Journal of School Psychology 107 (2024) 101390

Contents lists available at ScienceDirect

Journal of School Psychology

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

Emotional intersection: Delineating test anxiety, emotional disorders, and student well-being

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A R T I C L E I N F O

Action Editor: Kathrin Maki
Editor: Craig A. Albers

Keywords:
Test anxiety
Generalized anxiety
Panic disorder
Social anxiety
Major depression
Well-being

A B S T R A C T

Previous studies have shown how test anxiety is positively related to symptoms of emotion disorder and that highly test anxious persons can meet diagnostic thresholds for emotion disorder. However, many studies are somewhat dated and based on older conceptualizations of key constructs. In addition, well-being is rarely considered alongside test anxiety and emotion disorder. In the present study, we addressed this limitation by using contemporaneous conceptualizations of test anxiety and emotion disorder, alongside school-related well-being (SRWB), using two analytic methods that are rarely combined to establish how constructs are related. The sample comprised 1167 participants ($n_{\text{male}} = 500$, $n_{\text{female}} = 621$, $n_{\text{non-binary}} = 21$, $n_{\text{declined to report}} = 25$; $M_{\text{age}} = 15.4$ years, $SD = 1.81$) from secondary and upper secondary education. Data were analyzed using psychometric network analysis and receiver-operator characteristic (ROC) curve analysis. The psychometric network analysis showed that test anxiety, generalized anxiety, panic disorder, social anxiety, major depression, and SRWB formed distinct and largely coherent communities. Generalized anxiety was principally linked to the worry and tension components of test anxiety, panic disorder to the physiological indicator's component, social anxiety and SRWB to the worry and cognitive interference components, and major depression to the cognitive interference component. The ROC curve analysis indicated that test anxiety scores from the 63rd to 75th scale percentiles could predict clinical risk with relatively high accuracy (0.79–0.88) and acceptable levels of sensitivity (0.75–0.86) and specificity (0.70–0.77). Results suggest that test anxiety, emotion disorder, and SRWB are distinct, albeit related constructs. Although constrained by the cross-sectional design, our findings suggest that high test anxiety presents an elevated risk for the development of emotion disorder.

1. Introduction

The present study explored how test anxiety, which is the psychological threat posed by potential failure in a performance-evaluative situation, was related to emotion disorder and school-related well-being. Test anxiety, which is a sub-clinical form of

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https://doi.org/10.1016/j.jsp.2024.101390
Received 15 December 2023; Received in revised form 15 October 2024; Accepted 15 October 2024
Available online 5 November 2024

anxiety, is considered problematic due to disrupting learning and achievement and showing negative associations with well-being and mental health. However, there are few studies based on contemporaneous approaches to test anxiety and emotion disorder that have addressed the extent to which they may co-occur. Furthermore, there is limited evidence on what threshold of severity test anxiety must be demonstrated to present a risk for emotion disorder. We address this gap in the literature by using psychometric network analysis and receiver-operator curve analysis to examine how test anxiety is related to school-related well-being and symptoms of four emotion disorders, including (a) generalized anxiety disorder, (b) panic disorder, (c) social anxiety disorder, and (d) major depressive disorder. Next, we define each of the three central constructs of the present investigation.

1.1. *Test anxiety*

Test anxiety refers to the worry, cognitive interference, and accompanying autonomous nervous system activation that can occur in performance-evaluative situations such as examinations (Putwain, von der Embse, et al., 2021). These reactions arise from the appraisal of the situation as a psychological threat (Spielberger, 1966). Failure can present a threat to one's self-worth and self-esteem, result in negative judgments from valued others (e.g., family members, peers, teachers), and potentially jeopardize one's educational or career aspirations (Banks & Smyth, 2015; Putwain, 2009). Test anxiety, like other emotions, can be conceived as a state or a trait. Specific episodes of elevated anxiety are referred to as a *state* and the relatively stable tendency to become anxious as a *trait*. In the present study we treated test anxiety as a situation-specific trait (Spielberger & Vagg, 1995), thus representing the tendency to become anxious specifically in performance-evaluative situations. In keeping with contemporaneous multidimensional conceptualizations, we define test anxiety as comprising two cognitive components (i.e., worry and cognitive interference) and two affective-physiological dimensions (i.e., tension and physiological indicators; Putwain, von der Embse, et al., 2021).

The importance of test anxiety as a construct is derived from the well-replicated finding of a negative correlation between test anxiety and achievement. For example, specific to the cognitive components of text anxiety, von der Embse et al.'s (2018) meta-analysis of 238 studies published between 1987 and 2017 showed a mean correlation of −0.29 with classroom tests and −0.26 with standardized examinations (those normed among a large population). For the affective-physiological components of text anxiety, there was a mean correlation of −0.18 with achievement tests and −0.13 with standardized examinations. The Multidimensional Test Anxiety Scale (MTAS), the measure of test anxiety we used in the present study, has also shown negative correlations between test anxiety and grades in standardized secondary ($r = -0.17$) and upper-secondary ($r = -0.31$) school exit examinations (Putwain, von der Embse, et al., 2021). Importantly, studies have shown that negative relations between test anxiety and achievement are not simply an artifact of prior low achievement and remain after controlling for prior achievement (Putwain et al., 2016).

1.2. *Emotion disorder*

Emotion disorder is a collective term for anxiety and mood disorders that share overlapping symptoms, causes, and risk factors (Barlow et al., 2016). The Diagnostic and Statistical Manual of Mental Disorders 5th Edition, Text Revised (DSM-5-TR; American Psychiatric Association [APA], 2022) included eleven anxiety disorders, seven bipolar disorders, and eight depressive disorders. In the present study, we focused on four emotion disorders, consisting of generalized anxiety disorder, panic disorder, social anxiety disorder (formerly known as social phobia), and major depressive disorder. We specifically focused on these four disorders for three reasons. First, in England, where the present study was conducted, these are the four most common disorders found in individuals ages 5–19 years (Vizard et al., 2018). Second, there are specific psychometrically robust measures with cut-points to indicate a possible diagnosis for these disorders, which is not necessarily the case for the other DSM-5 emotion disorders (Chorpita et al., 2005). Third, prior studies have shown these disorders often co-occur with high levels of test anxiety (e.g., 61%–76%; Herzer et al., 2014; King et al., 1995).

The defining feature of generalized anxiety disorder is excessive and persistent worry that is difficult to control (Stein & Sareen, 2015). Despite the term 'generalized,' which may imply worries are non-specific, worries can be multifocal and apply to myriad elements of one's life (e.g., family, health, school). Panic disorder is characterized by recurrent bursts of sudden severe anxiety and discomfort accompanied with physical symptoms that may include dizziness, feelings of choking, and heart palpitations, which is often referred to as a *panic attack* (Roy-Byrne et al., 2006). Panic attacks may also be accompanied by worry about the likelihood of recurrent panic attacks and the avoidance of situations that may trigger one. Social anxiety disorder refers to an intense fear of social or performance situations that are likely to result in embarrassment or humiliation that are either endured with extreme discomfort or entirely avoided (McNeil, 2010). Major depressive disorder is a discrete period of marked and severe changes in mood, pleasure, and interests; sadness and irritability; and the loss of enjoyment in personal, social, and work activities (Otte et al., 2016).

