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A Transdiagnostic Network Analysis of Childhood Trauma and Psychopathology

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Background and Hypothesis: **Psychiatric comorbidities suggest that symptoms overlap across different diagnoses; the transdiagnostic network approach is valuable for studying psychopathology. Childhood trauma is a common transdiagnostic risk factor for psychiatric disorders, but the complex relationship between childhood trauma and psychopathology has seldom been investigated using a large cross-sectional transdiagnostic sample.** ***Study Design***: **This study recruited 869 patients with different diagnoses, including 418 schizophrenia, 215 bipolar disorder, and 236 major depressive disorder. Participants completed psychiatric interviews and self-report questionnaires. We constructed dimension- and item-level Least Absolute Shrinkage and Selection Operator-based (LASSO) networks to explore the relationship between childhood trauma, psychopathology, and duration of illness. Moreover, we constructed directed acyclic graphs (DAGs) to tentatively clarify the potential directions of associations among these variables. Network Comparison Tests (NCTs) were conducted for different diagnostic groups and gender-stratified groups.** ***Study Results***: **The transdiagnostic LASSO networks showed that different types of childhood trauma exerted distinct impacts on various psychopathological dimensions. Emotional abuse was linked to depressive symptoms, physical abuse to excited symptoms, sexual abuse to positive and disorganized symptoms, emotional neglect to depressive symptoms and motivation and pleasure (MAP) deficits factor of negative symptoms, and physical neglect to MAP factor. The DAG findings generally concurred with the LASSO network. The NCT showed comparable networks.** ***Conclusions***: **Our findings suggest that childhood trauma is significantly associated with the development of psychopathology across different diagnostic groups. The affective pathway model suggests that early identification and tailored interventions would be needed for people with a history of childhood trauma.**

Key words: transdiagnostic/childhood trauma/psychopathology/network analysis

Introduction

Growing empirical evidence suggests that psychiatric comorbidity is prevalent,[1–3] such that shared symptoms can be commonly found across different diagnoses.[3–5] This contributed to the "paradigm shift" toward the transdiagnostic approach to psychopathology. Moreover,

the network approach to psychopathology posits that disorders emerge from complex interplays among symptoms rather than being the mere consequence of an underlying disease.[6–9] Network analysis can examine independent relationships between symptoms while controlling for the effects of all other symptoms in the network, and can better reflect the interactions between symptoms and other clinically relevant variables, for identifying potential intervention targets.[10,11]

Childhood trauma is a common transdiagnostic risk factor for psychiatric disorders, and empirical evidence consistently reported a high prevalence of childhood trauma in severe mental disorders, including schizophrenia (SCZ), bipolar disorder (BPD), and major depressive disorder (MDD).[12,13] Since the human brain is developing during childhood and adolescence, the youth population is particularly vulnerable to the negative impacts of childhood trauma,[14] which could result in psychopathology.[15–21]

However, several issues regarding the relationship between childhood trauma and psychopathology remained unresolved in the extant literature. First, different types of childhood trauma were often aggregated into a composite score, precluding a nuanced examination of the distinct impacts of different childhood trauma types.[22] Different childhood trauma types can elicit different psychological or biological (eg, affecting the hypothalamic-pituitary-adrenal axis) stress responses.[23,24] Although childhood trauma increased the risk for psychiatric disorders,[24–26] the potential mechanisms and pathways mediating such association remained elusive.

A recent meta-analysis suggested that childhood (emotional/physical/sexual) abuse was consistently related to depressive symptoms and positive symptoms in psychosis patients,[15] whereas childhood (emotional/physical) neglect was related to the depressive symptoms and negative symptoms (albeit the lesser robust evidence), whether childhood trauma would be related to manic/excited symptoms and disorganized symptoms in psychosis patients was seldom studied.[15] A previous study investigated the relationship of childhood trauma with onset age (but not clinical symptoms) using a sample with different psychiatric diagnoses.[21] Notably, previous studies on childhood trauma and psychopathology mainly employed correlation analysis and regression modeling.[15,21,27] To better capture the multifactorial nature of psychopathology and the complex interplay between various factors, network analysis is a more powerful method.[10]

To date, several network analysis studies unveiled the relationships between childhood trauma and psychopathology,[19,20,27–32] though some of them did not clarify the specific effects of different types of childhood trauma on different psychopathological dimensions.[19,28,29] For instance, Isvoranu et al's item-level network analysis demonstrated that childhood trauma (regardless of type) was connected with positive and negative psychotic symptoms via general psychopathology.[27] Torregrossa et al's dimension-level network analysis showed direct links between childhood trauma and negative symptoms,[32] as well as various schizotypy subscales[31] in SCZ patients. Schlesselmann et al found that only sexual abuse was directly linked to psychopathology[30]; another study found direct connections between emotional and sexual abuse with symptoms of somatization, depression, and anger-hostility in nonpsychotic patients.[20]

While many network analysis studies used the traditional 3-factor model (positive, negative, and general symptoms) of the Positive and Negative Syndrome Scale (PANSS),[27,32,33] it is feasible to adopt the PANSS 5-factor model, which includes the PANSS excited and disorganized symptoms.[34] Illness duration may influence the impact of childhood trauma on symptoms[35] but has seldom been included in network analysis studies.[27,30,32] Male and female patients may show a different relationship of childhood trauma with psychopathology,[14,24,36,37] but the gender effect on network structure remains unclear.

