# Distinct neural correlates of a reward-based motor skill learning in early and advanced stages

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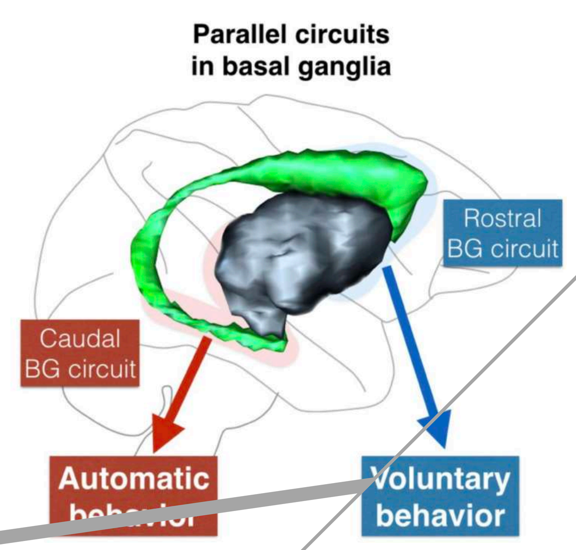
**Th646**

## Introduction

- Motor skill learning is a complex process of generating new movement patterns guided by evaluative feedbacks to perform a motor task better, faster and more accurately
- The basal ganglia (BG) plays a key role in reward-based motor skill learning
- Recent primate studies suggest rostro-caudally separated circuits in the caudate nucleus for object skill learning
- Little has been known about the exact role of BG, especially caudate nucleus, in reward-based motor skill learning in human



