Network Analysis of Trauma in Patients With Early-Stage Psychosis

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Abstract

Objectives: Childhood trauma (ChT) is a risk factor for psychosis. Negative lifestyle factors such as rumination, negative schemas, and poor diet and exercise are common in psychosis. The present study aimed to perform a network analysis of interactions between ChT and negative lifestyle in patients and controls.

Methods: We used data of patients with early-stage psychosis (n = 500) and healthy controls (n = 202). Networks were constructed using 12 nodes from five scales: the Brief Core Schema Scale (BCSS), Brooding Scale (BS), Dietary Habits Questionnaire, Physical Activity Rating, and Early Trauma Inventory Self Report-Short Form (ETI). Graph metrics were calculated.

Results: The nodes with the highest predictability and expected influence in both patients and controls were cognitive (Co) and emotional domains (Em) of the BS and emotional abuse (EMO) of the ETI. The EMO was a mediator in the shortest pathway connecting the ETI and negative lifestyle for both groups. The negative other (NO) and negative self (NS) of the BCSS mediated EMO to other BCSS or BS for patients and controls, respectively.

Conclusion: Our findings suggest that rumination and EMO were central symptoms in both groups and that NO and NS played important mediating roles for patients and controls, respectively.

Trial Registration: ClinicalTrials.gov identifier: CUH201411002

Introduction

Network analysis has been employed to investigate a) psychotic experiences,[1] potential pathways between psychotic symptoms and environmental risk factors or childhood trauma (ChT),[2] and transdiagnostic experiences surrounding auditory verbal hallucinations[3] in b) general population samples as well as interactions among a wide array of psychotic symptoms[4] or among positive, negative, and depressive symptoms,[5] prediction of treatment responses,[6] negative symptom systems,[7] and pathways linking psychotic symptoms with ChT[8] or post-traumatic stress[9] in psychosis or schizophrenia. To date, only one study on the issue of trauma in psychosis[8] has used a network approach; that study was based on data from patients but not from healthy controls.

Rumination is a repetitive and negatively valenced thinking style characterized by “the tendency to repetitively analyze one’s problems, concerns, and feelings of distress without taking action to make positive changes”.[10] Several studies have explored the relationships of rumination with depression,[11] negative symptoms,[12] positive symptoms,[13] and suicidality[14] in psychosis. People with psychosis reported extreme negative evaluations of both self and others.[15] Furthermore, individuals with psychosis showing suicidal ideation held more negative evaluations of self and others than did those without suicidal ideation.[16] Moreover, in individuals with psychosis, negative beliefs following trauma were

closely associated with psychotic experiences.[17] Patients with schizophrenia tend to have poor diets, characterized by high intake of saturated fat and low consumption of fiber and fruit,[18] and to have lower levels of physical activity compared with the general population.[19] One study reported that physical abuse was linked to elevated systolic blood pressure, whereas emotional abuse and neglect in women were linked to overweight in patients with schizophrenia.[20] Also in a non-clinical population, individuals with adverse childhood experiences were at increased risk of poor health outcomes such as physical inactivity, overweight or obesity, and diabetes.[21] Taken together, these findings suggest that in individual s with psychosis, ChT is associated with rumination, negative schemas, poor diet, and reduced physical activity, which can be grouped as a “negative life style”.

Our first aim was to understand how from a network perspective, ChT and negative life style interact in a given network and what are the central and bridge symptoms. The second aim was to determine whether the network characteristics of the two domains would remain the same or be altered after including positive (P) and negative symptoms (N) of psychosis as a third domain in the network. Therefore, in the present study, networks consisting of two or three domains were estimated and analyzed in patients with early-stage psychosis. The characteristics of these networks were compared to those of healthy controls.

Method

Study Sample

Data were collected as part of the longitudinal multicenter Korean Early Psychosis Study (KEPS), which has been described in detail elsewhere.[22] The sample comprised 500 patients with early-stage psychosis and 202 healthy controls. The inclusion criteria required that subjects be between 19 and 58 years of age and meet the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV)[23] criteria for schizophrenia spectrum disorders (SZ, schizoaffective disorder, schizophreniform disorder, psychotic disorder not otherwise specified [NOS]), brief psychotic disorder, or delusional disorder. Individuals who had been treated with antipsychotics for < 2 years were considered to be in early-stage psychosis. W**ritten informed consents were obtained from all the participants.** All experimental protocols were approved by the Ethics Committee of the Chonbuk National University Hospital (approval number CUH 2014-11-002). All procedures were performed in accordance with relevant guidelines.

