Poster 295

Imbalanced Dual Systems of Decision Making in Healthy Older Adults and Stroke

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Introduction

- Healthy decision making is driven by a dual-system of control comprising habitual (fast, automatic) and goal-directed (slow, deliberate) strategies. Each are thought to be implemented in separate cortico-basal ganglia loops.[1]
- Goal-directed control has been shown to decline with healthy aging, with increased use of habitual strategies.[2]
- An imbalance of this dual-system has also been found in various basal ganglia-related neurological diseases, such as Parkinson's Disease, Obsessive Compulsive Disorder, and Binge-eating Disorder.[3,4]
- Given the presence of local and remote structural damage and neural dysfunction after stroke, it is possible that this dual-system balance may be impaired beyond healthy aging in individuals with stroke.
- Here, we examine (1) the behavioral effects of stroke on the balance between habitual and goal-directed decision-making compared to healthy young adults (YA) and healthy older adults (OA), and (2) examine cortico-striatal functional connectivity in a preliminary analysis of a subset of data.

Methods

- Forty-one participants (25 YA, 11 OA, 7 stroke) were trained on and completed a two-step Markov Decision Task, adapted from Daw et al. (2011)[5] and Gillan et al. (2015[6]; Fig 1). Data from 6 participants were thrown out due to low learning rates on the task (2 YA, 3 OA, 1 stroke). MRI data collection was disrupted due to COVID-19; thus, we present fMRI data on 4 stroke participants and use data from 30 YA from the Human Connectome Project.

Task

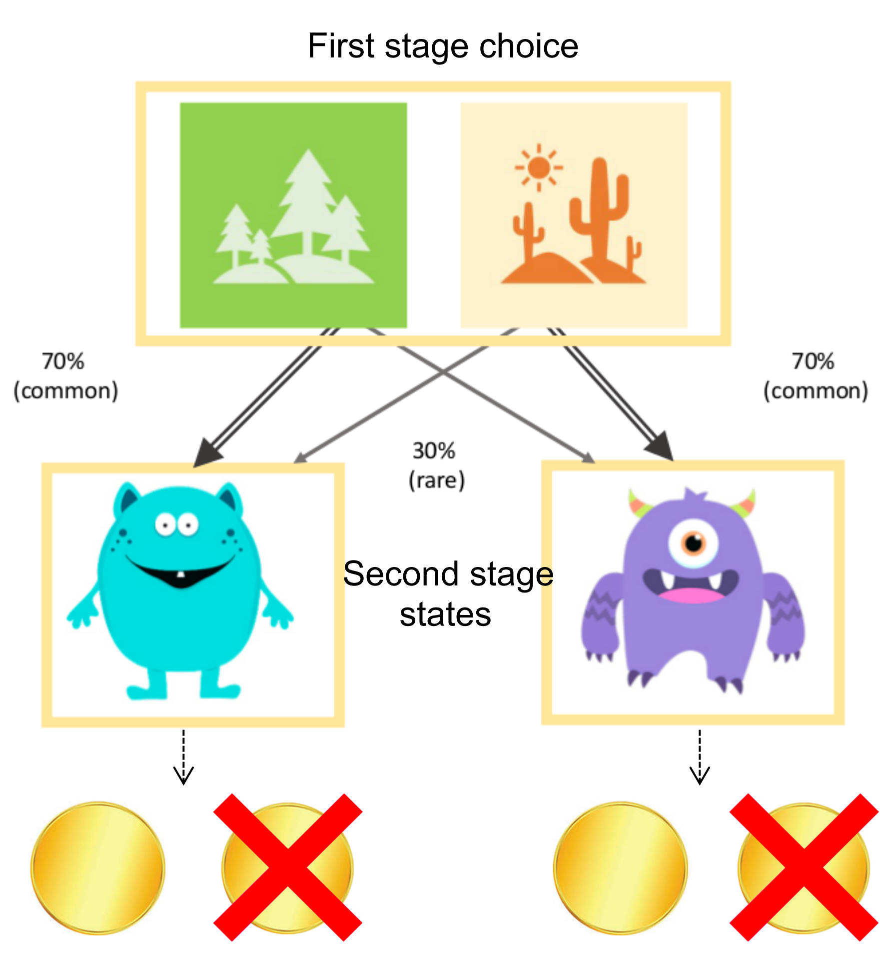

Figure 1. Two-stage Markov decision task (adapted from ref. X) On each trial, participants made a choice between two locations. One location more commonly (70%) led to one of the second-stage states, and rarely (30%) led to the other. Each second-stage state was associated with slowly changing reward probabilities.