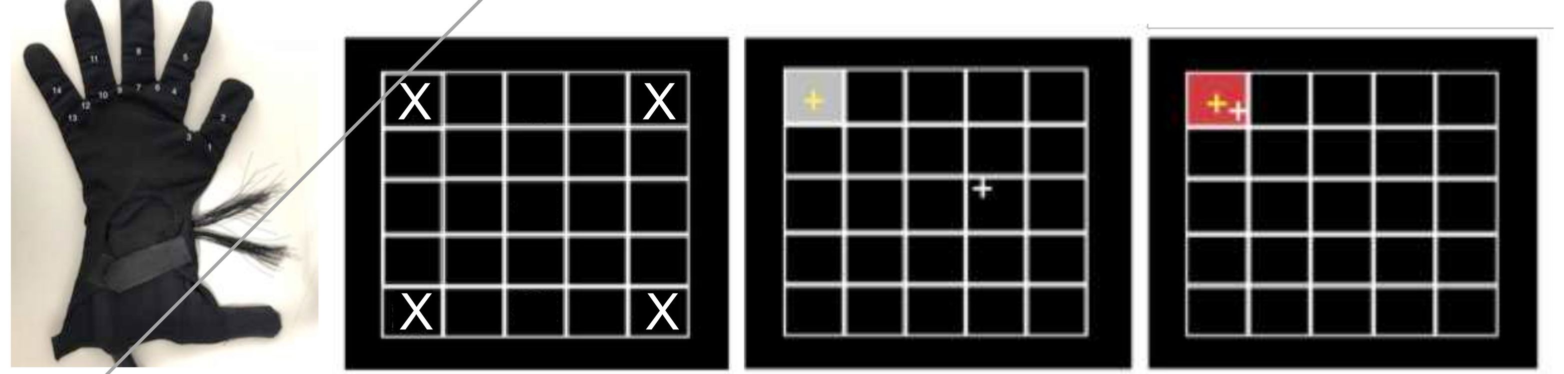

Kim and Hikosaka, 2015

## Research questions

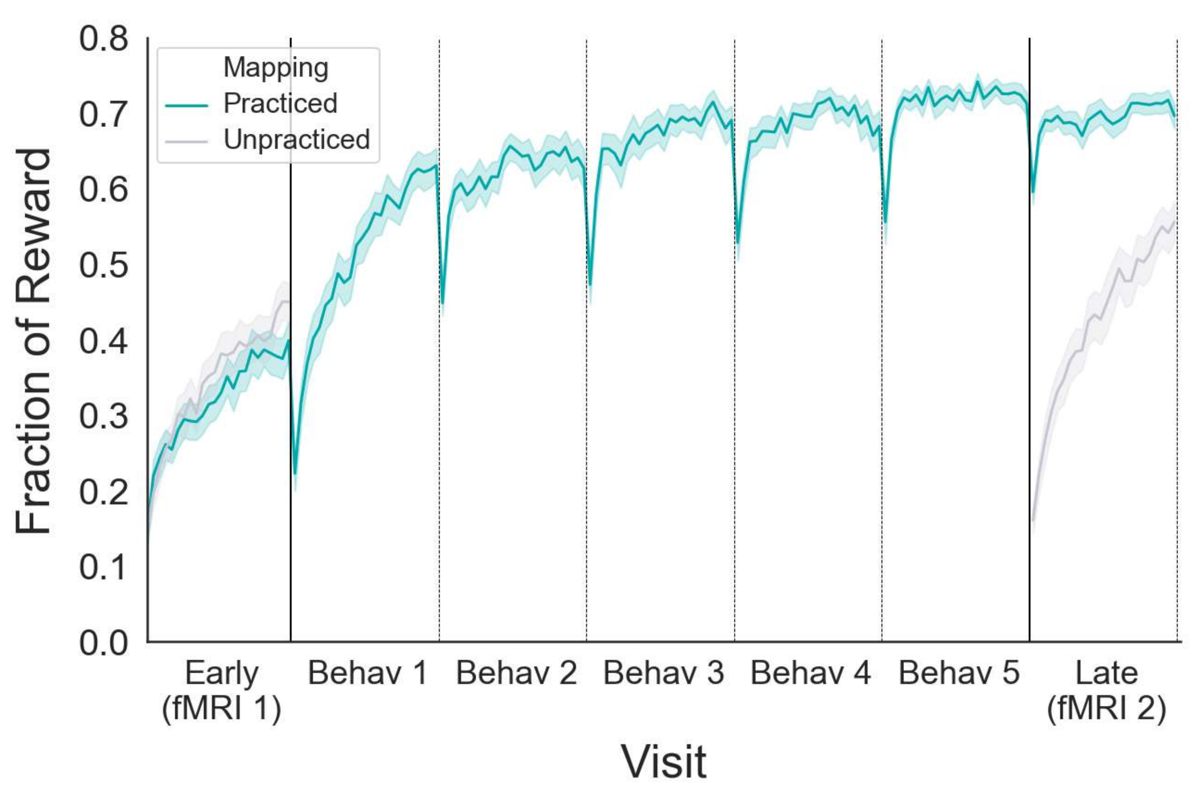
- Is the human caudate nucleus functionally separated for the early and advanced stages of motor skill learning, as suggested by previous primate studies for object skill learning?
- How are the basal ganglia and the cortical regions related with reward (such as vmPFC) different in representing motor skill learning?

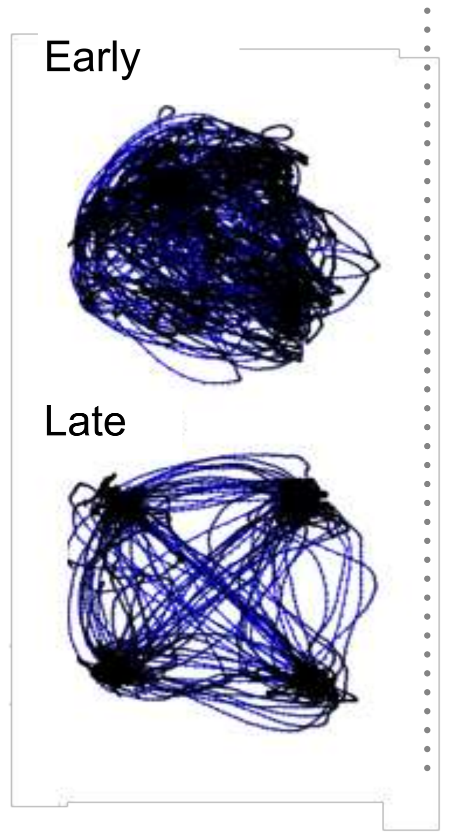
## Experimental design

- Explained in Th647 poster (<Building a "cognitive map" of a reward-based motor skill learning>)

