Personality and Individual Differences 246 (2025) 113332

Contents lists available at ScienceDirect

Personality and Individual Differences

journal homepage: www.elsevier.com/locate/paid

The relationship between test anxiety and neuroticism: a network analysis approach

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ARTICLE INFO

Keywords:
Test anxiety
Neuroticism
High school students
Network analysis

ABSTRACT

Objective: The study aims to construct a psychological network to identify key factors and bridging nodes while investigating the relationship between test anxiety and neuroticism.
Methods: We surveyed 717 high school students using the Multidimensional Test Anxiety Scale and the Neuroticism subscale of the Big Five Inventory-2. We used the graphical LASSO method and R to construct a regularized partial correlation network between test anxiety and neuroticism.
Results: According to the network, worry about test results and panic before exams are at the center of test anxiety, while vulnerability to sadness is at the core of neuroticism. We identified tension susceptibility as the primary bridging node between the test anxiety and neurotic networks.
Conclusion: Tension susceptibility is a key link between neuroticism and test anxiety. Intervention strategies aimed at reducing tension are critical for lowering test anxiety in neurotic individuals. Targeted interventions, such as mindfulness meditation and emotional regulation strategies, can effectively reduce test anxiety, especially in people with high neuroticism.

1. Introduction

Test anxiety refers to a wide range of negative emotional responses caused by exam situations. We can classify it as a situationally specific personality trait, exhibiting both situational and trait-like characteristics (Spielberger, 1966). People with high test anxiety will feel nervous and panic in evaluation situations, often followed by physiological reactions such as sweaty palms and accelerated heart rate. According to studies, test anxiety not only affects individuals' physical and mental health, as well as academic performance (Culler & Holahan, 1980), but can even impair their cognitive functions (Wei et al., 2022). However, over the last 15 years, the incidence of high test anxiety among high school students in China has remained high and stable at around 30 % (Huang & Zhou, 2019). Given the prevalence and persistence of test anxiety, understanding its onset and development is critical for developing effective interventions.

Personality traits are one of the important influencing factors of test anxiety (Chamorro-Premuzic et al., 2008). von der Embse et al. (2018), in a meta-analysis spanning 30 years of empirical research, concluded that neuroticism significantly and positively correlates with test anxiety, with the strongest effect among the five personality traits ($r = 0.46$). Neuroticism primarily affects two aspects of an individual's life: cognition and emotion. In terms of cognition, neurotic individuals tend to have negative cognition (Ormel et al., 2013) and are prone to frequent intrusive thoughts and mind wandering (Munoz et al., 2013). In terms of emotion, some studies refer to neuroticism as “negativity” because it is often associated with stronger negative emotions like anxiety, tension, and depression (Costa & McCrae, 1992). Furthermore, emotional variability, which manifests as emotional instability, closely correlates with neuroticism (Hepburn & Eysenck, 1989). Not only that individuals with neuroticism tend to experience greater volatility in their negative emotions (Mader et al., 2023). Many studies have confirmed that neuroticism is a high-risk factor for increased susceptibility to multiple mental illnesses and the coexistence of different anxiety disorders (Huang et al., 2015; Kalin, 2020; Regzedmaa et al., 2024; Schmidt & Riniolo, 1999; Widiger & Oltmanns, 2017).

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https://doi.org/10.1016/j.paid.2025.113332
Received 7 April 2025; Received in revised form 22 May 2025; Accepted 9 June 2025
Available online 14 June 2025

Recent personality and social psychology research has increasingly highlighted the importance of context (Matthews et al., 2024). This is especially relevant for understanding how situational stressors, such as academic testing, interact with traits like neuroticism. Test anxiety is a context-dependent response that tends to occur more frequently in individuals high in neuroticism. Neuroticism heightens anxiety vulnerability by intensifying negative emotions and maladaptive thought patterns (Wang et al., 2025), making such individuals more susceptible to test anxiety in evaluative situations (Chamorro-Premuzic et al., 2008; Schmidt & Riniolo, 1999).