This study aimed to address these knowledge gaps by utilizing network analysis on a transdiagnostic sample. The network structure between different diagnoses and gender-stratified groups would be also tested. Finally, both dimension- and item-level network analyses would be explored. Based on prior findings,[14,21,36,37] we hypothesized that childhood trauma would show strong connections with psychopathological dimensions in the transdiagnostic sample, and patients with different diagnoses and gender-stratified groups would show different psychopathology and network structures.

Methods

Participants

A total of 869 psychiatric patients were recruited from Shanghai Mental Health Centre and Suzhou Guangji Hospital. Our clinical participants had the DSM-IV diagnosis of SCZ, MDD, or BPD, based on the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition.[38] All participants were Han Chinese. Exclusion criteria included (1) a history of neurological disorders, (2) a history of brain damage or any disorder known to affect the brain, (3) substance abuse, and (4) comorbid psychiatric diagnoses. The majority of our clinical sample (93.4%) were taking psychotropic medications. In our sample, 11 participants had missing data on a total of 14 items of the questionnaires or interviews, and we employed the Expectation Maximization Algorithm for data imputation.[39]

This study was approved by the Ethics Committee of the Shanghai Mental Health Centre (Protocol number: 2017-19R; 2021-49) and the Ethics Committee of the Suzhou Guangji Hospital (Protocol number: 2020-005). Written informed consent had been obtained from each participant.

Measures

The Clinical Assessment Interview for Negative Symptoms[40] The Clinical Assessment Interview for Negative Symptoms (CAINS) is a second-generation negative symptom scale. It contains 13 items and assesses 2 dimensions of negative symptoms, including the motivation and pleasure (MAP) deficits factor (comprising 9 items) and the expressivity (EXP) deficits factor (comprising 4 items). Higher ratings indicate more severe negative symptoms. Previous studies have utilized the CAINS in patients with SCZ, BPD, and MDD.[41,42] The Chinese version of the CAINS has been shown to have good reliability and validity.[43,44] The Cronbach's alpha coefficient was 0.897 for the MAP factor and 0.912 for the EXP factor in our sample.

The Positive and Negative Syndrome Scale[33] The PANSS contains 30 items and evaluates the severity of psychotic and general symptoms. Following the previous method,[45] we calculated the severity of PANSS positive, depressive, disorganized, and excited symptoms, but discarded the PANSS negative symptom,[34] because the latter would be more comprehensively captured using the CAINS. The PANSS 5-factor structure in SCZ, BPD, and MDD had received support based on prior evidence.[46] The PANSS demonstrated good reliability and validity,[47] and its 5-factor model showed strong convergent validity within the Chinese population.[48,49] The Cronbach's alpha coefficients in our sample were 0.752, 0.711, 0.473, and 0.497 for PANSS positive, depressive, disorganized, and excited symptoms, respectively.

The Childhood Trauma Questionnaire-Short Form[50] The Childhood Trauma Questionnaire-Short Form (CTQ-SF) contains 28 items and evaluates 5 different types of childhood trauma, namely (1) sexual abuse, (2) physical abuse, (3) emotional abuse, (4) physical neglect, and (5) emotional neglect. Each type of childhood trauma is rated in 5 items, while an additional 3 items constitute the Minimization/Denial (MD) validity scale, which is used to evaluate underreporting.[51] Each item is scored from 1 (never true) to 5 (very true), higher ratings imply that childhood trauma was more severe. We applied the established cutoff scores to determine the level of a specific trauma type.[51] The cumulative level of all childhood trauma types was calculated in this study. Previous studies have administered the CTQ-SF to various psychiatric disorders.[52] The Chinese version of the CTQ-SF has been shown to have good reliability and validity.[53] In our sample, Cronbach's alpha coefficients were 0.792, 0.782, 0.833, 0.793, and 0.484 for emotional abuse, physical abuse, sexual abuse, emotional neglect, and physical neglect, respectively.

Data Analysis

Descriptive Analysis The mean and SD of all variables were calculated. We examined gender differences in these variables using independent sample *t* tests. Moreover, we examined the group differences in these variables between different diagnoses. All comparative analyses were carried out using the SPSS v22.0.[54] The significance level was set at $\alpha = 0.05$. Cohen's *d* was estimated for the effect size.