Task Modeling and Group Behavioral Analysis

- Decision making behavior was fit at the subject-level, according to a hybrid algorithm from Daw et al. (2011)[5]
- Choices were assumed to be driven by a weighted combination, *w*, of learned action values via model-based reinforcement learning (Bellman's equation) and model-free SARSA (lambda) TD learning. A weighting greater than 0.5 indicates goal-directed behavior, a weighting less than 0.5 indicates habitual behavior.
- R Stan's Markov Chain Monte Carlo (MCMC) technique was used to perform Bayesian parameter estimation.
- A Kruskal-Wallis test was used to examine differences in mean *w* between groups.

Resting-State Analysis

- We used the CONN toolbox for preprocessing and first-and second-level analyses.
- We examined seed-to-voxel and a priori seed-to-seed intrahemispheric connectivity of the caudate and putamen[7] (defined individually with Freesurfer) to the lateral prefrontal cortices (LPFC) and lateral sensorimotor regions (SM) respectively, defined with CONN's network atlases.

Results

1. Healthy OA and individuals with stroke were least goal-directed.

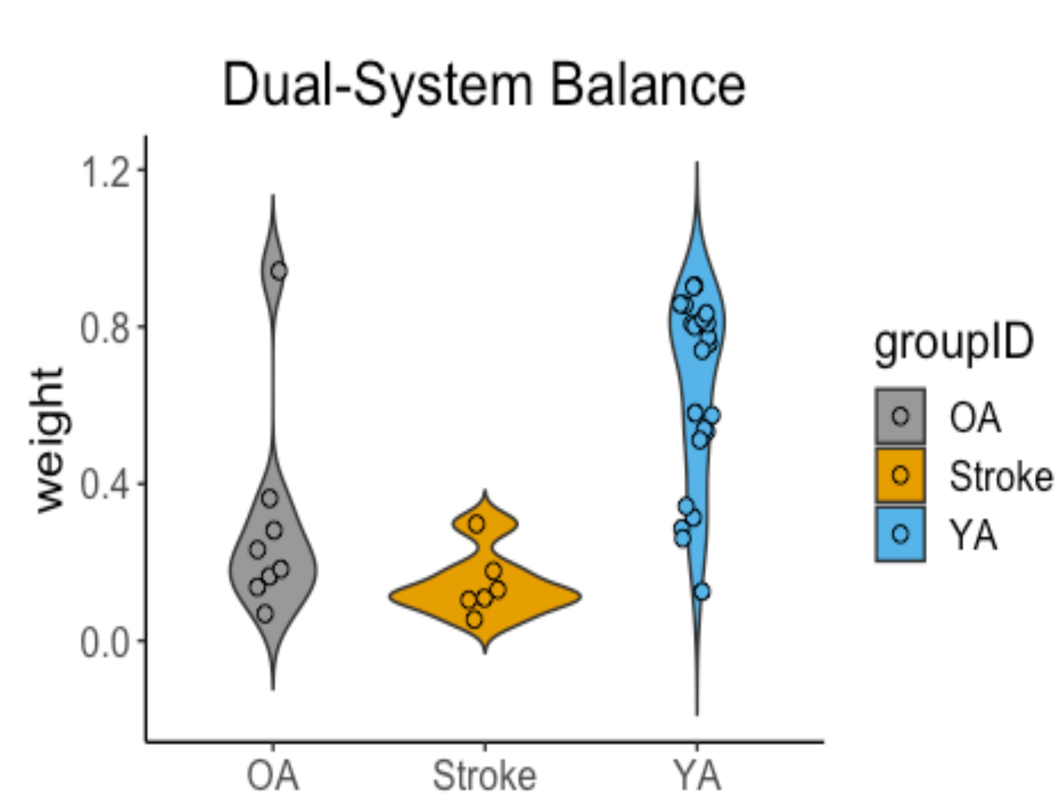

Figure 2. Behavioral Results. Overall the YA group was most goal-directed (mean w=0.64), followed by the OA group (mean w=0.29), then the stroke group (mean w=0.15). w was significantly different between groups (χ^2 =15.99, $p<0.001$), where the YA group was significantly more goal-directed than both the OA and stroke groups ($p<0.05$). No significant difference was found between the stroke and OA groups.