Clarifying the relationship between test anxiety and neuroticism helps us understand the mechanism of test anxiety. In previous studies, researchers explored the interaction mechanism between test anxiety and neuroticism by introducing mediating or moderating variables, such as self-esteem, fear of negative evaluation, intolerance of uncertainty (Zhang & An, 2016), and self-efficacy (Tu & Shi, 2008). Although this method has special value in understanding specific causal paths, it has some limitations. For example, mediation and moderation analysis are based on the premise of latent variables and often assume a linear causality, which may overlook the complex interactions and specific mechanisms that may exist between variables, limiting our comprehensive understanding of the relationship between test anxiety and neuroticism. Additionally, most prior studies have focused on mediating or moderating variables, explaining when or why test anxiety and neuroticism are related, but often neglecting how their specific components interact. In contrast, this study directly examines their structural relationship at the item level, without third variables, to clarify how cognitive and emotional symptoms are linked across the two constructs.

In recent years, network analysis has evolved as a popular statistical tool, providing a more extensive and nuanced view of variable interactions (Borsboom et al., 2021; Borsboom & Cramer, 2013; Epskamp et al., 2018). Contrasted with classic mediation and moderation analyses, network analysis does not rely on a one-way cause-and-effect relationship. It allows researchers to examine both direct and indirect relationships between variables to evaluate how important each is in the whole structure. This method can reveal the intricate connections between various factors, including node centrality, path strength, and bridge nodes that link different psychological networks (Jones et al., 2021). Network analysis aids our understanding of the direct relationship between test anxiety and neuroticism.

To summarize, earlier studies on the relationship between test anxiety and neuroticism have primarily relied on traditional latent variable models. They assume that all questionnaire items affect the dimensions equally and may overlook their interactions. Therefore, this study aims to construct a regularized partial correlation network linking test anxiety and neuroticism to help identify core and bridge nodes, thereby clarifying the complex relationships between these two psychological constructs. Specifically, we address the following research questions:

(1) What are the central components of test anxiety and neuroticism in the estimated network?

(2) Which components act as bridge nodes that link the two constructs?

2. Methods

2.1. Participants

This study utilized a cluster sampling method to survey first- and second-year high school students from a school located in Yancheng City, Jiangsu Province. A total of 806 questionnaires were distributed, resulting in 717 valid responses, translating to a response rate of 90.0 % after excluding 89 invalid surveys due to inaccuracies or patterned responses. The participants had a mean age of $M = 16.06$ years ($SD = 0.74$), with ages spanning from 14 to 19 years. Among the respondents, 328 were male (45.7 %) and 389 were female (54.3 %); additionally, 347 were first-year students (48.4 %) and 370 were second-year students (51.6 %). Ethical approval for this study was granted by the Ethics Committee of Nanjing University, and all the participates signed the informed consent form with the consent of their parents and guardians.

2.2. Measures

2.2.1. Multidimensional Test Anxiety Scale (MTAS)

The Multidimensional Test Anxiety Scale (MTAS) comprises 16 items, organized into four subscales: worry, cognitive interference, tension, and physiological indicators, with each subscale consisting of four items (Bai et al., 2024; Putwain, von der Embse, et al., 2021). Participants responded to items on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), and no reverse scoring was applied. Total scores ranged from 16 to 80, with higher scores indicating greater levels of test anxiety. In this study, the Cronbach's α coefficient for the MTAS was 0.93, reflecting excellent internal consistency.

2.2.2. Big Five Inventory-2 (BFI-2) neuroticism subscale

The neuroticism subscale of the Big Five Inventory-2 (BFI-2) contains 12 items categorized into three subdimensions: anxiety, depression, and volatility, with four items allocated to each subdimension (Soto & John, 2017; Zhang et al., 2022). Participants rated these items on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), with six items reverse-coded. Scores for the BFI-2 neuroticism subscale range from 12 to 60, with higher scores signifying more pronounced neurotic traits. The Cronbach's α coefficient recorded for the BFI-2 neuroticism subscale in this study was 0.85, indicating good internal reliability.