Network Construction and Centrality Estimation Since most variables in our samples were non-normal, we transformed these variables using the R package "huge" version 1.3.4.[55,56] Then, we constructed a partial correlation network, in which correlations between 2 variables were corrected for all the other variables in the network. In the resultant network, nodes would be connected by edges (partial correlations representing the estimated relationships). Then, we applied the Extended Bayesian Information Criterion Graphical Least Absolute Shrinkage and Selection Operator (EBICglasso) procedure to shrink the number of edges,[57–60] based on a penalty which decreased the strength of some of the parameter estimates, while others are set to zero. The tuning parameter was set as 0.5,[59] so that edges with weak strength would become zero, resulting in a more stable and interpretable network. For network visualization, we used the Fruchterman-Reingold algorithm which placed nodes that are more connected closer together and nodes that have higher centrality indices closer to the center of the graph (see figure 1).[61]

For each node, we computed the centrality indices of strength, betweenness and closeness,[62–64] as well as predictability and expected influence (EI).[65,66] The predictability would be visualized as a ring-shaped pie chart around a given node. In addition, we estimated the network accuracy and stability. The details for centrality indices and stability estimation can be found in supplementary materials. The nonparametric bootstrapped CIs of the difference between each pair strength centrality and edge weights were calculated. Network construction, centrality calculation, and visualization of the network were performed with "qgraph" and "mgm" packages implemented in R statistical software.[67,68] Network stability was estimated using the "bootnet" package implemented in R statistical software.[69]

Directed Acyclic Graphs Construction We employed the directed acyclic graphs (DAGs) as an exploratory tool to investigate potential directional dependencies from childhood trauma to psychopathology at both the dimension and item levels. A DAG is based on counterfactual-based logic,[70,71] which in this context involves modeling hypothetical scenarios to understand how different outcomes in psychopathology might have manifested, had the experiences of childhood trauma been different or absent. This counterfactual reasoning allows a structured examination of the complex, potentially directed relationships between specific childhood traumas and subsequent psychopathological symptoms. Although DAG is a

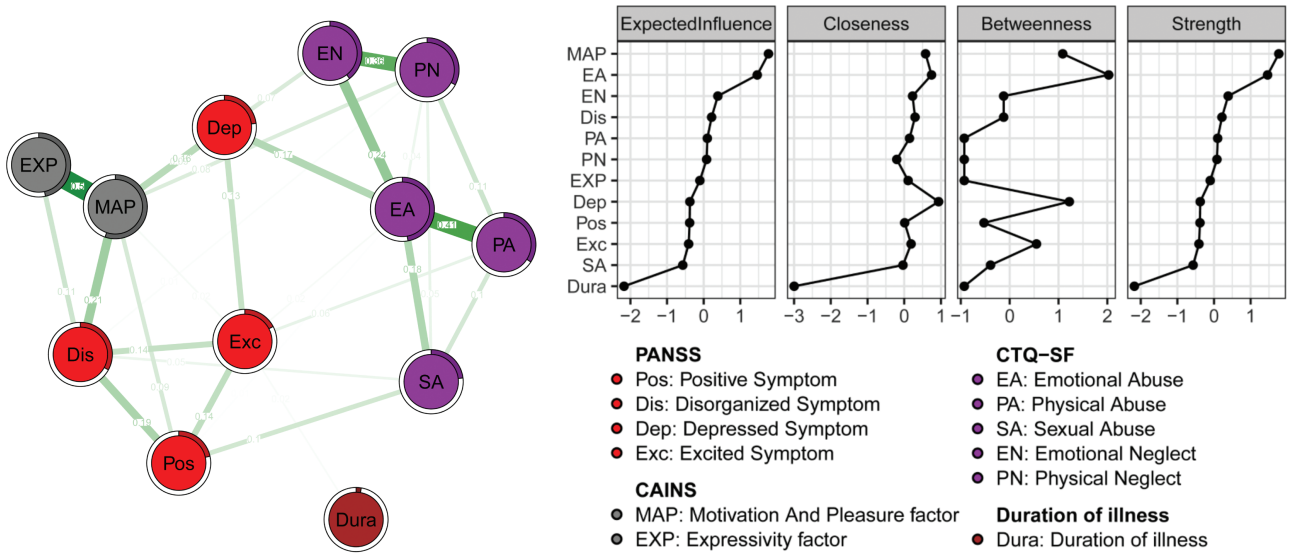

Fig. 1. The estimated regularized network structure of childhood trauma types, psychotic symptoms dimensions, and duration of illness in the transdiagnostic sample (left) and the centrality indices of nodes in the network (right). The value of each edge represents the strength of the correlations. The green edges (for the online version) or positive edge values (for the print version) indicate positive partial correlations, while the red edges (for the online version) or negative edge values (for the print version) indicate negative partial correlations. Thicker lines represent stronger connections. The ring around each node represents its predictability values. Centrality indices are shown as standardized *z* scores. *Note*: CAINS, the Clinical Assessment Interview for Negative Symptoms; CTQ-SF, the Childhood Trauma Questionnaire-Short Form; PANSS, the Positive and Negative Syndrome Scale.

sophisticated method, its results must be interpreted carefully, because it involves strict assumptions such as causal sufficiency, exclusion of "unobserved confounders," and presumptions that all relevant variables would have been measured and their relationships inferred would be causal.[70] Details of the assumptions and limitations of DAG have been reported in the literature.[70,72]

The DAG construction employed the *hill-climbing* algorithm via the "bnlearn" package implemented in R statistical software.[70,72] This algorithm is a score-based greedy search method that adjusts the network structure to optimize the Bayesian Information Criterion.[70] We started with an empty network and iteratively evaluated edge modifications, including additions, deletions, and reversals to refine the network structure.[70] To mitigate the risk of false associations, a consensus model approach incorporating 1000 bootstrap resamples was used. Each sample underwent the *hill-climbing* process with 5 random restarts and 10 perturbations per restart to minimize the risks associated with local maxima. Similar to previous research, we only considered those connections present in over 85% of the bootstrapped samples as stable enough to be included in the final network.[73] Additionally, directional edges were confirmed if they were observed in a majority (>50%) of the bootstrap iterations.[73,74] As such, the DAG results showed a "consensus" network, which summarized the "thresholded" findings across these DAGs from the 1000 bootstrap samples, and provided a representation of the inferred networks.[72] Details of the edges in the consensus DAGs can be found in supplementary tables S3 and S4.