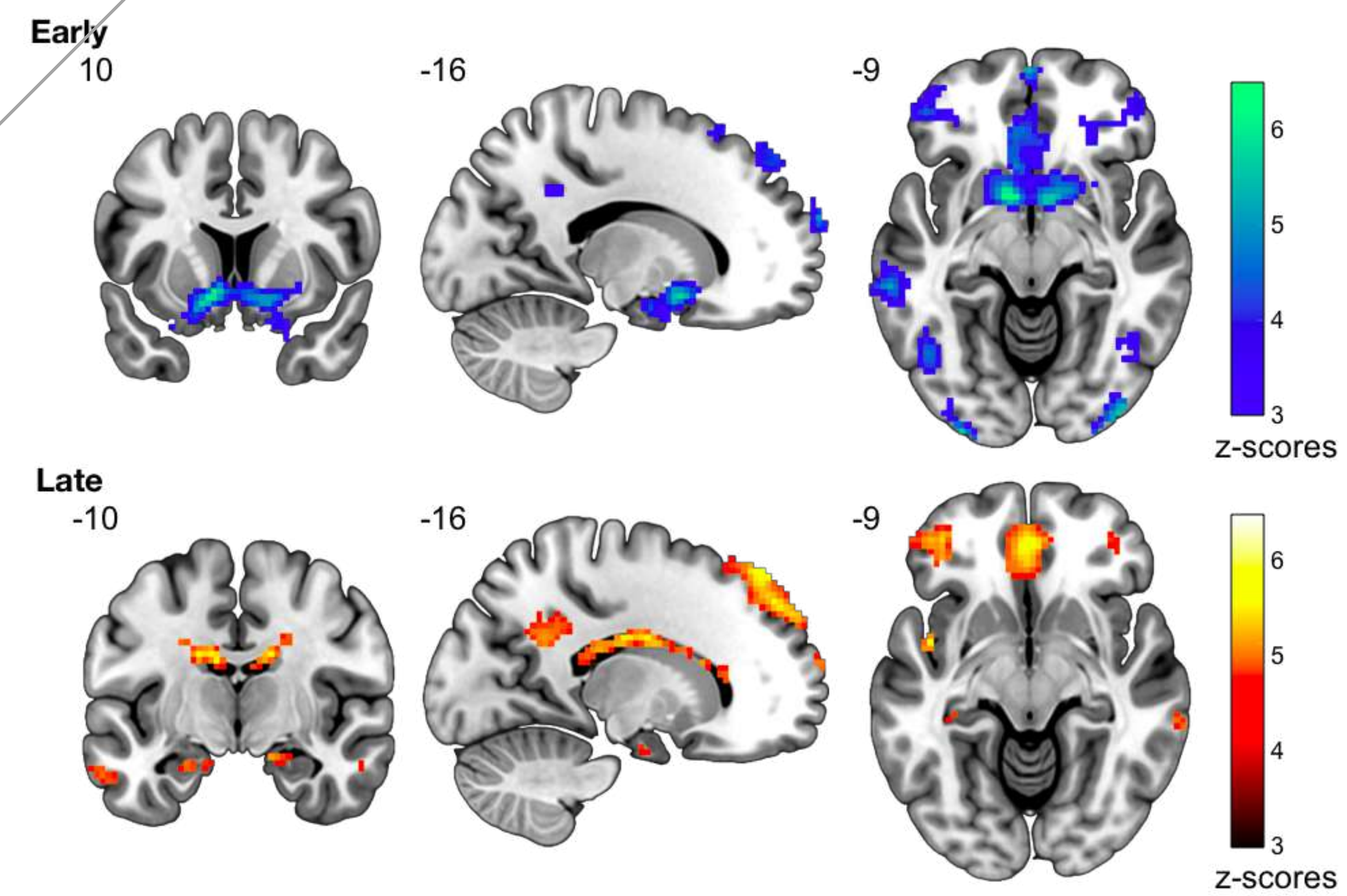


## Improvement of motor skill to the plateau level



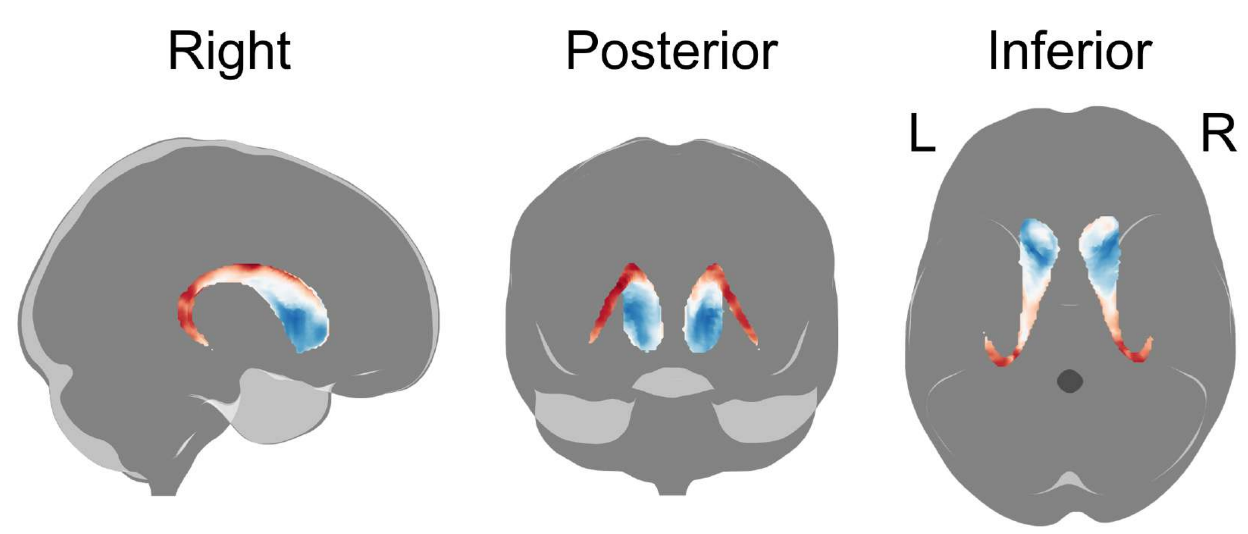



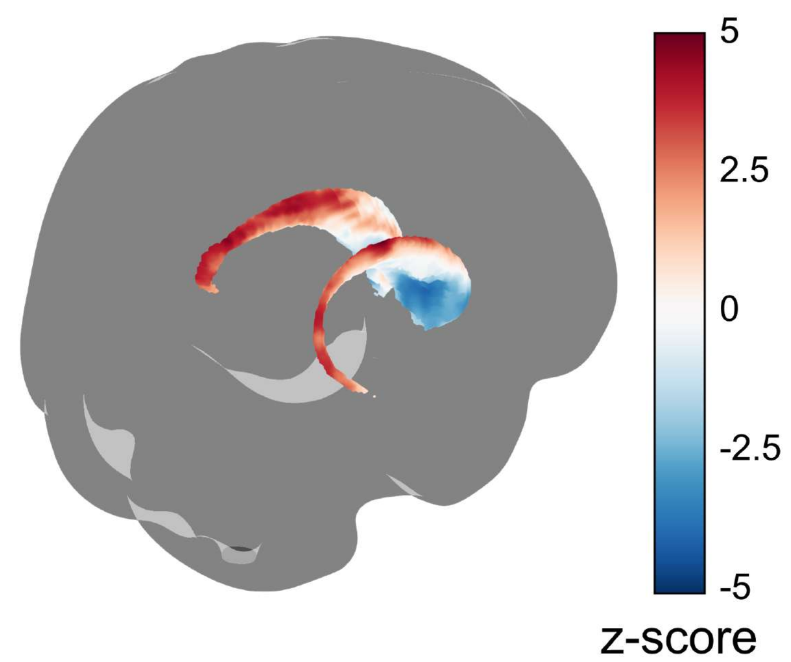

## Neural correlates of reward modulation in early and advanced stages of learning




- Voxel-wise GLM analysis with a parametric regressor modulating reward rate estimated every 1 second (Uncorrected $p < 0.001$, cluster size > 30 voxels)