2.3. Statistical analysis

Descriptive statistical analyses were executed using IBM SPSS Statistics 26.0, whereas the network analysis was performed with R version 4.3.1.

2.3.1. Network analysis

Network analysis is a statistical method that views psychological constructs as systems of interacting components (Borsboom & Cramer, 2013). A network includes two main elements: nodes and edges. Nodes represent observed variables, and edges reflect statistical associations between them. In psychological research, nodes are often individual items from questionnaires. For example, each item on a test anxiety or neuroticism scale can be treated as a node. This item-level approach is widely used in detailed modeling of symptom interactions (McNally, 2016; Robinaugh et al., 2020). Defining each node as a questionnaire item allows for the identification of specific components that shape the structure and interaction of test anxiety and neuroticism.

There are several types of network models, including correlation networks, partial correlation networks, and regularized partial correlation networks (Isvoranu & Epskamp, 2023). Correlation networks include all pairwise correlations but may reflect spurious links. Partial correlation networks estimate direct relationships by controlling for other variables, but they can still overfit complex data (Epskamp & Fried, 2018). To address this, we used a regularized partial correlation network based on the graphical least absolute shrinkage and selection operator (GLASSO) method (Friedman et al., 2008; Johal & Rhemtulla, 2023). This approach reduces false positives by shrinking weak connections toward zero and retains only the most meaningful edges.

To estimate the network structure underlying the relationship between test anxiety and neuroticism, a Gaussian graphical model (GGM) was employed. For regularization, the GLASSO method was utilized, allowing for the retention of meaningful connections while minimizing false-positive edges within the network. Visualization was accomplished using the R package *qgraph*. In this representation, blue edges indicate positive correlations, while red edges reflect negative correlations. Both the intensity and thickness of the edges serve to reveal the strength of correlations between nodes, with darker and thicker edges denoting stronger associations.

2.3.2. Centrality analysis

Centrality metrics were calculated for the network's nodes. While previous studies have typically used the strength index to measure node centrality, known for its high stability, this measure can exhibit bias in networks that involve negative correlations. To address this potential bias, the more stable expected influence (EI) index was utilized to quantify each node's importance within the network structure (Robinaugh et al., 2016). In this study, the node with the highest EI value within each construct was identified as the core component of the respective network. Furthermore, the *networktools* package provided calculations for the bridge centrality index of each node. This study focused on the bridge expected influence (BEI) to assess individual nodes' connectivity with other communities, designating the top 20 % of nodes exhibiting the highest BEI values as bridge nodes (Jones et al., 2021). In addition, the *bootnet* package enabled the evaluation of edge weight differences, implementing non-parametric bootstrap tests (n = 1000) to establish 95 % confidence intervals (CIs) for the edge weights, thereby ensuring the reliability of edge weight estimates. To assess centrality stability, the *corStability* function calculated the centrality stability coefficient (CS coefficient). A CS value of 0.7 indicates the maximum permissible reduction in sample size, while a CS value exceeding 0.5 reflects good centrality stability, with a minimum acceptable threshold set at 0.25 (Epskamp et al., 2018).

3. Results

3.1. Descriptive statistics

Table 1 reports descriptive statistics and correlations among test anxiety (worry, cognitive interference, tension, physiological indicators) and neuroticism (anxiety, depression, volatility) subscales. As shown in Table 1, test anxiety subscales were strongly correlated, with coefficients ranging from 0.66 to 0.77. This indicates that the four dimensions are closely related and may reflect a common underlying construct. Moderate correlations were also observed between test anxiety and neuroticism. Table 2 presents item-level means and standard deviations. Items related to worry (e.g., "Before a test/exam, I am worried I will fail", $M = 3.68$) had relatively higher scores, suggesting that participants tended to report more cognitive and emotional aspects of test anxiety. In contrast, physiological items such as "During a test or exam, I experience stomach discomfort" ($M = 2.31$) had lower scores. This pattern suggests that test anxiety in this sample is more cognitive than physical in nature. For neuroticism, higher scores on items like "Can be tense" ($M = 3.57$) indicate a tendency toward emotional reactivity.