Measures

The severity of psychiatric symptoms was assessed using the Positive and Negative Syndrome Scale (PANSS).[24] For self-rating scales, the Brief Core Schema Scale (BCSS),[15] Brooding Scale (BS),[25] Early Trauma Inventory Self Report-Short Form (ETI),[26] Dietary Habits Questionnaire (DHQ)[27] and Physical Activity Rating (PAR)[28] were employed.The BCSS consist of four subscales: negative self (NS), positive self (PS), negative others (NO), and positive others (PO). The DHQ is a 20-item self-administered questionnaire consisting of three subcategories: five items for diet regularity, six items for balanced diet, and nine items for unhealthy diet and eating habits. This scale was developed based on dietary guidance

published by the Korean Ministry for Health, Welfare and Family Affairs (2010).[29] The total score is categorized as indicating poor (20-49), usual (50-79), or good (80-100) diet. The PAR is a questionnaire that rates the individual's level of physical activity, with scores ranging from 0 (avoids walking or exercise) to 7 (runs more than 10 miles per week or spends more than 3 hours per week in comparable physical activity). As all scores for each parameter exhibited skewed distributions based on the Shapiro–Wilk test, they were normalized using nonparanormal transformation.[30,31]

Network estimation

Networks were constructed using 12 nodes: NS, PS, NO, and PO from the BCSS; Em and Co from the BS; DHQ; PAR; and GT, EMO, PHY, and SEXU from the ETI). We fitted a Gaussian graphical model (GGM) to the data. The GGM networks were regularized via a graphical lasso (GLASSO) algorithm[32] in combination with the extended Bayesian information criterion (EBIC) model. A tuning hyperparameter γ for the EBIC was set to 0.5.[33] The edges were calculated by partial correlations. We used the R-packages 'bootnet (estimateNetwork)' and 'qgraph' to estimate and visualize all networks.[34]

Network analysis

Global network metrics

Global network metrics consisting of network density, global strength, averaged clustering coefficient, modularity index (Q), and characteristic path length were calculated using the R packages 'qgraph' and 'igraph'.

Local network metrics

Although strength is regarded as the most reliably estimated centrality index it does not necessarily indicate the degree to which a node can be predicted by the remaining intranetwork nodes. To examine node predictability, we estimated the proportion of each node's variance accounted for by its connections to other nodes in the network, using the 'mgm'package (Version 1.2-2). In addition, as strength centrality uses the sum of absolute weights, whether positive or negative, which might distort interpretation, we estimated expected influence (EI), i.e., the sum of all edges of a node.[35] To detect symptoms that bridged the two domains (ChT and negative life style) or three domains (ChT, negative life style and P and N on the PANSS), bridge EI was calculated. Bridge EI is the sum of the values (+ or −) of all edges that connect a node to all nodes that are not part of the same community.[36] Bridge symptoms that play a primary role in connecting two or more psychiatric symptoms or domains[37] were defined as those items scoring higher than the 80th percentile for the bridge EI metric. We also computed the shortest pathways[38] from each subscale of the ETI to negative life style or to P and N within the network. To determine the EI, bridge EI, and shortest pathway, the R-packages 'mgm', 'qgraph', 'networktools',[39] and 'igraph' were used, respectively.

Network comparison

We investigated network structures and global strength using the Network Comparison Test (NCT) in the R package. For global network metrics (network density, averaged clustering coefficient, modularity index [Q], and characteristic path length), the 'NetworkToolbox' packagewas used to explore whether the overall level of network connectivity was equal among the networks.

Network accuracy and stability

The accuracy and stability of the network were examined using the R package 'bootnet', version 1.4.2. First, we bootstrapped (1,000 iterations) the 95% confidence intervals around the edge weights to assess the accuracy of the edge weights. Second, we used the case-dropping subset bootstrap (1,000 iterations) to examine the stability of the order of the node centrality indices. A correlation stability coefficient (CS-coefficient), a measure that quantifies the stability of node centrality indices, was also calculated. Finally, we tested for significant differences in edge weights and node centralities using the bootstrapped difference tests.

Results

Participants' demographic and clinical characteristics

The proportion of males was lower ($p = 0.027$) and the mean age was younger ($p < 0.001$) in patients compared to controls. The scores on the NS and NO of the BCSS, the Em and Co on the BS, the GT, EMO, PHY, and SEXU on the ETI, and the DHQ were significantly higher in patients compared to controls. Notably, although the DHQ score was significantly higher in patients, scores ranging from 50 to 79 are categorized as usual; hence, there was no actual difference between the two groups. The PAR score was significantly lower in patients (Table S1).

Global network metrics

Comparisons between the two groups revealed no significant differences in all global network metrics except the average clustering coefficient (Table S2).

Local network metrics

The nodes showing the highest predictability in both groups were Co and Em of the BS (Figures 1 and S1 and Table S3). The node with highest EI in both groups was EMO of the ETI (Figures 2 and S2). In patients, the shortest pathway from each subscale node of the ETI to the BS nodes always connected through the EMO node (Figure 3-a). However, in controls, it always connected via the NS node and/or EMO. In patients, the connection order for the BS nodes was Em and Co, whereas it was the reverse in controls. With respect to the shortest pathway from each subscale node of the ETI to the BCSS nodes, EMO played the same mediating role in both groups (except for SEXU in the controls, which connected directly to NS). However, the connection order for the BCSS nodes was NO and NS in patients and the reverse in controls (Figure 3-b). When P and N of the PANSS were included in the network, the shortest pathway from each subscale node of the ETI to the P or N node always connected through the NO node

(Figure 4). The bridge symptoms between the two domains were EMO, NO and Em in patients and EMO, NS and SEXU in controls (Figure 5). The bridge symptoms among the three domains in patients were the same as in the two-domain model (Figure S3).

Network accuracy and stability

The results of the edge weight bootstrap analysis (Figure S4) showed substantial overlap among the 95% CIs of the edge weights. However, some of the strongest edges showed non-overlapping CI values. The CS coefficients for node strength and bridge EI were 0.25 in both groups (Table S4 and S5). The results of bootstrapped difference tests for EI, bridge EI, edge weights and strength centralities are presented in Figures S1–S9.

