Supplementary material

Methods

Network topological analysis

‘Strength’, which reflected, on average, the sum of all neighboring link weights of individual nodes. Strength of a node \( i \) can be computed as the sum of the connectivity weights of the edges attached to each node \( i \) [1, 2],

\[
s_i = \sum_{j \in N, i \neq j} w_{ij}
\]

[\text{S1}]

Where \( k \) is a proportion, it varies between zero and one, where \( k=0 \) indicates that no connections are present, \( k=1 \) indicates that the network is fully connected, and \( 0<k<1 \) represents the fraction of all possible connections that are present in the network.

Global brain network segregation was assessed via the calculation of clustering coefficient. ‘Clustering coefficient’, a measure of the propensity of the network, formed clusters that was computed as the average fraction of triangles out of all connected triples [3]. The clustering coefficient of a node \( 0<C_i<1 \) is a ratio that defines the proportion of possible connections that actually exist between the nearest neighbors of a node, reflecting the large-scale network segregation [3, 4]

\[
C_i = \sum_{l \in G} \frac{\sum_{h \in G} (w_{il}w_{ih}w_{jh})^{1/3}}{k_i(k_i-1)/2}
\]

[\text{S2}]

Where \( k_i \) is the degree of node \( i \), and the \( w_{ij} \) is the weight between node \( i \), and node \( j \) in the network. The mean clustering coefficient of network \( C \) is the average over each node’s clustering coefficient, reflecting the level of local connectedness of a node.

\[
C = \frac{1}{N} C_i
\]

[\text{S3}]

Brain network integration was assessed using characteristic path length. Characteristic path length represented the average of shortest paths between brain regions in the network. The increase in average path length represented loss of network integration. The characteristic path length (\( L_p \)) is the mean minimal travel distance between nodes in the network, reflecting the large-scale integration[4, 5]

\[
L_p = \frac{1}{N(N-1)} \sum_{i \neq j} \min\{L_{i,j}\}
\]

[\text{S4}]
Where \( \min\{L_{i,j}\} \) is the shortest path length between the \( i \)th node and the \( j \)th node.

‘Nodal efficiency’ reflected the extent of fault tolerant and the robustness of the network after deletion of individual nodes. The local efficiency reflects how much the network is fault tolerant and show how efficient the communication is among the first neighbors of the node when it is removed [5], which is computed as follows:

\[
E_i = \frac{1}{(N-1)} \sum_{G(i)} \frac{1}{\min\{L_{i,j}\}}
\]

[S5]

\[
E = \frac{1}{N} \sum_{i \neq j} E_i
\]

[S6]

Where \( E_i \) is the local efficiency of node \( i \); Where \( G_i \) denotes the subgraph composed of the nearest neighbors of node \( i \).

**Rich club coefficient**

For all individual structural networks the weighted-rich club coefficient \( \emptyset^w(k) \) was computed as follows [6].

1. All non-zero connections of the examined FABIRC -weighted network were ranked in respect to their weight, resulting in a vector \( W^{ranked} \).

2. Within the connectivity matrix \( M \), for each value of degree \( k \), the sub-graph of nodes with a degree larger than \( k \) was selected (with \( k \) defined as the number of each node’s binary connections).

3. The number of links \( E_{>k} \) present between the members of the subset was determined and the sum of their collective weight \( W_{>k} \) was computed.

4. The maximal level of connectivity between the top number \( E_{>k} \) of connections in the network was determined, again computed as the sum of the weights.

5. The weighted rich club parameter \( \emptyset^w(k) \) was computed as the ratio between \( W_{>k} \) and this sum of the strongest number of links \( E_{>k} \) in the total network. Formally, \( \emptyset^w(k) \) is given by [7].

\[
\emptyset^w(k) = \frac{W_{>k}}{\sum_{i=1}^{E_{>k}} W_{i \ \text{ranked}}}
\]

[S7]
\( \psi^w(k) \) is typically normalized relative to a set of comparable random networks, to determine the extent to which empirically observed connection density between rich club nodes exceeds that predicted by the random null model, driven by node degree alone. Comparison of \( \psi^w(k) \) to \( \psi_{\text{random}}(k) \) obtained from a population of random networks, resulted in a normalized rich club coefficient \( \psi_{\text{norm}} \). Formally, A normalized coefficient \( \psi_{\text{norm}} \) greater than 1 over a range of \( k \) suggests the existence of rich club organization in a network[8]. To this end, for each network, a population of \( m=1,000 \) random networks[9] were computed by shuffling the links in \( M \), preserving the weights of the connections as well as the (binary) degree sequence and thus all node degrees (including the hubs) in the network[9]. This algorithm does not preserve the weight distribution of the nodes[10]. For each random network the rich club coefficient \( \psi_{\text{random}} \) was computed over all levels of \( k \) and \( \psi_{\text{random}}^w(k) \) was computed as the average rich club coefficient over the 1,000 random networks. Note that the normalized rich club coefficient is invariant for an overall connectivity of the network, enabling the possibility of comparing \( \psi^w(k) \) between groups.

Results

Individual rich club selection

Group differences (ANCOVA; age and gender covariates) were observed in rich club connectivity strength (\( F(3,220)= 16.323, P<0.001, \eta^2= 0.182 \)). Significant reductions were in rich club connectivity strength in aMCI versus NC \( (P<0.001) \), d-AD versus NC \( (P<0.001) \), aMCI versus SCD \( (P<0.001) \), d-AD versus SCD \((P<0.001, \text{Figure S1A})\).

Group differences in feeder connectivity strength \( (F(3,220)= 37.259, P<0.001, \text{partial } \eta^2= 0.506) \). Feeder connectivity strength significantly decreased in SCD versus NC \( (P<0.001) \), aMCI versus NC \( (P<0.001) \), and d-AD versus aMCI \( (P<0.001) \), no significant difference in SCD versus aMCI (\text{Figure S1B}).

Similar group differences were in local connectivity strength \( (F(3,220)= 83.919, P<0.001, \text{partial } \eta^2= 0.534) \). Local connectivity strength significantly decreased in SCD versus NC \( (P<0.001) \), d-AD versus SCD \( (P=0.045) \), and d-AD versus aMCI \( (P<0.001) \), no significant difference in SCD versus aMCI \( (P>0.05, \text{Figure S1C}) \).

Effects of fiber length

Across all the groups of subjects, rich club connections showed the longest fibers (rich club | feeder | local, mean/std 83.175/7.86682 | 70.697/4.62046 | 62.674/4.39247; \text{Figure S2A}) than feeder \( (P<0.001) \) and local connections \( (P<0.001) \), supporting previous findings that rich club connections mostly spanned long distances and constituted a high-cost feature of brain architecture [11]. Feeder connections were
significantly longer than local connections \((P < 0.001)\). Across all the groups of subjects, the set of rich club connections \((\text{mean/std 0.427/0.02531})\) displayed a significantly higher level of FABIRC as compared to feeder \((\text{mean/std 0.398/0.02159})\) and local connections \((\text{mean/std 0.387/0.02285})\) \((P < 0.001 | P < 0.001)\), suggesting a higher level of microstructural organization of rich club connections in the brain network \((\text{Figure S2B})\). Furthermore, feeder connections also showed a higher level of FABIRC than local connections \((P < 0.001)\).

To examine whether the observed relatively stable rich club was not just an effect of the relatively stable longer distances in SCD, an additional analysis was performed \([11-13]\). FABIRC measurements was corrected for influences of physical length by regressing out average fiber length across each category of connections.

The results still revealed group differences \((\text{ANCOVA; age, gender, and average fiber length across each category of connections as covariates})\) in rich club connectivity strength \((F(3,220) = 13.326, \ P < 0.001, \ \eta^2 = 0.154)\). Significantly lower FABIRC of rich club connectivity strength was in aMCI \((P < 0.001)\) and d-AD \((P < 0.001)\) compared to NC. In addition, significant lower FABIRC rich club connectivity strength in aMCI \((P = 0.001)\) and d-AD \((P = 0.003)\) compared to SCD was observed, and no significant group differences was observed neither between SCD with NC nor between aMCI with d-AD \((\text{Figure S3A})\).

Group differences in feeder connectivity strength \((F(3,220) = 34.143, \ P < 0.001, \ \text{partial } \eta^2 = 0.318)\). Feeder connectivity strength significantly decreased in SCD versus NC \((P = 0.005)\), aMCI versus SCD \((P = 0.001)\), d-AD versus SCD \((P < 0.001)\), and no significant difference in d-AD versus aMCI \((\text{Figure S3B})\).

Similar group differences in local connectivity strength \((F(3,220) = 53.406, \ P < 0.001, \ \text{partial } \eta^2 = 0.421)\). Local connectivity strength significantly decreased in SCD versus NC \((P < 0.001)\), aMCI versus SCD \((P < 0.001)\), d-AD versus SCD \((P < 0.001)\), and no significant difference in d-AD versus aMCI \((\text{Figure S3C})\).

**Age-matched replication dataset**

**Rich club disturbances with disease progression**

The rich club coefficient \((\emptyset)\) was significantly lower in all patient groups relative to controls, but especially at low-degree k-levels: \(k=3-7\) in SCD patients, \(k=4-13\) in aMCI patients, and \(k=2-16\) in d-AD patients (Bonferroni-corrected, Table S15-16).

Normalized rich club coefficients \((\emptyset_{\text{norm}})\) were significantly higher in all patient groups relative to controls, but especially at low-degree k-levels: \(k=7-13\) in SCD patients, \(k=5-12\) in aMCI patients, and \(k=4-13,16\) in d-AD patients (Bonferroni-
Significant group differences (ANOVA) were observed in rich club connectivity strength \((F(3, 220)=10.848, P<0.001, \eta^2=0.153)\), feeder connectivity strength \((F(3, 220)=55.035, P<0.001, \eta^2=0.478)\), and local connectivity strength \((F(3, 220)=96.976, P<0.001, \eta^2=0.618; \text{Table S19})\). Post hoc comparisons revealed decreased local and feeder connectivity strength in the SCD group versus NC \((P<0.001)\), and the d-AD group versus the aMCI group \((P<0.001)\). There was no significant difference between aMCI group and the SCD group. Significant rich club connectivity strength reductions were seen in the d-AD patients versus NC: \((P<0.001)\). There were no other significant differences between groups \((P>0.05; \text{Table S20})\).

**Network topological metrics**

Group differences (ANOVA) were observed for the strength metric \((F(3, 220)=88.561, P<0.001, \eta^2=0.596, \text{Table S21})\). Post hoc comparisons revealed decreased strength in the SCD group versus NC \((P<0.001)\), and the d-AD group versus the aMCI group \((P<0.001)\). There was no significant difference between aMCI group and the SCD group (Table S22).

Group differences (ANOVA) were observed for the clustering coefficient \((F(3, 220)=11.586, P<0.001, \eta^2=0.116)\). Significant reductions were seen in the d-AD patients versus NC: \((P<0.001)\). There were no other significant differences between groups \((P>0.05)\). In addition, there were significant group differences in normalized clustering coefficient \((F(3, 220)=34.436, P<0.001, \eta^2=0.365)\). Post hoc comparisons revealed decreased normalized clustering coefficient in the SCD group versus NC \((P<0.001)\), and the d-AD group versus the aMCI group \((P<0.001)\). There was no significant difference between aMCI group and the SCD group (Table S21-22).

There were significant group differences in characteristic path length \((F(3, 220)=39.791, P<0.001, \eta^2=0.399)\). Post hoc comparisons revealed decreased characteristic path length in the SCD group versus NC \((P<0.001)\), and the d-AD group versus the aMCI group \((P<0.001)\). There was no significant difference between aMCI group and the SCD group. Group differences were also observed for the normalized characteristic path length \((F(3, 220)=4.365, P=0.003, \eta^2=0.068)\). There was no significant difference between groups (Table S21-22).

**Behavioral correlation analysis**

In NC patients, the normalized rich club coefficient was significantly negative correlated with AVLT-D performance, after Bonferroni corrections \((k=3)\). In addition, in d-AD patients, normalized rich club coefficient showed a significantly negative
association with AVLT-D (k=2) and AVLT-R (k=6). These relationships were not observed in SCD and aMCI patients (Table S23). For rich club coefficient, in SCD patients, this metric was significantly positive correlated with AVLT-D performance, after Bonferroni corrections (k=5). aMCI group showed a similar positive relationship between rich club coefficient and AVLT-D (k=12-16), AVLT-I (k=3), and MoCA (k=3). In addition, in d-AD patients, rich club coefficient showed a significantly positive association with AVLT-I (k=2), MMSE (k=2,8) and MoCA (k=2). These relationships were not observed in NC (Table S24).

In SCD patients, the AVLT-D performance was significantly positively correlated with feeder connectivity strength after Bonferroni corrections: those people who showed poorer memory performance tended to suffer from a greater disruption of feeder connections involving peripheral regions (r=0.426). Similar results were also found in aMCI patients (r=0.486). This relationship seen in SCD and aMCI patients was not displayed by NC or d-AD patients (Table S25).

After Bonferroni corrections, in SCD patients, the AVLT-D performance was significantly negatively correlated with strength (r= 0.398). Similar association was also between AVLT-d and characteristic path length (r= -0.390). In aMCI patients, the AVLT-D performance was significantly negatively correlated with normalized clustering coefficient (r= -0.423). Similar association was also between AVLT-R and clustering coefficient (r= 0.361). These relationships were not displayed by NC and d-AD patients (Table S26).

After Bonferroni corrections, network topological metrics was significantly correlated with rich club/feeder/local connectivity strength (Table S27). Previous studies have extensively used these network topological metrics in AD studies to reveal the differences between AD patients and normal subjects. Our results showed that there is a significant correlation between white matter lesion load and network results, indicating that rich club organization analysis is reliable.
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### Tables

**Table S1.** Post hoc testing on age and education from ANOVA.

| Demographics | (I) Group | (J) Group | Mean Difference (I-J) | SE | P  | 95% Confidence Interval for Difference |
|--------------|-----------|-----------|-----------------------|----|----|--------------------------------------|
|              |           |           | Lower Bound           |    |    | Upper Bound                          |
| **Age**      |           |           |                       |    |    |                                      |
|              | NC        | SCD       | -2.059                | 1.728 | 0.235 | -5.465 - 1.347                       |
|              | NC        | aMCI      | -3.996                | 1.618 | 0.014 | -7.185 - 0.807                       |
|              | NC        | d-AD      | -7.654                | 1.671 | <0.001 | -10.948 - 4.359                      |
|              | SCDC      | NC        | 2.059                 | 1.728 | 0.235 | -1.347 - 5.465                       |
|              | SCDC      | aMCI      | -1.937                | 1.740 | 0.014 | -5.367 - 1.493                       |
|              | SCDC      | d-AD      | -5.594                | 1.790 | 0.002 | -9.123 - 2.066                       |
|              | aMCI      | SCDC      | 3.996                 | 1.618 | 0.014 | 0.807 - 7.185                        |
|              | aMCI      | d-AD      | 1.937                 | 1.740 | 0.267 | -1.493 - 5.367                       |
|              | d-AD      | SCDC      | 5.594                 | 1.790 | 0.031 | -6.977 - 2.066                       |
|              | d-AD      | aMCI      | 3.657                 | 1.684 | 0.026 | 0.338 - 6.977                        |
|              | NC        | SCD       | 7.654                 | 1.671 | <0.001 | 4.359 - 10.948                      |
|              | NC        | aMCI      | 1.202                 | 0.911 | 0.188 | -0.593 - 2.996                       |
|              | NC        | d-AD      | 2.103                 | 0.941 | 0.026 | 0.248 - 3.957                       |
|              | SCDC      | NC        | 0.751                 | 0.973 | 0.441 | -1.166 - 2.667                       |
|              | SCDC      | aMCI      | 1.952                 | 0.980 | 0.048 | 0.022 - 3.883                       |
|              | SCDC      | d-AD      | 2.853                 | 1.008 | 0.005 | 0.867 - 4.839                       |
|              | aMCI      | SCDC      | -1.202                | 0.911 | 0.188 | -2.996 - 0.593                       |
|              | aMCI      | d-AD      | -1.952                | 0.980 | 0.048 | -3.883 - 0.022                      |
|              | d-AD      | SCDC      | 0.901                 | 0.948 | 0.343 | -0.967 - 2.769                      |
|              | d-AD      | aMCI      | -2.103                | 0.941 | 0.026 | -3.957 - 0.248                       |
|              | d-AD      | NC        | -2.853                | 1.008 | 0.005 | -4.839 - 0.867                      |
|              | d-AD      | aMCI      | -0.901                | 0.948 | 0.343 | -2.769 - 0.967                      |

**Education**

| Demographics | (I) Group | (J) Group | Mean Difference (I-J) | SE | P  | 95% Confidence Interval for Difference |
|--------------|-----------|-----------|-----------------------|----|----|--------------------------------------|
|              |           |           | Lower Bound           |    |    | Upper Bound                          |
|              |           |           |                       |    |    |                                      |
| **Age**      |           |           |                       |    |    |                                      |
|              | NC        | SCD       | -0.751                | 0.973 | 0.441 | -2.667 - 1.166                       |
|              | NC        | aMCI      | 1.202                 | 0.911 | 0.188 | -0.593 - 2.996                       |
|              | NC        | d-AD      | 2.103                 | 0.941 | 0.026 | 0.248 - 3.957                       |
|              | SCDC      | NC        | 0.751                 | 0.973 | 0.441 | -1.166 - 2.667                       |
|              | SCDC      | aMCI      | 1.952                 | 0.980 | 0.048 | 0.022 - 3.883                       |
|              | SCDC      | d-AD      | 2.853                 | 1.008 | 0.005 | 0.867 - 4.839                       |
|              | aMCI      | SCDC      | -1.202                | 0.911 | 0.188 | -2.996 - 0.593                       |
|              | aMCI      | d-AD      | -1.952                | 0.980 | 0.048 | -3.883 - 0.022                      |
|              | d-AD      | SCDC      | 0.901                 | 0.948 | 0.343 | -0.967 - 2.769                      |
|              | d-AD      | aMCI      | -2.103                | 0.941 | 0.026 | -3.957 - 0.248                       |
|              | d-AD      | NC        | -2.853                | 1.008 | 0.005 | -4.839 - 0.867                      |
|              | d-AD      | aMCI      | -0.901                | 0.948 | 0.343 | -2.769 - 0.967                      |
Table S2. Post hoc testing on cognitive variables from ANCOVA with age, gender and education as covariates.

