Xu, T. et al.: Altered asymmetry of amygdala volume mediates food addiction and weight gain

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Supplementary Materials

Measurements

Chinese version of the Barratt Impulsiveness Scale-11 (BIS-11). The BIS-11 is a widely used 30-item scale that measures trait impulsiveness in adults. The Chinese version of the BIS-11 consists of three subscales: nonplanning impulsiveness (NI), motor impulsiveness (MI), and cognitive impulsiveness (CI). Cognitive impulsiveness reflects impulsive thoughts and anticipation of the results of actions. Motor impulsiveness reflects the impulse to act. Nonplanning impulsiveness reflects a lack of future planning. Each item was measured on a 5-point Likert score from 1 "never" to 5 "very often". The score range for each subscale is from 10 to 50 points; the subscale scores and the total score are converted to a range of 0 to 100 points. That is, the score of each subscale = [(Sum of points of each item - 10) ÷ 40] × 100, and the total score = the sum of the three subscales/3. Higher scores indicate higher impulsiveness.

Yale Food Addiction Scale (YFAS2.0). The YFAS2.0 which consists of 35 questions scored on an 8-level Likert scale ranging from 0 to 7, was used to assess food addiction. The YFAS2.0 provides two scoring methods: symptom count or diagnostic threshold. Only symptom count, which was within the range of 0–11 (the higher the score, the higher the level of FA), was used in this study.

Beck Depression inventory (BDI) and Beck Anxiety inventory (BAI). The BDI has been widely used as an assessment instrument in evaluating key symptoms of depression. Each of the 21 symptoms and attitudes contained in the BDI is scored on a 4-point continuum from 0 (absent) to 3 (very severe). The BAI is a 21-item assessment instrument in evaluating the level of anxiety, each item of which is scored on a 4-point Likert-type. The items of BDI and BAI are summed linearly to create a score which ranges from 0 to 63 respectively. Higher scores of BDI or BAI indicate higher depressive or anxious symptoms.

Network estimation

Mean values for NI in BIS-11, YFAS 2.0, BMI, BDI, BAI, and amygdalar LI were examined for all participants. The network was then assessed using the 'quickNet' R package {https://github.com/LeiGuo0812/quickNet}. The network structure was estimated using the enhanced Least Absolute Shrinkage and Selection Operator (eLASSO) method, which combines logistic regression analysis with an optimisation process to determine the best connection method for each symptom. This algorithm produces a sparse network model that controls for redundant correlations and is much easier to interpret than the original model. Model selection is based on the Extended Bayesian Information Criterion (EBIC) (Chen & Chen, 2008). Connected lines are called edges, and the thickness of an edge represents the strength of the association, with thicker being stronger. The colour of the edges indicates the direction of the association (e.g., blue edges indicate positive associations; red edges indicate negative associations). The network is visualised using the Fruchterman-Reingold algorithm (Epskamp et al., 2018), where nodes that have stronger and more frequent associations with another node are located closer to each other in space and are visually more concentrated in the network.

Results

Table S1 Multivariate tests on laterization index of amygdala and NAcc

		value	F	df1	df2	p
group	Pillai's Trace	0.23177	10.710	2	71	< .001
	Wilks' Lambda	0.768	10.710	2	71	< .001
	Hotelling's Trace	0.30170	10.710	2	71	< .001
	Roy's Largest Root	0.30170	10.710	2	71	< .001
eTIV	Pillai's Trace	0.00588	0.210	2	71	0.811
	Wilks' Lambda	0.994	0.210	2	71	0.811
	Hotelling's Trace	0.00591	0.210	2	71	0.811
	Roy's Largest Root	0.00591	0.210	2	71	0.811
age	Pillai's Trace	0.08922	3.478	2	71	0.036
	Wilks' Lambda	0.911	3.478	2	71	0.036
	Hotelling's Trace	0.09796	3.478	2	71	0.036
	Roy's Largest Root	0.09796	3.478	2	71	0.036

Note, eTIV estimated Total Intracranial Volume.

The MANOVA with laterization index of amygdala and NAcc as dependent variables, the main effect of 'group' was significant. The 'eTIV' effect is marginally significant, and age also has a significant effect on the dependent variables.