Discussion

This childhood adversity can affect many aspects of personal development. Assuming that ChT may lead to negative life style factors such as rumination, negative schemas, poor diet, and reduced physical exercise, we conducted network analysis to explore dynamic interactions between ChT and negative life style in individuals with early-stage psychosis. Our results revealed several central symptoms within a network, which could ultimately prove to be important targets for clinical intervention.

In terms of global network metrics, only the average clustering coefficient differed significantly between the patient and control groups. As a higher clustering coefficient value means a more connected neighborhood around one particular node, this suggests that the 12 symptoms studied in patients were much more highly connected in a triangular fashion, producing greater negative impact on one another. Given that clustering coefficients tend to decline with the age,[40] our finding may be due to the age difference between the groups. However, no test controlling for covariates is available at present.

With respect to local network metrics, in both groups, the node with the highest predictability was rumination, which indicates that variance in rumination was highly predicted by its relationships with other symptoms in the network. Numerous factors may trigger rumination including negative affect, childhood adversity,[41] stable individual traits, and failure to achieve a goal.[42] Rumination has also been regarded as a common pathway leading to the development of mental disorders.[43] EMO was the most influential central symptom in both groups, although its EI value was slightly higher in patients compared to controls. EMO and emotional neglect have been considered the most frequent forms of severe trauma in patients with schizophrenia.[44] Few studies have addressed the specificity of childhood adversity effects; EMO and PHY were correlated with dissociative symptoms in patients with schizophrenia[44]; emotional neglect was associated with psychotic experiences in a general population cohort[45]; and PHY and SEXU were associated with positive symptoms in first-episode psychosis.[46] Therefore, these findings suggest that, from the perspective of “factors that are influenced and influential”, rumination and EMO are key central factors that should be targeted for psychosocial intervention in patients with psychosis.

With regard to the shortest pathway between ChT and negative life style, the results suggest that EMO played the same mediating role between the two in both groups. However, a key difference was that in controls, this pathway always led through NS following EMO and then connected to rumination or NO. More importantly, in the network including P and N, the pathway for patients was always through NO following EMO and was then connected to P or N. Thus, these findings suggest that, although EMO was an important meditator in both groups, NO and NS were more crucial as differentiating meditators for patients and controls, respectively. Several studies have demonstrated a mediating role of negative beliefs about others between trauma and psychotic symptoms[17] and a close association of negative views of others with paranoia.[47] It is noteworthy that the NS schema is also closely associated with persecutory delusions[48] and auditory verbal hallucinations.[49] In a community sample, previous evidence indicated that early trauma led to reduced self-esteem[50] or negative self-referential processing.[51] Taken together, our findings suggest that patients with early-stage psychosis may benefit from psychotherapeutic treatment targeting NO. One systematic review of schema therapy indicated initial significant results in terms of reducing early maladaptive schemas and improving symptoms related to personality disorders, but evidence for other mental disorders is currently sparse.[52] The question of why NO or NS was a more important meditator in patients than in controls needs to be clarified in future studies. The relative importance of NO vs. NS in patients vs. controls was supported by the findings about bridge symptoms. Interestingly, when P and N were included in the network, three bridge symptoms (EMO, NO, and Em) remained the same. As bridge symptoms connect different domains within a network, the activation of these bridge symptoms might be expected to distribute the activation toward other domains. This emphasizes the importance of intervening in NO to reduce P and N in patients with psychosis. Importantly, the CS coefficients for node strength and bridge EI were above the recommended 0.25 cutoff in both groups, making their interpretation acceptable.

A few limitations associated with the current study need to be acknowledged. First, we used cross-sectional data to examine the association between ChT and negative life style, which did not allow us to identify potentially causal relations. Second, poor diet in patients was not confirmed in the present study. Patient's age may have affected the results, again raising the importance of age matching between the groups. Despite these caveats, the strength of our study lay in the use of a network approach to examine interrelationships between ChT and negative life style in patients and controls. In summary, we found that rumination and EMO were central symptoms in both groups, and NO and NS played important mediating roles for patients and controls, respectively. These findings highlight the importance of targeting central or mediating symptoms to improve patients' recovery. Future research focusing specifically on these symptoms could be invaluable when designing interventions for patients exposed to ChT.

Declarations

Author contributions: Chung Y. contributed to the conceptualization, funding, supervision, writing review & editing; M. K. Kheirabad, Y. H. Piao, L. Li, Lee B., Kim W., J. Sui and T. B. Nguyen did data analysis and

writing a draft. Kim S., Lee B., Kim J., Yu J., Lee K., Won S., Lee S., Kim S., Kang S., Kim E. contributed to the data acquisition. Yun J., F. Z. Rami did write review & editing.

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Data availability: The data supporting the findings are fully available without restriction. Relevant data are available from the corresponding author upon request.