Table 2
Scores for each item of test anxiety and neuroticism ($N = 717$).

Item	*M*	*SD*
Test Anxiety (MTAS)	50.93	12.12
M1: Before a test/ exam, I am worried I will fail.	3.68	1.04
M2: I forget previously known material before taking a test/ exam.	3.41	1.01
M3: Even when I have prepared for a test/ exam, I feel nervous about it.	3.65	1.00
M4: Before I take a test/ exam, my hands tremble.	2.61	1.19
M5: During tests/ exams, I worry about the consequences of failing.	3.51	1.10
M6: I forget facts I have learnt during tests/exams.	3.24	1.07
M7: I feel tense before taking a test/exam.	3.27	1.08
M8: My heart races when I take a test/exam.	3.09	1.10
M9: After a test/exam, I am worried I have failed.	3.60	1.04
M10: During tests/exams, I forget things that I have learnt.	3.24	1.03
M11: Just before I take a test/exam, I feel panicky.	3.01	1.11
M12: During a test/ exam, I experience stomach discomfort.	2.31	1.12
M13: During a test/ exam, I worry that I gave the wrong answers.	3.56	1.03
M14: During tests/exams, I find it hard to concentrate.	2.83	1.09
M15: Before a test/exam, I feel nervous.	3.41	1.04
M16: During a test/ exam, my muscles are tight.	2.52	1.09
Neuroticism (BFI-2-N)	35.04	7.69
N1: Is relaxed, handles stress well. (R)	2.85	0.98
N2: Stays optimistic after experiencing a setback. (R)	2.50	1.02
N3: Is moody, has up and down mood swings.	2.77	1.15
N4: Can be tense.	3.57	0.95
N5: Feels secure, comfortable with self. (R)	3.11	0.10
N6: Is emotionally stable, not easily upset. (R)	2.66	1.09
N7: Worries a lot.	3.24	1.04
N8: Often feels sad.	3.04	1.06
N9: Keeps their emotions under control. (R)	2.63	1.03
N10: Rarely feels anxious or afraid. (R)	3.24	1.02
N11: Tends to feel depressed, blue.	2.83	1.09
N12: Is temperamental, gets emotional easily.	2.61	1.08

Notes: Items followed by (R) are reverse-coded.

3.2. Network analysis

3.2.1. Graphical networks

The graphical LASSO network of MTAS and BFI-2-N is presented in Fig. 1. The network separates into two clusters: test anxiety (M1–M16) and neuroticism (N1−N12). Within test anxiety, nodes related to worry (M1, M5, M9), tension (M7, M11, M15), cognitive interference (M2, M6, M10), and physiological symptoms (M4, M8, M12, M16) show stronger and denser connections within dimensions, supporting the MTAS four-factor structure. In contrast, M3, M13, and M14 appear more isolated, indicating weaker internal ties, consistent with previous findings (Putwain, Stockinger, et al., 2021). At the item level, the strongest link in test anxiety is between M6 and M10 (cognitive interference), suggesting high coupling in cognition-related stress responses. In neuroticism, the strongest link is between N8 and N11, both reflecting depressive traits, implying their centrality in the neuroticism network. Cross-network edges are generally weak, except for the notable link between M3 and N4, which may serve as an emotional bridge between

Table 1
The relationship between test anxiety and neuroticism ($N = 717$).