Table S2 Multivariate tests on left and right volume of amygdala and NAcc

		value	F	df1	df2	p
group	Pillai's Trace	0.274	6.50	4	69	< .001
	Wilks' Lambda	0.726	6.50	4	69	< .001
	Hotelling's Trace	0.377	6.50	4	69	< .001
	Roy's Largest Root	0.377	6.50	4	69	< .001
eTIV	Pillai's Trace	0.390	11.04	4	69	< .001
	Wilks' Lambda	0.610	11.04	4	69	< .001
	Hotelling's Trace	0.640	11.04	4	69	< .001
	Roy's Largest Root	0.640	11.04	4	69	< .001
age	Pillai's Trace	0.110	2.13	4	69	0.087
	Wilks' Lambda	0.890	2.13	4	69	0.087
	Hotelling's Trace	0.123	2.13	4	69	0.087
	Roy's Largest Root	0.123	2.13	4	69	0.087

Note, eTIV estimated Total Intracranial Volume.

MANOVA with volume of left and right amygdala and NAcc as dependent variables, the main effect of 'group' was significant. The 'age' effect is marginally significant, and 'eTIV' also has a significant effect on the dependent variables.

Table S3 Contingency tables of co-morbid binge eating

	Bulimia		
group	**true**	**false**	**Total**
HC	0	39	39
Obesity	3	30	33
Total	3	69	72

Note, N = 72, $\chi^2 = 3.70$, df=1, p=0.054

We deleted the 3 participants and repeated the comparison of asymmetry of the amygdala or NAcc in two groups, we still found that the amygdala in the OB group was more significantly rightward asymmetry than the HC group ($F = 20.16$, $p < 0.001$), and no significant difference in NAcc ($F = 0.60$, $p = 0.439$) in two groups.