| COV: Age & Gender & Education | (I) Group | (J) Group | Mean Difference (I-J) | SE | P  | 95% Confidence Interval for Difference |
|-------------------------------|-----------|-----------|----------------------|----|----|---------------------------------------|
|                               |            |           |                      |    |    | Lower Bound | Upper Bound |
| **AVLT-Immediate Recall Scores** |           |           |                      |    |    |            |            |
| NC                            | SCD        | 0.738     | 0.344                | 0.033 | 0.060 | 1.416 |
|                               | aMCI       | 2.687     | 0.325                | <0.001 | 2.046 | 3.328 |
|                               | d-AD       | 5.126     | 0.352                | <0.001 | 4.432 | 5.819 |
| SCD                           | NC         | -0.738    | 0.344                | 0.033 | -1.416 | -0.060 |
|                               | aMCI       | 1.949     | 0.340                | <0.001 | 1.279 | 2.620 |
|                               | d-AD       | 4.388     | 0.363                | <0.001 | 3.671 | 5.104 |
| aMCI                          | NC         | -2.687    | 0.325                | <0.001 | -3.328 | -2.046 |
|                               | SCD        | -1.949    | 0.340                | <0.001 | -2.620 | -1.279 |
|                               | d-AD       | 2.438     | 0.331                | <0.001 | 1.786 | 3.090 |
| d-AD                          | NC         | -5.126    | 0.352                | <0.001 | -5.819 | -4.432 |
|                               | SCD        | -4.388    | 0.363                | <0.001 | -5.104 | -3.671 |
|                               | aMCI       | -2.438    | 0.331                | <0.001 | -3.090 | -1.786 |
| **AVLT-Delayed Recall Scores** |           |           |                      |    |    |            |            |
| NC                            | SCD        | 1.285     | 0.527                | 0.016 | 0.246 | 2.324 |
|                               | aMCI       | 5.589     | 0.498                | <0.001 | 4.606 | 6.571 |
|                               | d-AD       | 8.208     | 0.539                | <0.001 | 7.144 | 9.271 |
| SCD                           | NC         | -1.285    | 0.527                | 0.016 | -2.324 | -0.246 |
|                               | aMCI       | 4.303     | 0.521                | <0.001 | 3.276 | 5.331 |
|                               | d-AD       | 6.923     | 0.557                | <0.001 | 5.824 | 8.021 |
| aMCI                          | NC         | -5.589    | 0.498                | <0.001 | -6.571 | -4.606 |
|                               | SCD        | -4.303    | 0.521                | <0.001 | -5.331 | -3.276 |
|                               | d-AD       | 2.619     | 0.507                | <0.001 | 1.620 | 3.619 |
| d-AD                          | NC         | -8.208    | 0.539                | <0.001 | -9.271 | -7.144 |
|                               | SCD        | -6.923    | 0.557                | <0.001 | -8.021 | -5.824 |
|                               | aMCI       | -2.619    | 0.507                | <0.001 | -3.619 | -1.620 |
| **AVLT-Recognition Scores**   |            |           |                      |    |    |            |            |
| NC                            | SCD        | 0.738     | 0.630                | 0.243 | -0.504 | 1.980 |
|                               | aMCI       | 3.785     | 0.596                | <0.001 | 2.611 | 4.960 |
|                               | d-AD       | 7.622     | 0.645                | <0.001 | 6.351 | 8.894 |
| SCD                           | NC         | -0.738    | 0.630                | 0.243 | -1.980 | 0.504 |
|                               | aMCI       | 3.047     | 0.623                | <0.001 | 1.819 | 4.276 |
|                               | d-AD       | 6.884     | 0.666                | <0.001 | 5.571 | 8.198 |
| aMCI                          | NC         | -3.785    | 0.596                | <0.001 | -4.960 | -2.611 |
|                               | SCD        | -3.047    | 0.623                | <0.001 | -4.276 | -1.819 |
|                               | d-AD       | 3.837     | 0.606                | <0.001 | 2.642 | 5.032 |
| d-AD                          | NC         | -7.622    | 0.645                | <0.001 | -8.894 | -6.351 |
|                               | SCD        | -6.884    | 0.666                | <0.001 | -8.198 | -5.571 |
|                               | aMCI       | -3.837    | 0.606                | <0.001 | -5.032 | -2.642 |
| **MMSE**                      | NC         | 0.238     | 0.758                | 0.754 | -1.257 | 1.733 |
|                               | aMCI       | 2.751     | 0.717                | <0.001 | 1.337 | 4.166 |
|                               | d-AD       | 10.110    | 0.776                | <0.001 | 8.579 | 11.640 |
|       | NC     | aMCI   | SCi   | d-AD   | NC     | aMCI   | SCi   | d-AD   |
|-------|--------|--------|-------|--------|--------|--------|-------|--------|
| SCD   | -0.238 | 2.513  | 0.750 | 0.754  | -1.733 | 1.034  | 3.992 |
| aMCI  | -2.751 | -2.513 | 0.750 | 0.754  | <0.001 | -3.992 | -1.034|
| d-AD  | 9.872  | 7.358  | 0.802 | <0.001 | 8.291  | 5.920  | 8.797 |
| aMCI  | NC     | -2.751 | 0.717 | 0.001  | -4.166 | -1.337 |
| SCD   | -2.513 | 0.750  | 0.001 | -3.992 | -1.034 |
| d-AD  | 7.358  | 0.730  | <0.001| 5.920  | 8.797  |
| d-AD  | NC     | -10.110| 0.776 | <0.001 | -11.640| -8.579 |
| SCD   | -9.872 | 0.802  | <0.001| -11.453| -8.291 |
| aMCI  | -7.358 | 0.730  | <0.001| -8.797 | -5.920 |
| MoCA  | NC     | 1.422  | 0.698 | 0.043  | 0.046  | 2.798  |
| aMCI  | 5.981  | 0.660  | <0.001| 4.679  | 7.282  |
| d-AD  | 12.466 | 0.714  | <0.001| 11.057 | 13.874 |
| SCD   | NC     | -1.422 | 0.698 | 0.043  | -2.798 | -0.046 |
| aMCI  | 4.558  | 0.690  | <0.001| 3.197  | 5.919  |
| d-AD  | 11.043 | 0.738  | <0.001| 9.588  | 12.499 |
| aMCI  | NC     | -5.981 | 0.660 | <0.001 | -7.282 | -4.679 |
| SCD   | -4.558 | 0.690  | <0.001| -5.919 | -3.197 |
| d-AD  | 6.485  | 0.671  | <0.001| 5.161  | 7.809  |
| d-AD  | NC     | -12.466| 0.714 | <0.001 | -13.874| -11.057|
| SCD   | -11.043| 0.738  | <0.001| -12.499| -9.588 |
| aMCI  | -6.485 | 0.671  | <0.001| -7.809 | -5.161 |
| k (degree) | NC (Mean, SD) | SCD (Mean, SD) | aMCI (Mean, SD) | d-AD (Mean, SD) | F | p< | ES<sup>b</sup> | Post hocs<sup>c</sup> |
|------------|---------------|----------------|-----------------|----------------|----|-----|--------|----------------|
| 1          | 0.999 (0.000) | 0.999 (0.001) | 0.999 (0.001)  | 0.999 (0.001) | 6.048 | <0.001 | 0.077 | NC>d-AD |
| 2          | 0.998 (0.001) | 0.997 (0.002) | 0.997 (0.002)  | 0.996 (0.003) | 14.656 | <0.001 | 0.168 | NC, SCD, aMCI>d-AD |
| 3          | 0.996 (0.003) | 0.993 (0.004) | 0.993 (0.004)  | 0.989 (0.005) | 26.453 | <0.001 | 0.267 | NC>SCD, aMCI>d-AD |
| 4          | 0.992 (0.004) | 0.986 (0.006) | 0.984 (0.006)  | 0.978 (0.007) | 45.085 | <0.001 | 0.383 | NC>SCD, aMCI>d-AD |
| 5          | 0.985 (0.006) | 0.975 (0.008) | 0.973 (0.008)  | 0.963 (0.010) | 66.922 | <0.001 | 0.479 | NC>SCD, aMCI>d-AD |
| 6          | 0.974 (0.008) | 0.962 (0.011) | 0.959 (0.009)  | 0.945 (0.013) | 68.930 | <0.001 | 0.487 | NC>SCD, aMCI>d-AD |
| 7          | 0.964 (0.009) | 0.948 (0.012) | 0.943 (0.012)  | 0.925 (0.017) | 67.637 | <0.001 | 0.482 | NC>SCD, aMCI>d-AD |
| 8          | 0.945 (0.011) | 0.933 (0.014) | 0.925 (0.013)  | 0.906 (0.022) | 53.441 | <0.001 | 0.424 | NC>SCD, aMCI>d-AD |
| 9          | 0.929 (0.011) | 0.918 (0.015) | 0.909 (0.017)  | 0.886 (0.027) | 45.661 | <0.001 | 0.386 | NC>aMCI>d-AD; SCD>d-AD |
| 10         | 0.914 (0.012) | 0.902 (0.015) | 0.893 (0.019)  | 0.868 (0.028) | 47.527 | <0.001 | 0.395 | NC>aMCI>d-AD; SCD>d-AD |
| 11         | 0.898 (0.014) | 0.886 (0.018) | 0.877 (0.022)  | 0.849 (0.034) | 38.875 | <0.001 | 0.349 | NC>aMCI>d-AD; SCD>d-AD |
| 12         | 0.886 (0.016) | 0.870 (0.025) | 0.859 (0.025)  | 0.827 (0.043) | 32.090 | <0.001 | 0.306 | NC>aMCI>d-AD; SCD>d-AD |
| 13         | 0.867 (0.020) | 0.851 (0.033) | 0.841 (0.031)  | 0.810 (0.048) | 22.093 | <0.001 | 0.233 | NC>aMCI>d-AD; SCD>d-AD |
| 14         | 0.854 (0.024) | 0.835 (0.039) | 0.820 (0.040)  | 0.785 (0.065) | 19.727 | <0.001 | 0.214 | NC>aMCI>d-AD; SCD>d-AD |
| 15         | 0.838 (0.025) | 0.817 (0.045) | 0.803 (0.043)  | 0.766 (0.068) | 18.648 | <0.001 | 0.204 | NC>aMCI>d-AD; SCD>d-AD |
| 16         | 0.823 (0.029) | 0.801 (0.054) | 0.787 (0.046)  | 0.756 (0.062) | 13.803 | <0.001 | 0.160 | NC, SCD>d-AD |

<sup>a</sup>Values from ANCOVA with age and gender as covariates.

<sup>b</sup>Effect size; partial η² for rich club coefficient.

<sup>c</sup>Least significant difference; post hoc testing on rich club coefficient based on means adjusted for age, gender.

aMCI: amnestic mild cognitive impairment; d-AD: dementia of Alzheimer’s disease; NC: normal control; SCD: subjective cognitive decline.
Table S4. Post hoc testing on rich club coefficient from ANCOVA with age and gender as covariates (Bonferroni-corrected for groups).

| k (degree) | (I) Group | (J) Group | Mean Difference (I-J) | SE | P | 95% Confidence Interval for Difference |
|------------|-----------|-----------|-----------------------|----|---|--------------------------------------|
|            | NC        | aMCI      | 0.000 0.000           | 1.000 | 0.000 0.001 0.000 0.001 |
| 1          | NC        | aMCI      | -0.001 0.000          | 1.000 | <0.001 | -0.001 0.000 0.001 0.000 |
|            | SCD       | aMCI      | 0.000 0.000           | 1.000 | 0.000 0.000 0.000 0.000 |
|            | NC        | d-AD      | 0.000 0.000           | 0.024 | 0.000 0.000 0.000 0.000 |
|            | aMCI      | SCD       | 0.000 0.000           | 1.000 | 0.000 0.000 0.000 0.000 |
|            | d-AD      | NC        | -0.001 0.000          | <0.001 | -0.001 0.000 0.001 0.000 |
|            |            | NC        | -0.001 0.000          | 0.017 | 0.000 0.000 0.000 0.000 |
|            |            | aMCI      | 0.000 0.000           | 0.016 | <0.001 0.000 0.000 0.000 |
| 2          |            | SCD       | 0.000 0.000           | 0.042 | 0.000 0.000 0.000 0.000 |
|            | NC        | d-AD      | 0.002 0.000           | 0.006 | 0.000 0.000 0.001 0.000 |
|            | aMCI      | SCD       | 0.000 0.000           | 1.000 | -0.001 0.000 0.000 0.000 |
|            | d-AD      | NC        | -0.001 0.000          | 0.017 | -0.002 0.000 0.000 0.000 |
|            |            | NC        | -0.003 0.000          | <0.001 | -0.004 0.000 0.001 0.000 |
|            |            | aMCI      | 0.000 0.000           | 0.002 | -0.003 0.000 0.000 0.000 |
|            |            | d-AD      | 0.001 0.000           | 0.001 | 0.000 0.000 0.000 0.000 |
| 3          |            | SCD       | 0.003 0.001           | 0.002 | 0.001 0.000 0.000 0.000 |
|            | NC        | d-AD      | 0.000 0.000           | 0.002 | -0.005 0.000 0.000 0.000 |
|            | aMCI      | SCD       | 0.000 0.000           | 1.000 | -0.002 0.000 0.000 0.000 |
|            | d-AD      | NC        | -0.004 0.001          | <0.001 | 0.002 0.000 0.000 0.000 |
|            |            | NC        | -0.003 0.001          | 0.001 | -0.005 0.000 0.000 0.000 |
|            |            | aMCI      | 0.000 0.000           | 1.000 | -0.002 0.000 0.000 0.000 |
|            |            | d-AD      | 0.004 0.001           | <0.001 | 0.002 0.000 0.000 0.000 |
| 4          |            | SCD       | 0.006 0.001           | <0.001 | 0.003 0.000 0.000 0.000 |
|            | NC        | d-AD      | -0.004 0.001          | <0.001 | -0.009 0.000 0.000 0.000 |
|            | aMCI      | SCD       | -0.004 0.001          | <0.001 | -0.006 0.000 0.000 0.000 |
|            | d-AD      | NC        | 0.013 0.001           | <0.001 | 0.010 0.000 0.000 0.000 |
|     | NC    | aMCI  | d-AD  | NC    | aMCI  | d-AD  |
|-----|-------|-------|-------|-------|-------|-------|
| SCD | -0.06 | 0.01  | <0.001| -0.09 | -0.03 | 0.01  |
|     | 0.001 | 0.001 | 1.000 | -0.02 | 0.04  |
|     | 0.004 | 0.010 |       |       |       |       |
| aMCI| -0.07 | 0.01  | <0.001| -0.10 | -0.04 | 0.02  |
|     | 0.006 | 0.001 |       |       |       |       |
|     |       |       | <0.001|       |       |       |
| d-AD| -0.13 | 0.01  | <0.001| -0.16 | -0.01 | <0.001|
|     | 0.007 | 0.001 |       |       |       |       |
|     |       |       | <0.001|       |       |       |
| NC  | SCD   | 0.09  | <0.001| 0.05  | 0.013 | 0.01  |
|     | 0.011 | 0.001 | <0.001| 0.08  | 0.015 |       |
|     | 0.021 | 0.001 | <0.001| 0.17  | 0.025 |       |
| SCD | NC    | -0.09 | <0.001| -0.13 | -0.05 | 0.006 |
|     | 0.002 | 0.001 |       |       |       |       |
|     |       |       | <0.001|       |       |       |
| aMCI| -0.01 | 0.002 | <0.001| -0.15 | -0.08 | 0.002 |
|     | 0.011 | 0.002 |       |       |       |       |
|     |       |       | <0.001|       |       |       |
| d-AD| d-AD  | NC    | <0.001| -0.25 | -0.17 | 0.006 |
|     | 0.021 | 0.001 |       |       |       |       |
|     |       |       | <0.001|       |       |       |
| SCD | NC    | -0.12 | <0.001| -0.17 | -0.07 | 0.008 |
|     | 0.003 | 0.002 | 0.720 |       |       |       |
|     | 0.016 | 0.002 | 0.000 |       |       |       |
|     |       |       | <0.001|       |       |       |
| aMCI| NC    | -0.15 | <0.001| -0.20 | -0.10 | 0.023 |
|     | 0.003 | 0.002 | 0.720 |       |       |       |
|     | 0.013 | 0.002 |       |       |       |       |
|     |       |       | <0.001|       |       |       |
| d-AD| d-AD  | NC    | <0.001| -0.33 | -0.23 | 0.008 |
|     | 0.028 | 0.002 |       |       |       |       |
|     |       |       | <0.001|       |       |       |
| SCD | NC    | -0.13 | <0.001| -0.19 | -0.06 | 0.011 |
|     | 0.005 | 0.002 | 0.352 |       |       |       |
|     | 0.022 | 0.003 |       |       |       |       |
|     |       |       | <0.001|       |       |       |
| aMCI| NC    | -0.17 | <0.001| -0.23 | -0.11 | 0.011 |
|     | 0.005 | 0.002 | 0.352 |       |       |       |
|     | 0.017 | 0.002 |       |       |       |       |
|     |       |       | <0.001|       |       |       |
| d-AD| d-AD  | NC    | <0.001| -0.41 | -0.28 | 0.011 |
|     | 0.034 | 0.002 |       |       |       |       |
|     |       |       | <0.001|       |       |       |
| SCD | NC    | -0.17 | <0.001| -0.29 | -0.15 | 0.024 |
|     | 0.017 | 0.002 |       |       |       |       |
|     |       |       | <0.001|       |       |       |
| aMCI| d-AD  | NC    | <0.001| -0.24 | -0.11 | 0.011 |
|     | 0.019 | 0.003 | <0.001| 0.011 | 0.026 |       |
|          | d-AD  | NC    | aMCI  | SCD      | d-AD    | NC    | aMCI  | SCD    |
|----------|-------|-------|-------|----------|---------|-------|-------|--------|
|          | 0.037 | -0.011| 0.008 | 0.026    | <0.001  | 0.019 | -0.037| <0.001 |
| d-AD     | 0.037 | -0.011| 0.008 | 0.026    | <0.001  | 0.019 | -0.037| <0.001 |
| NC       |       |       |       |          |         |       |       |        |
| aMCI     |       |       |       |          |         |       |       |        |
| SCDS     |       |       |       |          |         |       |       |        |
| d-AD     | 0.037 |       |       |          |         |       |       |        |
| SCDS     |       |       |       |          |         |       |       |        |
| aMCI     |       |       |       |          |         |       |       |        |
| SCDS     |       |       |       |          |         |       |       |        |
| NC       |       |       |       |          |         |       |       |        |
| aMCI     |       |       |       |          |         |       |       |        |
| SCDS     |       |       |       |          |         |       |       |        |
| d-AD     | 0.037 |       |       |          |         |       |       |        |
| SCDS     |       |       |       |          |         |       |       |        |
| aMCI     |       |       |       |          |         |       |       |        |
| SCDS     |       |       |       |          |         |       |       |        |
| NC       |       |       |       |          |         |       |       |        |
| aMCI     |       |       |       |          |         |       |       |        |
| SCDS     |       |       |       |          |         |       |       |        |
| d-AD     | 0.037 |       |       |          |         |       |       |        |
| SCDS     |       |       |       |          |         |       |       |        |
| aMCI     |       |       |       |          |         |       |       |        |
| SCDS     |       |       |       |          |         |       |       |        |
| NC       |       |       |       |          |         |       |       |        |
| aMCI     |       |       |       |          |         |       |       |        |
| SCDS     |       |       |       |          |         |       |       |        |
| d-AD     | 0.037 |       |       |          |         |       |       |        |
| SCDS     |       |       |       |          |         |       |       |        |
| aMCI     |       |       |       |          |         |       |       |        |
| SCDS     |       |       |       |          |         |       |       |        |
| NC       |       |       |       |          |         |       |       |        |
| aMCI     |       |       |       |          |         |       |       |        |
| SCDS     |       |       |       |          |         |       |       |        |
| d-AD     | 0.037 |       |       |          |         |       |       |        |
| SCDS     |       |       |       |          |         |       |       |        |
| aMCI     |       |       |       |          |         |       |       |        |
| SCDS     |       |       |       |          |         |       |       |        |
|     | NC   | aMCI | 0.023 | 0.005 | <0.001 | 0.008 | 0.037 |
|-----|------|------|-------|-------|--------|-------|-------|
|     | d-AD | 0.053| 0.006 | <0.001| 0.038  | 0.068 |
| SCD | NC   | -0.013| 0.006 | 0.145 | -0.028 | 0.002 |
|     | aMCI | 0.010 | 0.006 | 0.506 | -0.005 | 0.025 |
|     | d-AD | 0.041 | 0.006 | <0.001| 0.025  | 0.056 |
|     | NC   | -0.023| 0.005 | <0.001| -0.037 | -0.008|
| aMCI| SCD  | -0.010| 0.006 | 0.506 | -0.025 | 0.005 |
|     | d-AD | 0.031 | 0.005 | <0.001| 0.016  | 0.045 |
| d-AD| NC   | -0.053| 0.006 | <0.001| -0.068 | -0.038|
|     | SCD  | -0.041| 0.006 | <0.001| -0.056 | -0.025|
|     | aMCI | -0.031| 0.005 | <0.001| -0.045 | -0.016|
|     | NC   | 0.015 | 0.007 | 0.162 | -0.003 | 0.032 |
| aMCI| SCD  | 0.023 | 0.006 | <0.001| 0.006  | 0.040 |
|     | d-AD | 0.052 | 0.007 | <0.001| 0.035  | 0.070 |
|     | NC   | -0.015| 0.007 | 0.162 | -0.032 | 0.003 |
| SCD | NC   | -0.053| 0.007 | 1.000 | -0.009 | 0.026 |
|     | aMCI | 0.008 | 0.007 | 1.000 | -0.009 | 0.026 |
|     | d-AD | 0.038 | 0.007 | <0.001| 0.019  | 0.056 |
|     | NC   | -0.023| 0.006 | <0.001| -0.040 | -0.006|
| aMCI| SCD  | -0.008| 0.007 | 1.000 | -0.026 | 0.009 |
|     | d-AD | 0.029 | 0.006 | <0.001| 0.012  | 0.046 |
| d-AD| NC   | -0.052| 0.007 | <0.001| -0.070 | -0.035|
|     | SCD  | -0.038| 0.007 | <0.001| -0.056 | -0.019|
|     | aMCI | -0.029| 0.006 | <0.001| -0.046 | -0.012|
|     | NC   | 0.018 | 0.009 | 0.240 | -0.005 | 0.040 |
| aMCI| SCD  | 0.031 | 0.008 | <0.001| 0.009  | 0.052 |
|     | d-AD | 0.064 | 0.008 | <0.001| 0.041  | 0.086 |
|     | NC   | -0.018| 0.009 | 0.240 | -0.040 | 0.005 |
| SCD | NC   | -0.031| 0.008 | 0.001 | -0.052 | -0.009|
|     | aMCI | 0.013 | 0.009 | 0.749 | -0.010 | 0.036 |
|     | d-AD | 0.046 | 0.009 | <0.001| 0.022  | 0.070 |
|     | NC   | -0.064| 0.008 | <0.001| -0.086 | -0.041|
| aMCI| SCD  | -0.046| 0.009 | <0.001| -0.070 | -0.022|
|     | d-AD | -0.033| 0.008 | <0.001| -0.055 | -0.011|
|     | NC   | 0.019 | 0.009 | 0.234 | -0.005 | 0.043 |
| aMCI| SCD  | 0.031 | 0.009 | <0.001| 0.008  | 0.054 |
|     | d-AD | 0.066 | 0.009 | <0.001| 0.042  | 0.090 |
|     | NC   | -0.019| 0.009 | 0.234 | -0.043 | 0.005 |
| SCD | NC   | -0.031| 0.009 | 0.002 | -0.054 | -0.008|
|     | aMCI | 0.013 | 0.009 | 1.000 | -0.012 | 0.037 |
|     | d-AD | 0.047 | 0.009 | <0.001| 0.022  | 0.073 |
|     | NC   | -0.066| 0.009 | <0.001| -0.090 | -0.042|
| aMCI| SCD  | -0.047| 0.009 | <0.001| -0.073 | -0.022|
|     | d-AD | -0.035| 0.009 | <0.001| -0.058 | -0.011|
|        | NC   | SCD  | 0.020 | 0.009 | 0.207 | -0.005 | 0.044 |
|--------|------|------|-------|-------|-------|--------|-------|
| aMCI   | 0.031| 0.009| 0.003 | 0.007 | 0.054 |
| d-AD   | 0.059| 0.009| <0.001| 0.034 | 0.083 |
| SCD    | NC   | -0.020| 0.009 | 0.207 | -0.044 | 0.005 |
| aMCI   | 0.011| 0.009| 1.000 | -0.014 | 0.036 |
| d-AD   | 0.039| 0.010| 0.001 | 0.013 | 0.065 |
| aMCI   | NC   | -0.031| 0.009 | 0.003 | -0.054 | -0.007 |
| SCD    | -0.011| 0.009| 1.000 | -0.036 | 0.014 |
| d-AD   | 0.028| 0.009| 0.015 | 0.004 | 0.052 |
| d-AD   | NC   | -0.059| 0.009 | <0.001| -0.083 | -0.034 |
| SCD    | -0.039| 0.010| 0.001 | -0.065 | -0.013 |
| aMCI   | -0.028| 0.009| 0.015 | -0.052 | -0.004 |
Table S5. Normalized rich club coefficient.

