Neural Mechanisms of Hierarchical Planning during Navigation

Balaguer Jan[1], Hassabis Demis[2], Spiers Hugo[2], Summerfield Chris[1]

1 University of Oxford, Oxford, UK. 2 University College London, London, UK.

1 Introduction

Planning, or making multiple decisions in order to achieve a **goal**, is computationally costly. Efficient planning can be achieved by exploiting hierarchical representations.

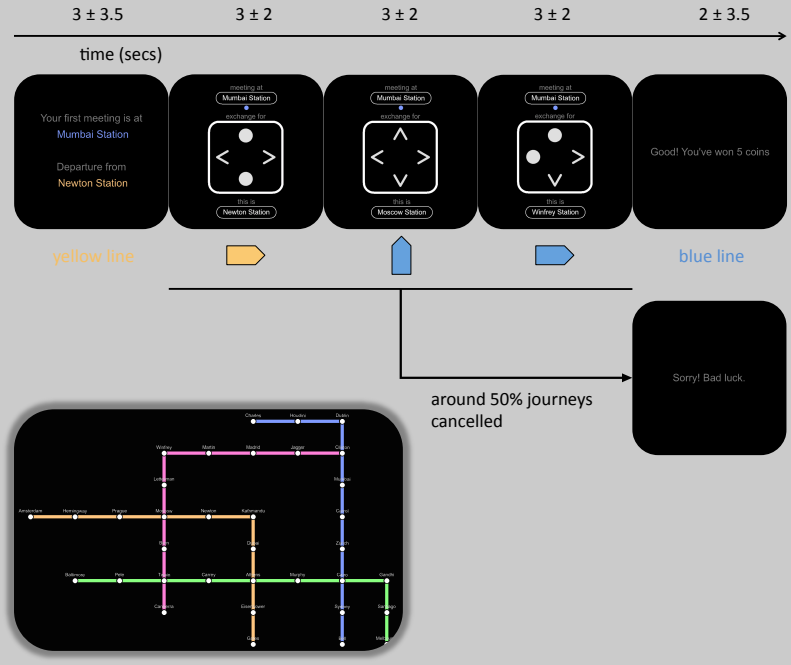
It has been shown that humans spontaneously chunk abstract spaces into multiple **contexts** in a **hierarchical fashion** [1].

However, it is still unknown whether **humans plan hierarchically, and if so, which brain regions are involved**.

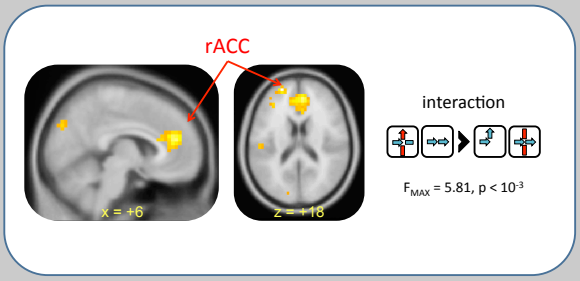
2 Methods

N = 19 participants (age 25.3±4.0, 11 males) performed a navigation task within a virtual **subway network** (*station* = state and *line* = context) with which they were familiar from earlier training, while undergoing **functional Magnetic Resonance Imaging (fMRI)**. Completed journeys were financially rewarded after participation (journeys could be randomly cancelled on every step, with fixed probability, motivating efficient navigation). The map was shown during a preliminary training session but not during the scanning session. Possible directions (actions) were North / South / East / West. **Regular**, **exchange** and **elbow** stations allowed us to disentangle between effects due to *number of possible directions*, *direction switch*, and *line switch*.

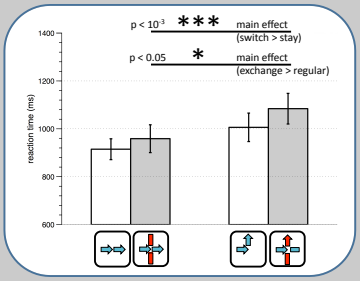
3 Design



4 Results 1 – rACC signals context switch



BOLD activity during navigation

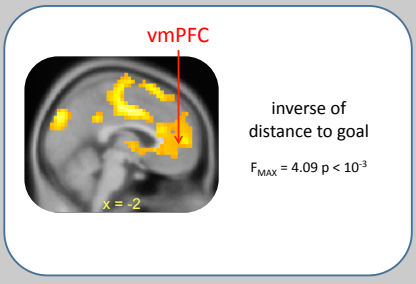


Reaction Times (RT)

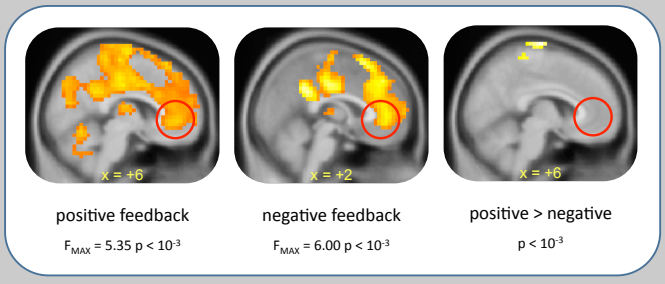
Greater activation was found in more rostral portions of the anterior cingulate cortex (rACC) for switches of context, as shown by its sensitivity to the interaction *[switch > stay exchange] > [switch > stay regular]*.

This result is in contrast with Reaction Times (RT), for which main effects of *[switch > stay]* and *[exchange > regular]* are significant, but not the interaction.

5 Results 2 – vmPFC tracks distance to goal but not reward



Distance to goal



Feedback

BOLD activity in the ventromedial prefrontal cortex (vmPFC) **inversely correlates with distance to goal**.

Strikingly, it was consistently activated at the end of each journey (feedback time), independently of the outcome (positive or negative).

6 Discussion

This results provide evidence that humans exploit hierarchical structures during navigation, dividing the space into multiple *contexts*.

The **rACC** plays a key role in signalling **context switching** in pursuit of reward.

Additionally, we report evidence for a new role of the vmPFC in tracking distance to goal but not reward outcome.

References

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Correspondence : jdobalaguer@gmail.com