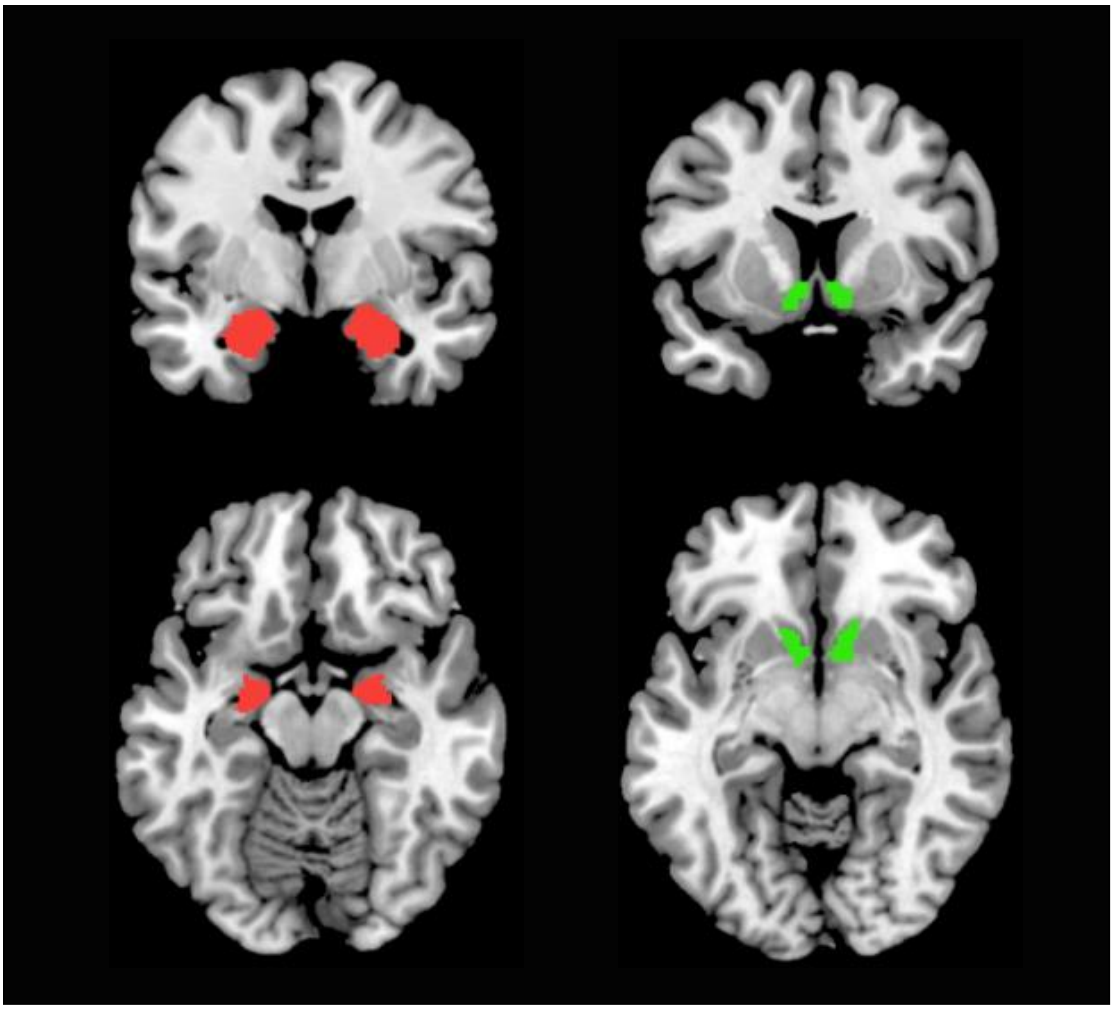

Figure S1 Visualization of the amygdala and NAcc. Red color represents the amygdala and green representing the NAcc. Top of image is the coronal view and bottom is the axial view of the brain.

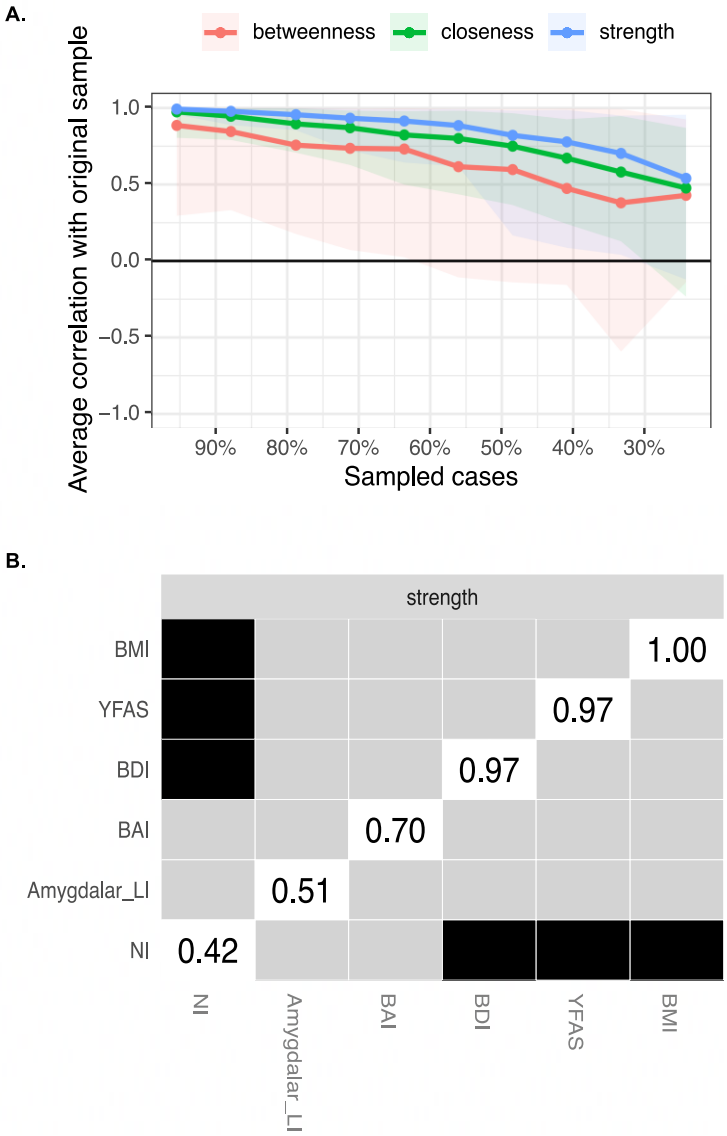

Figure S2 Network structure stability. The x axis in panel A represents the percentage of cases that were included, and the y axis represents the average correlations between the original centrality indices and the estimated centrality after certain cases were excluded. Different colored lines reflect various network features, and the gradations show the quantile range from the 2.5th to the 97.5th. The variations in centrality strength are displayed in Panel B. A black square signifies that the strength of one node differs greatly from another node.