| k (degree) | NC Mean | NC SD | SCD Mean | SCD SD | aMCI Mean | aMCI SD | d-AD Mean | d-AD SD | F | p^a | Es^b | Post hocs^c |
|------------|---------|-------|----------|-------|-----------|--------|-----------|--------|----|-----|-------|------------|
| 1          | 1.000   | 0.000 | 1.000    | 0.000 | 1.000     | 0.000  | 1.000     | 0.000  | 0.843 | 0.472 | 0.013 | -            |
| 2          | 1.001   | 0.001 | 1.001    | 0.001 | 1.001     | 0.001  | 1.001     | 0.001  | 3.464 | 0.017 | 0.051 | -            |
| 3          | 1.001   | 0.001 | 1.002    | 0.002 | 1.002     | 0.001  | 1.003     | 0.002  | 6.095 | <0.001 | 0.086 | NC<d-AD      |
| 4          | 1.002   | 0.002 | 1.003    | 0.003 | 1.004     | 0.003  | 1.006     | 0.004  | 14.162 | <0.001 | 0.180 | NC, SCD<d-AD |
| 5          | 1.003   | 0.002 | 1.005    | 0.004 | 1.007     | 0.003  | 1.009     | 0.005  | 20.561 | <0.001 | 0.241 | NC<aMCI, d-AD; SCD<d-AD |
| 6          | 1.004   | 0.003 | 1.007    | 0.005 | 1.010     | 0.005  | 1.015     | 0.008  | 33.989 | <0.001 | 0.345 | NC<aMCI<d-AD; SCD<d-AD |
| 7          | 1.006   | 0.004 | 1.010    | 0.007 | 1.015     | 0.006  | 1.021     | 0.011  | 32.910 | <0.001 | 0.337 | NC<aMCI, d-AD; SCD<d-AD |
| 8          | 1.008   | 0.004 | 1.016    | 0.007 | 1.021     | 0.008  | 1.027     | 0.013  | 37.332 | <0.001 | 0.366 | NC<aMCI; NC<SCD<d-AD |
| 9          | 1.011   | 0.006 | 1.022    | 0.009 | 1.025     | 0.011  | 1.032     | 0.015  | 32.025 | <0.001 | 0.331 | NC<aMCI; NC<SCD<d-AD |
| 10         | 1.015   | 0.007 | 1.027    | 0.010 | 1.031     | 0.013  | 1.037     | 0.016  | 28.020 | <0.001 | 0.302 | NC<aMCI; NC<SCD<d-AD |
| 11         | 1.018   | 0.008 | 1.032    | 0.013 | 1.034     | 0.015  | 1.040     | 0.019  | 20.707 | <0.001 | 0.243 | NC<SCD, aMCI, d-AD |
| 12         | 1.022   | 0.011 | 1.036    | 0.016 | 1.039     | 0.020  | 1.042     | 0.027  | 9.440  | <0.001 | 0.127 | NC<aMCI, d-AD |
| 13         | 1.024   | 0.011 | 1.041    | 0.023 | 1.041     | 0.024  | 1.047     | 0.035  | 7.343  | <0.001 | 0.102 | NC<d-AD      |
| 14         | 1.028   | 0.014 | 1.046    | 0.027 | 1.041     | 0.029  | 1.011     | 0.201  | 1.001  | 0.394  | 0.015 | -            |
| 15         | 1.030   | 0.015 | 1.051    | 0.033 | 1.050     | 0.029  | 1.191     | 1.925  | 0.199  | 0.897  | 0.003 | -            |
| 16         | 1.034   | 0.021 | 1.035    | 0.172 | 0.994     | 0.259  | 0.818     | 0.460  | 5.046  | 0.002  | 0.072 | -            |

^a Values from ANCOVA with age and gender as covariates.

^b Effect size; partial \( \eta^2 \) for normalized rich club coefficient.

^c Least significant difference; post hoc testing on normalized rich club coefficient based on means adjusted for age, gender.

aMCI: amnestic mild cognitive impairment; d-AD: dementia of Alzheimer’s disease; NC: normal control; SCD: subjective cognitive decline.
Table S6. Post hoc testing on normalized rich club coefficient from ANCOVA with age and gender as covariates (Bonferroni-corrected for groups).

| k (degree) | (I) Group | (J) Group | Mean Difference (I-J) | SE | P | 95% Confidence Interval for Difference | Lower Bound | Upper Bound |
|------------|-----------|-----------|-----------------------|----|---|----------------------------------------|------------|------------|
|            | NC        | SCD       | 0.000                 | 0.000 | 1.000 | 0.000 | 0.000 |
| 1          | NC        | aMCI      | 0.000                 | 0.000 | 1.000 | 0.000 | 0.000 |
|            | NC        | d-AD      | 0.000                 | 0.000 | 1.000 | 0.000 | 0.000 |
|            | SCD       | NC        | 0.000                 | 0.000 | 1.000 | 0.000 | 0.000 |
|            | SCD       | aMCI      | 0.000                 | 0.000 | 0.767 | 0.000 | 0.000 |
|            | SCD       | d-AD      | 0.000                 | 0.000 | 1.000 | 0.000 | 0.000 |
|            | aMCI      | NC        | 0.000                 | 0.000 | 1.000 | 0.000 | 0.000 |
|            | aMCI      | SCD       | 0.000                 | 0.000 | 0.767 | 0.000 | 0.000 |
|            | aMCI      | d-AD      | 0.000                 | 0.000 | 1.000 | 0.000 | 0.000 |
|            | d-AD      | NC        | 0.000                 | 0.000 | 1.000 | 0.000 | 0.000 |
|            | d-AD      | SCD       | 0.000                 | 0.000 | 1.000 | 0.000 | 0.000 |
|            | d-AD      | aMCI      | 0.000                 | 0.000 | 1.000 | 0.000 | 0.000 |
| 2          | NC        | SCD       | 0.000                 | 0.000 | 0.420 | -0.001 | 0.000 |
|            | NC        | aMCI      | 0.000                 | 0.000 | 0.543 | -0.001 | 0.000 |
|            | NC        | d-AD      | -0.001                | 0.000 | **0.010** | -0.001 | 0.000 |
|            | SCD       | NC        | 0.000                 | 0.000 | 0.420 | 0.000 | 0.001 |
|            | SCD       | aMCI      | 0.000                 | 0.000 | 1.000 | 0.000 | 0.001 |
|            | SCD       | d-AD      | 0.000                 | 0.000 | 1.000 | -0.001 | 0.000 |
|            | aMCI      | NC        | 0.000                 | 0.000 | 0.543 | 0.000 | 0.001 |
|            | aMCI      | SCD       | 0.000                 | 0.000 | 1.000 | -0.001 | 0.000 |
|            | aMCI      | d-AD      | 0.000                 | 0.000 | 0.833 | -0.001 | 0.000 |
|            | d-AD      | NC        | 0.001                 | 0.000 | **0.010** | 0.000 | 0.001 |
|            | d-AD      | SCD       | 0.000                 | 0.000 | 1.000 | 0.000 | 0.001 |
|            | d-AD      | aMCI      | 0.000                 | 0.000 | 0.833 | 0.000 | 0.001 |
| 3          | NC        | SCD       | -0.001                | 0.000 | 0.094 | -0.002 | 0.000 |
|            | NC        | aMCI      | -0.001                | 0.000 | 0.474 | -0.002 | 0.000 |
|            | NC        | d-AD      | -0.001                | 0.000 | **<0.001** | -0.002 | -0.001 |
|            | SCD       | NC        | 0.001                 | 0.000 | 0.094 | 0.000 | 0.002 |
|            | SCD       | aMCI      | 0.000                 | 0.000 | 1.000 | -0.001 | 0.001 |
|            | SCD       | d-AD      | -0.001                | 0.000 | 0.760 | -0.002 | 0.000 |
|            | aMCI      | NC        | 0.001                 | 0.000 | 0.474 | 0.000 | 0.002 |
|            | aMCI      | SCD       | 0.000                 | 0.000 | 1.000 | -0.001 | 0.001 |
|            | aMCI      | d-AD      | -0.001                | 0.000 | 0.999 | -0.002 | 0.000 |
|            | d-AD      | NC        | 0.001                 | 0.000 | **<0.001** | 0.001 | 0.002 |
|            | d-AD      | SCD       | 0.001                 | 0.000 | 0.760 | 0.000 | 0.002 |
|            | d-AD      | aMCI      | 0.001                 | 0.000 | 0.999 | 0.000 | 0.002 |
| 4          | NC        | SCD       | -0.001                | 0.001 | 0.259 | -0.003 | 0.000 |
|            | NC        | aMCI      | -0.002                | 0.001 | **0.007** | -0.003 | 0.000 |
|            | NC        | d-AD      | -0.004                | 0.001 | **<0.001** | -0.005 | -0.002 |
|         | SCD   | aMCI  | d-AD  |
|---------|-------|-------|-------|
| NC      | 0.001 | 0.001 | 0.259 |
| aMCI    | -0.001| 0.001 | 1.000 |
| d-AD    | -0.002| 0.001 | 0.001 |

|         | SCD   | aMCI  | d-AD  |
|---------|-------|-------|-------|
| NC      | 0.002 | 0.001 | 0.007 |
| aMCI    | 0.001 | 0.001 | 1.000 |
| d-AD    | -0.002| 0.001 | 0.013 |

|         | SCD   | aMCI  | d-AD  |
|---------|-------|-------|-------|
| NC      | 0.004 | 0.001 | <0.001|
| aMCI    | 0.002 | 0.001 | 0.013 |
| d-AD    | 0.002 | 0.001 | 0.001 |

|         | SCD   | aMCI  | d-AD  |
|---------|-------|-------|-------|
| NC      | -0.002| 0.001 | 0.096 |
| aMCI    | -0.003| 0.001 | 0.277 |
| d-AD    | -0.006| 0.001 | <0.001|

|         | SCD   | aMCI  | d-AD  |
|---------|-------|-------|-------|
| NC      | 0.002 | 0.001 | 0.096 |
| aMCI    | -0.002| 0.001 | 0.277 |
| d-AD    | -0.004| 0.001 | <0.001|

|         | SCD   | aMCI  | d-AD  |
|---------|-------|-------|-------|
| NC      | 0.003 | 0.001 | <0.001|
| aMCI    | 0.002 | 0.001 | 0.023 |
| d-AD    | 0.002 | 0.001 | <0.001|

|         | SCD   | aMCI  | d-AD  |
|---------|-------|-------|-------|
| NC      | -0.003| 0.001 | 0.062 |
| aMCI    | -0.006| 0.001 | <0.001|
| d-AD    | -0.010| 0.001 | <0.001|

|         | SCD   | aMCI  | d-AD  |
|---------|-------|-------|-------|
| NC      | 0.003 | 0.001 | 0.062 |
| aMCI    | -0.003| 0.001 | 0.051 |
| d-AD    | -0.007| 0.001 | <0.001|

|         | SCD   | aMCI  | d-AD  |
|---------|-------|-------|-------|
| NC      | 0.006 | 0.001 | <0.001|
| aMCI    | 0.004 | 0.001 | <0.001|
| d-AD    | 0.002 | 0.001 | <0.001|

|         | SCD   | aMCI  | d-AD  |
|---------|-------|-------|-------|
| NC      | -0.004| 0.001 | 0.022 |
| aMCI    | -0.009| 0.001 | <0.001|
| d-AD    | -0.014| 0.001 | <0.001|

|         | SCD   | aMCI  | d-AD  |
|---------|-------|-------|-------|
| NC      | 0.004 | 0.001 | 0.022 |
| aMCI    | -0.004| 0.002 | 0.024 |
| d-AD    | -0.009| 0.002 | <0.001|

|         | SCD   | aMCI  | d-AD  |
|---------|-------|-------|-------|
| NC      | 0.009 | 0.001 | <0.001|
| aMCI    | 0.004 | 0.002 | 0.024 |
| d-AD    | -0.005| 0.001 | <0.001|

|         | SCD   | aMCI  | d-AD  |
|---------|-------|-------|-------|
| NC      | 0.014 | 0.001 | <0.001|
| aMCI    | 0.009 | 0.002 | <0.001|
| d-AD    | 0.005 | 0.001 | <0.001|

|         | SCD   | aMCI  | d-AD  |
|---------|-------|-------|-------|
| NC      | -0.007| 0.002 | <0.001|
| aMCI    | -0.012| 0.002 | <0.001|
|     | d-AD | NC       | aMCI    | SCDD   | AD     |
|-----|------|----------|---------|--------|--------|
| d-AD| -0.018 | 0.002 | <0.001 | -0.022 | -0.013 |
| NC  | 0.007 | 0.002 | <0.001 | 0.002 | 0.012 |
| aMCI| -0.005 | 0.002 | 0.075 | -0.010 | 0.000 |
| SCDD| -0.011 | 0.002 | <0.001 | -0.015 | -0.006 |
| d-AD| -0.006 | 0.002 | 0.006 | -0.010 | -0.001 |
| SCDD| 0.005 | 0.002 | 0.075 | 0.000 | 0.010 |
| aMCI| 0.006 | 0.002 | 0.006 | 0.001 | 0.010 |
| d-AD| 0.018 | 0.002 | <0.001 | 0.013 | 0.022 |
| NC  | 0.011 | 0.002 | <0.001 | 0.006 | 0.015 |
| aMCI| -0.014 | 0.002 | <0.001 | -0.020 | -0.009 |
| d-AD| -0.020 | 0.002 | <0.001 | -0.026 | -0.015 |
| SCDD| NC     | aMCI    | d-AD    |        |        |
| aMCI| 0.014 | 0.002 | <0.001 | 0.009 | 0.020 |
| SCDD| 0.003 | 0.002 | 0.837 | -0.003 | 0.010 |
| aMCI| -0.006 | 0.002 | 0.031 | -0.012 | 0.000 |
| d-AD| 0.020 | 0.002 | <0.001 | 0.015 | 0.026 |
| NC  | 0.009 | 0.002 | <0.001 | 0.003 | 0.016 |
| aMCI| 0.006 | 0.002 | 0.031 | 0.000 | 0.010 |
| SCDD| NC     | aMCI    | d-AD    |        |        |
| aMCI| 0.016 | 0.002 | <0.001 | 0.009 | 0.022 |
| SCDD| 0.004 | 0.003 | 0.786 | -0.003 | 0.011 |
| aMCI| -0.005 | 0.003 | 0.022 | -0.012 | 0.001 |
| d-AD| 0.021 | 0.002 | <0.001 | 0.015 | 0.028 |
| NC  | 0.009 | 0.003 | 0.002 | 0.002 | 0.016 |
| aMCI| 0.005 | 0.002 | 0.160 | -0.001 | 0.012 |
| SCDD| NC     | aMCI    | d-AD    |        |        |
| aMCI| 0.014 | 0.003 | <0.001 | 0.006 | 0.021 |
| SCDD| -0.003 | 0.003 | 1.000 | -0.011 | 0.005 |
| aMCI| -0.007 | 0.003 | 0.096 | -0.015 | 0.001 |
| d-AD| 0.016 | 0.003 | <0.001 | 0.009 | 0.024 |
| NC  | 0.003 | 0.003 | 1.000 | -0.005 | 0.011 |
| aMCI| -0.005 | 0.003 | 0.591 | -0.012 | 0.003 |
| SCDD| NC     | aMCI    | d-AD    |        |        |
| aMCI| 0.021 | 0.003 | <0.001 | 0.013 | 0.028 |
| SCDD| 0.007 | 0.003 | 0.096 | -0.001 | 0.015 |
| aMCI| 0.005 | 0.003 | 0.591 | -0.003 | 0.012 |
| d-AD| SCDD   |        |        |        |        |

| SCDD| 0.014 | 0.004 | 0.005 | -0.024 | -0.003 |

| SCDD| 0.005 | 0.003 | 0.096 | -0.001 | 0.015 |
| d-AD| 0.005 | 0.003 | 0.591 | -0.003 | 0.012 |
| SCDD| NC     | aMCI    | d-AD    |        |        |
| aMCI| 0.003 | 0.003 | 0.006 | 0.006 | 0.024 |
| SCDD| -0.007 | 0.003 | 0.096 | -0.015 | 0.001 |
| aMCI| 0.016 | 0.003 | <0.001 | 0.009 | 0.024 |
| d-AD| 0.003 | 0.003 | 1.000 | -0.005 | 0.011 |
| SCDD| NC     | aMCI    | d-AD    |        |        |
| aMCI| 0.021 | 0.003 | <0.001 | 0.013 | 0.028 |
| SCDD| 0.007 | 0.003 | 0.096 | -0.001 | 0.015 |
| aMCI| 0.005 | 0.003 | 0.591 | -0.003 | 0.012 |
| d-AD| SCDD   |        |        |        |        |

| SCDD| 0.014 | 0.004 | 0.005 | -0.024 | -0.003 |

| SCDD| 0.005 | 0.003 | 0.096 | -0.001 | 0.015 |

| SCDD| NC     | aMCI    | d-AD    |        |        |
| aMCI| 0.016 | 0.003 | <0.001 | 0.009 | 0.024 |
| SCDD| -0.007 | 0.003 | 0.096 | -0.015 | 0.001 |
| aMCI| 0.003 | 0.003 | 1.000 | -0.005 | 0.011 |
| d-AD| 0.005 | 0.003 | 0.591 | -0.012 | 0.003 |
| SCDD| NC     | aMCI    | d-AD    |        |        |
| aMCI| 0.021 | 0.003 | <0.001 | 0.013 | 0.028 |
| SCDD| 0.007 | 0.003 | 0.096 | -0.001 | 0.015 |
| aMCI| 0.005 | 0.003 | 0.591 | -0.003 | 0.012 |
| d-AD| SCDD   |        |        |        |        |

| SCDD| 0.014 | 0.004 | 0.005 | -0.024 | -0.003 |

| SCDD| 0.005 | 0.003 | 0.096 | -0.001 | 0.015 |
|     | aMCI     | NC   | d-AD | d-AD |
|-----|----------|------|------|------|
| 12  | -0.016   | 0.004| <0.001 | -0.027 | -0.006|
| SCD | -0.018   | 0.004| <0.001 | -0.029 | -0.008|
| NC  | 0.144    | 0.004| 0.005  | 0.030  | 0.024 |
| aMCI| -0.003   | 0.004| 1.000  | -0.014 | 0.008 |
| d-AD| -0.005   | 0.004| 1.000  | -0.016 | 0.006 |
| NC  | 0.016    | 0.004| <0.001 | 0.006  | 0.027 |
| aMCI| 0.003    | 0.004| 1.000  | -0.008 | 0.014 |
| d-AD| -0.002   | 0.004| 1.000  | -0.012 | 0.008 |
| NC  | 0.018    | 0.004| <0.001 | 0.008  | 0.029 |
| SCD | 0.005    | 0.004| 1.000  | -0.006 | 0.016 |
| aMCI| 0.002    | 0.004| 1.000  | -0.008 | 0.012 |
| 13  | NC       | 0.017 | 0.005 | 0.006  | 0.004  | 0.031 |
| SCD | 0.001    | 0.005 | 1.000  | -0.014 | 0.015 |
| NC  | -0.004   | 0.005| 1.000  | -0.018 | 0.010 |
| NC  | 0.017    | 0.005| <0.001 | 0.008  | 0.034 |
| NC  | -0.001   | 0.005| <0.001 | -0.010 | 0.018 |
| SCD | -0.004   | 0.005| 1.000  | -0.018 | 0.009 |
| NC  | 0.021    | 0.005| <0.001 | 0.008  | 0.034 |
| NC  | 0.004    | 0.005| 1.000  | -0.010 | 0.018 |
| 14  | SCD      | -0.020 | 0.022 | 1.000  | -0.079 | 0.040 |
| NC  | -0.017   | 0.021| 1.000  | -0.074 | 0.040 |
| SCD | 0.013    | 0.021| 1.000  | -0.044 | 0.071 |
| NC  | 0.020    | 0.022| 1.000  | -0.040 | 0.079 |
| d-AD| 0.033    | 0.023| 0.895  | -0.028 | 0.094 |
| NC  | 0.017    | 0.021| 1.000  | -0.040 | 0.074 |
| SCD | -0.003   | 0.023| 1.000  | -0.064 | 0.059 |
| NC  | 0.031    | 0.021| 0.934  | -0.027 | 0.088 |
| d-AD| 0.013    | 0.021| 1.000  | -0.071 | 0.044 |
| 15  | SCD      | 0.007  | 0.210 | 1.000  | -0.553 | 0.566 |
| NC  | 0.036    | 0.201| 1.000  | -0.500 | 0.572 |
| d-AD| -0.109   | 0.200| 1.000  | -0.643 | 0.425 |
| NC  | 0.007    | 0.210| 1.000  | -0.566 | 0.553 |
| SCD | 0.029    | 0.216| 1.000  | -0.546 | 0.605 |
| NC  | -0.116   | 0.214| 1.000  | -0.687 | 0.455 |
| NC  | -0.036   | 0.201| 1.000  | -0.572 | 0.500 |
| d-AD| -0.145   | 0.201| 1.000  | -0.680 | 0.390 |
| d-AD| 0.109    | 0.200| 1.000  | -0.425 | 0.643 |
| aMCI| 0.116    | 0.214| 1.000  | -0.455 | 0.687 |
| aMCI| 0.145    | 0.201| 1.000  | -0.390 | 0.680 |
|       | NC   | SCD  | aMCI | d-AD | SCD  | aMCI | d-AD | SCD  | aMCI | d-AD |
|-------|------|------|------|------|------|------|------|------|------|------|
| NC    |      | 0.011| 0.059| 1.000| -0.167| 0.146|
| aMCI  |      | 0.020| 0.056| 1.000| -0.131| 0.170|
| d-AD  | 0.183| 0.056| 0.008| 0.034| 0.333|
| SCD   | NC   | 0.011| 0.059| 1.000| -0.146| 0.167|
| aMCI  | 0.030| 0.060| 0.009| 0.034| 0.354|
| d-AD  | 0.194| 0.060| 0.009| 0.034| 0.354|
| aMCI  | NC   | -0.020| 0.056| 1.000| -0.170| 0.131|
| SCD   | -0.030| 0.060| 1.000| -0.192| 0.131|
| d-AD  | 0.164| 0.056| 0.024| 0.014| 0.313|
| d-AD  | NC   | -0.183| 0.056| 0.008| -0.333| -0.034|
| SCD   | -0.194| 0.060| 0.009| -0.354| -0.034|
| aMCI  | -0.164| 0.056| 0.024| -0.313| -0.014|
Table S7. Post hoc testing on rich club, feeder, local connectivity strength from ANCOVA with age and gender as covariates (Bonferroni-corrected for groups).

