, the current study demonstrates two new areas of activation. Within insular cortex and the claustrum, a significant BOLD response was observed during conditions of visuomotor adaptation.

These two additional regions of activation may be a consequence of the increased complexity inherent in the viewing window task. Previous work using viewing window type tasks have also shown patterns of additional activation when compared to whole-viewing conditions[3].

The increased demand of spatial and temporal integration, and the necessity to differentially allocate attentional resources may also play a role in the activity observed.

Implications

These results confirm the diverse nature of the systems recruited to perform a required visuomotor adaptation, and offers two new areas requiring further research targeting their role in this essential skill

References

1) Baugh LA, Marotta JJ. A new window into the interactions between perception and action. J. Neurosci. Methods 2007; 160: 128-134.

2) Girgenrath M, Bock O, Seitz RJ. An fMRI study of brain activation in a visual adaptation task: activation limited to sensory guidance. Exp. Brain Res. 2008; 184: 561-569.

3) James, T., Huh, E., & Kim, S. (2009). The fusiform face area is recruited more for sequential than holistic processing: an aperture viewing study. Journal of Vision, 9.

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NSERC CRSNG MHRC Centre on AGING