1.3. *School-related well-being*

Well-being has been defined in numerous and sometimes very different ways. Nonetheless, two strands of research have emerged in the extant literature referring to distinct but related aspects of well-being (Ryan & Deci, 2001). *Hedonic* (or subjective) well-being refers to the presence of life satisfaction, happiness, and pleasure. Conversely, *eudaimonic* (or psychological) well-being encompasses personal growth, having a purpose in life, and environmental mastery. In addition, well-being could refer to a specific domain of one's life (e.g., home, work, school, family) or to one's life in general (Diener et al., 2003). In the present study we focused on subjective well-being at school or what we term school-related well-being (SRWB). SRWB comprises the presence of positive (e.g., enjoying lessons, feeling accepted, confidence in learning) and the absence of negative (e.g., worries, bullying, poor academic progress) facets of school experiences (Hascher, 2003, 2008). Like test anxiety, SRWB can be conceptualized as a state, referring to well-being at a certain moment (such as during a particular activity) at school, or as a trait, referring to general well-being while at school. We treat SRWB as a trait to conceptually align with test anxiety and the measurement of emotion disorder.

1.4. Does test anxiety co-occur with emotion disorder?

Conceptually, it is possible to see how test anxiety would relate to emotion disorder. Worry about potential failure and its consequences (i.e., a central feature of test anxiety) may be one of the persistent issues that contributes to generalized anxiety disorder and pressured examination situations may trigger an episode of panic disorder. Social anxiety disorder and test anxiety both arise, in part, in performance situations. Intense anxieties associated with examinations could precipitate low mood and a loss of interest and enjoyment of school (i.e., major depressive disorder). Except for Putwain, Stockinger, et al. (2021), prior studies have either examined how test anxiety is correlated with symptoms of emotion disorder or have examined at what point test anxiety becomes sufficiently severe to meet diagnostic thresholds. The latter can be instructive for informing the interpretation of test anxiety scores (American Educational Research Association et al., 2014) and may be particularly important to the decision making of practitioners, who may wish to identify highly test anxious students for support, intervention, and examination accommodation(s).

Studies involving children, adolescents, and adults have shown that highly test anxious students often meet diagnostic thresholds for social anxiety, generalized anxiety, and major depression (Beidel et al., 1994; Beidel & Turner, 1988; Herzer et al., 2014; King et al., 1995). Although these studies confirm high test anxiety scores and emotion disorder co-occur, the identification of the range of test anxiety scores that might inform practitioner decision making was also impeded by each study using unique and arbitrary points on which to determine ‘high’ test anxiety (see Putwain et al., 2023, for details). In addition, they are somewhat outdated because they used diagnostic criteria that have subsequently changed, and except for Herzer et al. (2014), used Sarason et al.’s (1960) unidimensional measure of test anxiety. In short, these studies may not reflect contemporaneous understanding of test anxiety and emotion disorder (see Rajagopalan & Gordon, 2016). To address this concern, we included two cognitive (i.e., worry and cognitive interference) and two affective-physiological components (i.e., tension and physiological indicators) of test anxiety. This multidimensional conceptualization may be instructive in considering how test anxiety relates to emotion disorder. The worry component could relate more strongly to emotion disorders characterized by worries (e.g., generalized anxiety disorder, social anxiety), whereas the physiological indicators component may relate more strongly to emotion disorders characterized by physical symptoms (e.g., panic disorder). This possibility is explored further below when considering the use of psychometric network analysis.

More recently, von der Embse et al. (2021) used receiver-operator characteristic (ROC) curve analysis to identify MTAS scores that could indicate risk for generalized anxiety and panic disorder. Using pre-existing cut scores for likely diagnosis on the Revised Child Anxiety and Depression Scale (RCADS; Chorpita et al., 2005), results showed a MTAS score of 58 (72nd percentile) was indicative of likely generalized anxiety diagnosis and a MTAS score of 60 (75th percentile) was indicative of likely panic disorder diagnosis. Although ROC curve analysis may be a more reliable approach to the identification for test anxiety cut scores, von der Embse et al.’s sample was overrepresented by female participants. A replication with a gender-balanced sample as well as the inclusion of additional emotion disorders (i.e., social anxiety and major depression) is needed. Other studies have shown how highly test anxious children and adolescents report higher scores on RCADS subscales for generalized anxiety, panic disorder, social anxiety, and major depression (Weems et al., 2010; $ds = 0.71–0.95$) and total and subscale scores on the Revised Children’s Manifest Anxiety Scale (RCMAS; King et al., 1995; Reynolds & Richmond, 1978, 1979; $ds = 0.72–2.67$).

The co-occurrence between high test anxiety scores and emotion disorder offers three conceptual possibilities. First, test anxiety may represent a discrete emotion disorder, or sub-type, that is not currently represented in classification systems such as the DSM-5 (APA, 2013) and the International Classification of Diseases 11th Edition (World Health Organization, 2018). The implication is that test anxiety is comorbid with other discrete emotion disorders. This possibility was rejected in the development of DSM-5 due to a lack of evidence (LeBeau et al., 2010), which further emphasizes the need for studies like the present. Second, test anxiety may be considered an indicator of an existing emotion disorder. For example, excessive worries could characterize generalized anxiety, panic attacks before or during examinations (i.e., panic disorder), avoidance of examination situations (i.e., social anxiety), and loss of interest (i.e., major depression).

Third, based on transdiagnostic critiques of nosological classification of emotion disorder (e.g., Carragher et al., 2015; Dalgleish et al., 2020), test anxiety may be considered psychopathological if present in extreme forms when disrupting a person’s functioning (e.g., avoiding examinations or impaired cognitive functioning during examinations). In this case, discrete categories of emotion disorder are not necessary. One transdiagnostic approach, the Network Theory of Psychopathology (Borsboom, 2017; Borsboom & Cramer, 2013; Robinaugh et al., 2020), proposes that mental disorders are composed of networks of symptoms (i.e., nodes) linked by chains of mutual causation (i.e., edges) to form communities. Activation of nodes will spread throughout a community more quickly and strongly in nodes with greater physical proximity and that share stronger edges. Iterative chains of recursive feedback loops function to maintain activation with a community. From this perspective, symptoms of emotion disorders are not reflective of an underlying disease state. Rather, the activated community of symptoms *is* the disorder.

1.5. Psychometric network analysis

Psychometric network analysis is a variable-centered analytic technique that shows visually and numerically how observed variables such as questionnaire items (i.e., network nodes) are organized and related. The relations between nodes (i.e., network edges) in a cross-sectional design represent the conditional associations between variables based on individual differences (Borsboom et al., 2021). Somewhat analogous to factor analysis, nodes that share strong edges and with physical proximity are described as a community (Tang et al., 2022). The advantage of using psychometric network analysis over other variable-centered analyses, like factor analysis and general linear models, to examine a group of potentially co-occurring variables like test anxiety, emotion disorder, and well-being is that (a) edges based on partial correlations represent the unique associations between two nodes controlling for relations with all other nodes, (b) communities are based on these unique relations, and (c) nodes that are instrumental in their communities or bridging communities can be identified.