References

1. Murphy, J., McBride, O., Fried, E. & Shevlin, M. Distress, impairment and the extended psychosis phenotype: a network analysis of psychotic experiences in an US general population sample. *Schizophrenia bulletin*, **44** (4), 768–777 (2018).
2. Isvoranu, A. M., Borsboom, D., van Os, J. & Guloksuz, S. A network approach to environmental impact in psychotic disorder: brief theoretical framework. *Schizophr. Bull*, **42** (4), 870–873 (2016).
3. Wigman, J. T., de Vos, S., Wichers, M., van Os, J. & Bartels-Velthuis A. A. A transdiagnostic network approach to psychosis. *Schizophrenia bulletin*, **43** (1), 122–132 (2017).
4. van Rooijen, R., Ploeger, A. & Kret, M. E. The dot-probe task to measure emotional attention: A suitable measure in comparative studies? *Psychonomic bulletin & review*, **24** (6), 1686–1717 (2017).
5. van Rooijen, G. *et al.* A state-independent network of depressive, negative and positive symptoms in male patients with schizophrenia spectrum disorders. *Schizophr. Res*, **193**, 232–239 (2018).
6. Esfahlani, F. Z., Sayama, H., Visser, K. F. & Strauss, G. P. Sensitivity of the positive and negative syndrome scale (PANSS) in detecting treatment effects via network analysis. *Innovations in clinical neuroscience*, **14** (11–12), 59 (2017).
7. Levine, S. Z. & Leucht, S. Identifying a system of predominant negative symptoms: network analysis of three randomized clinical trials. *Schizophr. Res*, **178** (1–3), 17–22 (2016).
8. Isvoranu, A. M. *et al.* A network approach to psychosis: pathways between childhood trauma and psychotic symptoms. *Schizophrenia bulletin*, **43** (1), 187–196 (2016).

9. Hardy, A., O'Driscoll, C., Steel, C. & Van Der Gaag, M. Berg, D. A network analysis of post-traumatic stress and psychosis symptoms.*Psychological Medicine*,1–8(2020).
10. Nolen-Hoeksema, S. & Morrow, J. A prospective study of depression and posttraumatic stress symptoms after a natural disaster: the 1989 Loma Prieta Earthquake. *Journal of personality and social psychology*, **61** (1), 115 (1991).
11. Thomas, N., Ribaux, D. & Phillips, L. J. Rumination, depressive symptoms and awareness of illness in schizophrenia. *Behavioural and cognitive psychotherapy*, **42** (2), 143 (2014).
12. Halari, R. *et al.* Rumination and negative symptoms in schizophrenia. *The Journal of nervous and mental disease*, **197** (9), 703–706 (2009).
13. Badcock, J. C., Paulik, G. & Maybery, M. T. The role of emotion regulation in auditory hallucinations. *Psychiatry research*, **185** (3), 303–308 (2011).
14. Ahrens, B. & Linden, M. Is there a suicidality syndrome independent of specific major psychiatric disorder? Results of a split half multiple regression analysis. *Acta Psychiatry. Scand*, **94** (2), 79–86 (1996).
15. Fowler, D. *et al.* The Brief Core Schema Scales (BCSS): psychometric properties and associations with paranoia and grandiosity in non-clinical and psychosis samples. *Psychol Med*, **36** (6), 749–759 (2006).
16. Fialko, L. *et al.* Understanding suicidal ideation in psychosis: findings from the Psychological Prevention of Relapse in Psychosis (PRP) trial. *Acta Psychiatry. Scand*, **114** (3), 177–186 (2006).
17. Kilcommons, A. M. & Morrison, A. P. Relationships between trauma and psychosis: an exploration of cognitive and dissociative factors. *Acta Psychiatry. Scand*, **112** (5), 351–359 (2005).
18. Dipasquale, S. *et al.* The dietary pattern of patients with schizophrenia: a systematic review. *Journal of psychiatric research*, **47** (2), 197–207 (2013).
19. Daumit, G. L. *et al.* Physical activity patterns in adults with severe mental illness. *The Journal of nervous and mental disease*, **193** (10), 641–646 (2005).
20. Rajkumar, R. P. The impact of childhood adversity on the clinical features of schizophrenia.*Schizophrenia research and treatment*, (2015).
21. Hughes, K. *et al.* The effect of multiple adverse childhood experiences on health: a systematic review and meta-analysis. *The Lancet Public Health*, **2** (8), e356–e366 (2017).
22. Kim, S. W. *et al.* Design and methodology of the Korean early psychosis cohort study. *Psychiatry investigation*, **14** (1), 93 (2017).
23. DSM *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, Washington DC, 1994).
24. Kay, S. R., Fiszbein, A. & Opler, L. A. The positive and negative syndrome scale (PANSS) for schizophrenia. *Schizophrenia bulletin*, **13** (2), 261 (1987).
25. Kim, J. H. *et al.* The development of the brooding scale. *Psychiatry investigation*, **16** (6), 443 (2019).