Abbreviations: Body mass index, BMI; Beck depression inventory, BDI; Beck anxiety inventory, BAI; Nonplanning impulsiveness, NI; Yale food addiction scale, YFAS; Amygdalar LI, Amy_LI

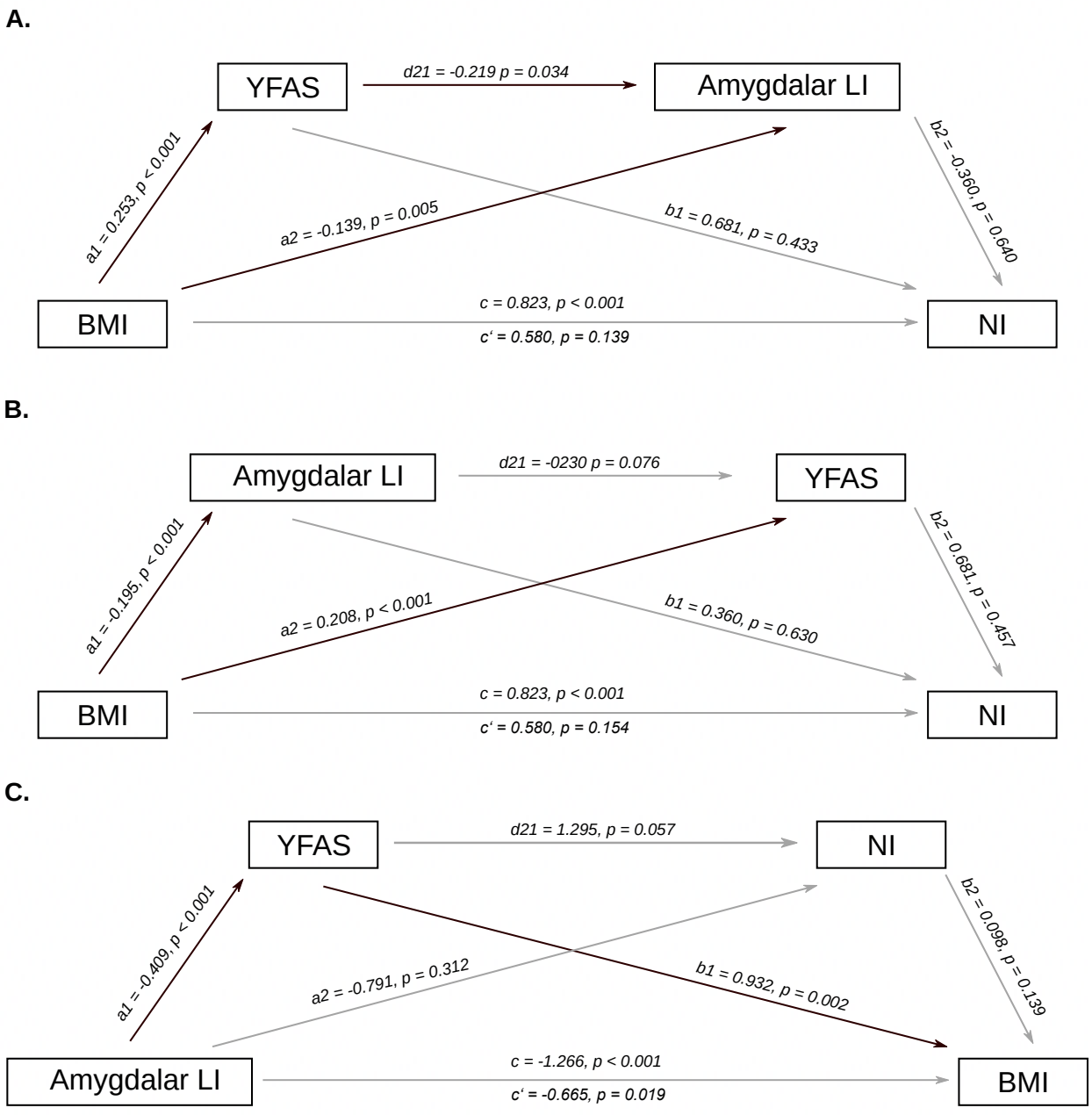

Figure S3 Results of other multiple chain mediation analysis. Panel A, B and C displayed the results of multiple chained mediation analysis between NI, YFAS, Amygdalar LI, and BMI in different pattern. Among each panel, the thick black arrows indicate significant results.
Abbreviations: Lateralization index, LI; Body mass index, BMI; Beck depression inventory, BDI; Beck anxiety inventory, BAI; Nonplanning impulsiveness, NI; Yale food addiction scale, YFAS