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. worry									
2. cognitive interference	0.66**								
3. tension	0.77**	0.66**							
4. physiological indicators	0.54**	0.61**	0.71**						
5. anxiety	0.36**	0.36**	0.34**	0.29**					
6. depression	0.22**	0.34**	0.26**	0.30**	0.62**				
7. volatility	0.13**	0.24**	0.19**	0.23**	0.48**	0.59**			
8. Test Anxiety	0.86**	0.84**	0.91**	0.83**	0.39**	0.32**	0.23**		
9. Neuroticism	0.27**	0.37**	0.31**	0.32**	0.87**	0.87**	0.85**	0.37**	

** $P < 0.01$.

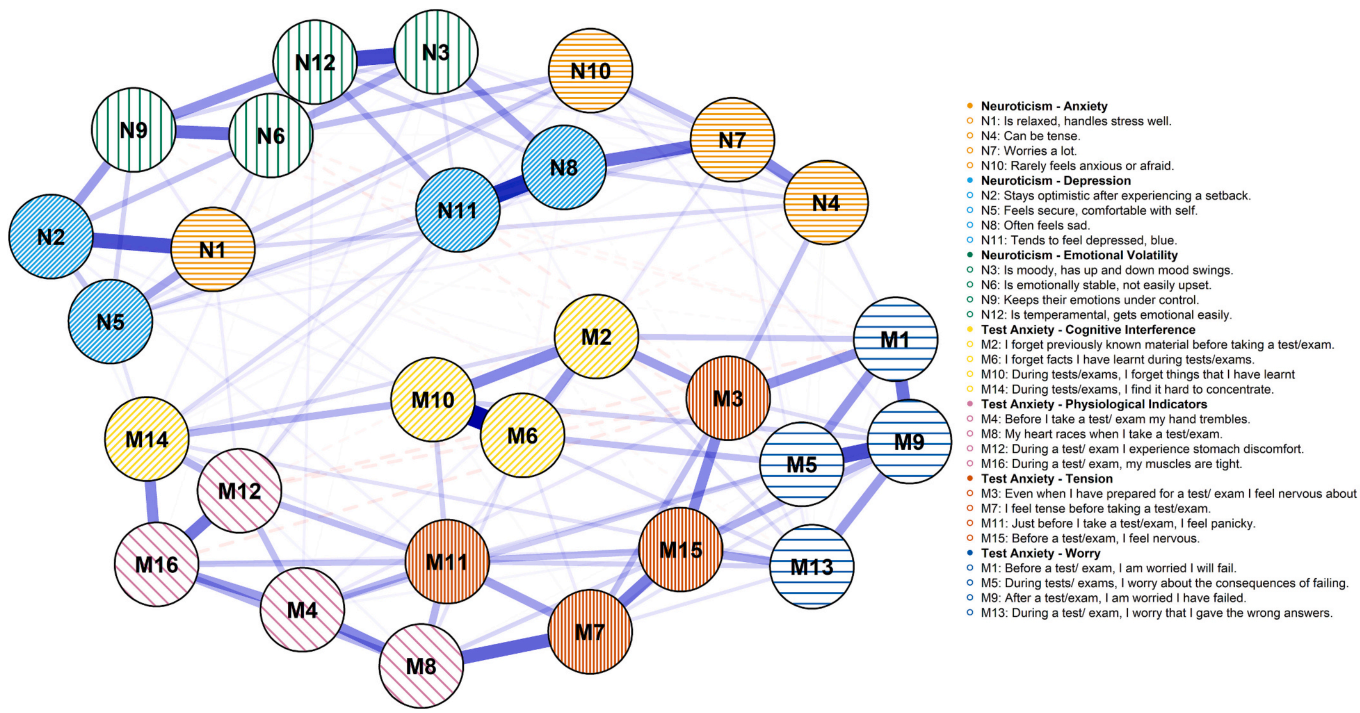

Fig. 1. Network estimation of test anxiety and neuroticism.
Note. The thickness of the edge weights (blue lines) indicates the strength of the association between two nodes (items). Blue edges represent positive, and red edges negative, semi-partial correlations, regularized via EBICglasso. Test anxiety indicators are labelled as M1 to M16 and neuroticism as N1 to N12.

the two constructs.