Few studies have examined relations between test anxiety, emotion disorder, and well-being using psychometric network analysis. In one notable example, Putwain, Stockinger, et al. (2021) examined a network of test anxiety, generalized anxiety, panic disorder, and SRWB in a sample of adolescents preparing for high-stakes examinations. Test anxiety, generalized anxiety, panic disorder, and SRWB formed into distinct communities (i.e., test anxiety was cognate to, rather than an indicator of, generalized anxiety disorder, panic disorder, and SRWB). As proposed earlier, the multidimensional component of test anxiety was notable in showing relations with generalized anxiety disorder, panic disorder, and SRWB. Generalized anxiety shared positive edges with the worry and tension components of test anxiety, panic disorder shared positive edges with physiological indicators, and SRWB shared negative edges with cognitive interference. Although the utility of psychometric network analysis in considering the co-occurrence (or otherwise) of test anxiety, emotion disorder, and SRWB was highlighted, only two emotion disorders (i.e., generalized anxiety and panic disorder) were considered. To address this limitation, we also included social anxiety and major depression.

1.6. How does test anxiety relate to school-related well-being?

Conceptually it is also possible to see how test anxiety would relate to SRWB. As SRWB is the balance of positive and negative aspects of school life, chronic and intense test anxiety could detract from positive school experiences to lower one's overall level of subjective well-being. Indeed, studies have shown negative correlations between test anxiety and SRWB in secondary school students (e.g., Hascher, 2007; Putwain, Gallard, et al., 2021; Putwain, von der Embse, et al., 2021). In addition, Steinmayr et al. (2016) showed with undergraduates that the worry component of test anxiety predicted lower life satisfaction and mood 12 months later after controlling for autoregressive and concurrent relations. These findings confirm that, as expected, test anxiety and SRWB are negatively related.

It is important to consider SRWB alongside emotion disorder, although related, as distinct constructs (see Suldo et al., 2016; Suldo & Shaffer, 2008), and SRWB may show unique relations with test anxiety. Relatively few studies, however, have investigated relations among test anxiety, emotion disorder, and SRWB, simultaneously. Psychometric network analysis is an ideal method with which to establish how test anxiety is related to SRWB alongside emotion disorder as edges are estimated from partial correlations, hence conditioned by the relations between all other nodes included within a network (Borsboom et al., 2021). In circumstances where networks, like ours, are composed of highly related nodes and potentially overlapping constructs, the holistic nature of psychometric network analysis can identify the substantive communities and the links between them.

1.7. Aim of the present study

The present study's principal aim was to examine relations among test anxiety, emotion disorder, and SRWB in a sample of adolescent students. Previous studies have used psychometric network analysis (Putwain, Stockinger, et al., 2021) and ROC curve analysis (von der Embse et al., 2021) to examine test anxiety in relation to emotion disorder and SRWB but included only generalized anxiety and panic disorder. We offer more theoretically and analytically robust tests of test anxiety, emotion disorder, and SRWB relations by also including social anxiety and major depression and by bringing together psychometric network analysis and ROC curve analysis as complementary approaches. We posed two research questions:

Research Question 1: Using psychometric network analysis, do test anxiety, emotion disorder, and SRWB cohere into distinct communities of nodes and how are these communities related? Building on Putwain, von der Embse, et al. (2021), we hypothesized that test anxiety, emotion disorder, and SRWB would form coherent and distinct communities (Hypothesis 1a); the worry and tension components of test anxiety would share positive edges with generalized anxiety (Hypothesis 1b), physiological indicators would share positive edges with panic disorder (Hypothesis 1c), and cognitive interference would share negative edges with SRWB (Hypothesis 1d). We expected social anxiety and major depression would share negative edges with test anxiety but leave open the question to which component(s) they would link.

Research Question 2: Assuming that a distinct community of test anxiety nodes can be identified, using ROC curve analysis, can MTAS cut scores be identified for generalized anxiety disorder, panic disorder, social anxiety, and major depression? Building on von der Embse et al. (2021), we tentatively hypothesized that MTAS cut scores would be around the 72nd–75th percentiles on the MTAS scale (Hypothesis 2).

2. Method

2.1. Participants and procedure

Participants included 1167 students drawn from 12 English secondary schools covering Years 7–13 with a mean age of 15.4 years ($SD = 1.81$). There were 500 male participants, 621 female participants, 25 declined to report their gender, and 21 indicated a non-binary gender. The ethnic heritage was primarily white British ($n = 997$, 85.4%) with fewer participants identifying as Black/Black British ($n = 21$, 1.8%), South Asian/British South Asian ($n = 46$, 4.0%), Chinese/British Chinese ($n = 4$, 0.3%), other ($n = 41$, 3.5%), or dual heritage ($n = 58$, 5.0%) backgrounds. Free school meal (FSM) eligibility was used as a proxy for a low-income family background; 194 (16.6%) participants were eligible. In the school years that data were collected (2021–2022 and 2022–2023), there were 20.9% and 22.7%, respectively, of students in English secondary education eligible for FSM, and 28.6% and 29.6%, respectively, of students from a non-white background (Department for Education, 2023). Accordingly, the sample included slightly fewer participants from low-income families and was more ethnically homogenous than typical for England.

There were 714 participants in secondary education (Years 7–11; 61.2%), including 445 (42.2%) in Year 10 and Year 11 following the program of study leading to school exit examinations. An additional 453 participants were in upper secondary education (Years 12–13; 38.8%) following the program of study leading to upper secondary school exit examinations used for university entrance. Data were collected between January and March of the school year. The secondary school exit examinations (i.e., General Certificate of Secondary Education) are taken at the end of Year 11 and the upper secondary exit examinations (i.e., Certificate of Secondary Education: Advanced Level and/or Business and Technology Education Council) are taken at the end of Year 13 and are scheduled in May and June of the school year. Students in Years 7–10 and Year 12 sat for internal end-of-year school examinations, often under standardized conditions (depending on the school policy). Although some participants were in the school years leading to exit examinations, none were in the period immediately prior to taking such examinations.

Schools belonging to the professional initial teacher education networks of the institutions of the first and third authors and who had expressed an interest in identifying students who may require additional support for test anxiety or poor mental health and well-being were invited to participate via email. The study was approved by an institutional research ethics committee (22/EDN/027). Written permission was provided by the school head teacher of participating schools and opt-out consent provided by parents. Two weeks prior to data collection, participants were provided with a hard-copy information sheet that explained the purpose of the study, namely how different measures of mental health, well-being, and test anxiety can be used to help identify those students who may require additional support. Data were collected anonymously in a period of the school timetable used for administrative purposes by the regular teacher following a script. Teachers were asked to follow the script as this would help to ensure data were collected in a standardized fashion.

Questionnaires were hosted on an online survey platform and took approximately 15 min to complete. The class teachers provided students who did not wish to participate, or who were opted-out by their parents, with an alternate activity, and participants also were asked to provide consent at the point of data collection. To minimize missing data, the online survey platform prompted participants if they had missed a question; survey data could not be submitted until all responses were completed. Accordingly, there were no missing data. Participants who chose to withdraw their participation mid-survey (e.g., if they felt uncomfortable answering one or more questions) were informed that they could close the web browser and no data would be saved.