| ANCOVA COV: Age & Gender | (I) Group | (J) Group | Mean Difference (I-J) | SE     | P      | 95% Confidence Interval for Differenceb | Lower Bound | Upper Bound |
|--------------------------|-----------|-----------|-----------------------|--------|--------|----------------------------------------|------------|-------------|
| Rich Club Connectivity Strength | NC        | SCD       | 0.660                 | 0.375  | 0.481  | -0.339 - 1.659                         |            |             |
|                           | aMCI      | AD        | 1.570                 | 0.355  | <0.001 | 0.628 - 2.521                         |            |             |
|                           | AD        | SCD       | 2.215                 | 0.373  | <0.001 | 1.221 - 3.209                         |            |             |
|                           | aMCI      | AD        | 0.914                 | 0.377  | 0.097  | -0.091 - 1.919                         |            |             |
|                           | AD        | NC        | 1.555                 | 0.392  | 0.001  | 0.511 - 2.600                         |            |             |
| Feeder Connectivity Strength | aMCI     | NC        | -1.574                | 0.355  | <0.001 | -2.521 - 0.628                        |            |             |
|                           | SCD       | aMCI      | -0.914                | 0.377  | 0.097  | -1.919 - 0.091                        |            |             |
|                           | AD        | AD        | 0.641                 | 0.366  | 0.487  | -0.333 - 1.614                        |            |             |
|                           | AD        | SCG       | -0.641                | 0.366  | 0.487  | -1.614 - 0.333                        |            |             |
|                           | aMCI      | d-AD      | 2.215                 | 0.373  | <0.001 | -3.209 - 1.221                        |            |             |
|                           | SCG       | d-AD      | 1.555                 | 0.392  | 0.001  | -2.600 - 0.511                        |            |             |
|                           | aMCI      | d-AD      | 0.641                 | 0.366  | 0.487  | -1.614 - 0.333                        |            |             |
| Local Connectivity Strength | SCG       | NC        | 9.500                 | 1.415  | <0.001 | 5.733 - 13.267                        |            |             |
|                           | aMCI      | aMCI      | 12.889                | 1.340  | <0.001 | 9.320 - 16.457                        |            |             |
|                           | AD        | AD        | 19.608                | 1.408  | <0.001 | 15.859 - 23.357                       |            |             |
|                           | AD        | SCG       | 10.108                | 1.479  | <0.001 | 6.169 - 14.046                        |            |             |
|                           | aMCI      | d-AD      | -2.215                | 0.373  | <0.001 | -3.209 - 1.221                        |            |             |
|                           | SCG       | d-AD      | -1.555                | 0.392  | 0.001  | -2.600 - 0.511                        |            |             |
|                           | aMCI      | d-AD      | 0.641                 | 0.366  | 0.487  | -1.614 - 0.333                        |            |             |
Table S8. Post hoc testing on network topological metrics from ANCOVA with age and gender as covariates (Bonferroni-corrected for groups).

| Network Topological Metrics | (I) Group | (J) Group | Mean Difference (I-J) | SE | P  | 95% Confidence Interval for Difference |
|-----------------------------|-----------|-----------|------------------------|----|----|---------------------------------------|
|                             |           |           |                        |    |    | Lower Bound | Upper Bound |
| Strength                    | NC        | SCD       | 0.704                  | 0.079 | <0.001 | 0.494 | 0.915 |
|                             |           | aMCI      | 0.935                  | 0.075 | <0.001 | 0.736 | 1.134 |
|                             |           | d-AD      | 1.377                  | 0.079 | <0.001 | 1.168 | 1.586 |
|                             | SCD       | NC        | -0.704                 | 0.079 | <0.001 | -0.915 | -0.494 |
|                             |           | aMCI      | 0.230                  | 0.079 | 0.024  | 0.019 | 0.442 |
|                             |           | d-AD      | 0.673                  | 0.082 | <0.001 | 0.453 | 0.892 |
|                             | aMCI      | SCD       | -0.230                 | 0.079 | <0.001 | -0.442 | -0.019 |
|                             |           | d-AD      | 0.442                  | 0.077 | <0.001 | 0.238 | 0.647 |
|                             | d-AD      | NC        | -1.377                 | 0.079 | <0.001 | -1.586 | -1.168 |
|                             |           | SCD       | -0.673                 | 0.082 | <0.001 | -0.892 | -0.453 |
|                             |           | aMCI      | -0.442                 | 0.077 | <0.001 | -0.647 | -0.238 |
| Clustering Coefficient     | NC        | SCD       | -0.015                 | 0.004 | 0.003  | 0.004 | 0.026 |
|                             |           | aMCI      | 0.019                  | 0.004 | <0.001 | 0.008 | 0.029 |
|                             |           | d-AD      | 0.026                  | 0.004 | <0.001 | 0.015 | 0.037 |
|                             | SCD       | NC        | -0.015                 | 0.004 | 0.003  | -0.026 | -0.004 |
|                             |           | aMCI      | 0.003                  | 0.004 | 1.000  | -0.008 | 0.015 |
|                             |           | d-AD      | 0.011                  | 0.004 | 0.101  | -0.001 | 0.022 |
|                             | aMCI      | SCD       | -0.003                 | 0.004 | 1.000  | -0.015 | 0.008 |
|                             |           | d-AD      | 0.007                  | 0.004 | 0.486  | -0.004 | 0.018 |
|                             | d-AD      | NC        | -0.026                 | 0.004 | <0.001 | -0.037 | -0.015 |
|                             |           | SCD       | -0.011                 | 0.004 | 0.101  | -0.022 | 0.001 |
|                             |           | aMCI      | -0.007                 | 0.004 | 0.486  | -0.018 | 0.004 |
|                             | NC        | SCD       | -0.158                 | 0.031 | <0.001 | -0.240 | -0.076 |
|                             |           | aMCI      | -0.145                 | 0.029 | <0.001 | -0.223 | -0.068 |
|                             |           | d-AD      | -0.340                 | 0.031 | <0.001 | -0.422 | -0.259 |
| Normalized Clustering Coefficient | NC                  | SCD       | 0.158                  | 0.031 | <0.001 | 0.076  | 0.240 |
|                             |           | aMCI      | 0.013                  | 0.031 | 1.000  | -0.070 | 0.095 |
|                             |           | d-AD      | -0.182                 | 0.032 | <0.001 | -0.268 | -0.097 |
|                             | aMCI      | SCD       | 0.145                  | 0.029 | <0.001 | 0.068  | 0.223 |
|                             |           | d-AD      | -0.195                 | 0.030 | <0.001 | -0.275 | -0.115 |
| Characteristic Path Length | NC        | SCD       | -0.348                 | 0.065 | <0.001 | -0.521 | -0.176 |
|                             |           | aMCI      | -0.468                 | 0.061 | <0.001 | -0.631 | -0.305 |
|                             |           | d-AD      | -0.760                 | 0.064 | <0.001 | -0.931 | -0.588 |
|          | NC     | 0.348  | 0.065  | <0.001  | 0.176  | 0.521  |
|----------|--------|--------|--------|----------|--------|--------|
| SCD      | aMCI   | -0.119 | 0.065  | 0.408    | -0.293 | 0.054  |
|          | d-AD   | -0.411 | 0.068  | <0.001   | -0.591 | -0.231 |
| aMCI     | NC     | 0.468  | 0.061  | <0.001   | 0.305  | 0.631  |
|          | SCD    | 0.119  | 0.065  | 0.408    | -0.054 | 0.293  |
|          | d-AD   | -0.292 | 0.063  | <0.001   | -0.460 | -0.124 |
| d-AD     | NC     | 0.760  | 0.064  | <0.001   | 0.588  | 0.931  |
|          | SCD    | 0.411  | 0.068  | <0.001   | 0.231  | 0.591  |
|          | aMCI   | 0.292  | 0.063  | <0.001   | 0.124  | 0.460  |
| NC       | SCD    | -0.005 | 0.002  | 0.135    | -0.011 | 0.001  |
|          | aMCI   | 0.000  | 0.002  | 1.000    | -0.006 | 0.005  |
|          | d-AD   | -0.007 | 0.002  | 0.015    | -0.013 | -0.001 |
|          | 0.005  | 0.002  | 0.135   | -0.001  | 0.011  |
|          | 0.005  | 0.002  | 0.212   | -0.001  | 0.011  |
|          | -0.002 | 0.002  | 1.000   | -0.008  | 0.004  |
|          | -0.005 | 0.002  | 0.212   | -0.011  | 0.001  |
|          | -0.006 | 0.002  | 0.021   | -0.012  | -0.001 |
| aMCI     | NC     | 0.000  | 0.002  | 1.000    | -0.005 | 0.006  |
|          | SCD    | -0.005 | 0.002  | 0.212    | -0.011 | 0.001  |
|          | d-AD   | -0.006 | 0.002  | 0.021    | -0.012 | -0.001 |
| d-AD     | NC     | 0.007  | 0.002  | 0.015    | 0.001  | 0.013  |
|          | SCD    | 0.002  | 0.002  | 1.000    | -0.004 | 0.008  |
|          | aMCI   | 0.006  | 0.002  | 0.021    | 0.001  | 0.012  |
Table S9. Whole-brain structural connectivity of nodes with the highest number of aberrant connections in patient groups compared with NC. Nodes with the highest number of aberrant connections in each patient groups (range = 11 to 27 aberrant connections), based on two-sample t-test (NC versus each patient groups) with FDR corrected to the P values to correct for multiple comparisons across all edges. Significance was set at \( P<0.05 \). The bold nodes represent the rich club nodes in all groups.

| Region          | MNI    | Number of Connections |
|-----------------|--------|-----------------------|
|                 | x      | y        | z      | SCD vs. NC | aMCI vs. NC | d-AD vs. NC |
| CAU.L           | -11.46 | 11       | 9.24   | 15         | 15          | 22          |
| CAU.R           | 14.84  | 12.07    | 9.42   | 12         | 14          | 20          |
| ORBmid.L        | -30.65 | 50.43    | -9.62  | 11         | 9           | 7           |
| PCUN.L          | -7.24  | -56.07   | 48.01  | 19         | 27          |
| SFGdor.R        | 21.9   | 31.12    | -43.82 | 17         | 17          |
| MOG.L           | -32.39 | -80.73   | 16.11  | 16         | 18          |
| PCUN.R          | 9.98   | -56.05   | 43.77  | 15         | 26          |
| THA.L           | -10.85 | -17.56   | 7.98   | 15         | 20          |
| SPG.R           | 26.11  | -59.18   | 62.06  | 15         | 17          |
| HIP.L           | -25.03 | -20.74   | -10.13 | 15         | 16          |
| HIP.R           | 29.23  | -19.78   | -10.33 | 15         | 13          |
| SPG.L           | -23.45 | -59.56   | 58.96  | 14         | 22          |
| DCG.L           | -5.48  | -14.92   | 41.57  | 14         | 17          |
| ORBsup.L        | -16.56 | 47.32    | -13.31 | 14         | 15          |
| OLF.L           | -8.06  | 15.05    | -11.46 | 13         | 13          |
| CALL            | -7.14  | -78.67   | 6.44   | 13         | 13          |
| ACG.R           | 8.46   | 37.01    | 15.84  | 13         | 12          |
| PUT.R           | 27.78  | 4.91     | 2.46   | 12         | 17          |
| ACG.L           | -4.04  | 35.4     | 13.95  | 12         | 15          |
| PUT.L           | -23.91 | 3.86     | 2.4    | 12         | 15          |
| SOG.L           | -16.54 | -84.26   | 28.17  | 12         | 14          |
| ORBmid.R        | 33.18  | 52.59    | -10.73 | 12         | 12          |
| CUN.L           | -5.93  | -80.13   | 27.22  | 12         |
| PHG.R           | 25.38  | -15.15   | -20.47 | 11         | 17          |
| IFGtriang.R     | 50.33  | 30.16    | 14.17  | 11         | 16          |
| INS.L           | -35.13 | 6.65     | 3.44   | 11         | 14          |
| PCG.L           | -4.85  | -42.92   | 24.67  | 11         | 14          |
| SMA.R           | 8.62   | 0.17     | 61.85  | 11         | 13          |
| TPOsup.R        | 48.25  | 14.75    | -16.86 | 11         | 13          |
| LING.R          | 16.29  | -66.93   | -3.87  | 11         | 12          |
| THA.R           | 13     | -17.55   | 8.09   | 11         | 14          |
| IFGtriang.L     | -45.58 | 29.91    | 13.99  | 17         |
| MFG.R           | 37.59  | 33.06    | 34.04  | 14         |
| DCG.R           | 8.02   | -8.83    | 39.79  | 14         |
|                |        |        |       |   |
|----------------|--------|--------|-------|---|
| ORBinf.R       | -41.22 | 32.23  | -11.91| 13|
| SMA.L          | -5.32  | 4.85   | 61.38 | 13|
| SFGmed.R       | 9.1    | 50.84  | 30.22 | 13|
| INS.R          | 39.02  | 6.25   | 2.08  | 13|
| CUN.R          | 13.51  | -79.36 | 28.23 | 13|
| ITG.L          | -49.77 | -28.05 | -23.17| 13|
| ITG.R          | 53.69  | -31.07 | -22.32| 13|
| MFG.L          | -33.43 | 32.73  | 35.46 | 12|
| ORBinf.L       | -35.98 | 30.71  | -12.11| 12|
| SFGmed.L       | -4.8   | 49.17  | 30.89 | 12|
| LING.L         | -14.62 | -67.56 | -4.63 | 12|
| SOG.R          | 24.29  | -80.85 | 30.59 | 12|
| SFGdor.L       | -18.45 | 34.81  | 42.2  | 11|
| PoCG.R         | 41.43  | -25.49 | 52.55 | 11|
| PCL.L          | -7.63  | -25.36 | 70.07 | 11|
Table S10. Post hoc testing on nodal efficiency from ANCOVA with age and gender as covariates (Bonferroni-corrected for groups).

| COV: Age & Gender | (I) Group | (J) Group | Mean Difference (I-J) | SE | P   | 95% Confidence Interval for Difference |
|-------------------|-----------|-----------|-----------------------|----|-----|---------------------------------------|
|                   |           |           |                       |    |     | Lower Bound                          |
|                   |           |           |                       |    |     | Upper Bound                          |
| CAU.L Efficiency  | NC        | SCD       | 0.021                 | 0.006 | 0.005 | 0.005 - 0.037                      |
|                   | NC        | aMCI      | 0.016                 | 0.006 | 0.031 | 0.001 - 0.032                      |
|                   | NC        | AD        | 0.021                 | 0.006 | 0.004 | 0.005 - 0.038                      |
|                   | SCD       | aMCI      | -0.021                | 0.006 | 0.005 | -0.037 - 0.005                     |
|                   | SCD       | AD        | 0.000                 | 0.006 | 1.000 | -0.017 - 0.017                     |
|                   | aMCI      | NC        | -0.016                | 0.006 | 0.031 | -0.032 - 0.001                     |
|                   | aMCI      | SCD       | 0.005                 | 0.006 | 1.000 | -0.012 - 0.021                     |
|                   | aMCI      | AD        | 0.005                 | 0.006 | 1.000 | -0.011 - 0.021                     |
|                   | d-AD      | SCD       | -0.021                | 0.006 | 0.004 | -0.038 - 0.005                     |
|                   | d-AD      | aMCI      | 0.014                 | 0.006 | 0.071 | -0.011 - 0.029                     |
|                   | d-AD      | AD        | 0.023                 | 0.006 | <0.001| 0.008 - 0.038                     |
| CAU.R Efficiency  | NC        | SCD       | -0.014                | 0.006 | 0.071 | -0.029 - 0.001                     |
|                   | NC        | aMCI      | 0.014                 | 0.005 | 0.044 | 0.000 - 0.028                     |
|                   | NC        | AD        | 0.023                 | 0.006 | <0.001| -0.006 - 0.023                    |
|                   | SCD       | aMCI      | 0.000                 | 0.006 | 1.000 | -0.015 - 0.015                     |
|                   | SCD       | AD        | 0.009                 | 0.006 | 0.788 | -0.007 - 0.024                     |
|                   | aMCI      | NC        | -0.014                | 0.005 | 0.044 | -0.028 - 0.000                     |
|                   | aMCI      | SCD       | 0.000                 | 0.006 | 1.000 | -0.015 - 0.015                     |
|                   | aMCI      | AD        | 0.009                 | 0.005 | 0.662 | -0.006 - 0.023                    |
|                   | d-AD      | NC        | -0.023                | 0.006 | <0.001| -0.038 - 0.008                     |
|                   | d-AD      | SCD       | -0.009                | 0.006 | 0.788 | -0.024 - 0.007                     |
|                   | d-AD      | aMCI      | -0.009                | 0.005 | 0.662 | -0.023 - 0.006                     |
| ORBmid.L Efficiency | NC      | SCD       | 0.092                 | 0.020 | <0.001| 0.040 - 0.145                     |
|                   | NC        | aMCI      | 0.095                 | 0.019 | <0.001| 0.045 - 0.145                     |
|                   | NC        | AD        | 0.097                 | 0.020 | <0.001| 0.045 - 0.149                     |
|                   | SCD       | aMCI      | 0.003                 | 0.020 | 1.000 | -0.050 - 0.055                     |
|                   | SCD       | AD        | 0.005                 | 0.021 | 1.000 | -0.050 - 0.059                     |
|                   | aMCI      | NC        | -0.095                | 0.019 | <0.001| -0.145 - 0.045                     |
|                   | aMCI      | SCD       | -0.003                | 0.020 | 1.000 | -0.055 - 0.050                     |
|                   | aMCI      | AD        | -0.002                | 0.019 | 1.000 | -0.049 - 0.053                     |
|                   | d-AD      | NC        | -0.097                | 0.020 | <0.001| -0.149 - 0.045                     |
|                   | d-AD      | SCD       | -0.005                | 0.021 | 1.000 | -0.059 - 0.050                     |
|                   | d-AD      | aMCI      | -0.002                | 0.019 | 1.000 | -0.053 - 0.049                     |
Table S11. Partial Pearson’s correlations between rich club, feeder and local connectivity strength and clinical performance. Partial Pearson’s correlations controlled for age, gender, and education were used to assess how rich club, feeder and local connectivity related to clinical performance in each group. The bold numbers represent significant correlations at $P<0.05$ without Bonferroni corrections. The star-labeled numbers represent significant correlations at $P<0.05$ after Bonferroni corrections for the number of cognitive test variables (AVLT-immediate recall, AVLT-delayed recall, AVLT-recognition, MMSE and MoCA).