26. Bremner, J. D., Bolus, R. & Mayer, E. A. Psychometric properties of the early trauma inventory–self report. *The Journal of nervous and mental disease*, **195** (3), 211 (2007).
27. Jhon, M. *et al.* Gender-specific risk factors for low bone mineral density in patients taking antipsychotics for psychosis. *Human Psychopharmacology: Clinical and Experimental*, **33** (1), e2648 (2018).
28. Jackson, A. S. *et al.* Prediction of functional aerobic capacity without exercise testing. *Med sci sports exerc*, **22** (6), 863–870 (1990).
29. Ministry for Health, Welfare and Family Affairs. *Dietary Reference Intakes For Koreans. Sejong* (Ministry for Health, Welfare and Family Affairs, Korea, 2010).
30. Epskamp, S., Borsboom, D. & Fried, E. I. Estimating psychological networks and their accuracy: A tutorial paper. *Behav. Res. Methods*, **50** (1), 195–212 (2018).
31. Liu, H., Lafferty, J. & Wasserman, L. The nonparanormal: Semiparametric estimation of high dimensional undirected graphs.*Journal of Machine Learning Research*, **10**(10), (2009).
32. Friedman, J., Hastie, T. & Tibshirani, R. Sparse inverse covariance estimation with the graphical lasso. *Biostatistics*, **9** (3), 432–441 (2008).
33. Boccaletti, S., Latora, V., Moreno, Y., Chavez, M. & Hwang, D. U. Complex networks: Structure and dynamics. *Physics reports*, **424** (4–5), 175–308 (2006).
34. Glück, T. M., Knefel, M. & Lueger-Schuster, B. A network analysis of anger, shame, proposed ICD-11 post-traumatic stress disorder, and different types of childhood trauma in foster care settings in a sample of adult survivors. *European journal of psychotraumatology*, **8** (sup3), 1372543 (2017).
35. Robinaugh, D. J., Millner, A. J. & McNally, R. J. Identifying highly influential nodes in the complicated grief network. *Journal of abnormal psychology*, **125** (6), 747 (2016).
36. Levinson, C. A. *et al.* Social anxiety and eating disorder comorbidity and underlying vulnerabilities: Using network analysis to conceptualize comorbidity. *International Journal of Eating Disorders*, **51** (7), 693–709 (2018).
37. Jones, P. J., Ma, R. & McNally, R. J. Bridge centrality: A network approach to understanding comorbidity.*Multivariate Behavioral Research*,1–15(2019).
38. Dijkstra, E. W. A note on two problems in connexion with graphs. *Numerische mathematik*, **1** (1), 269–271 (1959).
39. Jones, P. J. & Networktools Assorted tools for identifying important nodes in networks. R package version 1.1. 0. *Computer Software]*. Retrieved from https://CRAN. Rproject. org/package = networktools (2017).
40. Masuda, N., Sakaki, M., Ezaki, T. & Watanabe, T. Clustering coefficients for correlation networks. *Frontiers in neuroinformatics*, **12**, 7 (2018).
41. Cui, Y. *et al.* Psychological factors intervening between childhood trauma and suicidality in first-episode psychosis. *Psychiatry research*, **293**, 113465 (2020).

42. Smith, J. M. & Alloy, L. B. A roadmap to rumination: A review of the definition, assessment, and conceptualization of this multifaceted construct. *Clinical psychology review*, **29** (2), 116–128 (2009).
43. Kinderman, P. A psychological model of mental disorder. *Harvard review of psychiatry*, **13** (4), 206–217 (2005).
44. Schäfer, I. *et al.* Dissociative symptoms in patients with schizophrenia: relationships with childhood trauma and psychotic symptoms. *Compr. Psychiatr*, **53** (4), 364–371 (2012).
45. Croft, J. *et al.* Association of trauma type, age of exposure, and frequency in childhood and adolescence with psychotic experiences in early adulthood. *JAMA psychiatry*, **76** (1), 79–86 (2019).
46. Ajnakina, O. *et al.* Impact of childhood adversities on specific symptom dimensions in first-episode psychosis. *Psychol Med*, **46** (2), 317–326 (2016).
47. Valiente, C., Cantero, D., Sánchez, Ã., Provencio, M. & Wickham, S. Self-esteem and evaluative beliefs in paranoia. *Journal of behavior therapy and experimental psychiatry*, **45** (2), 297–302 (2014).
48. Smith, B. *et al.* Emotion and psychosis: links between depression, self-esteem, negative schematic beliefs and delusions and hallucinations. *Schizophrenia research*, **86** (1–3), 181–188 (2006).
49. Scott, M., Rossell, S. L., Meyer, D., Toh, W. L. & Thomas, N. Childhood trauma, attachment and negative schemas in relation to negative auditory verbal hallucination (AVH) content. *Psychiatry research*, **290**, 112997 (2020).
50. Turner, H. A., Finkelhor, D. & Ormrod, R. The effects of adolescent victimization on self-concept and depressive symptoms. *Child maltreatment*, **15** (1), 76–90 (2010).
51. Jopling, E., Tracy, A. & LeMoult, J. Childhood maltreatment, negative self-referential processing, and depressive symptoms during stress. *Psychology research and behavior management*, **13**, 79 (2020).
52. Taylor, C. D., Bee, P. & Haddock, G. Does schema therapy change schemas and symptoms? A systematic review across mental health disorders. *Psychology and Psychotherapy: Theory, Research and Practice*, **90** (3), 456–479 (2017).