Network Comparison Test Network Comparison Tests (NCTs) were used to examine the differences in network structure between different diagnoses and between gender-stratified groups. The invariance of network structure, global strength, and edge weights between the networks of the 2 subgroups was tested using 2-tailed permutation tests (10 000 times).[75] NCTs were performed using the "Network Comparison Test" package[75] implemented in R statistical software. The significance threshold was set at $P < .05$. The R scripts are shown in S5 of the supplementary materials.

Results

Sample Characteristics

Table 1 shows the demographics and clinical characteristics of the transdiagnostic sample ($n = 869$). Male participants showed higher levels of the EXP deficit factor ($P < .01$) of negative symptoms, but lower levels of emotional abuse and depressive symptoms ($P < .01$) than female participants. However, NCT results did not find any difference across gender in the global strength invariance test (3.86 vs 3.96, $P = .76$), or network invariance test ($M = 0.20$, $P = .15$).

Network at the Dimension Level

Figure 1 shows the resultant regularized network of the transdiagnostic sample ($n = 869$) with 12 nodes (ie, childhood trauma types, psychopathological dimensions, and duration of illness). After controlling for the inter-relationships between nodes, we observed positive

Table 1. Descriptive Summary of the Participants and Group Effects

	Total (n = 869) Mean, SD	Male (n = 371) Mean, SD	Female (n = 498) Mean, SD	χ^2/t (df = 867)	P	φ_c/Cohen's d
Age (y)	28.98 (10.76)	27.96 (9.77)	29.73 (11.39)	−2.413	**.016**	−0.17
Length of education (y)	13.54 (2.95)	13.33 (2.77)	13.69 (3.08)	−1.783	.075	−0.12
Duration of illness (mo)	65.23 (67.07)	61.19 (61.32)	68.24 (70.96)	−1.533	.126	−0.11
Medication dose (CPZ [mg/d])[a]	287.95 (237.36)	283.76 (231.17)	291.48 (242.76)	−0.391	.696	−0.03
Number of admissions[b]	0.89 (3.71)	0.69 (1.46)	1.05 (4.80)	−1.338	.181	−0.10
Marital status[b]				10.448	**.015**	0.11
Single	560 (64.4%)	262 (71.8%)	298 (62.0%)			
Married	256 (29.5%)	95 (26.0%)	161 (33.5%)			
Divorced	29 (3.3%)	8 (2.2%)	21 (4.4%)			
Widowed	1 (0.1%)	0 (0%)	1 (0.2%)			
Diagnosis				14.987	**.001**	0.092
SCZ	418 (48.1%)	205 (55.3%)	213 (42.8%)			
MDD	236 (27.2%)	80 (21.6%)	156 (31.3%)			
BPD	215 (24.7%)	86 (23.2%)	129 (25.9%)			
CTQ-SF						
Emotional abuse	8.33 (3.85)	7.92 (3.56)	8.64 (4.02)	−2.770	**.006**	−0.19
Physical abuse	6.40 (2.6)	6.58 (2.85)	6.27 (2.39)	1.748	.081	0.12
Sexual abuse	5.89 (2.1)	5.85 (2.23)	5.91 (2.01)	−0.390	.697	−0.03
Emotional neglect	12.59 (4.89)	12.49 (4.87)	12.67 (4.9)	−0.558	.577	−0.04
Physical neglect	8.72 (3.03)	8.82 (2.92)	8.64 (3.12)	0.834	.404	0.06
Minimization/Denial	0.69 (0.89)	0.70 (0.88)	0.67 (0.91)	0.469	.639	0.03
Cumulative level of childhood trauma[c]	1.09 (1.26)	1.05 (1.24)	1.11 (1.27)	−0.734	.463	−0.05
PANSS[d]						
Positive symptom	6.01 (3.21)	6.23 (3.6)	5.85 (2.88)	1.725	.085	0.12
Disorganized symptom	4.65 (1.96)	4.75 (2.04)	4.58 (1.9)	1.287	.198	0.09
Depressive symptom	6.59 (3.41)	6.06 (3.13)	6.99 (3.55)	−4.020	**.000**	−0.28
Excited symptom	5.10 (1.89)	4.99 (1.81)	5.19 (1.94)	−1.527	.127	−0.10
CAINS						
MAP deficits factor	11.61 (6.99)	12.06 (6.99)	11.26 (6.97)	1.675	.094	0.11
EXP deficits factor	3.10 (2.89)	3.45 (2.92)	2.84 (2.84)	3.082	**.002**	0.21

