LONGITUDINAL ASSESSMENT OF GRAPH THEORY MEASURES IN EARLY HIV INFECTION

484

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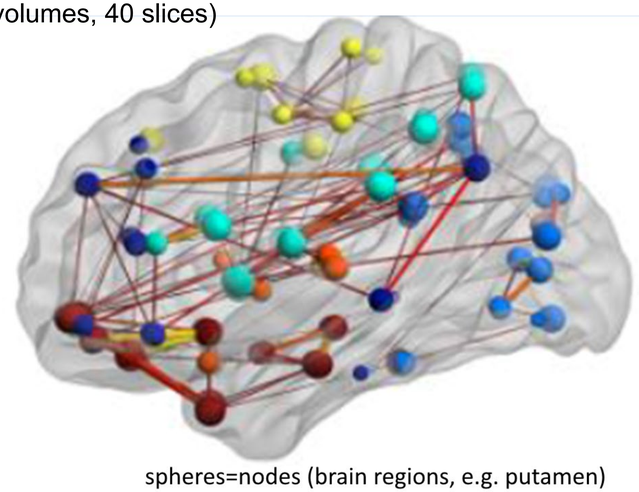
CTI Neuro Imaging

BACKGROUND

Advanced imaging techniques have shown that the brain is comprised of complex networks that work together to support function. Graph theory adapted for neuroscience can be used to quantitatively assess connectivity and derive biologically meaningful brain network metrics. We used graph theory to analyze longitudinal resting state functional MRI (RS-fMRI) data from the Chicago Early HIV Infection Study to quantify changes in brain network status in initial stages of infection and at two- year follow-up.

METHODS

- **Baseline**: 44 HIV+ (42M, 3F, mean age 32.9 +/- 10.6 years) and 17 seronegative controls (14M, 3F, mean age 31.2 +/- 8.5 years)
- **Follow-up**: 41 HIV+ and 16 seronegative controls imaged an average of 26.8 +/- 10 months later
- RS-fMRI data acquired on 3T Siemens Trio (TR/TE/resolution = 2.5 s/20 ms/1.7x1.7x3 mm^3, 235 volumes, 40 slices)



spheres=nodes (brain regions, e.g. putamen)
lines=edges (correlation between regions)
colors=clusters

$$L = \frac{1}{n}\sum_{i \in N} L_i = \frac{1}{n} \sum_{i \in N} \frac{\sum_{j \in N, j \neq i} d_{ij}}{n-1},$$

where L_i is the average distance between node i and all other nodes.

Fig 1. Network metrics and equation for calculating path length

Global path length was ***higher*** in HIV+ compared to controls both in early infection and two years later.

- Average signal from 116 regions of the AAL template [1] were extracted and used to calculate graph theory metrics [2] (Fig. 1). Global metrics were averaged over all 116 ROIs and compared in the groups at each timepoint using t-tests.
- After identifying global network metrics that differed in the groups, recursive feature elimination [3] was used to identify the ten regions (i.e. nodes) that most discriminated HIV+ and controls.

RESULTS

The graph below shows significantly longer global path length in the HIV+ group at baseline and follow-up. Table on the right shows the top 10 most group-discriminating regions based on path length at both timepoints.

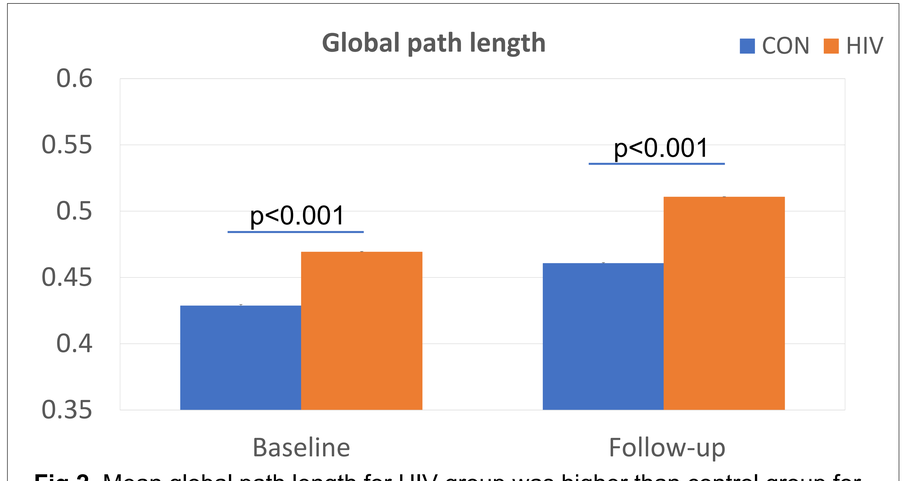


Fig 2. Mean global path length for HIV group was higher than control group for both timepoints (p<0.001). Error bars represent standard deviation.

CONCLUSIONS

- **We found significantly longer global path length in PLWH compared to healthy controls in both early infection and at two-year follow-up.**
- Path length represents the shortest distance between two nodes and is frequently used as a measure of network integration [2], which refers to the capacity of the brain to combine information across many regions.
- Our results indicate that network efficiency is affected during the early period of HIV infection and continues to worsen over the clinical course.
- Changes in the 10 most impacted regions between baseline and follow-up may shed light on network reorganization.
- These findings may provide insight into early development of HIV associated neurocognitive disorder in virally suppressed HIV patients.

Table 1. Top 10 group-discriminating brain regions based on path length at both timepoints.

Baseline	Two-year follow-up
1. Occipital_Inf_R	1. Parietal_Sup_L
2. Temporal_Sup_R	2. Cingulum_Mid_R
3. Cingulum_Mid_R	3. Vermis_7
4. Temporal_Inf_R	4. Temporal_Pole_Mid_R
5. Lingual_R	5. Frontal_Mid_Orb_L
6. Fusiform_R	6. Cerebellum_Crus2_L
7. Cerebellum_6_R	7. Precuneus_L
8. Precentral_R	8. Cerebellum_8_L
9. Occipital_Inf_L	9. Frontal_Sup_Orb_L
10. Putamen_R	10. Temporal_Pole_Sup_L

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