2.2. Measures

Test anxiety was measured using the (MTAS; Putwain, von der Embse, et al., 2021; von der Embse et al., 2021). The MTAS comprises 16 items and four subscales, with four items per subscale. The subscales are Worry (e.g., "During tests/exams, I worry about the consequences of failing"), Cognitive Interference (e.g., "I forget facts I have learnt during tests/exams"), Tension (e.g., "Just before I take a test/exam, I feel panicky"), and Physiological Indicators (e.g., "My heart races when I take a test/exam"). Participants responded to items on a 5-point scale (1 = *strongly disagree*, 3 = *neither agree nor disagree*, and 5 = *strongly agree*). Data collected using the MTAS has shown excellent construct validity (Putwain, von der Embse, et al., 2021; von der Embse et al., 2021), test-retest reliability over a 4-month interval (*r*s = 0.65–0.82; Putwain, von der Embse, et al., 2021), internal consistency (e.g., ωs = 0.83–0.89; Putwain, von der Embse, et al., 2021; von der Embse et al., 2021), and measurement invariance (gender, age, and FSM eligibility; Fenouillet et al., 2023; von der Embse et al., 2021). McDonald's ωs in the present study were 0.86–0.90 (see Table 1).

SRWB was measured using the School-Related Well-Being Scale (Stockinger et al., 2023). This six-item unidimensional scale encompasses cognitive and affective evaluations of subjective well-being at school. Participants responded to items (e.g., "All in all, I am content with my day-to-day school experiences") on a 5-point scale (1 = *not true at all*, 3 = *partly true*, and 5 = *completely true*). Studies have supported the unidimensional factor structure and internal consistency of SWBS data (αs = 0.87–0.93; Stockinger et al., 2023),

Table 1
Descriptive statistics for test anxiety, school-related well-being, and emotion disorder.

Scales	Range	*M*	*SD*	ω	Skewness	Kurtosis
Test Anxiety Total	16–80	53.99	13.88	0.77	−0.34	−0.19
Worry	4–20	14.71	3.94	0.87	−0.69	−0.04
Cognitive Interference	4–20	13.97	3.94	0.86	−0.42	−0.46
Tension	4–20	14.72	4.07	0.90	−0.75	0.02
Physiological Indicators	4–20	11.16	4.48	0.87	0.22	−0.92
School-Related Well-Being	5–30	20.30	5.37	0.91	−0.48	−0.03
Emotion Disorder						
Generalized Anxiety	0–18	7.75	4.98	0.90	0.41	−0.83
Panic Disorder	0–27	7.75	6.89	0.94	0.83	−0.37
Social Anxiety	0–27	13.53	7.98	0.93	0.02	−1.10
Major Depression	0–30	10.62	8.30	0.94	0.68	−0.48

Note. A hierarchical omega coefficient was estimated for the test anxiety total score.

test-retest reliability over a 4-month interval ($rs = 0.68$; Putwain et al., 2020), and have shown scores to be conceptually distinct from related constructs including emotions, adaptability, and academic buoyancy (e.g., Putwain, Stockinger, et al., 2021; Stockinger et al., 2023). McDonald's ω in the present study was 0.91 (see Table 1).

Subscales from the Revised Children's Anxiety and Depression Scale (RCADS; Chorpita et al., 2005) were used to measure generalized anxiety (six items), panic disorder (nine items), social anxiety (nine items), and major depression (10 items) symptomology. Example items include "I worry that bad things will happen to me" (i.e., generalized anxiety), "When I have a problem my heart beats really fast" (i.e., panic disorder), "I worry what other people think of me" (i.e., social anxiety), and "I feel sad or empty" (i.e., major depression). Participants responded to items on a 4-point scale (0 = *never*, 1 = *sometimes*, 2 = *often*, and 3 = *always*). These widely used scales have shown construct validity (i.e., items load onto target factors; Donnelly et al., 2018), internal consistency (αs = 0.74–87; Chorpita et al., 2005; Piqueras et al., 2017), and test-retest reliability over 1-week ($rs = 0.63–0.85$; Chorpita et al., 2000) and 3-month (ICCs = 0.79–0.86; Kösters et al., 2015) intervals. McDonald's ωs in the present study were 0.90–0.94 (see Table 1).

The utility of the RCADS subscales for identifying risk of emotion disorder was established by Chorpita et al. (2005) who asked 513 child and adolescent participants ($M_{age} = 12.9$ years) referred for assessment to complete the RCADS following a diagnostic interview with a clinician. A ROC curve analysis was used to identify cut points that maximized sensitivity (i.e., that a participant with a diagnosis would be correctly identified by RCADS scores) and specificity (i.e., that a participant without a diagnosis would be correctly identified by RCADS scores). Sensitivity (0.59–0.78) and specificity (0.64–0.92) scores indicated that RCADS cut scores for generalized anxiety, social anxiety, panic disorder, and major depression could identify a likely risk of diagnosis with reasonable to high accuracy. The strong psychometric properties of the RCADS combined with ease of use and cut scores indicated high practical utility for practitioners in risk assessment and service evaluation (Wolpert et al., 2015).

2.3. Analytic strategy

A twofold analytic strategy was adapted. First, we estimated a psychometric network analysis in R 4.2.1 using the "network tools" package version 1.5.0 (Jones, 2017). A visual presentation of the psychometric network analysis was plotted using a Gaussian graphical model (GGM) in which nodes (i.e., items) are represented as circles (colored differently to assist the reader to identify their respective scale) and the relations between items as edges. Edges were estimated as partial correlations (i.e., the correlation between two nodes, controlling for the correlations between all other nodes in the network). Positive edges are shown in blue and negative edges in red. The strength of a partial correlation is represented as the thickness of the edge (i.e., a stronger partial correlation is shown as a thicker edge). The Fruchterman-Reingold algorithm (Fruchterman & Reingold, 1991) was used to place nodes in the GGM that positions nodes with stronger edges more centrally.

A visual inspection of the GGM can assist in identifying which nodes cohere together into distinct communities. Nodes forming distinct communities would be positioned more closely and share stronger edges. Specifically, we used GGM to judge whether test anxiety nodes form a distinct and coherent community (i.e., distinct from communities of emotion disorder and well-being nodes). In addition, it is possible to visualize how communities are located within a network through their positioning and their edges. Communities positioned more closely, and that share stronger edges, share conceptual similarities. Nodes that share multiple and/or strong edges with others within the network can be identified (as noted above, these are located more centrally). Moreover, nodes from neighboring communities may share edges that link those communities (referred to as bridge nodes). The GGM is instructive in showing whether a community of test anxiety nodes is located more closely to one or more of the emotion disorders or well-being and if specific nodes are bridging communities.

In all networks, especially those like ours that contain closely related nodes, balance is required between specificity (i.e., the inclusion of false positive edges) and sensitivity i.e., (the exclusion of true positive edges). We applied the Least Absolute Shrinkage and Selection Operator (LASSO) to regularize partial correlations (Friedman et al., 2008). LASSO regularization fixes small, and potentially spurious, partial correlations below a certain level to zero. The balance between specificity and sensitivity is established using the tuning hyperparameter γ. Hyperparameter values are usually set between $\gamma = 0$ (greater but potential spurious edges) and $\gamma = 0.5$ (fewer but more authentic edges). Although we chose a stringent hyperparameter ($\gamma = 0.5$), the network was still identified as showing multiple small edges ($\lambda < 0.1 * \lambda_{max}$; Williams & Rast, 2020). To further increase specificity (i.e., reduce potentially spurious edges), the LASSO was thresholded (Janková & van de Geer, 2018). The resulting network may lose further sensitivity (i.e., a sparser network) but will retain the most authentic and meaningful edges.