Note: $P < .05$ are bold. BPD, bipolar disorder; CAINS, the Clinical Assessment Interview for Negative Symptoms; CPZ, chlorpromazine equivalents; CTQ-SF, the Childhood Trauma Questionnaire-Short Form; EXP, expressivity; MAP, motivation and pleasure; MDD, major depressive disorder; PANSS, the Positive and Negative Syndrome Scale; SCZ, schizophrenia.
[a]Medication dose was calculated for only antipsychotic medication.
[b]Data on the number of admissions is missing for 78 participants, and marital status information is missing for 23 participants.
[c]Threshold scores, established by Bernstein et al,[51] were employed to quantify the level of each specific subtype of trauma. The cumulative level of childhood trauma is quantified as the aggregate severity level across each subtype of childhood trauma.
[d]The PANSS positive symptom = sum of items P1, G9, P3, P5; disorganized symptom = sum of items P2, G11, N5; depressive symptom = sum of items G2, G6, G3; excited symptom = sum of items P7, G14, P4, G8.

connections between emotional abuse and the PANSS depressive symptoms, as well as between physical abuse and the PANSS excited symptoms, and between sexual abuse and the PANSS positive and disorganized symptoms, and between emotional neglect and the PANSS depressive symptoms and the CAINS MAP factor, and between physical neglect and the CAINS MAP factor.

The centrality indices of each node are also shown in figure 1. Notably, the CAINS MAP factor showed the highest strength and EI, followed by emotional abuse, indicating their strong connections with other nodes in the network. Emotional abuse also showed the highest betweenness, followed by depressive symptoms, indicating that it may function as a bridge connecting different parts of the network. Network stability and accuracy analyses showed relatively narrow bootstrapped CIs, suggesting the edge weights were reliable and accurate. The correlation stability (CS) coefficients for strength and EI were both 0.75, exceeding the threshold and indicating satisfactory stability. However, the CS coefficient for betweenness (at 0.361) showed reasonable stability, while the CS coefficient for closeness was 0, far below the minimum threshold of 0.25.[70] Thus, we interpreted our results based on the indices of strength, EI, and betweenness. The predictability of nodes ranged from 2.6% (duration of illness) to 55.2% (CAINS MAP factor), with an average of 31.3% (see supplementary table S1 for details).

Network at the Item Level

Figure 2 shows the resultant regularized network of the transdiagnostic sample (n = 869) with 33 nodes (ie,

