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Hello Everyone, I am Hao-Lun Hsu, and I am from Georgia Tech. Today I would like to share our project with you, called Functional Connectivity Correlates to Individual Difference in Human Brains during Working Memory Task and Resting State.

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Working memory is described as the process that are used to temporarily store, organize, and manipulate information. Multiple brain regions support working memory and it can be modeled as the illustration shown in the slide. It consists of four components depending on their functions. Basically, a central executive is for supervising the integration of information in different format.

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To understand how multiple brain regions work together to support working memory, researchers usually utilized a functional connectivity analysis.

Current functional connectivity studies of working memory mainly focus on two directions -- how resting-state functional connectivity was impaired in individuals with abnormal working memory and how different types of information was processed by divergent brain networks within the working memory scope.

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However, a lack of studies asked whether the working memory network dynamics relate to normal individual performance differences.

Also, while resting-state functional connectivity studies were prevalent in network analyses on the brain, we wondered how the brain network changes from rest to task state in relation to working memory capacity.

1) This is a reasonable question to ask for working memory because by its definition, working memory is a consistent state of the brain while awake. We wondered how the brain would change by adding more working memory load

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Before we dig into the research, we hypothesize that there might be a stronger connection between prefrontal cortex, basal ganglia (caudate) and hippocampus based on the literature review. We are also supposed to see weaker connective network in resting state compared with in task state.

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In our project, we utilize the data from an open dataset, called human connectome project. There are two experiments for working memory tasks. I show a kind of illustration in the slide while the original tasks may be more comprehensive. Firstly, let's take a look at 2-back blocks. There are 6 terms in the blocks, indicating different pictures. The participants are asked to see the picture from left to right on the screen in each trial. Then the participants should press one of the bottoms to decide if the object in the current trial is in the same category as the one in the target. 2-back blocks means that the target will always be the one two trials before the current one. Instead of remembering dynamic targets, in 0-back block, the target will always be the one in the first trial.

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We have the access to the experiment results and the corresponding fMRI of 100 subjects. We show the performance in accuracy distribution here. To have a further analysis and comparison, we split them into two groups: 40 good performers and 60 poor performers.

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Then we made the correlation matrix in task state. The correlation matrics are based on 21 brain regions. We observe that there is higher level of correlation in good performers compared with in poor ones. And if we take a look at the matrics carefully, high correlation between cortex and hippocampus as well as between cortex and caudate.

Page 9 Louvain Method, c-finder, Greedy Modularity Maximization algorithm

Then we do the hierarchical clustering. We show the visualization of the brains with network science. The nodes represent parcellation of the left hemisphere. The brain regions in the same cluster are with the same color. The edges indicate the correlation. we found stronger connections between nodes and a more activated network in good performers versus bad performers.

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We specifically targeted functional connectivity among the thalamus-hippocampus-prefrontal cortex circuits, we also plotted out the brain activity across time series during the working memory task for these 3 areas. It showed that in good performers, the thalamus showed opposite activity direction from cortex while hippocampus showed similar trends to cortex. In the poor performers group, there's weak correspondence among these three areas.

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We also do the same process with the data in resting state while there is only tiny difference in the correlation between two groups.

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Also, we could not get the meaningful clusters

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In this project, we show that there is a Strong connection between cortex, and caudate in good performers via fMRI in working task. We demonstrate that working memory should be supported by an interconnected network instead of a single brain region. However, it is difficult to tell the difference between two groups via resting fMRI. One interesting thing is that Amygdala, caudate and putamen were less activated during rest. Considering these areas were shown to be essential for emotion or motor tasks, it is reasonable to observe a 'sleep' mode for them during rest. Brain network becomes more activate from resting to task state in good performers. That's all I have for today's presentation. Thank you for listening.

Correlation coefficient:

Formula

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

r = correlation coefficient

x_i = values of the x-variable in a sample

$\bar{x}$ = mean of the values of the x-variable

y_i = values of the y-variable in a sample

$\bar{y}$ = mean of the values of the y-variable

Column x row: time series (point) x voxel, number of voxels in each brain region. In each subject, we average the values within each region and normalize the time series in region via z-score: z = (x – mean of the sample)/ standard deviation of the sample, and then do the correlation. We take average on the correlation matrix across group → clustering.
Correlation in brain: 0.5 is good enough.