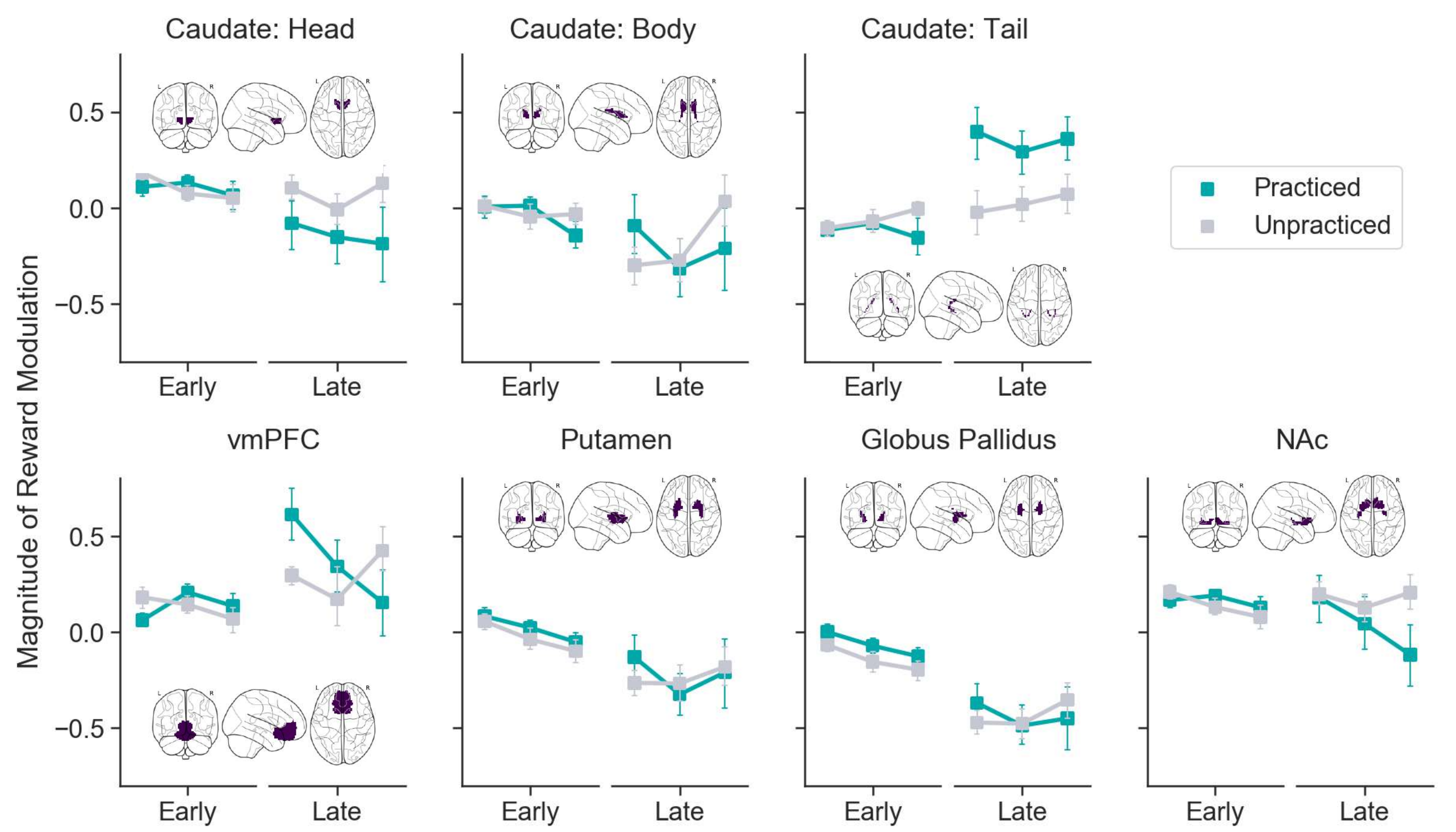
## Gradual transition of reward modulation in the caudate nucleus as a result of motor skill learning




- Late stage - Early stage: voxel-wise paired t-test, converted into z-scores
  - **Blue: higher reward modulation in Early stage**
  - **Red: higher reward modulation in Late stage**

## Region-of-interest (ROI) analysis




## Conclusion

- In consistent with primate studies for object skill learning, we found double dissociation of responses in the caudate nucleus to rewards in the early and late stages of motor skill learning.
- However, the changes of reward modulation was not found in cortical areas related with reward such as vmPFC.

## Future works

- We plan to…
  - manually extract ROIs for the entire caudate nucleus for further validation of our current results, to overcome difficulties in defining sub-regions of the caudate nucleus and individual differences in exact anatomical locations
  - conduct a 7-T fMRI experiment to investigate the role of fine structures of BG, e.g., substantial nigra, in reward-based motor skill learning
  - perform a TMS-fMRI study to causally investigate the suggested role of BG and cortico-subcortical interaction during acquisition of novel motor skills (Dayan et al.), targeting dlPFC for early stage and M1 for late/consolidation stage to perturb early skill acquisition and/or late skill consolidation

## References

- Kim, H. F., & Hikosaka, O. (2015). Parallel basal ganglia circuits for voluntary and automatic behaviour to reach rewards. Brain, 138(7), 1776-1800.
- Dayan, E., Herszage, J., Laor-Maayany, R., Sharon, H., & Censor, N. (2018). Neuromodulation of reinforced skill learning reveals the causal function of prefrontal cortex. Human brain mapping, 39(12), 4724-4732.

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