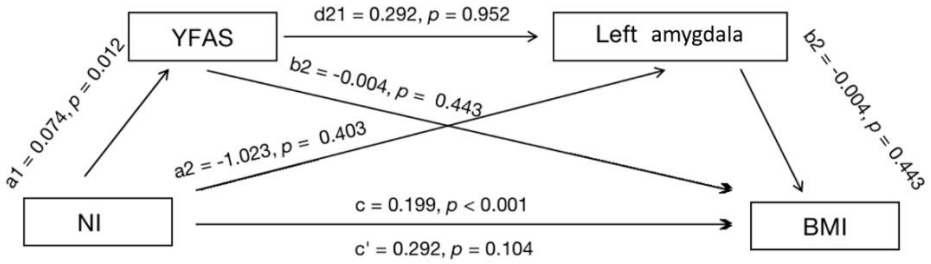

Figure S4 The results of multiple chain mediation analysis between NI, YFAS, the Left amygdala gray matter volume, and BMI.

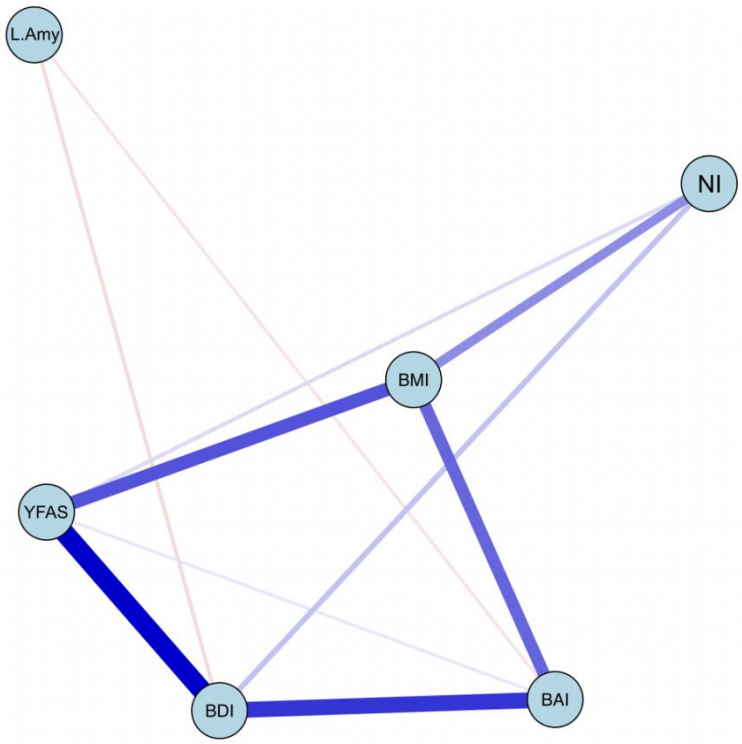

Figure S5 The network construction between left amygdala gray matter volume, BMI and multiple clinical symptoms. The left amygdala is quite irrelevant with the other factors. BMI, Body mass index; BDI, Beck depression inventory; BAI, Beck anxiety inventory; NI, Nonplanning impulsiveness; YFAS, Yale food addiction scale.