In addition to the GGM, centrality indices can be estimated to assist with the identification of nodes that show stronger numerous connections to others and that may bridge communities. We estimated Expected Influence (EI) indices (Borsboom et al., 2021; Robinaugh et al., 2016). One-step Expected Influence (EI1) is the sum of all edges directly shared with others in the network (i.e., a positive EI1 value indicates a node shares, on average, positive edges with other nodes). EI1 does not account, however, for the centrality of neighboring nodes. Node *i* may only share one edge with node *j*, but if node *j* shares many edges with others in the network, node *i* will show an indirect influence. The two-step Expected Influence (EI2) of node *i* is the sum of the nodes shared between node *j* and all others in the network (weighted for the strength of the edge between nodes i and *j*), plus the EI1 value of node *i* (i.e., a negative EI2 value indicates a node shares negative direct and indirect edges with others).

Bridge EI1 is the sum of direct nodes with those belonging to different communities (i.e., which connect one community with another). Bridge EI2 is the sum of direct and indirect weighted edges shared with nodes from other communities. Although statistical tests (e.g., the Bootstrap Difference Test) are available for some centrality indices to assist the identification of edges that substantially differ from others, they are not presently available for EI indices. Accordingly, we focused on descriptive differences in EI indices (i.e., whether certain nodes showed stronger positive or negative EI values) relative to others.

The stability and accuracy of the network was established in three ways using the "bootnet" package version 1.5.5 in R 4.2.1 (Burger et al., 2023; Epskamp et al., 2018). First, the accuracy of edge weights was checked using 2500 nonparametric bootstrapped samples to generate 95% confidence intervals (CIs) around edge weights. Edge weights can inform accuracy (i.e., if 95% CIs do not cross zero). Second, the stability of edge weights and EI indices were checked by correlating values from the original sample and sampled subsets with an increasing number of persons dropped. A strong correlation indicates a stable network. Checks (see Supplementary Materials Figs. S1–S3) revealed a highly accurate (i.e., few edge weights crossed zero) and stable (i.e., edge and EI statistics were relatively stable with a stability coefficient of 0.75 [i.e., 75% of the data could be dropped to retain with 95% certainty a correlation of 0.70 with the original dataset]).

In the second analysis, we conducted receiver operator characteristic (ROC) curve analysis in SPSS. The purpose of the ROC curve analysis was to establish whether MTAS cut scores could be identified as indicative of risk arising from internalizing problems (Streiner & Cairney, 2007). Existing cut points for RCADS scales have been established to identify those scores that can accurately predict a clinical diagnosis (Chorpita et al., 2005). We made use of the ROC curve analysis to establish whether MTAS scores could accurately predict these RCADS cut points (i.e., if MTAS scores can predict risk from internalizing problems). Accuracy was judged using the area under the curve (AUC) statistic, defined as the probability that a randomly chosen person with RCADS identified emotional distress will show a higher MTAS score. Separate AUC values were calculated for generalized anxiety, panic disorder, social anxiety, and major depression, and for comparative purposes for MTAS subscale scores as well as the total score. Streiner and Cairney (2007) suggested that AUCs with 0.90–1.0 values show high accuracy, 0.70–0.90 show moderate accuracy, and 0.50–0.70 show low accuracy.

The identification of a cut point is a compromise between false positives arising from choosing too low a score (i.e., identifying persons at risk of emotional distress when they are not) versus false positives arising from choosing too high a score (i.e., excluding those at risk of emotional distress when they are); this compromise is an inverse relationship where the higher one variable, the lower the other variable and vice versa. Sensitivity refers to whether MTAS scores can detect persons at risk from emotional distress (i.e., a true positive score). It is calculated as the proportion of persons identified with emotional distress at a specific MTAS score from the total number of persons with RCADS-derived emotional distress. Kilgus et al. (2014) suggested sensitivity values ≥ 0.80 are acceptable and ≥ 0.70 are borderline. Specificity refers to whether persons without emotional distress based on RCADS-derived cut scores can be accurately detected at a particular MTAS score (i.e., a true negative score; 1 – specificity is a false positive score). It is calculated as the proportion of persons at a specific MTAS score identified as not experiencing RCADS-derived emotional distress from the total number of persons without emotional distress. Sensitivity (y axis) and 1 – specificity (x axis) scores are plotted as a ROC curve. Kilgus et al. (2014) suggested that specificity values ≥ 0.70 are considered acceptable and ≥ 0.60 are borderline.

3. Results

3.1. Descriptive statistics

Descriptive statistics are shown in Table 1. Except for social anxiety, which showed a slight platykurtic distribution, skewness and kurtosis were within ± 1. The internal consistency for all scales was high (ωs ≥ 0.77).

3.2. Network analysis

3.2.1. LASSO Gaussian graphical model

The thresholded LASSO GGM is shown in Fig. 1. Edge weights for generalized anxiety (GA) ranged from 0.59 (GA3 and GA4) to -0.09 for test anxiety (TA) and well-being (WB; TA14 and WB1). A visual inspection of the GGM can be used to judge whether nodes cohered into distinct communities and whether specific nodes showed strong and/or multiple edges to form or bridge communities. In relation to the first point, the two most coherent communities were for well-being and major depression. The nodes within these constructs were positioned in proximity and were joined by positive edges. For test anxiety (TA14 excepted), nodes for the worry and tension components were placed centrally, with cognitive interference above and physiological indicators below. Nodes for each of the four test anxiety components were positioned in proximity and shared positive edges. This network architecture is consistent with the conceptualization of test anxiety with the cognitive interference and physiological indicators nodes having the least commonality.

Two panic disorder (PD) nodes (PD1 and PD3) were intermingled with the test anxiety nodes for physiological indicators (TA4, TA8, TA12, TA16); they were closely located and shared positive edges. These panic disorder and physiological indicators nodes described similar physical reactions (i.e., stomach discomfort and heart beating fast). The implication is that panic disorder and the physiological indicators component of test anxiety are not clearly differentiated. These panic disorder symptoms are somewhat interchangeable with the physiological indicators component of test anxiety and vice versa.

As noted above, TA14 (difficulty concentrating) was not positioned closely to, and did not share strong edges with, the other cognitive interference test anxiety nodes. Instead, the strongest edge was shared with a major depression (MD) node (MD7: Not thinking clearly) and it was positioned closest to two social anxiety (SA) nodes (SA1 and SA3; worry about doing poorly and others being angry). Difficulty concentrating in examinations may therefore be associated with the social threat posed by performance situations as well as the evaluative threat. Notwithstanding TA14, and the intermingling of panic disorder and the physiological indicators nodes, test anxiety emerged as a broadly coherent community. Major depression nodes shared positive edges with test anxiety nodes as expected (e.g., TA2: Forgetting learned content with MD7: Not thinking clearly). There were, however, also some unanticipated negative edges (e.g., TA7: Tension before an examination with MD9: Not wanting to move).