3.2.2. Centrality statistics

Fig. 2 shows the centrality results based on EI and BEI values. In the test anxiety network, M9 had the highest EI1 score and M11 the highest EI2 score. In the neuroticism network, N8 scored highest on both EI1 and EI2. It indicates that these nodes are core of their respective networks. BEI values were used to identify bridge nodes between the two networks. The top 20 % BEI values were observed for M14, M12, M3, N4, and N7. M14, M12, and M3 represent cognitive interference, physiological indicators, and tension in test anxiety, while N4 and N7 belong to the anxiety dimension of neuroticism. These nodes serve as key bridges between the two networks. Combined with the graphical model, the high BEI values of M3 and N4 highlight them as a crucial bridging pair. The correlation stability (CS) coefficient for Expected Influence exceeded 0.7 (Fig. A.2), supporting the reliability of centrality estimates.

4. Discussion

This study employed network analysis technology to construct a network structure of test anxiety and neuroticism and then explored the core elements of these networks, along with their points of intersection. The results indicated that within the test anxiety-neuroticism network: (1) Worry about test results (M9) and panic before the test (M11) serve

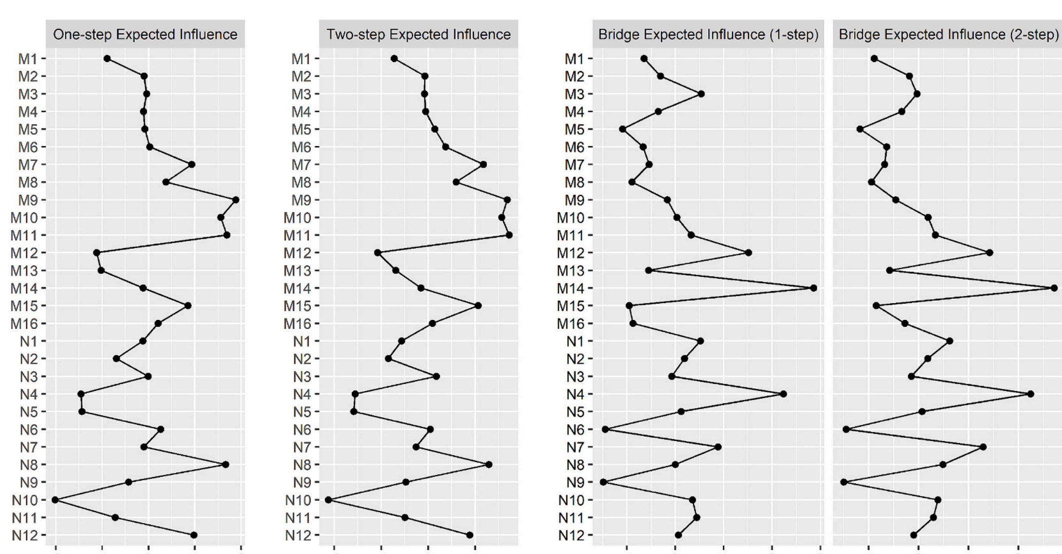

Fig. 2. Nodes centrality of networks in test anxiety and neuroticism.
Note: Nodes centrality is presented as *Z*-scores.

as the core elements of the test anxiety network, while sadness susceptibility (N8) is central to the neuroticism network; (2) Difficulty concentrating during the test (M14), susceptibility to tension (N4), stomach discomfort during the test (M12), easy worry (N7), and unconditional test tension (M3) act as the bridge nodes between test anxiety and neuroticism networks; (3) Notably, M3-N4 is the crucial bridge node linking test anxiety and neuroticism, with involuntary tension (N4) forming the pathway through which neuroticism influences test anxiety, representing the core of their interaction and transformation.