| COV: Age & Gender & Education | Rich Club Connectivity Strength | Feeder Connectivity Strength | Local Connectivity Strength |
|-----------------------------|--------------------------------|-----------------------------|-----------------------------|
|                             | AVLT-Immediate Recall Scores  | r  0.119                     | 0.192                       | 0.001                       |
|                             |                               | p  0.202                     | 0.089                       | 0.496                       |
|                             | AVLT-Delayed Recall Scores    | r  -0.150                    | 0.099                       | -0.012                      |
| NC DF=49                    |                               | p  0.146                     | 0.245                       | 0.467                       |
|                             | AVLT-Recognition Scores       | r  -0.153                    | 0.209                       | 0.112                       |
|                             |                               | p  0.141                     | 0.070                       | 0.218                       |
|                             | MMSE                          | r  0.085                     | 0.157                       | 0.120                       |
|                             |                               | p  0.278                     | 0.135                       | 0.201                       |
|                             | MoCA                          | r  -0.095                    | 0.231                       | 0.181                       |
|                             |                               | p  0.253                     | 0.051                       | 0.102                       |
| SCD DF=39                   | AVLT-Immediate Recall Scores  | r  0.047                     | 0.234                       | 0.087                       |
|                             |                               | p  0.386                     | 0.070                       | 0.294                       |
|                             | AVLT-Delayed Recall Scores    | r  0.223                     | 0.362                       | 0.214                       |
|                             |                               | p  0.080                     | 0.010*                      | 0.090                       |
|                             | AVLT-Recognition Scores       | r  -0.027                    | 0.162                       | -0.068                      |
|                             |                               | p  0.433                     | 0.156                       | 0.336                       |
|                             | MMSE                          | r  -0.018                    | 0.064                       | -0.039                      |
|                             |                               | p  0.456                     | 0.346                       | 0.405                       |
|                             | MoCA                          | r  0.152                     | 0.061                       | 0.006                       |
|                             |                               | p  0.171                     | 0.353                       | 0.486                       |
| aMCI DF=53                  | AVLT-Immediate Recall Scores  | r  0.118                     | 0.226                       | 0.019                       |
|                             |                               | p  0.195                     | 0.049                       | 0.446                       |
|                             | AVLT-Delayed Recall Scores    | r  0.231                     | 0.442                       | 0.149                       |
|                             |                               | p  0.045                     | <0.001*                     | 0.138                       |
|                             | AVLT-Recognition Scores       | r  0.164                     | 0.227                       | 0.007                       |
|                             |                               | p  0.116                     | 0.048                       | 0.480                       |
|                             | MMSE                          | r  0.177                     | 0.110                       | 0.023                       |
|                             |                               | p  0.098                     | 0.213                       | 0.433                       |
|                             | MoCA                          | r  0.241                     | 0.294                       | 0.086                       |
|                             |                               | p  0.038                     | 0.015                       | 0.266                       |
| d-AD DF=43                  | AVLT-Immediate Recall Scores  | r  0.021                     | 0.038                       | 0.071                       |
|                             |                               | p  0.446                     | 0.403                       | 0.321                       |
|                             | AVLT-Delayed Recall Scores    | r  0.033                     | 0.030                       | 0.074                       |
|                             |                               | p  0.415                     | 0.422                       | 0.315                       |
|                             | r  0.207                     | 0.205                       | 0.197                       |
| Test          | p    | r    | p    |
|--------------|------|------|------|
| AVLT-Recognition Scores | 0.086 | 0.089 | 0.097 |
| MMSE         | 0.340 | 0.040 | 0.034 |
| MoCA         | 0.472 | 0.088 | 0.161 |
Table S12. Partial Pearson’s correlations between nodal efficiency and clinical performance. Partial Pearson’s correlations controlled for age, gender and education were used to assess how the nodal efficiency of the CAU.L and ORBmid.L related to clinical performance in each group. The bold numbers represent significant correlations at $P<0.05$ without Bonferroni corrections. The star-labeled numbers represent significant correlations at $P<0.05$ after Bonferroni corrections for the number of cognitive test variables (AVLT-immediate recall, AVLT-delayed recall, AVLT-recognition, MMSE and MoCA).

| COV: Gender & Age & Education | CAU.L Efficiency | ORBmid.L Efficiency |
|--------------------------------|------------------|---------------------|
|                                | r                | p                   |
| AVLT-Immediate Recall Scores   | -0.178           | 0.208               |
| p                              | 0.105            | 0.071               |
| r                              | -0.126           | 0.098               |
| AVLT-Delayed Recall Scores     | p 0.190          | 0.247               |
| r                              | -0.035           | 0.111               |
| AVLT-Recognition Scores        | p 0.402          | 0.218               |
| MMSE                           | r 0.484          | 0.091               |
| MoCA                           | r 0.054          | -0.113              |
| p                              | 0.354            | 0.216               |
|                                | r -0.021         | -0.023              |
| p                              | 0.447            | 0.443               |
| r                              | 0.210            | -0.042              |
| AVLT-Immediate Recall Scores   | p 0.093          | 0.396               |
| r                              | 0.021            | 0.141               |
| AVLT-Delayed Recall Scores     | p 0.449          | 0.189               |
| MMSE                           | r 0.138          | 0.097               |
| MoCA                           | r -0.125         | -0.014              |
| p                              | 0.219            | 0.466               |
|                                | r -0.193         | 0.098               |
| p                              | 0.079            | 0.239               |
| r                              | -0.078           | 0.119               |
| AVLT-Immediate Recall Scores   | p 0.286          | 0.193               |
| r                              | -0.054           | 0.163               |
| AVLT-Delayed Recall Scores     | p 0.348          | 0.117               |
| r                              | -0.244           | 0.268               |
| MMSE                           | p **0.036**      | **0.024**           |
| MoCA                           | r 0.013          | 0.290               |
| p                              | 0.463            | **0.016**           |
|                                | r 0.253          | -0.045              |
| p                              | **0.047**        | 0.383               |
| r                              | 0.339            | 0.317               |
| AVLT-Immediate Recall Scores   | p **0.011**      | **0.017**           |
| r                              | 0.385            | 0.167               |
| Test          | r    | p   |       |
|--------------|------|-----|-------|
| AVLT-Recognition Scores | 0.290 | 0.004* | 0.136 |
| MMSE         | 0.235 | 0.026 | 0.437 |
| MoCA         | 0.235 | 0.060 | 0.497 |
Table S13. Demographic, clinical and cognitive test variables for age-matched dataset.

| Demographics and Neuropsychological Tests | NC  | SCD | aMCI | d-AD | F   | p<sup>a</sup> | E<sub>b</sub> |
|------------------------------------------|-----|-----|------|------|-----|------------|------------|
| Age (years)                              | 59  | 42  | 47   | 35   | 1.442| 0.232      | 0.024      |
|                                          | (7.60) | (7.54) | (7.81) | (8.09) |     |            |            |
| Education (years)                        | 10.76 | 11.21 | 10.77 | 8.94 | 1.802| 0.148      | 0.029      |
|                                          | (4.80) | (4.61) | (4.30) | (4.55) |     |            |            |
| Gender (F/M)                             | 38/21 | 25/17 | 25/22 | 23/13 | 1.612| 0.657      | -          |
| AVLT-Immediate Recall Scores             | 8.98  | 8.28  | 6.54  | 3.56  | 67.452| <0.001    | 0.555      |
|                                          | (1.90) | (1.82) | (1.55) | (1.85) |     |            |            |
| AVLT-Delayed Recall Scores               | 9.77  | 8.74  | 4.44  | 1.29  | 83.524| <0.001    | 0.607      |
|                                          | (3.04) | (2.76) | (2.78) | (1.81) |     |            |            |
| AVLT-Recognition Scores                  | 11.69 | 11.07 | 8.42  | 3.61  | 55.252| <0.001    | 0.506      |
|                                          | (2.62) | (2.46) | (3.51) | (3.16) |     |            |            |
| MMSE                                     | 27.75 | 27.92 | 25.47 | 16.97 | 62.692| <0.001    | 0.537      |
|                                          | (2.26) | (1.78) | (3.45) | (7.12) |     |            |            |
| MoCA                                     | 25.76 | 25.00 | 20.64 | 13.13 | 96.615| <0.001    | 0.641      |
|                                          | (3.37) | (2.94) | (3.78) | (5.57) |     |            |            |

<sup>a</sup> Values for age and education derived from ANOVA; gender from chi-square test; all clinical/cognitive variables from ANCOVA with education as covariates.

<sup>b</sup> Effect size; η<sup>2</sup> for demographic and clinical variables and partial η<sup>2</sup> for cognitive variables.

<sup>c</sup> Least significant difference; post hoc testing on cognitive variables based on means adjusted for education.

aMCI: amnestic mild cognitive impairment; AVLT: auditory verbal learning test; d-AD: dementia of Alzheimer’s disease; MMSE: mini-mental state examination; MoCA: Montreal cognitive assessment; NC: normal control; SCD: subjective cognitive decline.
Table S14. Post hoc testing on cognitive variables from ANCOVA with education as covariates for age-matched dataset.

| COV: Education (I) Group | (J) Group | Mean Difference (I-J) | SE | P       | 95% Confidence Interval for Difference |
|--------------------------|-----------|------------------------|----|---------|----------------------------------------|
|                          |           |                        |    |         | Lower Bound | Upper Bound |
| AVLT-Immediate Recall Scores | SCU       | NC                     | 0.783 | 0.372  | **0.037** | 0.048 | 1.518  |
|                          | SCU       | aMCI                  | 2.480 | 0.357  | <0.001   | 1.775 | 3.184  |
|                          | SCU       | d-AD                  | 5.366 | 0.398  | <0.001   | 4.580 | 6.152  |
|                          | SCD       | NC                     | -0.783 | 0.372  | **0.037** | -1.518 | -0.048 |
|                          | SCD       | aMCI                  | 1.697 | 0.383  | <0.001   | 0.940 | 2.454  |
|                          | SCD       | d-AD                  | 4.583 | 0.424  | <0.001   | 3.745 | 5.421  |
|                          | aMCI      | SCU                   | -2.480 | 0.357  | <0.001   | -3.184 | -1.775 |
|                          | aMCI      | SCD                   | -1.697 | 0.383  | <0.001   | -2.454 | -0.940 |
|                          | aMCI      | d-AD                  | 2.886 | 0.410  | <0.001   | 2.077 | 3.696  |
|                          | SCD       | SCU                   | 1.181 | 0.559  | **0.036** | 0.078 | 2.285  |
|                          | SCD       | aMCI                  | 5.398 | 0.536  | <0.001   | 4.340 | 6.456  |
|                          | SCD       | d-AD                  | 8.376 | 0.597  | <0.001   | 7.196 | 9.555  |
|                          | aMCI      | SCU                   | 4.217 | 0.576  | <0.001   | 3.080 | 5.354  |
|                          | aMCI      | SCD                   | 7.195 | 0.637  | <0.001   | 5.936 | 8.453  |
|                          | aMCI      | d-AD                  | 2.978 | 0.616  | <0.001   | 1.762 | 4.194  |
|                          | SCU       | SCU                   | 0.743 | 0.536  | <0.001   | -6.456 | -4.340 |
|                          | SCU       | aMCI                  | 4.217 | 0.576  | <0.001   | -5.354 | -3.080 |
|                          | SCU       | d-AD                  | 2.978 | 0.616  | <0.001   | 1.762 | 4.194  |
|                          | aMCI      | SCU                   | 3.330 | 0.593  | <0.001   | 2.159 | 4.501  |
|                          | aMCI      | SCD                   | 7.995 | 0.661  | <0.001   | 6.689 | 9.300  |
|                          | aMCI      | d-AD                  | 4.664 | 0.682  | <0.001   | 3.318 | 6.010  |
|                          | SCD       | SCU                   | -0.743 | 0.618  | 0.231 | -0.478 | 1.965  |
|                          | SCD       | aMCI                  | 2.587 | 0.637  | <0.001   | 1.329 | 3.845  |
|                          | SCD       | d-AD                  | 7.251 | 0.705  | <0.001   | 5.859 | 8.644  |
|                          | aMCI      | SCU                   | -3.330 | 0.593  | <0.001   | -4.501 | -2.159 |
|                          | aMCI      | SCD                   | -2.587 | 0.637  | <0.001   | -3.845 | -1.329 |
|                          | aMCI      | d-AD                  | 4.664 | 0.682  | <0.001   | 3.318 | 6.010  |
|                          | SCU       | SCU                   | -7.995 | 0.661  | <0.001   | -9.300 | -6.689 |
|                          | SCU       | aMCI                  | -7.251 | 0.705  | <0.001   | -8.644 | -5.859 |
|                          | SCU       | d-AD                  | -4.664 | 0.682  | <0.001   | -6.010 | -3.318 |
|                          | aMCI      | SCU                   | 0.081 | 0.786  | 0.918 | -1.470 | 1.633  |
|                          | aMCI      | SCD                   | 2.403 | 0.753  | **0.002** | 0.916 | 3.890  |
|                          | aMCI      | d-AD                  | 10.614 | 0.840  | <0.001   | 8.955 | 12.272 |
|            | NC     | aMCI   | d-AD   | MoCA   |
|------------|--------|--------|--------|--------|
| SCD        | -0.081 | 2.322  | 10.532 | -1.189 |
| aMCI       | 2.322  | -2.403 | 8.211  | 5.322  |
| d-AD       | 10.532 | -10.614| -8.211 | 12.362 |
| aMCI       | -2.403 | 5.322  | -8.211 | -5.322 |
| d-AD       | 8.211  | -10.614| -8.211 | 12.362 |
| NC         |        |        |        |        |
| aMCI       | 5.322  | 4.133  | 11.173 | -5.322 |
| d-AD       | 12.362 | 11.173 | 11.173 | 12.362 |
| MoCA       |        |        |        |        |
| SCD        | 1.189  | 4.133  | 11.173 | -5.322 |
| aMCI       | 5.322  | 4.133  | 11.173 | -5.322 |
| d-AD       | 12.362 | 11.173 | 11.173 | 12.362 |
| aMCI       | -5.322 | -4.133 | 7.040  | -7.040 |
| d-AD       | -12.362| -11.173| -7.040 | -7.040 |

**Note:** The above values represent statistical significance levels (p-values) for each comparison, with values in bold indicating significance at p < 0.001.
Table S15. Rich club coefficient for age-matched dataset.

| k (degree) | NC Mean | NC SD | SCD Mean | SCD SD | aMCI Mean | aMCI SD | d-AD Mean | d-AD SD | F   | p^a   | Es^b |
|------------|---------|-------|----------|-------|-----------|--------|-----------|--------|------|-------|------|
| 1          | 0.999   | 0.000 | 0.999    | 0.001 | 0.999     | 0.001  | 0.999     | 0.001  | 2.867| 0.038 | 0.046|
| 2          | 0.998   | 0.001 | 0.997    | 0.002 | 0.997     | 0.002  | 0.996     | 0.003  | 10.853| <0.001| 0.153|
| 3          | 0.996   | 0.003 | 0.993    | 0.004 | 0.994     | 0.003  | 0.989     | 0.005  | 27.048| <0.001| 0.311|
| 4          | 0.992   | 0.004 | 0.985    | 0.006 | 0.985     | 0.006  | 0.979     | 0.006  | 48.027| <0.001| 0.445|
| 5          | 0.985   | 0.006 | 0.975    | 0.008 | 0.974     | 0.008  | 0.963     | 0.009  | 64.814| <0.001| 0.519|
| 6          | 0.974   | 0.008 | 0.962    | 0.011 | 0.959     | 0.009  | 0.946     | 0.013  | 59.969| <0.001| 0.500|
| 7          | 0.961   | 0.009 | 0.949    | 0.012 | 0.944     | 0.012  | 0.925     | 0.018  | 58.885| <0.001| 0.495|
| 8          | 0.945   | 0.011 | 0.934    | 0.014 | 0.927     | 0.013  | 0.907     | 0.022  | 47.588| <0.001| 0.442|
| 9          | 0.929   | 0.011 | 0.918    | 0.015 | 0.911     | 0.017  | 0.888     | 0.026  | 41.479| <0.001| 0.409|
| 10         | 0.913   | 0.013 | 0.903    | 0.016 | 0.895     | 0.018  | 0.868     | 0.027  | 47.160| <0.001| 0.440|
| 11         | 0.898   | 0.014 | 0.886    | 0.019 | 0.879     | 0.022  | 0.851     | 0.031  | 37.201| <0.001| 0.383|
| 12         | 0.884   | 0.017 | 0.870    | 0.027 | 0.860     | 0.027  | 0.829     | 0.036  | 33.605| <0.001| 0.359|
| 13         | 0.867   | 0.020 | 0.851    | 0.035 | 0.842     | 0.032  | 0.812     | 0.038  | 24.729| <0.001| 0.292|
| 14         | 0.854   | 0.024 | 0.835    | 0.041 | 0.824     | 0.041  | 0.789     | 0.055  | 20.525| <0.001| 0.255|
| 15         | 0.838   | 0.026 | 0.818    | 0.047 | 0.809     | 0.041  | 0.772     | 0.058  | 18.634| <0.001| 0.237|
| 16         | 0.823   | 0.030 | 0.802    | 0.056 | 0.795     | 0.044  | 0.764     | 0.052  | 13.127| <0.001| 0.180|

^a Values from ANOVA.

^b Effect size; η^2 for rich club coefficient.
Table S16. Post hoc testing on rich club coefficient from ANOVA for age-matched dataset (Bonferroni-corrected for groups).