Social anxiety nodes did not cohere as a distinct community but as two factions. One faction contained nodes that focused on

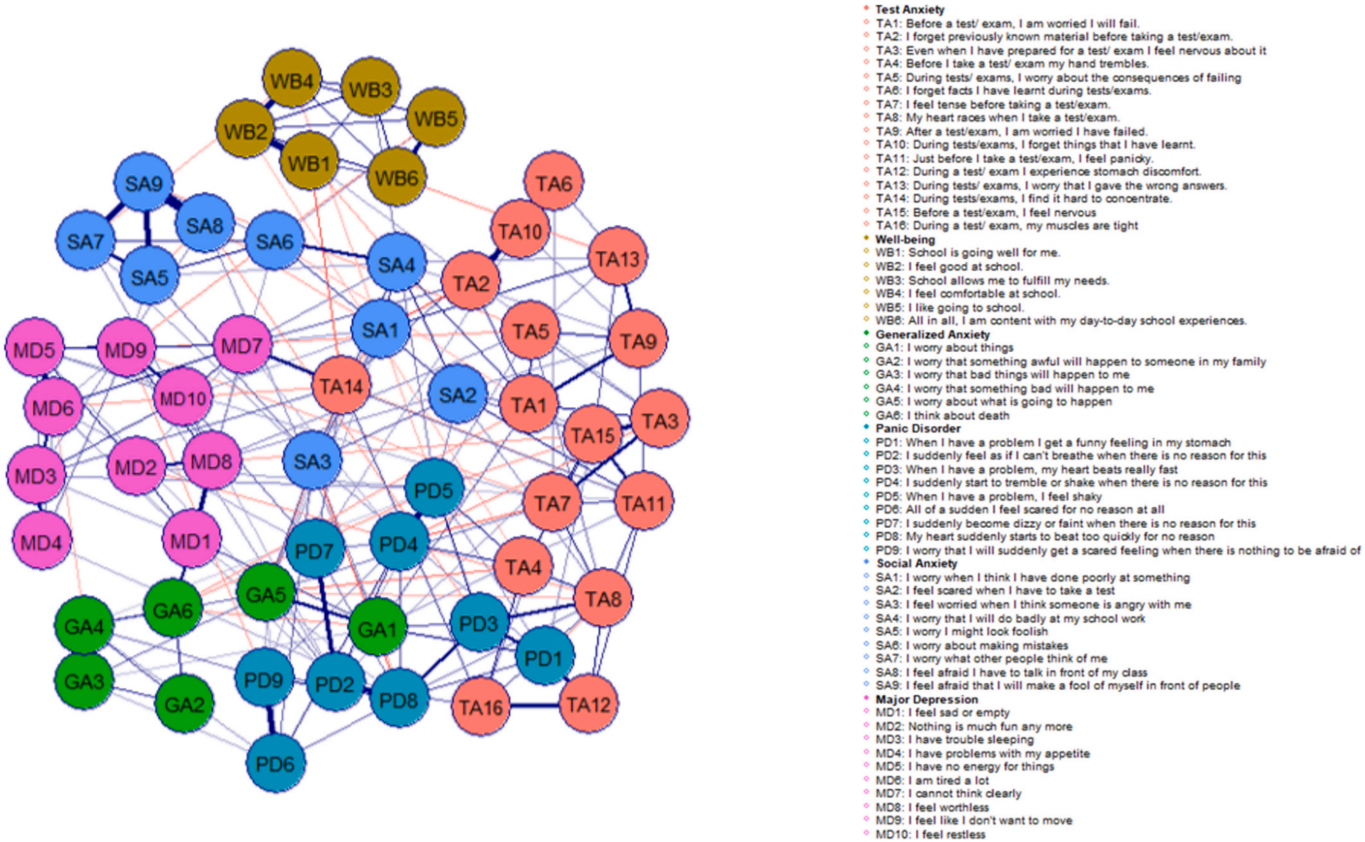

Fig. 1. Thresholded regularized LASSO network based on partial correlations.

embarrassment and humiliation (SA5–SA9) that was positioned close to SRWB and major depression nodes. The other faction contained nodes relating to performance threat (SA1–SA4) located closer to test anxiety nodes for worry and cognitive interference. Not surprisingly, the performance threat element of social anxiety showed a stronger link to test anxiety than the threat posed by negative social evaluations.

Additionally, generalized anxiety and panic disorder did not emerge as distinct, but rather intersecting communities that shared positive edges. One group of generalized anxiety nodes (GA2–GA6) that concerned something bad happening bordered major depression nodes on one side and panic disorder nodes on the other. The other two generalized anxiety nodes, referring to worry in general (GA1) and death (GA5), separated panic disorder nodes concerning light headedness (PD4, PD5, PD7) and feeling scared (PD2, PD6, PD8, PD9). As mentioned, the PD nodes for stomach discomfort and heart beating fast intermingled with physiological indicators nodes. The implication is that generalized anxiety and panic disorder are somewhat interrelated.

3.2.2. Expected influence indices

Expected influence values can be used to assist the identification of nodes that show strong and/or multiple direct (EI1) and indirect (EI2) positive or negative edges with other nodes (see Fig. 2). As there are no absolute guides for the interpretation of EI1 and EI2 values, we deal with these descriptively. That is, we describe nodes as having *strong* EIs relative to others in the network (i.e., these nodes shared the comparatively strongest combined positive and negative edges with others). PD1 (funny feeling in stomach) showed the strongest positive EI1 and EI2 indices ($\geq +1.5$) and shared strong positive edges to other panic disorder nodes and test anxiety physiological indicators nodes. Other nodes with strong positive EI indices were PD8 (heart beating fast), SA9 (negatively judged by others), and MD8 (feeling worthless). These nodes showed strong positive edges with other nodes in their communities.

The strongest negative EI1 and EI2 indices (i.e., ≥ -2) were shown for TA14 (difficulty concentrating in tests), which shared a negative edge with WB1 (school is going well). Other strong negative EI1 and EI2 indices were shown for GA6 and SA8. GA6 (thinking about death) shared negative edges with TA1 (worry about failing an exam) and TA15 (feeling nervous before an exam). SA8 (afraid of talking in front of class) shared a negative edge with WB5 (like going to school). WB5 (school is going well) and MD4 (problems with appetite) showed negative indirect EI indices (i.e., EI2 > EI1). MD4 (appetite problems) shared indirect negative edges with WB5 (like going to school) via MD9 (feeling restless) and TA15 (feeling nervous in an examination) via MD4 (problems with appetite).

Expected influence values can be used to assist the identification of nodes that show strong and/or multiple direct (bridge EI1) and indirect (bridge EI2) positive or negative edges that bridge with other communities. Like EIs, we treat the strength of bridge EIs descriptively, as their strength is relative to others. Strong positive bridge EI indices (≥ 2) were shown for TA11 (panicky about tests) and SA2 (scared about tests), which linked the communities of test anxiety and social anxiety nodes. GA1 (worry about things) showed a positive bridge EI index (i.e., ≥ 1.5) and linked directly and indirectly to the test anxiety community. Direct links were for TA1 (worry about failing) and TA11 and TA15 (panicky and nervous). The indirect links were through panic disorder nodes. TA8 (heart racing) bridged communities of test anxiety and panic disorder nodes (notably with PD3 with a corresponding focus on racing heart).