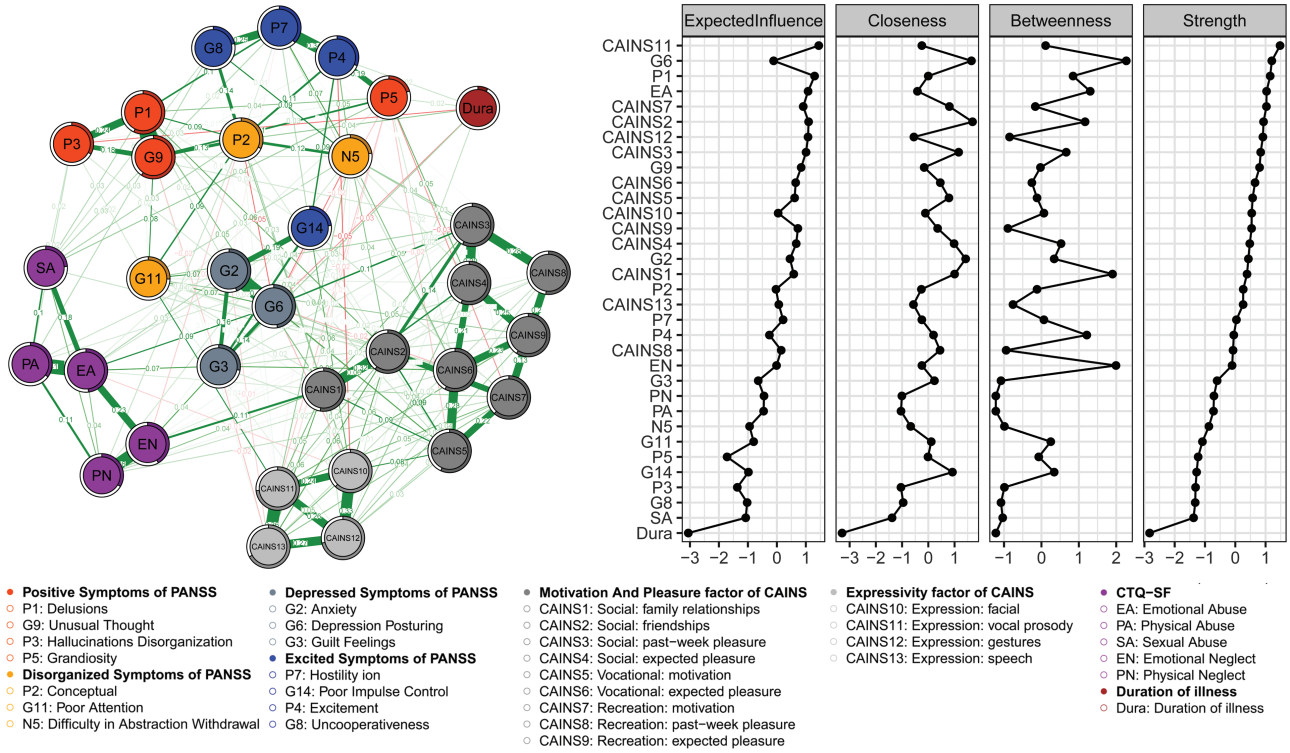

Fig. 2. The estimated regularized network structure of childhood trauma types, psychotic symptoms items (the PANSS and the CAINS), and duration of illness in the transdiagnostic sample (left) and the centrality indices of nodes in the network (right). The value of each edge represents the strength of the correlations. The green edges (for the online version) or positive edge values (for the print version) indicate positive partial correlations, while the red edges (for the online version) or negative edge values (for the print version) indicate negative partial correlations. Thicker lines represent stronger connections. The ring around each node represents its predictability values. Centrality indices are shown as standardized *z* scores. *Note*: CAINS, the Clinical Assessment Interview for Negative Symptoms; CTQ-SF, the Childhood Trauma Questionnaire-Short Form; PANSS, the Positive and Negative Syndrome Scale.

childhood trauma types, items of the CAINS and part of the PANSS, and duration of illness). After controlling for the inter-relationships between nodes, we observed similar connections between specific childhood trauma types and the items of specific psychopathological dimensions. Moreover, the duration of illness was positively connected with the nodes of disorganized and depressive symptoms, while negatively connected with the nodes of positive symptoms.

The centrality indices of each node are shown in supplementary table S2. The node of CAINS-11 (Expression: vocal prosody) showed the highest strength and EI, followed by P1 (Delusions), CAINS-2 (Social: friendship), and EA (emotional abuse). The results of network stability and accuracy analyses are shown in supplementary materials. The CS coefficients for strength and EI were both 0.75, suggesting stability. The CS coefficients for closeness and betweenness were both 0.128, indicating low levels of stability. The predictability of nodes ranged from 7.2% (duration of illness) to 72.6% (CAINS-11), with an average of 44.2%.

Directed Acyclic Graphs

In our analysis, DAGs were applied as an exploratory analysis to identify potential directional dependencies from childhood trauma to psychopathology. While our results should be interpreted with caution, the DAGs corroborated the network analysis results, showing conditional, directional dependencies between childhood trauma and specific psychopathological dimensions such as depressive, positive, and negative symptoms (see supplementary materials for details).

Network Comparison Between Diagnostic Groups

Table 2 shows the characteristics of SCZ ($n = 418$), MDD ($n = 236$), and BPD patients ($n = 215$). Relative to SCZ patients, MDD patients and BPD patients showed significantly higher levels of emotional abuse, emotional neglect, and depressive symptoms ($P < .05$), as well as lower levels of positive symptoms, negative symptoms (including the MAP factor and the EXP factor), and disorganized symptoms ($P < .05$). Moreover, they also scored lower in the MD subscale of the CTQ ($P < .01$) than SCZ patients, suggesting that they were less likely to underreport childhood trauma. Compared with SCZ patients, MDD patients showed higher marriage rates and experienced fewer hospital admissions ($P < .05$), although these differences were not statistically significant relative to BPD patients ($P > .05$). MDD

Table 2. Comparison of Demographic and Clinical Information Among the 3 Diagnostic Groups

	SCZ (n = 418) Mean, SD	MDD (n = 236) Mean, SD	BPD (n = 215) Mean, SD	$F(2, 867)$	P
Age (y)	28.51 (9.72)	30.41 (13.23)	28.32 (9.5)	2.897	.056
Length of education (y)	13.27[b] (2.98)	13.45[b] (3.03)	14.15[a] (2.74)	6.522	**.002**
Duration of illness (mo)	68.12[a] (66.63)	52.66[b] (65.57)	73.41[a] (67.95)	6.202	**.002**
Medication dose (CPZ [mg/d])	299.14[a] (231.94)	149.00[b] (143.36)	309.85[a] (265.2)	10.415	**<.001**
Number of admissions	1.27[a] (5.27)	0.32[b] (0.98)	0.83[ab] (1.44)	4.592	**.010**
Marital status				17.492	**.003**
Single	285 (70.7%)[a]	140 (59.6%)[b]	135 (64.9%)[ab]		
Married	100 (24.8%)[b]	90 (38.3%)[a]	66 (31.7%)[ab]		
Divorced	18 (4.5%)	4 (1.7%)	7 (3.4%)		
Widowed	0 (0%)	1 (0.4%)	0 (0%)		
CTQ-SF					
Emotional abuse	7.62[b] (3.33)	8.86[a] (4.13)	9.14[a] (4.2)	14.609	**<.001**
Physical abuse	6.28 (2.57)	6.33 (2.23)	6.71 (3)	2.103	.123
Sexual abuse	6.00 (2.35)	5.65 (1.7)	5.92 (1.98)	2.173	.114
Emotional neglect	11.92[b] (4.7)	13[a] (4.92)	13.46[a] (5.04)	8.318	**<.001**
Physical neglect	8.76 (2.89)	8.48 (3.07)	8.89 (3.26)	1.140	.320
Minimization/Denial	0.83[a] (0.94)	0.53[b] (0.84)	0.59[b] (0.83)	10.100	**<.001**
Cumulative level of childhood trauma	0.97[b] (1.22)	1.09[ab] (1.28)	1.31[a] (1.27)	5.263	**.005**
PANSS					
Positive symptom	7.11[a] (3.82)	4.78[b] (1.63)	5.2[b] (2.39)	54.823	**<.001**
Disorganized symptom	5.09[a] (2.26)	4.17[b] (1.54)	4.33[b] (1.52)	21.504	**<.001**
Depressive symptom	5.35[c] (2.77)	8.33[a] (3.52)	7.1[b] (3.47)	70.309	**<.001**
Excited symptom	5.15 (2.02)	4.97 (1.54)	5.16 (1.97)	0.745	.475
CAINS					
MAP deficits factor	12.87[a] (6.89)	10.46[b] (6.92)	10.41[b] (6.83)	13.548	**<.001**
EXP deficits factor	4.12[a] (2.88)	2.22[b] (2.45)	2.10[b] (2.69)	55.969	**<.001**