4.1. Core factors of test anxiety and neuroticism

The codes “After a test/exam, I am worried I have failed. (M9)” and “Just before I take a test/exam, I feel panicky. (M11)” were identified as the core elements of test anxiety. These findings suggest that worry about test outcomes and pre-exam panic are central components of test anxiety. These results are consistent with previous network analyses of test anxiety conducted by Putwain, Stockinger, et al. (2021). Additionally, the classical two-dimensional model of test anxiety indicates that test anxiety can be simplified into two components: worry and emotionality. The former refers to the cognitive concerns and negative expectations associated with the test before, during, and after the exam, while the latter refers to the anxious emotions and physiological responses triggered by the test (Liebert & Morris, 1967). The present results not only provide further support for the classical two-dimensional model of test anxiety but also imply that interventions can be targeted toward addressing worry about test outcomes and pre-exam panic. By focusing on these core nodes, it may be possible to activate or improve adjacent nodes, such as cognitive interference and physiological distress caused by test anxiety.

Furthermore, “Often feels sad. (N8)” is identified as the core trait of neuroticism, indicating that susceptibility to sadness, or depressive traits, is a key component of neuroticism. This core aspect of neuroticism is widely recognized by researchers, as neuroticism is strongly associated with negative emotional experiences (Digman, 1997; Ormel et al., 2013; Widiger & Oltmanns, 2017). Neuroticism is characterized by emotional instability, often manifesting as heightened anxiety, irritability, and mood fluctuations (Mader et al., 2023). Individuals with high neuroticism tend to experience more negative emotions such as anxiety and worry, particularly in stressful situations. In this study, sadness susceptibility (N8) as the core node of neuroticism reveals its significance in contributing to negative emotional experiences, which is critical for understanding an individual's psychological well-being. High levels of neuroticism negatively affect how individuals cope with stress, leading to a vicious cycle of anxiety, depression, and physiological responses.

4.2. Bridge nodes linking test anxiety and neuroticism

This study identifies multiple bridge nodes linking the networks of test anxiety and neuroticism. Specifically, difficulty concentrating during exams (M14), gastrointestinal discomfort (M12), unconditional test anxiety (M3), and susceptibility to tension and worry (N4 and N7) serve as bridge nodes. These nodes demonstrate high connectivity within their networks and significant cross-network interactions (Jones et al., 2021; McNally et al., 2017), indicating the reciprocal influences between test anxiety and neuroticism across cognitive and emotional dimensions. For example, difficulty concentrating during the test and stomach discomfort reflect the cognitive interference and physiological indicators dimensions in test anxiety, which are closely related to the depression dimension in neuroticism. In examination contexts, difficulty concentrating is usually due to the individual's cognitive resources being occupied by anxiety, which makes it impossible to effectively concentrate on the test task. That cognitive interference adversely affects exam performance and is associated with negative emotional experiences and physiological indicators, including stomach discomfort and accelerated heartbeat. Individuals with high neuroticism exhibit heightened sensitivity to negative emotions and a tendency toward negative cognitive patterns, including self-denial and pessimistic expectations. These factors can adversely affect their exam performance, even elicit somatic symptoms (Mader et al., 2023; Munoz et al., 2013; Widiger & Oltmanns, 2017).

4.3. The crucial bridge node: M3-N4

In addition, the connection between “Even when I have prepared for a test/exam, I feel nervous about it. (M3)” and “Can be tense. (N4)” was particularly significant. This finding indicates that elevated susceptibility to tension in neuroticism serves as a significant catalyst for the development of test anxiety. In the current network, M3-N4 serves as a critical bridge node, revealing the conversion mechanism from neuroticism to test anxiety (Cramer et al., 2010). That is, individuals with high neuroticism are more likely to experience tension before and after the test. And this emotion is manifested through individual cognitive interference, physical discomfort, and other physiological reactions, further exacerbating the anxiety experience. Nervousness susceptibility is one of the hallmark traits of neuroticism, reflecting neurotic individuals' sensitivity to stressors. It directly affects people's physiological and emotional reactions to stress (Ormel et al., 2013), promoting the development of test anxiety. On the contrary, this unconditional nervousness about the test stems from the individual's inherent concern about the test results and the panic that precedes it. The anxious and nervous emotions induced by the test situation stressor are likely to activate the adjacent neurotic core, specifically sadness susceptibility, resulting in stronger negative emotional reactions and cognitive intrusive thoughts (Hepburn & Eysenck, 1989; Munoz et al., 2013). When the two interact, negative feedback is generated at the individual's emotional, cognitive, and physiological levels, exacerbating the anxiety reaction (Regzedmaa et al., 2024).