Strong negative bridge EIs (i.e., ≥ -1.5) were shown for WB1 (school is going well), MD9 (feeling restless), and PD4 (trembling with no reason). WB1 linked communities of SRWB and test anxiety nodes through TA14 (difficulty concentrating). MD9 linked communities of depression and SRWB nodes through WB5 (like going to school). WB4 (feel comfortable at school) linked communities of well-being and social anxiety nodes directly, and SRWB and test anxiety nodes indirectly via WB1. PD4 (trembling with no reason) bridged communities of panic disorder and test anxiety with TA3 and TA7 (feeling nervous and tense about an exam).

3.3. Receiver operator characteristic curve analysis

To examine the second research question, a series of ROC curve analyses were performed (see Fig. 3). The purpose of these analyses was to establish clinically significant cut scores of the MTAS across various internalizing concerns, including generalized anxiety, panic disorder, social anxiety, and major depression. Table 2 shows the AUC values for MTAS total values and subscale scores and the cut scores identified as showing optimal sensitivity and specificity. The AUCs of the MTAS total and subscales scores all fell within the moderate accuracy range on all four emotion disorders and ranged from 0.72 (cognitive interference with social anxiety and panic disorder) to 0.88 (MTAS Total with panic disorder). MTAS total scores showed the cut points with the strongest sensitivity and specificity. These were 52 for generalized anxiety, 58 for panic disorder, 50 for social anxiety, and 56 for major depression. All cut scores yielded acceptable to borderline sensitivity, except for cognitive interference with generalized anxiety and tension with major depression. With regards to specificity, all cut scores were deemed acceptable to borderline.

Finally, we calculated the percentage of the current sample that met the MTAS cut points (i.e., RCADS-derived risk of diagnosis with an emotion disorder). The proportion with an MTAS score ≥ 50 (63rd percentile; i.e. social anxiety threshold) was 63%. The proportion with an MTAS score ≥ 52 (65th percentile; i.e., the generalized anxiety threshold) was 58.2%. The proportion with an MTAS score ≥ 56 (70th percentile; i.e., the major depression threshold) was 47.6%. The proportion with an MTAS score ≥ 58 (73rd percentile; the panic disorder threshold) was 41.8%.

4. Discussion

The aim of the present study was to establish how test anxiety was related to emotion disorders and SRWB in a sample of English secondary school students aged 11–18 years. A psychometric network analysis showed communities of test anxiety nodes to be distinct from communities of generalized anxiety, major depression, social anxiety, and SRWB nodes. Two panic disorder nodes intermingled with physiological indicators nodes indicating panic disorder was not as clearly differentiated from the physiological facet of test

A: Expected Influence Indices

B: Bridge Expected Influence Indices

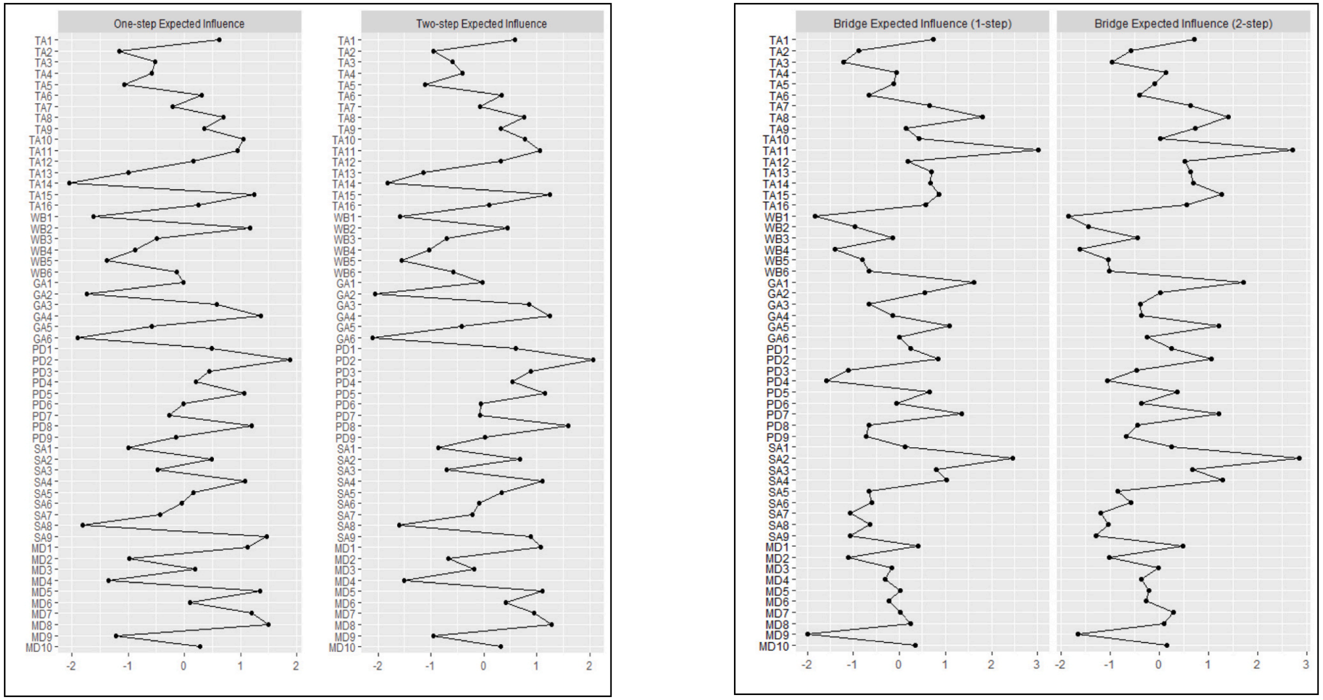

Fig. 2. Indices for one- and two-step expected influence (Panel A) and bridge expected influence (Panel B).

