He, J. et al.: How impulsivity and sensation seeking drive IGD tendency in healthy young adults: A resting-state MRI study

https://doi.org/10.1556/2006.2025.00063

Supplementary material 1.

Common Method Bias Test

Due to the self-report nature of the scales used in this study, it is necessary to conduct Principal Component Analysis (PCA) on all items of all scales. The Harman single factor method was used to obtain common method bias, and the variance of the maximum factor interpretation was 11.865% for the behavior-brain cross-sectional sample and 12.354% for the behavior longitudinal sample, both of which were below 40%, indicating that common method bias in this study was negligible.

Supplementary material 2

Overview of graph theory metrics

The Global Metrics used in this study include global efficiency, local efficiency, and clustering coefficient, which measure the overall connectivity and information transfer efficiency of the network. The Nodal Metrics include betweenness centrality, node centrality, node efficiency, node local efficiency, and node clustering coefficient, which measure the importance of individual nodes in the network and the efficiency of local information transfer.

Global Metrics

Global Efficiency

Definition: Measures the average inverse of the shortest path lengths between all pairs of nodes in a network, reflecting the overall connectivity and communication efficiency of the network.

Calculation Formula:

$$E_{glob} = \frac{1}{n(n-1)}\sum_{i \neq j}\frac{1}{d(i, j)}$$

n: Number of nodes in the network

d(i,j): Shortest path length between nodes i and j

Local Efficiency

Definition: Measures the efficiency of information transfer between a node and its neighbors, reflecting the fault tolerance and redundancy of the network. When a node fails, its neighbor nodes can still communicate effectively.

Calculation Formula:

$$E_{loc} = \frac{1}{n}\sum_{i \in V} E_{glob}(Gi)$$

n: Number of nodes in the network

V: All nodes

G_i: Subgraph formed by the neighbors of node i after removing node i

$E_{glob}(G_i)$: Global efficiency of subgraph G_i

Clustering Coefficient

Definition: Measures the degree to which nodes in a network form clusters (or triangles), reflecting the likelihood of connections among the neighbors of a node.

Calculation Formula:

$$C = \frac{1}{n}\sum_{v \in V}\frac{2e_v}{k_v(k_v - 1)}$$

n: Number of nodes in the network

v: node

V: All nodes

e_v: Number of actual edges among the neighbors of node v

k_v: Degree of node v, number of edges connected to node v

Nodal Metrics

Betweenness Centrality

Definition: Measures the importance of a node as a bridge in the shortest paths between other nodes in the network, reflecting the role of the node in the flow of information within the network.

Calculation Formula:

$$N_{bc}(i) = \sum_{i \neq j \neq k} \frac{\sigma_{jk}(i)}{\sigma_{jk}}$$

σ_{jk}: Total number of shortest paths from node j to node k

$\sigma_{jk}(i)$: Number of shortest paths from node j to node k that pass through node i

Degree Centrality

Definition: Typically refers to degree centrality, which is the number of other nodes to which a node is connected, reflecting the importance of the node in the network.

Calculation Formula:

$$K_{net} = \frac{1}{n} \sum_{i \in V} (k_i)$$

n: Number of nodes in the network

k_i: Degree of node i

Nodal Efficiency

Definition: Measures the connectivity of a node in the network and its ability to facilitate information propagation through that node.

Calculation Formula:

$$E_{nod}(i) = \frac{1}{n-1} \sum_{i \neq j} \frac{1}{d(i, j)}$$

n: Number of nodes in the network

d(i,j): Shortest path length between nodes i and j

Node Local Efficiency

Definition: Measures the global efficiency of the subgraph formed by the neighbors of a node, reflecting the efficiency of information transfer among the neighbors of that node.

Calculation Formula:

$E_{loc}(i) = E_{glob}(G_i)$

G_i: Subgraph formed by the neighbors of node i after removing node i

Eglob(Gi): Global efficiency of subgraph G_i

Node Clustering Coefficient

Definition: Measures the degree to which neighbors of a node form clusters (or triangles), reflecting the efficiency of local information communication.

Calculation Formula:

$$C_v = \frac{2e_v}{k_v (k_v - 1)}$$

v: node

ev: Number of actual edges among the neighbors of node v

kv: Degree of node v, number of edges connected to node v

Supplementary table S1. The brain regions between the different node metrics and IGD tendency of behavior-brain cross-sectional and behavior longitudinal samples.

Node indicators	Regions	Abbreviation	IGD r	IGD *p*
Behavior-brain cross-sectional (n=1205)				
aDc				
	Thalamus	THA.R	0.154	<0.001
aNe				
	Thalamus	THA.R	0.154	<0.001
aNle				
	Inferior frontal gyrus, triangular part	IFGtriang.L	-0.122	0.002
	Inferior frontal gyrus, triangular part	IFGtriang.R	-0.102	0.034
	Lingual gyrus	LING.R	0.143	<0.001
	Thalamus	THA.R	0.137	<0.001
aNcp				
	Inferior frontal gyrus, opercular part	IFGoperc.R	-0.130	<0.001
	Inferior frontal gyrus, triangular part	IFGtriang.L	-0.122	0.002
	Inferior frontal gyrus, triangular	IFGtriang.R	-0.108	0.015

	part			
	Cuneus	CUN.R	-0.120	0.003
	Inferior temporal gyrus	ITG.L	0.113	0.008
Behavior-brain longitudinal (n=485)				
aDc				
	Thalamus	THA.R	0.163	0.028
aNe				
	Thalamus	THA.R	0.163	0.028
aNle				
	Lingual gyrus	LING.R	0.180	0.006
aNcp				
	Lingual gyrus	LING.R	0.172	0.012

Note: Dc, Node Centrality; Ne, Node Efficiency; Nle, Node Local Efficiency; All P-values were obtained after Bonferroni correction.