Note: $P < .05$ are bold. Values with superscript letters a, b, and c are significantly different across groups after Bonferroni or Games-Howell adjustment (adjust $P < .05$). BPD, bipolar disorder; CAINS, the Clinical Assessment Interview for Negative Symptoms; CPZ, chlorpromazine equivalents; CTQ-SF, the Childhood Trauma Questionnaire-Short Form; EXP, expressivity; MAP, motivation and pleasure; MDD, major depressive disorder; PANSS, the Positive and Negative Syndrome Scale; SCZ, schizophrenia.

patients also had the shortest duration of illness and the lowest doses of antipsychotic medication ($P < .05$).

NCTs found no significant difference in the global strength invariance test among SCZ, MDD, and BPD patients (4.39 vs 3.59 vs 3.74, $P > .05$). However, in the network invariance test, SCZ patients showed significant differences compared with MDD ($M = 0.32$, $P < .05$) and/or BPD patients ($M = 0.33$, $P < .01$). After Holm correction, SCZ patients showed a weaker edge linking depressive symptoms with disorganized symptoms ($P < .01$) than MDD patients, as well as a weaker edge linking depressive symptoms with MAP factor of negative symptoms ($P < .01$), and a stronger edge linking depressive symptoms with positive symptoms ($P < .05$) than BPD patients.

Discussion

This is the first network analysis examining the relationship between childhood trauma and psychopathology in a large transdiagnostic clinical sample. Our findings revealed distinct associations between different types of childhood trauma and specific psychopathological dimensions. Emotional abuse was linked to depressive symptoms, physical abuse to excited symptoms, sexual abuse to positive and disorganized symptoms, and childhood neglect to negative symptoms. These patterns were consistent across both partial correlation networks and DAGs, highlighting the significant role of childhood trauma in shaping psychopathological outcomes.

Our findings supported the existence of differential effects of childhood trauma types on various psychopathological dimensions after controlling for the effect of duration of illness. Specifically, we found that emotional abuse was linked to depressive symptoms only, aligning with the extant literature.[15] Furthermore, our findings concurred with prior literature regarding the association of childhood neglect with negative and depressive symptoms[15,76] and the association of sexual abuse with positive symptoms.[77,78] Moreover, we found associations between physical abuse and excited symptoms, and between sexual abuse and positive symptoms and disorganized symptoms. Since previous studies seldom examined the relationship between excited and disorganized symptoms and childhood trauma,[15] our findings contributed valuable insights. Future research should further explore

these associations to better understand its implications for clinical practice.

Unlike previous studies which showed a link between childhood trauma and positive and negative symptoms through general psychopathology symptoms,[27,79] our item-level network analysis found direct connections between childhood neglect and the CAINS MAP factor, and between childhood abuse and positive symptoms. Since we measured psychopathology using the second-generation negative symptom scale (ie, CAINS) and the 5-factor model of the PANSS,[34] our work might benefit from a more refined measure for psychopathology than the method used in earlier studies. The MAP factor seems to be a key symptom across different disorders in the development of negative symptoms, as supported by the literature.[80–82] It also showed the highest strength and EI in our network. Moreover, our network identified emotional abuse as a critical node, with the highest betweenness, and high degrees of strength and EI. This result was consistent with previous studies using samples of psychotic patients, subclinical and nonclinical individuals.[15,83–85]

The DAGs were used to detect and delineate the most likely directions of causal relationships between nodes.[70] It utilized "conditional dependencies" between pairs of variables within the broader network context to offer insights into complex interactions. In our study, the DAG findings provided an exploratory perspective on the directionality of impacts, regarding how childhood trauma may result in psychopathological outcomes. For instance, depressive symptoms appeared to lie more "upstream" than all other symptoms in the DAG network, and directly depended on emotional abuse. Moreover, the MAP factor appeared to be directly dependent on emotional neglect and depressive symptoms, and positive symptoms appeared to depend on sexual abuse. In the most recent meta-analysis,[15] Alameda et al included 47 studies and found that depressive symptom was the most vulnerable psychopathology. Our results supported the well-known "affective pathway of psychosis," ie, depressive symptoms are transdiagnostic and could result in psychotic symptoms.[86,87] Having said that, these DAG findings must be interpreted with caution, due to many inherent limitations of DAGs, which rely heavily on strict assumptions.[70,88] Although the DAG findings cannot be directly compared with results gathered in undirected networks, we observed an apparent consistency of network patterns in our study, which suggested the links between certain types of childhood trauma and psychopathological domains.