Figures

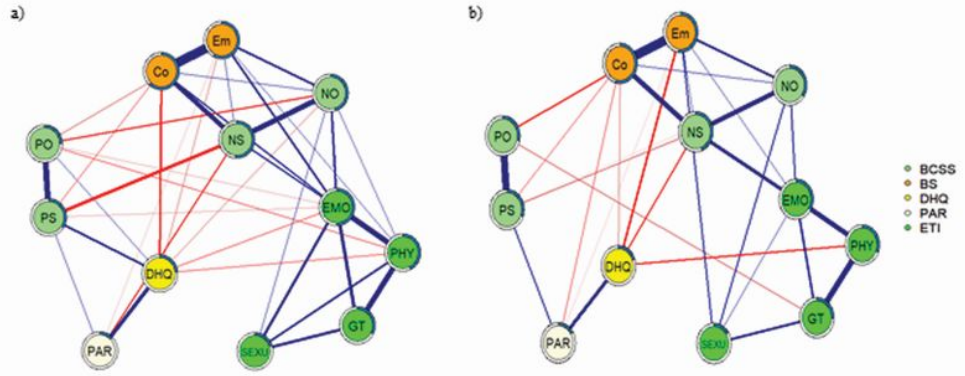

Figure 1

Estimated network structures of a) patients and b) controls. Graph features represent the following: edge thickness = strengths of the regularized partial correlations (positive in blue and negative in red); shaded area in the node perimeter=predictability. Abbreviation: BCSS, Brief Core Schema Scales; BS, Brooding Scale; Co, Cognitive subscale of the BS; DHQ, Dietary Habits Questionnaire; Em, Emotional subscale of the BS; EMO, Emotional abuse of the ETI; ETI, Early Trauma Inventory Self Report-Short Form; GT, General Traumatic experiences of the ETI; NO, Negative-Others of the BCSS; NS, Negative-Self of the BCSS; PAR, Physical Activity Rating; PHY, Physical abuse of the ETI; PO, Positive-Others of the BCSS; PS, Positive-Self of the BCSS; SEXU, Sexual abuse of the ETI.

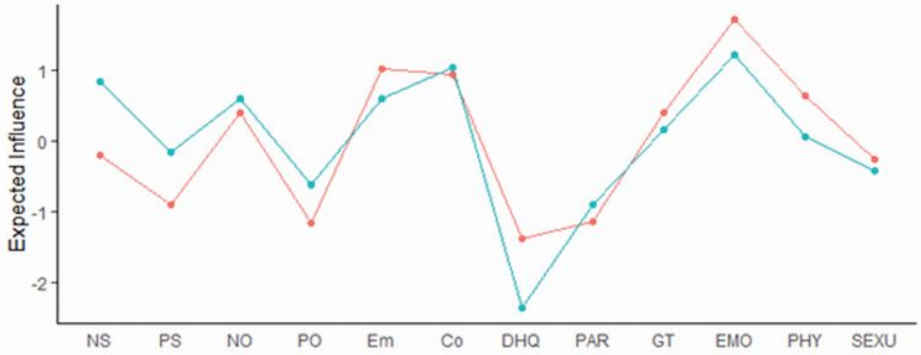

Figure 2

Expected influence for patients (red) and controls (blue). Abbreviation: Co, Cognitive subscale of the BS; DHQ, Dietary Habits Questionnaire; Em, Emotional subscale of the BS; EMO, Emotional abuse of the ETI; GT, General Traumatic experiences of the ETI; NO, Negative-Others of the BCSS; NS, Negative-Self of the BCSS; PAR, Physical Activity Rating; PHY, Physical abuse of the ETI; PO, Positive-Others of the BCSS; PS, Positive-Self of the BCSS; SEXU, Sexual abuse of the ETI.