| k (degree) | (I) Group | (J) Group | Mean Difference (I-J) | SE | P       | 95% Confidence Interval for Difference |
|------------|-----------|-----------|-----------------------|----|---------|---------------------------------------|
|            |           |           |                       |    |         | Lower Bound                          |
|            |           |           |                       |    |         | Upper Bound                          |
| 1          | NC        | SCD       | 0.000                 | 0.000 | 0.387   | 0.000                                |
|            |           | aMCI      | 0.000                 | 0.000 | 0.329   | 0.000                                |
|            |           | d-AD      | 0.000                 | 0.000 | 0.042   | 0.000                                |
|            | SCD       | NC        | 0.000                 | 0.000 | 0.387   | -0.001                              |
|            |           | aMCI      | 0.000                 | 0.000 | 1.000   | 0.000                                |
|            |           | d-AD      | 0.000                 | 0.000 | 1.000   | 0.000                                |
|            | aMCI      | NC        | 0.000                 | 0.000 | 0.329   | -0.001                              |
|            |           | SCD       | 0.000                 | 0.000 | 1.000   | 0.000                                |
|            |           | d-AD      | 0.000                 | 0.000 | 1.000   | 0.000                                |
|            | d-AD      | NC        | 0.000                 | 0.000 | 0.042   | -0.001                              |
|            |           | SCD       | 0.000                 | 0.000 | 1.000   | 0.000                                |
|            |           | aMCI      | 0.000                 | 0.000 | 1.000   | 0.000                                |
| 2          | NC        | SCD       | 0.001                 | 0.000 | 0.007   | 0.000                                |
|            |           | aMCI      | 0.001                 | 0.000 | 0.068   | 0.000                                |
|            |           | d-AD      | 0.002                 | 0.000 | <0.001* | 0.001                                |
|            | SCD       | NC        | -0.001                | 0.000 | 0.007   | -0.002                              |
|            |           | aMCI      | 0.000                 | 0.000 | 1.000   | -0.001                              |
|            |           | d-AD      | 0.001                 | 0.000 | 0.142   | 0.000                                |
|            | aMCI      | NC        | -0.001                | 0.000 | 0.068   | -0.002                              |
|            |           | SCD       | 0.000                 | 0.000 | -0.001  | 0.001                                |
|            |           | d-AD      | 0.001                 | 0.000 | 0.015   | 0.000                                |
|            | d-AD      | NC        | -0.002                | 0.000 | <0.001* | -0.003                              |
|            |           | SCD       | -0.001                | 0.000 | 0.142   | -0.002                              |
|            |           | aMCI      | -0.001                | 0.000 | 0.015   | -0.003                              |
|            | NC        | SCD       | 0.003                 | 0.001 | <0.001* | 0.001                                |
|            |           | aMCI      | 0.003                 | 0.001 | 0.003   | 0.001                                |
|            |           | d-AD      | 0.007                 | 0.001 | <0.001* | 0.005                                |
|            | SCD       | NC        | -0.003                | 0.001 | <0.001* | -0.005                              |
|            |           | aMCI      | -0.001                | 0.001 | 1.000   | -0.003                              |
|            |           | d-AD      | 0.004                 | 0.001 | <0.001* | 0.001                                |
|            | aMCI      | NC        | -0.003                | 0.001 | 0.003   | -0.004                              |
|            |           | SCD       | 0.001                 | 0.001 | -0.001  | 0.003                                |
|            |           | d-AD      | 0.004                 | 0.001 | <0.001* | 0.002                                |
|            | d-AD      | NC        | -0.007                | 0.001 | <0.001* | -0.009                              |
|            |           | SCD       | -0.004                | 0.001 | <0.001* | -0.006                              |
|            |           | aMCI      | -0.004                | 0.001 | <0.001* | -0.006                              |
|            | NC        | SCD       | 0.007                 | 0.001 | <0.001* | 0.004                                |
|            |           | aMCI      | 0.007                 | 0.001 | <0.001* | 0.004                                |
|            |           | d-AD      | 0.013                 | 0.001 | <0.001* | 0.010                                |
|     | NC       | aMCI     | d-AD     |
|-----|----------|----------|----------|
| SCD | -0.007   | 0.000    | 0.007    |
|     | 0.001    | 0.001    | 0.001    |
|     | <0.001*  | 1.000    | <0.001*  |
|     | -0.010   | -0.003   | 0.003    |
|     | -0.004   | 0.003    | 0.010    |
| aMCI| NC       | -0.007   | 0.000    |
|     | 0.001    | 0.001    |
|     | <0.001*  | 1.000    |
|     | -0.010   | -0.003   |
|     | -0.004   | 0.003    |
|     | 0.000    | 0.003    |
|     | <0.001*  | 0.003    |
|     | -0.010   | -0.003   |
|     | -0.004   | 0.003    |
| d-AD| NC       | -0.013   | 0.006    |
|     | 0.001    | 0.001    |
|     | <0.001*  | 1.000    |
|     | -0.016   | -0.006   |
|     | -0.010   | -0.003   |
|     | -0.009   | -0.003   |
|     | 0.000    | 0.002    |
|     | 0.002    |
|     | <0.001*  |
|     | -0.018   | 0.018    |
|     | 0.026    |
| NC  | SCD      | 0.010    | 0.011    |
|     | 0.002    | 0.002    |
|     | <0.001*  | 0.007    |
|     | 0.015    |
|     | 0.018    |
|     | 0.026    |
| SCD | NC       | -0.011   | 0.002    |
|     | 0.001    | 0.001    |
|     | <0.001*  | 1.000    |
|     | -0.015   | -0.006   |
|     | -0.017   | -0.008   |
|     | -0.015   | -0.006   |
| aMCI| SCD      | -0.002   | 0.002    |
|     | 0.001    | 0.001    |
|     | <0.001*  | 1.000    |
|     | -0.026   | -0.018   |
|     | -0.022   | -0.018   |
|     | -0.026   | 0.023    |
|     | -0.022   | 0.034    |
| d-AD| NC       | -0.022   | 0.002    |
|     | 0.001    | 0.001    |
|     | <0.001*  | 1.000    |
|     | -0.026   | -0.018   |
|     | -0.022   | -0.018   |
|     | -0.022   | 0.034    |
| NC  | SCD      | 0.012    | 0.015    |
|     | 0.002    | 0.002    |
|     | <0.001*  | 0.010    |
|     | 0.020    |
|     | 0.034    |
| SCD | NC       | -0.012   | 0.003    |
|     | 0.002    | 0.002    |
|     | <0.001*  | 0.766    |
|     | -0.017   | -0.006   |
|     | -0.010   | 0.023    |
|     | -0.002   | 0.009    |
| aMCI| SCD      | -0.003   | 0.003    |
|     | 0.002    | 0.002    |
|     | <0.001*  | 0.766    |
|     | -0.009   | -0.009   |
|     | -0.009   | 0.002    |
| d-AD| NC       | -0.015   | 0.002    |
|     | 0.001    | 0.001    |
|     | <0.001*  | 0.010    |
|     | 0.010    |
|     | 0.019    |
| aMCI| SCD      | -0.003   | 0.003    |
|     | 0.002    | 0.002    |
|     | <0.001*  | 0.766    |
|     | -0.009   | -0.009   |
|     | -0.009   | 0.002    |
| d-AD| NC       | -0.028   | 0.002    |
|     | 0.002    | 0.002    |
|     | <0.001*  | 0.010    |
|     | -0.034   | -0.022   |
|     | -0.034   | 0.019    |
| NC  | SCD      | 0.012    | 0.017    |
|     | 0.003    | 0.003    |
|     | <0.001*  | 0.005    |
|     | 0.019    |
|     | 0.019    |
| aMCI| SCD      | 0.005    | 0.003    |
|     | 0.003    | 0.003    |
|     | <0.001*  | 0.374    |
|     | -0.002   | 0.012    |
|     | -0.002   | 0.012    |
|     | -0.002   | 0.012    |
| d-AD| NC       | -0.017   | 0.003    |
|     | 0.002    | 0.002    |
|     | <0.001*  | 0.010    |
|     | -0.019   | -0.005   |
|     | -0.019   | 0.005    |
| aMCI| SCD      | -0.005   | 0.003    |
|     | 0.003    | 0.003    |
|     | <0.001*  | 0.374    |
|     | -0.012   | 0.002    |
|     | -0.012   | 0.002    |
|     | -0.012   | 0.002    |
| d-AD| NC       | -0.035   | 0.003    |
|     | 0.003    | 0.003    |
|     | <0.001*  | 0.010    |
|     | -0.043   | -0.028   |
|     | -0.043   | 0.019    |
|    8 | NC       | 0.011    | 0.018    |
|     | 0.003    | 0.003    |
|     | <0.001*  | 0.004    |
|     | 0.002    | 0.019    |
|     | 0.019    |
|     | 0.026    |
|     | 0.026    | 0.026    |
|       | d-AD  | 0.037 | 0.003 | <0.001* | 0.029 | 0.046 |
|-------|-------|-------|-------|---------|-------|-------|
| SCD   | NC    | -0.011| 0.003 | 0.004   | -0.019| -0.002|
|       | aMCI  | 0.007 | 0.003 | 0.165   | -0.001| 0.016 |
|       | d-AD  | 0.027 | 0.003 | <0.001* | 0.018 | 0.036 |
| aMCI  | NC    | -0.018| 0.003 | <0.001* | -0.026| -0.010|
|       | SCD   | -0.007| 0.003 | 0.165   | -0.016| 0.001 |
|       | d-AD  | 0.020 | 0.003 | <0.001* | 0.011 | 0.029 |
| d-AD  | NC    | -0.037| 0.003 | <0.001* | -0.046| -0.029|
|       | SCD   | -0.027| 0.003 | <0.001* | -0.036| -0.018|
|       | aMCI  | -0.020| 0.003 | <0.001* | -0.029| -0.011|
| NC    | SCD   | 0.011 | 0.004 | 0.018   | 0.001 | 0.020 |
|       | aMCI  | 0.017 | 0.003 | <0.001* | 0.008 | 0.026 |
|       | d-AD  | 0.040 | 0.004 | <0.001* | 0.031 | 0.050 |
| SCD   | NC    | -0.011| 0.004 | 0.018   | -0.020| -0.001|
|       | aMCI  | 0.007 | 0.004 | 0.429   | -0.003| 0.017 |
|       | d-AD  | 0.030 | 0.004 | <0.001* | 0.019 | 0.040 |
| aMCI  | NC    | -0.017| 0.003 | <0.001* | -0.026| -0.008|
|       | SCD   | -0.007| 0.004 | 0.429   | -0.017| 0.003 |
|       | d-AD  | 0.023 | 0.004 | <0.001* | 0.013 | 0.033 |
| d-AD  | NC    | -0.040| 0.004 | <0.001* | -0.050| -0.031|
|       | SCD   | -0.030| 0.004 | <0.001* | -0.040| -0.019|
|       | aMCI  | -0.023| 0.004 | <0.001* | -0.033| -0.013|
| NC    | SCD   | 0.011 | 0.004 | 0.026   | 0.001 | 0.020 |
|       | aMCI  | 0.018 | 0.004 | <0.001* | 0.009 | 0.028 |
|       | d-AD  | 0.045 | 0.004 | <0.001* | 0.035 | 0.055 |
| SCD   | NC    | -0.011| 0.004 | 0.026   | -0.020| -0.001|
|       | aMCI  | 0.007 | 0.004 | 0.326   | -0.003| 0.018 |
|       | d-AD  | 0.034 | 0.004 | <0.001* | 0.023 | 0.045 |
| aMCI  | NC    | -0.018| 0.004 | <0.001* | -0.028| -0.009|
|       | SCD   | -0.007| 0.004 | 0.326   | -0.018| 0.003 |
|       | d-AD  | 0.027 | 0.004 | <0.001* | 0.016 | 0.038 |
| d-AD  | NC    | -0.045| 0.004 | <0.001* | -0.055| -0.035|
|       | SCD   | -0.034| 0.004 | <0.001* | -0.045| -0.023|
|       | aMCI  | -0.027| 0.004 | <0.001* | -0.038| -0.016|
| NC    | SCD   | 0.012 | 0.004 | 0.032   | 0.001 | 0.024 |
|       | aMCI  | 0.019 | 0.004 | <0.001* | 0.008 | 0.030 |
|       | d-AD  | 0.048 | 0.005 | <0.001* | 0.035 | 0.060 |
| SCD   | NC    | -0.012| 0.004 | 0.032   | -0.024| -0.001|
|       | aMCI  | 0.007 | 0.005 | 0.828   | -0.005| 0.019 |
|       | d-AD  | 0.035 | 0.005 | <0.001* | 0.022 | 0.048 |
| aMCI  | NC    | -0.019| 0.004 | <0.001* | -0.030| -0.008|
|       | SCD   | -0.007| 0.005 | 0.828   | -0.019| 0.005 |
|       | d-AD  | 0.029 | 0.005 | <0.001* | 0.016 | 0.041 |
| d-AD  | NC    | -0.048| 0.005 | <0.001* | -0.060| -0.035|
|       | SCD   | -0.035| 0.005 | <0.001* | -0.048| -0.022|
|       | aMCI  | -0.029| 0.005 | <0.001* | -0.041| -0.016|
| SCD   | 0.014 | 0.005 | 0.069   | -0.001| 0.028 |
|   | NC       | aMCI     | d-AD     | SCD       | aMCI     | d-AD     | aMCI     | d-AD     | aMCI     | d-AD     | aMCI     | d-AD     | aMCI     | d-AD     |
|---|----------|----------|----------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 12| NC       | 0.023    | 0.005    | **<0.001***| 0.010    | 0.037    |          |          |          |          |          |          |          |          |
|   | d-AD     | 0.055    | 0.006    | **<0.001***| 0.040    | 0.070    |          |          |          |          |          |          |          |          |
|   | SCD      |          |          |           | aMCI     | 0.010    | 0.006    | 0.507    | -0.005   | 0.025    |          |          |          |          |
|   |          |          |          |           | d-AD     | 0.041    | 0.006    | **<0.001***| 0.025   | 0.057    |          |          |          |          |
|   | aMCI     | -0.023   | 0.005    | **<0.001***| -0.037   | -0.010   |          |          |          |          |          |          |          |          |
|   | SCD      | -0.010   | 0.006    | 0.507    | -0.025   | 0.005    |          |          |          |          |          |          |          |          |
|   | d-AD     | 0.032    | 0.006    | **<0.001***| 0.016    | 0.047    |          |          |          |          |          |          |          |          |
|   | NC       |          |          |           |          |          |          |          |          |          |          |          |          |          |
|   | d-AD     |          |          |           |          |          |          |          |          |          |          |          |          |          |
| 13| NC       |          |          |           | aMCI     | 0.009    | 0.007    | 1.000    | -0.009   | 0.026    |          |          |          |          |
|   | d-AD     |          |          |           |          |          |          |          |          |          |          |          |          |          |
|   | SCD      |          |          |           | aMCI     | 0.009    | 0.007    | **<0.001***| 0.021   | 0.058    |          |          |          |          |
|   |          |          |          |           | d-AD     | 0.039    | 0.007    | **<0.001***| 0.012   | 0.049    |          |          |          |          |
|   | aMCI     | -0.025   | 0.006    | **<0.001***| -0.041   | -0.009   |          |          |          |          |          |          |          |          |
|   | SCD      | -0.009   | 0.007    | 1.000    | -0.026   | 0.009    |          |          |          |          |          |          |          |          |
|   | d-AD     | 0.030    | 0.007    | **<0.001***| 0.012    | 0.049    |          |          |          |          |          |          |          |          |
|   | d-AD     |          |          |           |          |          |          |          |          |          |          |          |          |          |
| 14| NC       |          |          |           |          |          |          |          |          |          |          |          |          |          |
|   | d-AD     |          |          |           |          |          |          |          |          |          |          |          |          |          |
|   | SCD      |          |          |           | aMCI     | 0.011    | 0.008    | 1.000    | -0.012   | 0.034    |          |          |          |          |
|   |          |          |          |           | d-AD     | 0.046    | 0.009    | **<0.001***| 0.022   | 0.070    |          |          |          |          |
|   | aMCI     | -0.030   | 0.008    | 0.001    | -0.051   | -0.009   |          |          |          |          |          |          |          |          |
|   | SCD      | -0.011   | 0.008    | 1.000    | -0.034   | 0.012    |          |          |          |          |          |          |          |          |
|   | d-AD     | 0.035    | 0.009    | **0.001***| 0.012    | 0.059    |          |          |          |          |          |          |          |          |
|   | d-AD     |          |          |           |          |          |          |          |          |          |          |          |          |          |
| 15| NC       |          |          |           |          |          |          |          |          |          |          |          |          |          |
|   | d-AD     |          |          |           |          |          |          |          |          |          |          |          |          |          |
|   | SCD      |          |          |           | aMCI     | 0.010    | 0.009    | 1.000    | -0.014   | 0.034    |          |          |          |          |
|   |          |          |          |           | d-AD     | 0.047    | 0.010    | **<0.001***| 0.021   | 0.073    |          |          |          |          |
|   | aMCI     | -0.029   | 0.008    | 0.003    | -0.052   | -0.007   |          |          |          |          |          |          |          |          |
|   | SCD      | -0.010   | 0.009    | 1.000    | -0.034   | 0.014    |          |          |          |          |          |          |          |          |
|   | d-AD     | 0.037    | 0.009    | **0.001***| 0.012    | 0.062    |          |          |          |          |          |          |          |          |
|   | d-AD     |          |          |           |          |          |          |          |          |          |          |          |          |          |
| 41| NC       | -0.067   | 0.009    | **<0.001***| -0.090   | -0.043   |          |          |          |          |          |          |          |          |
|   | d-AD     | -0.047   | 0.010    | **<0.001***| -0.073   | -0.021   |          |          |          |          |          |          |          |          |
|   | aMCI     | -0.037   | 0.009    | **0.001***| -0.062   | -0.012   |          |          |          |          |          |          |          |          |
|       | SCD   | aMCI  | d-AD   | NC    | aMCI  | d-AD   |
|-------|-------|-------|--------|-------|-------|--------|
|       |       |       |        |       |       |        |
| d-AD  | 0.059 | 0.010 | <0.001*| 0.034 | 0.010 | 0.065  |
|       |       |       |        |       |       |        |
| aMCI  | NC    | -0.022| 0.009  | 0.113 | -0.046| 0.003  |
|       | aMCI  | 0.007 | 0.010  | 1.000 | -0.018| 0.033  |
|       | d-AD  | 0.038 | 0.010  | 0.002 | 0.010 | 0.065  |
|       |       |       |        |       |       |        |
| aMCI  | NC    | -0.029| 0.009  | 0.008 | -0.052| -0.005 |
|       | SCD   | -0.007| 0.010  | 1.000 | -0.033| 0.018  |
|       | d-AD  | 0.031 | 0.010  | 0.015 | 0.004 | 0.057  |
|       |       |       |        |       |       |        |
| d-AD  | NC    | -0.059| 0.010  | <0.001*| -0.085| -0.034 |
|       | SCD   | -0.038| 0.010  | 0.002 | -0.065| -0.010 |
|       | aMCI  | -0.031| 0.010  | 0.015 | -0.057| -0.004 |
Table S17. Normalized rich club coefficient for age-matched dataset.

| k (degree) | NC Mean | NC SD | SCD Mean | SCD SD | aMCI Mean | aMCI SD | d-AD Mean | d-AD SD | F    | p  | Es  |
|------------|---------|-------|----------|--------|------------|--------|------------|--------|-------|----|-----|
| 1          | 1.000   | 0.000 | 1.000    | 0.000  | 1.000      | 0.000  | 1.000      | 0.000  | 1.497 | 0.217 | 0.024 |
| 2          | 1.001   | 0.001 | 1.001    | 0.001  | 1.001      | 0.001  | 1.001      | 0.001  | 3.774 | 0.012 | 0.059 |
| 3          | 1.001   | 0.001 | 1.002    | 0.002  | 1.002      | 0.002  | 1.003      | 0.002  | 5.062 | 0.002 | 0.078 |
| 4          | 1.002   | 0.002 | 1.003    | 0.003  | 1.004      | 0.003  | 1.005      | 0.004  | 13.030 | <0.001 | 0.178 |
| 5          | 1.003   | 0.002 | 1.004    | 0.004  | 1.006      | 0.003  | 1.009      | 0.005  | 24.371 | <0.001 | 0.289 |
| 6          | 1.004   | 0.003 | 1.007    | 0.005  | 1.009      | 0.005  | 1.014      | 0.007  | 36.300 | <0.001 | 0.377 |
| 7          | 1.006   | 0.004 | 1.010    | 0.007  | 1.014      | 0.006  | 1.019      | 0.011  | 33.950 | <0.001 | 0.361 |
| 8          | 1.008   | 0.004 | 1.015    | 0.008  | 1.019      | 0.008  | 1.027      | 0.013  | 39.639 | <0.001 | 0.398 |
| 9          | 1.011   | 0.006 | 1.022    | 0.009  | 1.023      | 0.010  | 1.032      | 0.015  | 35.980 | <0.001 | 0.375 |
| 10         | 1.015   | 0.008 | 1.027    | 0.010  | 1.029      | 0.011  | 1.037      | 0.016  | 31.503 | <0.001 | 0.344 |
| 11         | 1.018   | 0.009 | 1.032    | 0.013  | 1.032      | 0.011  | 1.040      | 0.017  | 28.453 | <0.001 | 0.322 |
| 12         | 1.022   | 0.011 | 1.036    | 0.016  | 1.034      | 0.014  | 1.043      | 0.020  | 15.944 | <0.001 | 0.210 |
| 13         | 1.024   | 0.012 | 1.041    | 0.023  | 1.036      | 0.017  | 1.048      | 0.023  | 14.381 | <0.001 | 0.193 |
| 14         | 1.028   | 0.015 | 1.044    | 0.025  | 1.039      | 0.023  | 1.017      | 0.178  | 0.916  | 0.434 | 0.015 |
| 15         | 1.030   | 0.016 | 1.050    | 0.033  | 1.051      | 0.028  | 0.935      | 0.338  | 5.128  | 0.002 | 0.079 |
| 16         | 1.033   | 0.021 | 1.036    | 0.168  | 1.038      | 0.159  | 0.835      | 0.454  | 7.350  | <0.001 | 0.109 |

\(^a\) Values from ANOVA.