4.4. Implications and limitations

This study advances theoretical understanding of the link between test anxiety and neuroticism using network analysis. Unlike latent variable models, the network approach identifies central and bridge nodes underlying interactions between personality traits and emotional states. Findings extend the two-dimensional model of test anxiety by revealing its cognitive (e.g., worry) and emotional (e.g., panic) cores, and highlight sadness susceptibility as central to neuroticism. The M3–N4 bridge empirically supports the dynamic pathway through which neuroticism may shape situational anxiety.

The findings suggest that individuals high in neuroticism are particularly prone to experiencing elevated test anxiety due to their heightened emotional reactivity and sensitivity to tension. Therefore, interventions targeting this sensitivity may weaken the pathway from neuroticism to test anxiety. Mindfulness-based practices such as breath awareness and body scanning, have demonstrated effectiveness in reducing physiological arousal and emotional reactivity. Breath awareness helps regulate autonomic nervous system activity by lowering heart rate and increasing vagal tone, which can reduce anxiety-related physiological symptoms (Schöne et al., 2018). On the other hand, body scanning encourages awareness and release of muscle tension, thereby addressing the somatic expressions of stress identified in our network (Guthrie et al., 2022). These practices correspond to the central nodes of tension and stress sensitivity in our analysis and offer targeted strategies to disrupt the reinforcing loop between neuroticism and test anxiety.

While this study sheds light on adolescent test anxiety-neuroticism networks, several limitations should be noted. Its cross-sectional design prevents causal inference, and the use of a single cohort of Chinese high school students limits the generalizability of findings. Future studies should adopt longitudinal or experimental designs to better assess causality and explore how factors like gender, academic stage, and culture shape the test anxiety–neuroticism network. For example, research shows that females report higher levels of both traits, which may strengthen links between symptoms like worry and arousal (Anglim et al., 2022; Malespina et al., 2024; Robson et al., 2023). Additionally, cultural contexts may shape symptom expression of test anxiety (Nyroos et al., 2015); Asian students, for instance, may report more somatic symptoms due to academic pressure and emotional restraint (Robson et al., 2023). Thus, future studies could construct subgroup networks or conduct network comparison tests to examine these differences in network topology and node centrality.

5. Conclusion

In conclusion, network analysis revealed the multidimensional, intertwined relationship between test anxiety and neuroticism, as well as the identification of several key nodes, expanding our understanding of the interactive mechanism between the two traits. The study discovered that the core components of test anxiety are worry about test results and panic before the test, while the core of neuroticism is susceptibility to sadness. The two combine to form the core experience of neurotic individuals dealing with test anxiety. Moreover, key bridging nodes, such as unconditional tension and exam tension susceptibility, reveal how neuroticism influences test anxiety through stress sensitivity and emotional instability. These results help to clarify the cognitive-emotional pathways linking personality and situational anxiety and provide valuable implications for future theory and intervention.

CRediT authorship contribution statement

Yi Yang: Writing – review & editing, Writing – original draft, Validation, Formal analysis, Data curation. **Fang Wang:** Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Zheng Wang:** Writing – original draft, Data curation. **Renlai Zhou:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization.

Ethics statement

The Research Ethics Committee of the Department of Psychology, Nanjing University, approved the project.

Funding

This study was supported by Natural Science Foundation of China (Grant No. 32471094). We would like to express our gratitude for the support of the project.

Declaration of competing interest

None.

Acknowledgments

The authors thank the teachers and students who participated in the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.paid.2025.113332.

Data availability

The datasets generated for this research are available on request to the corresponding author.

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