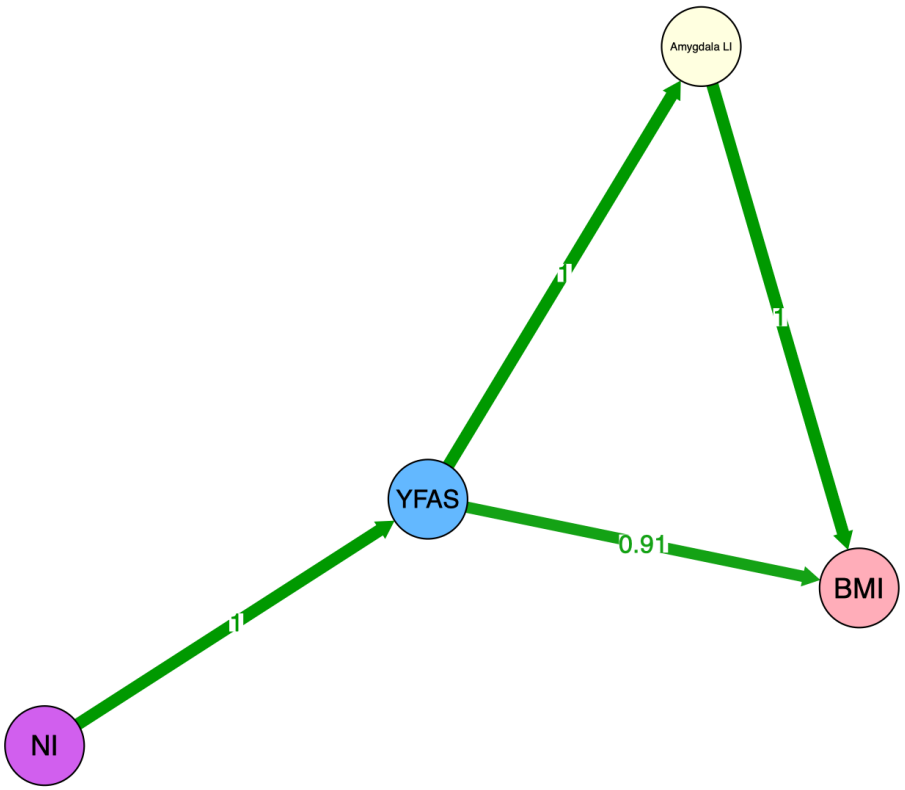

Figure S6 The Bayesian network about the Amydalar LI. BMI, Body mass index; NI, Nonplanning impulsiveness; YFAS, Yale food addiction scale; LI, laterization index. The numbers on the green line represent the likelihood (0-1) of this direction from 50,000 bootstrap.

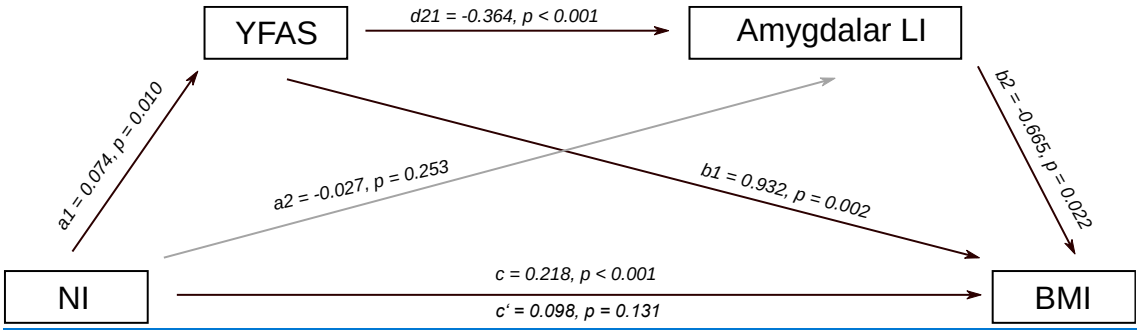

Figure S7 Results of multiple chain mediation analysis after deleting 3 binge eaters. It displays the results of multiple chain mediation analysis between NI, YFAS, amygdala LI, and BMI, and the thick black arrows indicate significant results.

Reference

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Epskamp, S., Borsboom, D., & Fried, E. I. (2018). Estimating psychological networks and their accuracy: A tutorial paper. *Behavior Research Methods*, *50*(1), 195–212. https://doi.org/10.3758/s13428-017-0862-1