\(^b\) Effect size; \(\eta^2\) for normalized rich club coefficient.
Table S18. Post hoc testing on normalized rich club coefficient from ANOVA for age-matched dataset (Bonferroni-corrected for groups).

| k (degree) | (I) Group | (J) Group | Mean Difference (I-J) | SE | P | 95% Confidence Interval for Difference |
|------------|-----------|-----------|-----------------------|----|----|---------------------------------------|
|            | SCD       | NC        | 0.000                 | 0.000 | 1.000 | 0.000 - 0.000 |
|            | aMCI      | NC        | 0.000                 | 0.000 | 1.000 | 0.000 - 0.000 |
|            | d-AD      | NC        | 0.000                 | 0.000 | 1.000 | 0.000 - 0.000 |
| 1          | SCD       | NC        | 0.000                 | 0.000 | 1.000 | 0.000 - 0.000 |
|            | aMCI      | NC        | 0.000                 | 0.000 | 1.000 | 0.000 - 0.000 |
|            | d-AD      | NC        | 0.000                 | 0.000 | 1.000 | 0.000 - 0.000 |
|            | SCD       | aMCI      | 0.000                 | 0.000 | 0.498 | 0.000 - 0.000 |
|            | d-AD      | aMCI      | 0.000                 | 0.000 | 0.384 | 0.000 - 0.000 |
|            | NC        | NC        | 0.000                 | 0.000 | 1.000 | 0.000 - 0.000 |
|            | SCF       | NC        | 0.000                 | 0.000 | 1.000 | 0.000 - 0.000 |
|            | aMCI      | SCF       | 0.000                 | 0.000 | 0.312 | 0.000 - 0.000 |
|            | d-AD      | SCF       | 0.000                 | 0.000 | 0.049 | 0.000 - 0.000 |
|            | SCD       | aMCI      | 0.000                 | 0.000 | 1.000 | 0.000 - 0.000 |
|            | d-AD      | aMCI      | 0.000                 | 0.000 | 0.384 | 0.000 - 0.000 |
| 2          | SCD       | NC        | 0.000                 | 0.000 | 0.049 | -0.001 - 0.000 |
|            | aMCI      | NC        | 0.000                 | 0.000 | 0.312 | -0.001 - 0.000 |
|            | d-AD      | NC        | -0.001                | 0.000 | 0.024 | -0.001 - 0.000 |
|            | SCD       | aMCI      | 0.000                 | 0.000 | 1.000 | 0.000 - 0.000 |
|            | d-AD      | aMCI      | 0.000                 | 0.000 | 0.384 | 0.000 - 0.000 |
|            | NC        | NC        | 0.000                 | 0.000 | 1.000 | 0.000 - 0.000 |
|            | SCF       | NC        | 0.000                 | 0.000 | 1.000 | 0.000 - 0.000 |
|            | aMCI      | SCF       | 0.000                 | 0.000 | 0.312 | 0.000 - 0.000 |
|            | d-AD      | SCF       | 0.000                 | 0.000 | 0.049 | 0.000 - 0.000 |
|            | SCD       | aMCI      | 0.000                 | 0.000 | 1.000 | 0.000 - 0.000 |
|            | d-AD      | aMCI      | 0.000                 | 0.000 | 0.384 | 0.000 - 0.000 |
| 3          | SCD       | NC        | -0.001                | 0.000 | 0.079 | -0.002 - 0.000 |
|            | aMCI      | NC        | -0.001                | 0.000 | 0.191 | -0.002 - 0.000 |
|            | d-AD      | NC        | -0.001                | 0.000 | 0.002 | -0.002 - 0.000 |
|            | SCD       | aMCI      | 0.000                 | 0.000 | 1.000 | -0.001 - 0.001 |
|            | d-AD      | aMCI      | 0.000                 | 0.000 | 0.620 | -0.002 - 0.000 |
|            | NC        | NC        | 0.001                 | 0.000 | 0.079 | 0.000 - 0.002 |
|            | SCF       | NC        | 0.001                 | 0.000 | 0.191 | 0.000 - 0.002 |
|            | aMCI      | SCF       | 0.000                 | 0.000 | 1.000 | -0.001 - 0.001 |
|            | d-AD      | SCF       | -0.001                | 0.000 | 0.620 | -0.002 - 0.000 |
|            | SCD       | aMCI      | 0.000                 | 0.000 | 1.000 | -0.001 - 0.002 |
|            | d-AD      | aMCI      | 0.000                 | 0.000 | 0.620 | 0.000 - 0.002 |
| 4          | SCD       | NC        | -0.001                | 0.000 | 0.178 | -0.003 - 0.000 |
|            | aMCI      | NC        | -0.002                | 0.000 | 0.003 | -0.003 - 0.000 |
|            | d-AD      | NC        | -0.004                | 0.000 | <0.001* | -0.005 - 0.002 |
|    | NC       | 0.001 | 0.001 | 0.178 | 0.000 | 0.003 |
|----|----------|-------|-------|-------|-------|-------|
| aMCI | -0.001 | 0.001 |       | 1.000 | -0.002 | 0.001 |
| d-AD | -0.002 | 0.001 |       | 0.001 | -0.004 | -0.001 |
| aMCI | 0.002 | 0.001 |       | 0.003 | 0.000 | 0.003 |
| SCD | 0.001 | 0.001 |       | 1.000 | -0.001 | 0.002 |
| d-AD | -0.002 | 0.001 |       | 0.042 | -0.003 | 0.000 |
| aMCI | 0.002 | 0.001 | 0.001 | 0.001 | 0.004 |       |
| d-AD | 0.004 | 0.001 | <0.001* | 0.002 | 0.005 |       |
| NC | 0.002 | 0.001 |       | 0.129 | -0.003 | 0.000 |
| aMCI | -0.004 | 0.001 | <0.001* | -0.005 |       | -0.002 |
| d-AD | -0.006 | 0.001 | <0.001* | -0.008 |       | -0.004 |
| SCD | 0.002 | 0.001 |       | 0.003 | 0.000 | 0.003 |
| aMCI | -0.002 | 0.001 |       | 0.053 | -0.004 | 0.000 |
| d-AD | -0.004 | 0.001 | <0.001* | -0.006 |       | -0.002 |
| aMCI | 0.002 | 0.001 |       | 0.015 | 0.000 | 0.004 |
| d-AD | 0.004 | 0.001 | <0.001* | 0.004 | 0.008 |       |
| NC | 0.002 | 0.001 |       | 0.009 | -0.006 | -0.001 |
| aMCI | -0.006 | 0.001 | <0.001* | -0.008 |       | -0.003 |
| d-AD | -0.010 | 0.001 | <0.001* | -0.013 |       | -0.008 |
| SCD | 0.003 | 0.001 |       | 0.009 | 0.001 | 0.006 |
| aMCI | -0.003 | 0.001 |       | 0.075 | -0.005 | 0.000 |
| d-AD | -0.007 | 0.001 | <0.001* | -0.010 |       | -0.004 |
| aMCI | 0.003 | 0.001 |       | 0.075 | 0.000 | 0.005 |
| d-AD | 0.006 | 0.001 | <0.001* | -0.007 |       | -0.002 |
| NC | 0.010 | 0.001 |       | 0.008 | 0.008 | 0.013 |
| aMCI | -0.005 | 0.001 |       | 0.05 | -0.008 | -0.001 |
| d-AD | -0.008 | 0.001 | <0.001* | -0.012 |       | -0.005 |
| SCD | 0.007 | 0.001 |       | 0.004 | 0.004 | 0.010 |
| aMCI | 0.005 | 0.001 | <0.001* | 0.002 | 0.007 |       |
| d-AD | 0.014 | 0.001 | <0.001* | 0.008 | 0.013 |       |
| NC | 0.009 | 0.001 |       | 0.005 | 0.001 | 0.008 |
| aMCI | -0.004 | 0.001 |       | 0.055 | -0.008 | 0.000 |
| d-AD | -0.009 | 0.002 | <0.001* | -0.013 |       | -0.005 |
| aMCI | 0.008 | 0.001 | <0.001* | 0.005 | 0.012 |       |
| SCD | 0.004 | 0.001 |       | 0.055 | 0.000 | 0.008 |
| d-AD | -0.005 | 0.002 |       | 0.002 | -0.009 | -0.001 |
| aMCI | 0.005 | 0.002 |       | 0.002 | 0.001 | 0.009 |

8 NC | 0.007 | 0.001 | <0.001* | -0.012 |       | -0.003 |
| aMCI | -0.011 | 0.002 | <0.001* | -0.015 |       | -0.007 |
|          |       |       |       |
|----------|-------|-------|-------|
| d-AD     | -0.018| 0.002 | <0.001*|
| SCD      | NC    | 0.007 | 0.003 |
|          | aMCI  | 0.004 | 0.213 |
|          | d-AD  | -0.011| <0.001*|
| aMCI     | NC    | 0.011 | 0.007 |
|          | SCD   | 0.004 | 0.213 |
|          | d-AD  | -0.008| <0.001*|
| d-AD     | NC    | 0.018 | 0.014 |
|          | SCD   | 0.011 | 0.006 |
|          | aMCI  | 0.008 | <0.001*|
| NC       | SCD   | -0.011| -0.016|
|          | aMCI  | -0.012| <0.001*|
|          | d-AD  | -0.021| <0.001*|
| aMCI     | NC    | 0.012 | 0.007 |
|          | SCD   | 0.001 | 1.000 |
|          | d-AD  | -0.009| <0.001*|
| d-AD     | NC    | 0.021 | 0.016 |
|          | SCD   | 0.010 | 0.004 |
|          | aMCI  | 0.009 | <0.001*|
| NC       | SCD   | -0.012| -0.018|
|          | aMCI  | -0.014| <0.001*|
|          | d-AD  | -0.022| <0.001*|
| SCD      | NC    | 0.012 | 0.006 |
|          | aMCI  | -0.002| 1.000 |
|          | d-AD  | -0.010| <0.001*|
| d-AD     | NC    | 0.022 | 0.016 |
|          | SCD   | 0.010 | 0.003 |
|          | aMCI  | 0.008 | <0.001*|
| NC       | SCD   | -0.014| -0.020|
|          | aMCI  | -0.014| <0.001*|
|          | d-AD  | -0.023| <0.001*|
| SCD      | NC    | 0.014 | 0.007 |
|          | aMCI  | 0.000 | 1.000 |
|          | d-AD  | -0.009| <0.001*|
| d-AD     | NC    | 0.023 | 0.016 |
|          | SCD   | 0.009 | 0.010 |
|          | aMCI  | 0.009 | 0.007 |
| SCD      | NC    | -0.014| <0.001*|
|    | NC  | aMCI   | d-AD | SCD  | aMCI   | d-AD | NC  | aMCI   | d-AD | SCD  | aMCI   | d-AD |
|----|------|--------|------|------|--------|------|-----|--------|------|------|--------|------|
| 12 |     | -0.012 | 0.003 |      | <0.001* |      | -0.021 | 0.003 | <0.001* |      | -0.029 | -0.012 |
|    | NC  | 0.014  | 0.003 |      | <0.001* | 0.006 | 0.022 |      |      |      |      |      |
|    | aMCI| 0.002  | 0.003 |      | 1.000  | -0.007 | 0.010 |      |      |      |      |      |
|    | d-AD| -0.007 | 0.003 |      | 0.257  | -0.016 | 0.002 |      |      |      |      |      |
| 13 |     | -0.012 | 0.003 |      | <0.001* | 0.004 | 0.020 |      |      |      |      |      |
|    | NC  | 0.012  | 0.003 |      | <0.001* | 0.004 | 0.022 |      |      |      |      |      |
|    | aMCI| -0.002 | 0.003 |      | 1.000  | -0.010 | 0.007 |      |      |      |      |      |
|    | d-AD| 0.009  | 0.003 |      | 0.066  | -0.018 | 0.000 |      |      |      |      |      |
|    | NC  | 0.012  | 0.004 |      | <0.001* | 0.012 | 0.029 |      |      |      |      |      |
|    | aMCI| -0.024 | 0.004 |      | <0.001* | -0.034 | -0.013 |      |      |      |      |      |
|    | SCD | 0.017  | 0.004 |      | <0.001* | 0.007 | 0.027 |      |      |      |      |      |
|    | aMCI| 0.005  | 0.004 |      | 1.000  | -0.006 | 0.015 |      |      |      |      |      |
|    | d-AD| -0.007 | 0.004 |      | 0.607  | -0.018 | 0.004 |      |      |      |      |      |
|    | NC  | 0.012  | 0.004 |      | 0.005  | 0.003 | 0.022 |      |      |      |      |      |
|    | aMCI| -0.005 | 0.004 |      | 1.000  | -0.015 | 0.006 |      |      |      |      |      |
|    | d-AD| -0.012 | 0.004 |      | 0.030  | -0.022 | -0.001 |      |      |      |      |      |
|    | NC  | 0.024  | 0.004 |      | <0.001* | 0.013 | 0.034 |      |      |      |      |      |
|    | aMCI| 0.007  | 0.004 |      | 0.607  | -0.004 | 0.018 |      |      |      |      |      |
|    | d-AD| 0.012  | 0.004 |      | 0.030  | 0.001 | 0.022 |      |      |      |      |      |
|    | NC  | -0.017 | 0.016 |      | 1.000  | -0.060 | 0.027 |      |      |      |      |      |
|    | aMCI| -0.012 | 0.016 |      | 1.000  | -0.054 | 0.030 |      |      |      |      |      |
|    | d-AD| 0.010  | 0.017 |      | 1.000  | -0.035 | 0.056 |      |      |      |      |      |
|    | NC  | 0.017  | 0.016 |      | 1.000  | -0.027 | 0.060 |      |      |      |      |      |
|    | aMCI| 0.005  | 0.017 |      | 1.000  | -0.041 | 0.051 |      |      |      |      |      |
|    | d-AD| 0.027  | 0.018 |      | 0.856  | -0.022 | 0.076 |      |      |      |      |      |
|    | NC  | -0.012 | 0.016 |      | 1.000  | -0.030 | 0.054 |      |      |      |      |      |
|    | aMCI| -0.005 | 0.017 |      | 1.000  | -0.051 | 0.041 |      |      |      |      |      |
|    | d-AD| 0.022  | 0.018 |      | 1.000  | -0.026 | 0.070 |      |      |      |      |      |
|    | NC  | -0.010 | 0.017 |      | 1.000  | -0.056 | 0.035 |      |      |      |      |      |
|    | aMCI| -0.027 | 0.018 |      | 0.856  | -0.076 | 0.022 |      |      |      |      |      |
|    | d-AD| -0.022 | 0.018 |      | 1.000  | -0.070 | 0.026 |      |      |      |      |      |
|    | NC  | -0.020 | 0.030 |      | 1.000  | -0.101 | 0.061 |      |      |      |      |      |
|    | aMCI| -0.021 | 0.029 |      | 1.000  | -0.099 | 0.058 |      |      |      |      |      |
|    | d-AD| 0.095  | 0.032 |      | 0.019  | 0.010 | 0.180 |      |      |      |      |      |
|    | NC  | 0.020  | 0.030 |      | 1.000  | -0.061 | 0.101 |      |      |      |      |      |
|    | aMCI| -0.001 | 0.032 |      | 1.000  | -0.086 | 0.085 |      |      |      |      |      |
|    | d-AD| 0.115  | 0.034 |      | 0.006  | 0.024 | 0.206 |      |      |      |      |      |
|    | NC  | 0.021  | 0.029 |      | 1.000  | -0.058 | 0.099 |      |      |      |      |      |
|    | aMCI| 0.001  | 0.032 |      | 1.000  | -0.085 | 0.086 |      |      |      |      |      |
|    | d-AD| 0.116  | 0.033 |      | 0.004  | 0.027 | 0.205 |      |      |      |      |      |
|    | NC  | -0.095 | 0.032 |      | 0.019  | -0.180 | -0.010 |      |      |      |      |      |
|    | aMCI| -0.115 | 0.034 |      | 0.006 | -0.206 | -0.024 |      |      |      |      |      |
|    | d-AD| -0.116 | 0.033 |      | 0.004  | -0.205 | -0.027 |      |      |      |      |      |
|     | SCD    | aMCI   | d-AD   | SCD    | aMCI   | d-AD   | aMCI   | d-AD   |
|-----|--------|--------|--------|--------|--------|--------|--------|--------|
| NC  | -0.003 | 0.046  | 1.000  | -0.127 | 0.121  |        |        |        |
| aMCI| -0.004 | 0.045  | 1.000  | -0.124 | 0.116  |        |        |        |
| d-AD| 0.199  | 0.049  | <0.001*| 0.069  | 0.328  |        |        |        |
| SCD | NC     | 0.003  | 0.046  | 1.000  | -0.121 | 0.127  |        |        |
| aMCI| -0.001 | 0.049  | 1.000  | -0.132 | 0.129  |        |        |        |
| d-AD| 0.202  | 0.052  | 0.001  | 0.062  | 0.341  |        |        |        |
| aMCI| NC     | 0.004  | 0.045  | 1.000  | -0.116 | 0.124  |        |        |
| SCD | 0.001  | 0.049  | 1.000  | -0.129 | 0.132  |        |        |        |
| d-AD| 0.203  | 0.051  | 0.001  | 0.067  | 0.339  |        |        |        |
| d-AD| NC     | -0.199 | 0.049  | <0.001*| -0.328 | -0.069 |        |        |
| SCD | -0.202 | 0.052  | 0.001  | -0.341 | -0.062 |        |        |        |
| aMCI| -0.203 | 0.051  | 0.001  | -0.339 | -0.067 |        |        |        |
Table S19. Rich club, feeder and local connectivity strength for age-matched dataset.

| ANOVA                     | F     | p \(^a\) | Es \(^b\) |
|---------------------------|-------|----------|-----------|
| Rich Club Connectivity Strength | 10.848 | <0.001   | 0.153     |
| Feeder Connectivity Strength    | 55.035 | <0.001   | 0.478     |
| Local Connectivity Strength    | 96.976 | <0.001   | 0.618     |

\(^a\) Values from ANOVA.

\(^b\) Effect size; \(\eta^2\) for rich club, feeder and local connectivity strength.
Table S20. Post hoc testing on rich club, feeder and local connectivity strength from ANOVA for age-matched dataset (Bonferroni-corrected for groups).

| ANOVA        | (I) Group | (J) Group | Mean Difference (I-J) | SE   | P       | 95% Confidence Interval for Difference |
|--------------|-----------|-----------|-----------------------|------|---------|----------------------------------------|
|              |           |           |                       |      |         | Lower Bound | Upper Bound |
| Rich Club Connectivity Strength | NC        | SCD       | 0.777                 | 0.393| 0.296   | -0.271 | 1.825       |
|              | aMCI      | SCD       | 1.506                 | 0.380| **0.001** | 0.491 | 2.521       |
|              | d-AD      | SCD       | 2.180                 | 0.412| <0.001* | 1.082 | 3.278       |
|              | NC        | aMCI      | -0.777                | 0.393| 0.296   | -1.825 | 0.271       |
|              | d-AD      | aMCI      | 0.729                 | 0.413| 0.476   | -0.373 | 1.831       |
|              | NC        | aMCI      | 1.403                 | 0.442| **0.011** | 0.224 | 2.582       |
|              | d-AD      | aMCI      | -1.506                | 0.380| **0.001** | -2.521 | -0.491      |
|              | NC        | d-AD      | -0.729                | 0.413| 0.476   | -1.831 | 0.373       |
|              | d-AD      | d-AD      | 0.674                 | 0.431| 0.719   | -0.476 | 1.823       |
| FCN          | NC        | SCD       | 10.164                | 1.569| <0.001* | 5.978  | 14.350      |
|              | aMCI      | SCD       | 12.632                | 1.520| <0.001* | 8.578  | 16.686      |
|              | d-AD      | SCD       | 20.263                | 1.644| <0.001* | 15.877 | 24.648      |
|              | NC        | aMCI      | -10.164               | 1.569| <0.001* | -14.350 | -5.978      |
|              | d-AD      | aMCI      | 2.468                 | 1.650| 0.819   | -1.935 | 6.871       |
|              | NC        | d-AD      | -2.468                | 1.650| 0.819   | -6.871 | 1.935       |
|              | d-AD      | d-AD      | 7.631                 | 1.721| <0.001* | 3.038  | 12.223      |
| Feeder Connectivity Strength | NC        | SCD       | 22.202                | 2.461| <0.001* | 15.637 | 28.767      |
|              | aMCI      | SCD       | 27.368                | 2.383| <0.001* | 21.010 | 33.726      |
|              | d-AD      | SCD       | 41.655                | 2.578| <0.001* | 34.777 | 48.532      |
|              | NC        | aMCI      | -22.202               | 2.461| <0.001* | -28.767 | -15.637     |
|              | d-AD      | aMCI      | 5.165                 | 2.588| 0.285   | -1.739 | 12.070      |
|              | NC        | d-AD      | -5.165                | 2.588| 0.285   | -12.070 | 1.739       |
|              | d-AD      | d-AD      | 14.287                | 2.700| <0.001* | 7.085  | 21.489      |
| Local Connectivity Strength | NC        | SCD       | -27.368               | 2.383| <0.001* | -33.726 | -21.010     |
|              | aMCI      | SCD       | -5.165                | 2.588| 0.285   | -12.070 | 1.739       |
|              | d-AD      | SCD       | 14.287                | 2.700| <0.001* | 7.085  | 21.489      |
|              | NC        | d-AD      | -41.655               | 2.578| <0.001* | -48.532 | -34.777     |
|              | d-AD      | d-AD      | -19.452               | 2.769| <0.001* | -26.838 | -12.067     |
|              | aMCI      | d-AD      | -14.287               | 2.700| <0.001* | -21.489 | -7.085      |
Table S21. Network topological metrics for age-matched dataset.

| ANOVA                        | F       | p<sup>a</sup> | Es<sup>b</sup> |
|------------------------------|---------|---------------|----------------|
| Strength                     | 88.561  | <0.001        | 0.596          |
| Clustering Coefficient       | 11.586  | <0.001        | 0.162          |
| Normalized Clustering Coefficient | 34.436  | <0.001        | 0.365          |
| Characteristic Path Length   | 39.791  | <0.001        | 0.399          |
| Normalized Characteristic Path Length | 4.365   | 0.005         | 0.068          |

<sup>a</sup> Values from ANOVA.