2. Healthy YA had greater caudate-LPFC connectivity; stroke had greater putamen-SM connectivity.

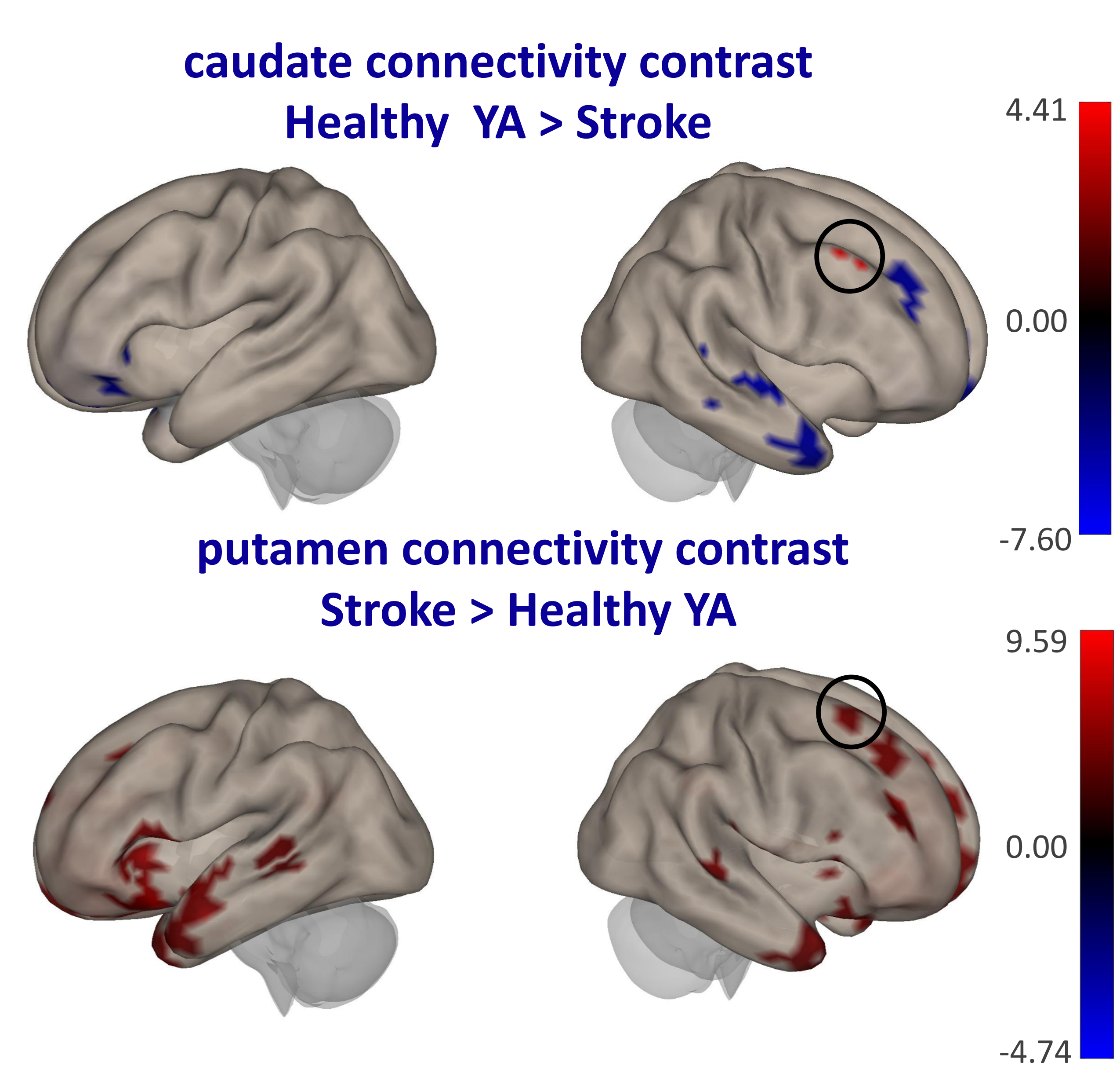

Figure 3. Resting-state connectivity. Top: averaged seed-to-voxel contrast (YA > stroke) results using bilateral caudate seeds; p<0.001 uncorrected, cluster-size p-FDR<0.05. Circled area highlights greater caudate-PFC connectivity in healthy young adults, which was significant in seed-to-seed analysis (p-FDR<0.02).

Bottom: averaged seed-to-voxel contrast (stroke >YA) results using bilateral putamen seeds; p<0.001 uncorrected, cluster-size p-FDR<0.05. Circled area highlights greater putamen-lateral sensorimotor region connectivity in stroke compared to healthy YA; however this was not significant in seed-to-seed analyses.

Discussion

- We replicated previous findings that YA were more goal-directed than healthy OA.[2]
- We did not find evidence for stroke altering decision-making behavior beyond healthy aging. However, more data is needed to determine the strength of these effects and draw more conclusive results.
- Lesion load and lesion location will likely also play a role in altering cortico-striatal connectivity, however, we had insufficient data to examine this.
- We have adapted data collection to continue online, and we are also now collecting measures of working memory, as working memory has been shown to protect against habitual decision making[8].

Acknowledgments

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