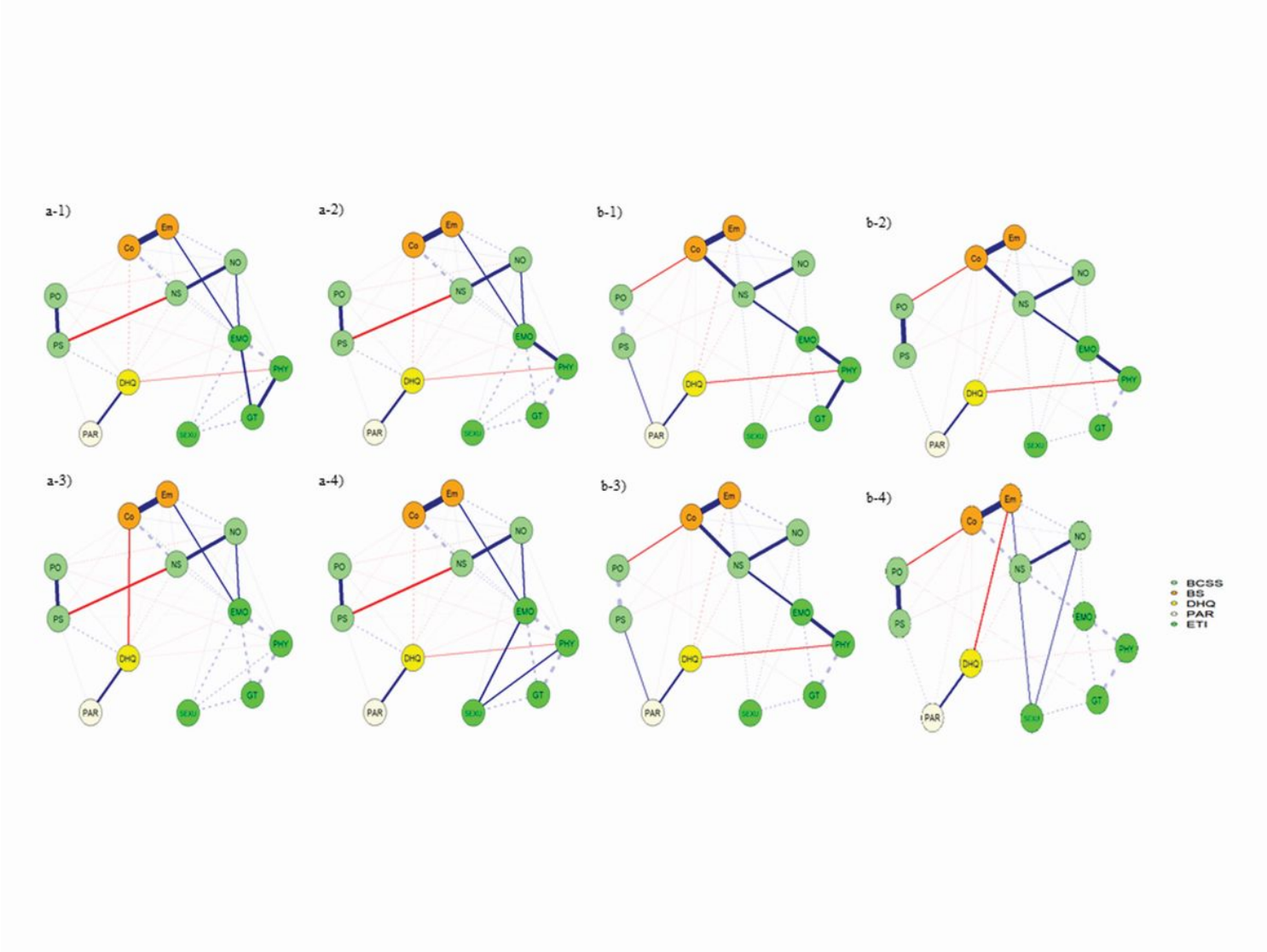

Figure 3

Shortest pathways from GT, EMO, PHY or SEXU to negative life style in a) patients (a-1, a-2, a-3 and a-4) and b) controls (b-1, b-2, b-3 and b-4). Thicker solid lines represent stronger connections; Dashed lines represent background connections existent within the network that are less relevant when investigating shortest paths. Abbreviation: same as in the figure 1