<sup>b</sup> Effect size; η<sup>2</sup> for network topological metrics.
Table S22. Post hoc testing on network topological metrics from ANOVA for age-matched dataset (Bonferroni-corrected for groups).

| ANOVA   | (I) Group | (J) Group | Mean Difference (I-J) | SE   | P       | 95% Confidence Interval for Difference |
|---------|-----------|-----------|-----------------------|------|---------|----------------------------------------|
|         |           |           |                       |      |         | Lower Bound | Upper Bound |
| Strength | NC        | SCD       | 0.737                 | 0.088| <0.001*| 0.503      | 0.970      |
|         |           | aMCI      | 0.922                 | 0.085| <0.001*| 0.696      | 1.149      |
|         |           | d-AD      | 1.424                 | 0.092| <0.001*| 1.179      | 1.669      |
|         | SCD       | NC        | -0.737                | 0.088| <0.001*| -0.970     | -0.503     |
|         |           | aMCI      | 0.186                 | 0.092| 0.272   | -0.060     | 0.432      |
|         |           | d-AD      | 0.688                 | 0.099| <0.001*| 0.425      | 0.951      |
|         | aMCI      | NC        | -0.922                | 0.085| <0.001*| -1.149     | -0.696     |
|         |           | SCD       | -0.186                | 0.092| 0.272   | -0.432     | 0.060      |
|         |           | d-AD      | 0.502                 | 0.096| <0.001*| 0.245      | 0.759      |
|         | d-AD      | NC        | -1.424                | 0.092| <0.001*| -1.669     | -1.179     |
|         |           | SCD       | -0.688                | 0.099| <0.001*| -0.951     | -0.425     |
|         |           | aMCI      | -0.502                | 0.096| <0.001*| -0.759     | -0.245     |
| Coefficient | NC     | SCD       | 0.015                 | 0.005| 0.014   | 0.002      | 0.027      |
|         |           | aMCI      | 0.016                 | 0.005| 0.005   | 0.003      | 0.028      |
|         |           | d-AD      | 0.028                 | 0.005| <0.001*| 0.015      | 0.042      |
| Normalized | SCD    | NC        | -0.015                | 0.005| 0.014   | -0.027     | -0.002     |
| Clustering |       | aMCI      | 0.001                 | 0.005| 1.000   | -0.012     | 0.014      |
|           |           | d-AD      | 0.014                 | 0.005| 0.057   | 0.000      | 0.028      |
| Coefficient | aMCI   | NC        | -0.016                | 0.005| 0.005   | -0.028     | -0.003     |
|           |           | SCD       | -0.001                | 0.005| 1.000   | -0.014     | 0.012      |
|           |           | d-AD      | 0.013                 | 0.005| 0.086   | -0.001     | 0.027      |
| d-AD     | NC        | d-AD      | -0.028                | 0.005| <0.001*| -0.042     | -0.015     |
|           | SCD       | -0.014                | 0.005| 0.057   | -0.028     | 0.000      |
|           | aMCI      | -0.013                | 0.005| 0.086   | -0.027     | 0.001      |
| NC       | SCD       | 0.181                 | 0.033| <0.001*| -0.270     | -0.092     |
|           | aMCI      | -0.148                | 0.032| <0.001*| -0.234     | -0.062     |
|           | d-AD      | -0.352                | 0.035| <0.001*| -0.446     | -0.259     |
| d-AD     | NC        | SCD       | 0.181                 | 0.033| <0.001*| 0.092      | 0.270      |
|           | aMCI      | 0.033                 | 0.035| 1.000   | -0.061     | 0.127      |
|           | d-AD      | -0.171                | 0.038| <0.001*| -0.272     | -0.071     |
| aMCI     | SCD       | 0.148                 | 0.032| <0.001*| 0.062      | 0.234      |
|           | aMCI      | -0.033                | 0.035| 1.000   | -0.127     | 0.061      |
|           | d-AD      | -0.204                | 0.037| <0.001*| -0.302     | -0.106     |
| Characteristic | NC    | SCD       | -0.380                | 0.072| <0.001*| -0.572     | -0.187     |
| Path Length |       | aMCI      | -0.465                | 0.070| <0.001*| -0.652     | -0.279     |
|           | d-AD      | -0.803                | 0.076| <0.001*| -1.005     | -0.601     |
|       | NC     | SCD    | aMCI   | d-AD   |
|-------|--------|--------|--------|--------|
| SCD   | 0.380  | 0.072  | <0.001* | 0.187  | 0.572  |
| aMCI  | -0.085 | 0.076  | 1.000  | -0.288 | 0.117  |
| d-AD  | -0.423 | 0.081  | <0.001* | -0.640 | -0.207 |
| aMCI  | 0.465  | 0.070  | <0.001* | 0.279  | 0.652  |
| SCD   | 0.085  | 0.076  | 1.000  | -0.117 | 0.288  |
| d-AD  | -0.338 | 0.079  | <0.001* | -0.549 | -0.127 |
| d-AD  | 0.803  | 0.076  | <0.001* | 0.601  | 1.005  |
| SCD   | 0.423  | 0.081  | <0.001* | 0.207  | 0.640  |
| aMCI  | 0.338  | 0.079  | <0.001* | 0.127  | 0.549  |
| NC    | SCD    | -0.007 | 0.003  | 0.042  | -0.014 | 0.000  |
| aMCI  | -0.001 | 0.002  | 1.000  | -0.008 | 0.005  |
| d-AD  | -0.008 | 0.003  | 0.024  | -0.015 | -0.001 |
| d-AD  | NC     | 0.007  | 0.003  | 0.042  | 0.000  | 0.014  |
| SCD   | 0.005  | 0.003  | 0.238  | -0.002 | 0.013  |
| aMCI  | -0.001 | 0.003  | 1.000  | -0.008 | 0.007  |
| d-AD  | -0.006 | 0.003  | 0.143  | -0.014 | 0.001  |
| SCD   | NC     | 0.008  | 0.003  | 0.024  | 0.001  | 0.015  |
| aMCI  | 0.001  | 0.003  | 1.000  | -0.007 | 0.008  |
| d-AD  | 0.006  | 0.003  | 0.143  | -0.001 | 0.014  |
### Table S23. Partial Pearson’s correlations between normalized rich club coefficients and clinical performance for age-matched dataset. Partial Pearson’s correlations controlled for education were used to assess how normalized rich club coefficients related to clinical performance in each group. The bold numbers represent significant correlations at \( P<0.05 \). The star-labeled numbers represent significant correlations at \( P<0.05 \) after Bonferroni corrections for the number of cognitive test variables (AVLT-immediate recall, AVLT-delayed recall, AVLT-recognition, MMSE and MoCa).

| COV: Education | k   | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   | 16   |
|----------------|-----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| AVLT-Immediate |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Delayed        |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| AVLT-Delayed   |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Recognition    |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| MMSE           |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| MoCA           |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| AVLT-Immediate |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Delayed        |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| AVLT-Delayed   |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Recognition    |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| MMSE           |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| MoCA           |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |

**Note:** Significant correlations at \( P<0.05 \).
|      | MMSE | MoCA |      | MMSE | MoCA |      | MMSE | MoCA |      | MMSE | MoCA |      |
|------|------|------|------|------|------|------|------|------|------|------|------|------|
| r    | -0.043 | 0.086 | -0.114 | -0.095 | -0.214 | -0.247 | -0.258 | -0.079 | -0.149 | -0.241 | -0.240 | -0.409 | -0.055 | -0.041 | 0.024 |
| p    | 0.411 | 0.325 | 0.274 | 0.309 | 0.128 | 0.094 | 0.084 | 0.339 | 0.216 | 0.100 | 0.101 | 0.012 | 0.387 | 0.415 | 0.450 |
| r    | -0.116 | 0.041 | -0.064 | -0.073 | -0.187 | -0.219 | -0.224 | -0.060 | -0.128 | -0.245 | -0.234 | -0.337 | -0.071 | -0.033 | -0.012 |
| p    | 0.271 | 0.415 | 0.368 | 0.351 | 0.161 | 0.122 | 0.117 | 0.376 | 0.250 | 0.096 | 0.106 | 0.034 | 0.356 | 0.431 | 0.475 |
Table S24. Partial Pearson’s correlations between rich club coefficients and clinical performance for age-matched dataset. Partial Pearson’s correlations controlled for education were used to assess how rich club coefficients related to clinical performance in each group. The bold numbers represent significant correlations at \(P<0.05\). The star-labeled numbers represent significant correlations at \(P<0.005\) after Bonferroni corrections for the number of cognitive test variables (AVLT-immediate recall, AVLT-delayed recall, AVLT-recognition, MMSE and MoCA).

| COV: Education | k | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|----------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|                | AVLT-Immediate Recall Scores | r 0.131 0.126 0.120 -0.088 0.086 -0.055 -0.005 0.040 -0.046 -0.031 0.054 0.066 0.047 0.104 0.170 |
|                | AVLT-Delayed Recall Scores | r 0.179 0.189 0.201 0.269 0.274 0.352 0.487 0.391 0.374 0.415 0.354 0.323 0.373 0.234 0.117 |
|                | AVLT-Recognition Scores | r 0.246 0.053 0.027 -0.031 -0.057 -0.147 -0.086 0.058 -0.037 0.059 0.065 0.054 0.028 0.089 0.128 |
|                | MMSE Scores | p 0.041 0.356 0.427 0.414 0.345 0.151 0.275 0.343 0.398 0.341 0.325 0.353 0.422 0.267 0.185 |
|                | MoCA Scores | r 0.301 0.095 0.051 0.014 0.022 -0.061 0.018 0.222 0.197 0.173 0.123 0.069 0.045 0.132 0.112 |
|                | SCD MMSE Scores | p 0.016 0.254 0.361 0.462 0.438 0.334 0.449 0.059 0.083 0.112 0.195 0.316 0.376 0.178 0.217 |
|                | SCD MoCA Scores | r 0.078 0.074 0.145 0.179 0.121 0.029 0.017 0.093 0.183 0.117 0.047 0.176 0.194 0.218 0.140 |

\[ \text{AVLT-Immediate Recall} \]
\[ \text{AVLT-Delayed Recall} \]
\[ \text{AVLT-Recognition} \]
\[ \text{MMSE} \]
\[ \text{MoCA} \]
\[ \text{SCD} \]
\[ \text{MMSE} \]
\[ \text{MoCA} \]
\[ \text{AVLT-Immediate Recall} \]
\[ \text{AVLT-Delayed Recall} \]
\[ \text{AVLT-Recognition} \]
\[ \text{MMSE} \]
\[ \text{MoCA} \]
\[ \text{SCD} \]
\[ \text{MMSE} \]
\[ \text{MoCA} \]
\[ \text{AVLT-Immediate Recall} \]
\[ \text{AVLT-Delayed Recall} \]
\[ \text{AVLT-Recognition} \]
\[ \text{MMSE} \]
\[ \text{MoCA} \]
\[ \text{SCD} \]
\[ \text{MMSE} \]
\[ \text{MoCA} \]
\[ \text{AVLT-Immediate Recall} \]
\[ \text{AVLT-Delayed Recall} \]
\[ \text{AVLT-Recognition} \]
\[ \text{MMSE} \]
\[ \text{MoCA} \]
|       | r     | 0.583 | 0.204 | 0.172 | 0.253 | 0.203 | 0.216 | 0.426 | 0.397 | 0.301 | 0.149 | 0.106 | 0.033 | 0.111 | 0.126 |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|       | p     | <0.001| 0.140 | 0.182 | 0.089 | 0.141 | 0.125 | 0.009 | 0.015 |       |       |       |       |       |       |
| MMSE  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|       | r     | 0.616 | 0.176 | 0.161 | 0.154 | 0.096 | 0.147 | 0.360 | 0.380 | 0.226 | 0.043 | 0.053 | -0.031 | -0.078 | -0.035 | 0.025 |
|       | p     | <0.001| 0.175 | 0.198 | 0.209 | 0.306 | 0.219 | 0.025 | 0.019 | 0.115 | 0.412 | 0.391 | 0.436 | 0.340 | 0.427 | 0.447 |
Table S25. Partial Pearson’s correlations between rich club, feeder and local connectivity strength and clinical performance for age-matched dataset. Partial Pearson’s correlations controlled for education were used to assess how rich club, feeder and local connectivity strength related to clinical performance in each group. The bold numbers represent significant correlations at $P<0.05$. The star-labeled numbers represent significant correlations at $P<0.05$ after Bonferroni corrections for the number of cognitive test variables (AVLT-immediate recall, AVLT-delayed recall, AVLT-recognition, MMSE and MoCA).

| COV: Education | Rich Club Connectivty Strength | Feeder Connectivity Strength | Local Connectivity Strength |
|----------------|-------------------------------|-----------------------------|-----------------------------|
| NC (DF=49)     |                               |                             |                             |
| AVLT-Immediate Recall Scores | r 0.105 | 0.194 | -0.040 |
| p 0.232 | 0.086 | 0.391 |
| AVLT-Delayed Recall Scores | r -0.148 | 0.120 | -0.045 |
| p 0.150 | 0.201 | 0.377 |
| AVLT-Recognition Scores | r -0.171 | 0.217 | 0.067 |
| p 0.115 | 0.063 | 0.321 |
| MMSE | p 0.060 | 0.168 | 0.103 |
| MoCA | p -0.078 | 0.231 | 0.234 |
| SCD (DF=36)    |                               |                             |                             |
| AVLT-Immediate Recall Scores | r 0.074 | 0.237 | 0.086 |
| p 0.329 | 0.076 | 0.304 |
| AVLT-Delayed Recall Scores | r 0.278 | 0.426 | 0.323 |
| p 0.046 | 0.003* | 0.024 |
| AVLT-Recognition Scores | r -0.079 | 0.128 | -0.054 |
| p 0.318 | 0.222 | 0.374 |
| MMSE | r 0.038 | 0.216 | 0.100 |
| MoCA | r 0.411 | 0.097 | 0.276 |
| aMCI (DF=42)   |                               |                             |                             |
| AVLT-Immediate Recall Scores | r 0.065 | 0.255 | 0.096 |
| p 0.338 | 0.048 | 0.268 |
| AVLT-Delayed Recall Scores | r 0.262 | 0.486 | 0.166 |
| p 0.043 | <0.001* | 0.140 |
| AVLT-Recognition Scores | r 0.155 | 0.233 | 0.000 |
| p 0.158 | 0.064 | 0.500 |
| MMSE | r 0.145 | 0.189 | 0.122 |
| MoCA | r 0.173 | 0.110 | 0.216 |
| d-AD (DF=28)   |                               |                             |                             |
| AVLT-Immediate Recall Scores | r 0.105 | 0.032 | 0.073 |
| p 0.290 | 0.434 | 0.350 |
| AVLT-Delayed Recall Scores | r 0.061 | 0.033 | 0.140 |
| p 0.375 | 0.432 | 0.230 |
|             | r       |       |       |
|-------------|---------|-------|-------|
| AVLT-Recognition Scores | 0.062   | 0.328 | 0.332 |
|             | p       | 0.372 | **0.038** | **0.037** |
| MMSE        | r       | -0.001| 0.215 | 0.265 |
|             | p       | 0.498 | 0.127 | 0.079 |
| MoCA        | r       | -0.060| 0.130 | 0.154 |
|             | p       | 0.376 | 0.247 | 0.209 |
Table S26. Partial Pearson’s correlations between network topological metrics and clinical performance for age-matched dataset. Partial Pearson’s correlations controlled for education were used to assess how network topological metrics related to clinical performance in each group. The bold numbers represent significant correlations at $P<0.05$ without Bonferroni corrections. The star-labeled numbers represent significant correlations at $P<0.05$ after Bonferroni corrections for the number of cognitive test variables (AVLT-immediate recall, AVLT-delayed recall, AVLT-recognition, MMSE and MoCA).

| COV: Education | Strength | Clustering Coefficient | Normalized Clustering Coefficient | Characteristic Path Length | Normalized Characteristic Path Length |
|----------------|----------|-------------------------|------------------------------------|---------------------------|---------------------------------------|
| AVLT-Immediate | r 0.061  | -0.031                  | -0.157                             | -0.059                    | 0.024                                 |
| Recall Scores  | p 0.335  | 0.413                   | 0.135                              | 0.342                     | 0.433                                 |
| AVLT-Delayed   | r 0.001  | 0.120                   | -0.046                             | 0.022                     | 0.124                                 |
| Recall Scores  | p 0.498  | 0.200                   | 0.375                              | 0.439                     | 0.192                                 |
| AVLT-Recogntion| r 0.114  | 0.071                   | -0.181                             | -0.085                    | 0.072                                 |
| NC             |          |                         |                                    |                           |                                       |
|                |          |                         |                                    |                           |                                       |
| SCD            |          |                         |                                    |                           |                                       |
|                |          |                         |                                    |                           |                                       |
| AVLT-Immediate | r 0.160  | 0.058                   | -0.291                             | -0.136                    | -0.059                                |
| Recall Scores  | p 0.169  | 0.364                   | 0.038                              | 0.208                     | 0.363                                 |
| AVLT-Delayed   | r 0.398  | 0.138                   | -0.339                             | -0.390                    | -0.215                                |
| Recall Scores  | p 0.006* | 0.205                   | 0.019                              | 0.007*                    | 0.098                                 |
| AVLT-Recogntion| r 0.016  | 0.105                   | -0.122                             | 0.045                     | 0.139                                 |
| SCD            |          |                         |                                    |                           |                                       |
|                |          |                         |                                    |                           |                                       |
| AVLT-Immediate | r 0.170  | 0.051                   | -0.239                             | -0.092                    | -0.084                                |
| Recall Scores  | p 0.135  | 0.372                   | 0.059                              | 0.276                     | 0.294                                 |
| AVLT-Delayed   | r 0.328  | 0.207                   | -0.423                             | -0.264                    | -0.160                                |
| Recall Scores  | p 0.015  | 0.089                   | 0.002*                             | 0.042*                    | 0.150                                 |
| AVLT-Recogntion| r 0.111  | 0.361                   | -0.178                             | -0.054                    | -0.137                                |
| aMCI           |          |                         |                                    |                           |                                       |
|                |          |                         |                                    |                           |                                       |
| AVLT-Immediate | r 0.170  | 0.051                   | -0.239                             | -0.092                    | -0.084                                |
| Recall Scores  | p 0.135  | 0.372                   | 0.059                              | 0.276                     | 0.294                                 |
| AVLT-Delayed   | r 0.328  | 0.207                   | -0.423                             | -0.264                    | -0.160                                |
| Recall Scores  | p 0.015  | 0.089                   | 0.002*                             | 0.042*                    | 0.150                                 |
| AVLT-Recogntion| r 0.111  | 0.361                   | -0.178                             | -0.054                    | -0.137                                |
| d-AD           |          |                         |                                    |                           |                                       |
|                |          |                         |                                    |                           |                                       |
| AVLT-Immediate | r 0.066  | -0.143                  | -0.287                             | 0.004                     | -0.196                                |
| Recall Scores  | p 0.365  | 0.225                   | 0.062                              | 0.492                     | 0.150                                 |
| AVLT-Delayed   | r 0.102  | -0.003                  | -0.024                             | -0.040                    | -0.151                                |
| Recall Scores  | p 0.296  | 0.493                   | 0.450                              | 0.416                     | 0.213                                 |
|                | r  | 0.329 | 0.071 | -0.140 | -0.302 | -0.064 |
|----------------|----|-------|-------|--------|--------|--------|
| p              | 0.038 | 0.354 | 0.230 | 0.052  | 0.368  |
| AVLT-Recognition Scores |     |       |       |        |        |        |
| r              | 0.240 | 0.144 | -0.114| -0.165 | -0.062 |
| p              | 0.100 | 0.225 | 0.274 | 0.192  | 0.373  |
| MMSE           |     |       |       |        |        |        |
| r              | 0.136 | -0.068 | -0.118| -0.097 | -0.111 |
| p              | 0.237 | 0.360 | 0.267 | 0.305  | 0.280  |
| MoCA           |     |       |       |        |        |        |
Table S27. Partial Pearson’s correlations between network topological metrics and rich club/feeder/local connectivity strength. Partial Pearson’s correlations controlled for age and gender were used to assess how network topological metrics related to rich club/feeder/local connectivity strength. The bold numbers represent significant correlations at $P<0.05$. The star-labeled numbers represent significant correlations at $P<0.05$ after Bonferroni corrections for the number of variables (=15).

|                  | Rich Club Connectivity Strength | Feeder Connectivity Strength | Local Connectivity Strength |
|------------------|---------------------------------|-----------------------------|-----------------------------|
| **COV: Age & Gender** |                                 |                             |                             |
| Strength         | $r$ 0.579                       | $p <0.001^*$                | $0.945$                     |
|                  |                                 |                             | $p <0.001^*$                |
|                  |                                 |                             | $0.977$                     |
| Clustering Coefficient | $r$ 0.282                       | $p <0.001^*$                | $0.564$                     |
|                  |                                 |                             | $p <0.001^*$                |
|                  |                                 |                             | $0.524$                     |
| Characteristic Path Length | $r$ -0.552                      | $p <0.001^*$                | -0.884                      |
|                  |                                 |                             | $p <0.001^*$                |
|                  |                                 |                             | -0.894                      |
| Normalized Clustering Coefficient | $r$ -0.568                      | $p <0.001^*$                | -0.721                      |
|                  |                                 |                             | $p <0.001^*$                |
|                  |                                 |                             | -0.608                      |
| Normalized Characteristic Path Length | $r$ -0.408                      | $p <0.001^*$                | -0.341                      |
|                  |                                 |                             | $p <0.001^*$                |
|                  |                                 |                             | -0.242                      |
|                  |                                 |                             | $p 0.002^*$                 |
**Figures**

**Figure S1.** Group differences in rich club networks properties based on individual rich club selection. Bar graphs display the mean (standard error) age and gender-corrected values for (A) rich club, (B) feeder and (C) local connectivity strength (N=183). *P<0.05, **P<0.01, ***P<0.001.

**Figure S2.** (A) Length of rich club, feeder, and local connections across all the groups of subjects (N=183). Connection length estimated from the fiber length in mm between pairs of connected nodes for each network. (B) FABIRC of rich club, feeder, and local connections across all the groups of subjects (N=183).
**Figure S3.** Group differences in rich club networks properties by regressing out average fiber length. Bar graphs display the mean (standard error) age and gender-corrected values for (A) rich club, (B) feeder and (C) local connectivity strength (N=183). *P*<0.05, **P**<0.01, ***P***<0.001.
**Figure S4.** Nodes with the highest number of aberrant connections in (A) SCD, (B) aMCI, and (D) d-AD compared with NC. Nodes with the highest number of aberrant connections in each patient groups (range = 11 to 27 aberrant connections), based on two-sample t-test (NC versus each patient groups) with FDR corrected to the P values to correct for multiple comparisons across all edges. Significance was set at $P<0.05$. The red nodes represent the affected nodes in each group.