This study did not find any gender effect on the network. The gender-stratified subgroups did not differ in global strength nor network invariance, suggesting similar underlying mechanisms from childhood trauma to psychopathology across genders. Although some studies have identified gender differences in psychopathology,[14,36,37] their findings often contradicted each other, partially related to variations in sample sizes or measurement methods.[89–91] Notably, some studies did not report any gender differences.[24,89,92] More research is needed in this area.

Although our NCTs did not reveal significant differences in global strength among SCZ, MDD, and BPD patients, they did unmask distinct network structures. Specifically, SCZ patients showed unique connectivity patterns in how their symptoms were related to depressive symptoms, suggesting that there might be different underlying mechanisms of disease manifestation across these disorders. According to the hysteresis principle of network theory, a symptom that arises within a network may influence other connected symptoms, potentially leading to cascading effects where more symptoms may arise to form a more interconnected network.[6] This might suggest that interventions targeting depressive symptoms in MDD patients may address negative and disorganized symptoms more effectively than SCZ patients, whose symptoms are less interconnected. In contrast, despite the higher levels of depressive symptoms in BPD patients, their influence on positive symptoms was comparatively weak, suggesting that treatments focusing on depressive symptoms in BPD might not effectively address positive symptoms as they might in SCZ patients. These findings underscored the importance of disorder-specific treatment strategies that account for unique symptom dynamics within each diagnostic category. The different relationships of depressive symptoms across different disorders suggested different pathways in symptom progression, highlighting the need for tailored therapeutic approaches. Future studies should try to unravel these complex relationships, for better intervention strategies and thus treatment outcomes. However, these structural differences did not extend to the connections between childhood trauma and psychopathology. The patterns linking childhood trauma to psychopathology were consistent across all 3 diagnostic groups, consistent with previous findings.[25,88] This consistency might indicate that, while the symptom profiles are distinct, the fundamental effects of childhood trauma on later psychopathology remain similar, potentially influencing the pathways to different clinical diagnoses. Notably, the MD scale of the CTQ-SF is significantly higher in SCZ patients compared with those with MDD and BPD, suggesting that SCZ patients were more likely to underreport childhood trauma than the other groups. In fact, a previous study reported a low prevalence of childhood trauma in SCZ patients compared with BPD and MDD patients, though the MD subscale had not been used.[13] Given that many previous studies using the CTQ did not include the MD score,[12] future studies should include this subscale to better capture childhood trauma in SCZ samples.

Our study has several strengths, including a large sample size, the advantage of using network analyses, and a second-generation negative symptom scale. Collectively, these strengths bolstered the reliability and extended the applicability of our findings. However, we

acknowledged several limitations. Despite our relatively large transdiagnostic sample, we only included SCZ, MDD, and BPD patients, and ignored other non-psychosis diagnoses. This might limit the generalizability of our findings. Second, the cross-sectional design weakened the inferences of causative relationships between the connected nodes. Future research should employ a follow-up design to examine how the network structure would change over time. While our DAG results aligned with those from the partial correlation network, the findings of DAG must be interpreted with caution. The *hill-climbing algorithm* in DAG only represents 1 potential model of Bayesian network and causality, and has many limitations, such as settling at poor local maxima.[74] Furthermore, cognitive function is a well-known potential mediator in the pathways from childhood trauma to psychopathology, as suggested by previous theory[93] and evidenced in recent network studies in nonclinical populations.[94,95] Future research should include measures of cognitive functions in network analyses, since the absence of a common related variable may lead to faulty causal hypotheses.[69] In addition, some measures in our study, such as the CTQ, were in self-report format. Future research should employ more reliable tools, particularly structured interviews, to better measure these variables. Likewise, the reliability of measurements for PANSS disorganized and excited symptoms was relatively low, possibly due to the heterogeneity of our sample, which included patients with different psychiatric disorders. Previous reliability studies primarily involved patients with SCZ.[48,49] Future studies should consider measurement tools that are more suitable for transdiagnostic applications. Finally, given that all our participants were Han Chinese, our findings not be generalizable to non-Chinese settings. Future research should include a more ethnic-diverse sample to enhance the generalizability of the results.

To conclude, our study supported the implications and roles of childhood trauma in developmental psychopathology in patients with SCZ, MDD, and BDP. Early identification and targeted intervention for people with a history of childhood trauma may potentially avert the onset of severe psychiatric symptoms. Future research should recruit larger and more diverse samples to clarify our findings, and should explore the underlying mechanisms through which childhood trauma would mold the psychopathological network across one's lifespan.

Supplementary Material

Supplementary material is available at https://academic.oup.com/schizophreniabulletin/.

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