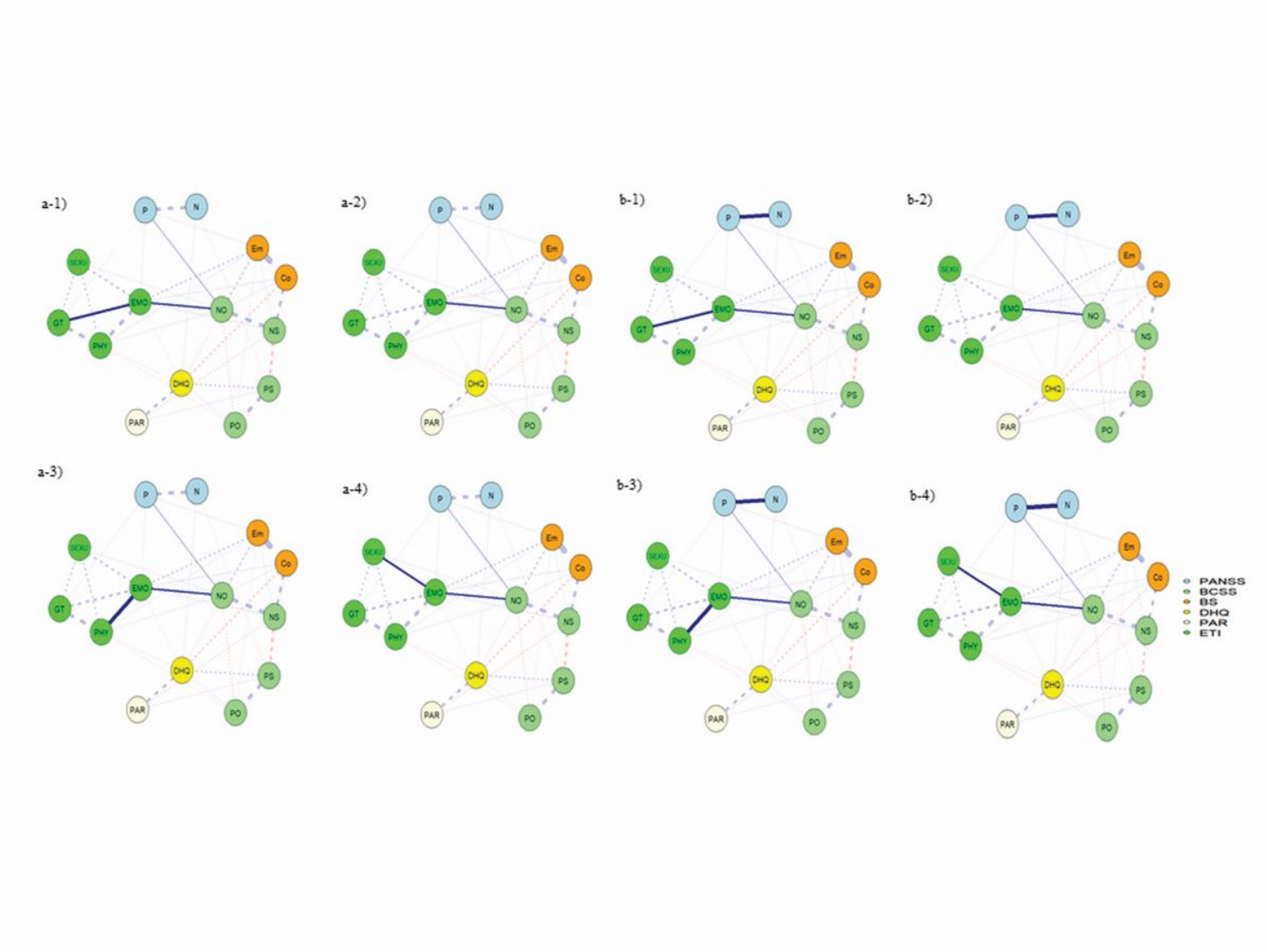

Figure 4

Shortest pathways from GT, EMO, PHY or SEXU to P (a-1, a-2, a-3 and a-4) or N (b-1, b-2, b-3 and b-4) in patients. Thicker solid lines represent stronger connections; Dashed lines represent background connections existent within the network that are less relevant when investigating shortest paths. Abbreviation: same as in the figure 1

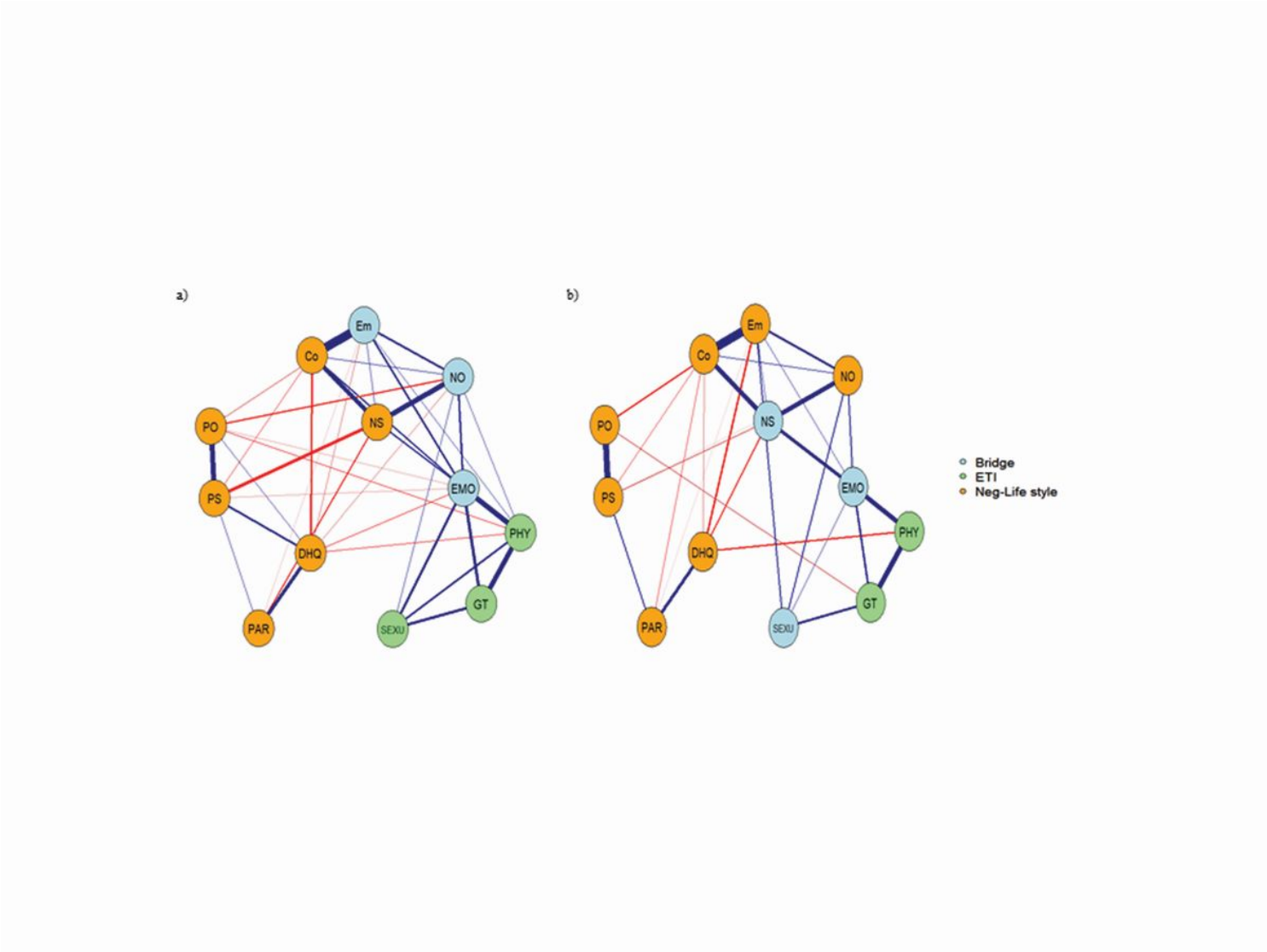

Figure 5

Bridge symptoms between two domains (childhood trauma and negative life style) in a) patients and b) controls. Abbreviation: same as in the figure 1

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplement.pdf