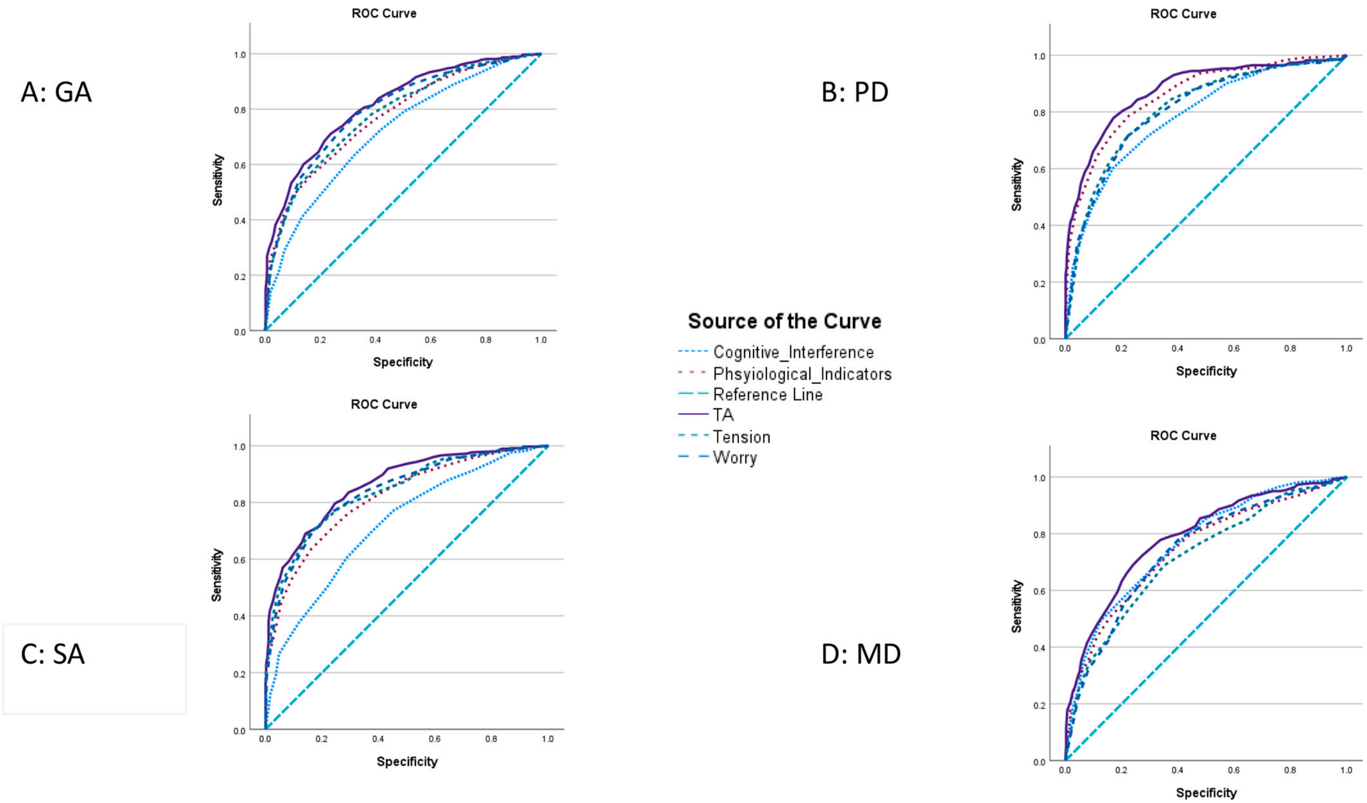

Fig. 3. Receiver operator characteristic curve with general anxiety, panic disorder, social anxiety, and depression.
Note. Panel A: Generalized Anxiety (GA). Panel B: Panic Disorder (PD). Panel C: Social Anxiety (SA). Panel D: Major Depression (MD).

Table 2
Conditional probability statistics of the diagnostic accuracy of MTAS total and subscale scores relative to scales of general anxiety, panic disorder, social anxiety, and major depression.

Outcome	Predictor	AUC [95% CI]	Cut Score	Sensitivity	Specificity
Generalized Anxiety	MTAS Total	0.82 [0.80, 0.84]	52	0.80	0.77
	Worry	0.80 [0.77, 0.82]	15	0.78	0.67
	Cognitive Interference	0.72 [0.69, 0.74]	15	0.63	0.68
	Tension	0.78 [0.76, 0.81]	15	0.78	0.62
	Physiological Indicators	0.77 [0.75, 0.80]	10	0.77	0.60
Panic Disorder	MTAS Total	0.88 [0.85, 0.90]	58	0.86	0.71
	Worry	0.81 [0.78, 0.83]	16	0.83	0.62
	Cognitive Interference	0.79 [0.76, 0.81]	15	0.78	0.62
	Tension	0.81 [0.79, 0.84]	16	0.84	0.63
	Physiological Indicators	0.86 [0.84, 0.88]	12	0.85	0.67
Social Anxiety	MTAS Total	0.86 [0.84, 0.88]	50	0.84	0.71
	Worry	0.84 [0.82, 0.86]	14	0.84	0.64
	Cognitive Interference	0.72 [0.69, 0.75]	14	0.70	0.62
	Tension	0.84 [0.92, 0.86]	15	0.79	0.74
	Physiological Indicators	0.82 [0.79, 0.83]	10	0.77	0.70
Major Depression	MTAS Total	0.79 [0.76, 0.81]	56	0.75	0.70
	Worry	0.74 [0.71, 0.77]	16	0.71	0.67
	Cognitive Interference	0.77 [0.74, 0.79]	15	0.70	0.67
	Tension	0.72 [0.69, 0.75]	16	0.69	0.65
	Physiological Indicators	0.74 [0.72, 0.77]	11	0.74	0.62

Note. AUC = Area Under the Curve; MTAS = Multidimensional Test Anxiety Scale.

anxiety. Nodes (i.e., individual items) within communities were connected by positive edges (i.e., relations). In addition, test anxiety nodes shared positive edges with the four emotion disorders and negative edges with SRWB. Several 'influential' nodes were identified as links between communities of test anxiety and emotion disorder. In the ROC analyses, cut points for MTAS total scores were identified with relatively high accuracy for emotion disorder and showed acceptable thresholds for sensitivity (i.e., persons correctly identified with an emotion disorder) and specificity (i.e., persons correctly identified without an emotion disorder).

4.1. Communities and edges within the network architecture

The community architecture of test anxiety nodes mirrored the conceptual composition into worry, cognitive interference, tension, and physiological indicators. Nodes for these test anxiety components were proximally located and shared strong positive edges. This configuration was consistent with Putwain, Stockinger, et al.'s (2021) network analysis and was consistent with correlations shown in factor analytic studies (e.g., Fenouillet et al., 2023; von der Embse et al., 2021). Based on conceptual distinctions, we expected test anxiety nodes would form a discrete community, distinct from communities of nodes from the four emotion disorders and SRWB and linked via positive and negative edges, respectively. Findings generally supported this proposition and the earlier findings of Putwain, Stockinger, et al. (2021). The community of test anxiety nodes was largely distinct from those of generalized anxiety, major depression, social anxiety, and SRWB, but less so for panic disorder. Hypothesis 1a (i.e., test anxiety, emotion disorder, and SRWB would form coherent and distinct communities) was largely supported.

Direct and indirect positive edges were shown between worry and tension and generalized anxiety nodes (supporting Hypothesis 1b: Worry and tension components of test anxiety will share positive edges with generalized anxiety), and between physiological indicators and panic disorder nodes (supporting Hypothesis 1c: Physiological indicators will share positive edges with panic disorder). The specific edges that linked generalized anxiety to worry were for unspecified worry (i.e., generalized anxiety) and worry about potential failure worry nodes. The specific edges that linked panic disorder nodes to physiological indicators were physical symptoms elicited by unspecified problems (i.e., panic disorder) and physical problems experienced during tests (i.e., physiological indicators). These findings are consistent with Putwain, Stockinger, et al.'s (2021) network analysis as well as studies showing positive correlations between test anxiety, generalized anxiety, and panic disorder (Weems et al., 2010).

These edges may indicate that either tests and examinations are one problem in which generalized anxiety and panic disorder symptoms arise or that there is an underlying common cause of both worry and generalized anxiety, and physiological indicators and panic disorder. The cognitive attentional syndrome (Nordahl & Wells, 2019) may provide a common mechanism for worry and generalized anxiety, and anxiety sensitivity (Olatunji & Wolitzky-Taylor, 2009), a common mechanism for panic disorder and physiological indicators. In addition, the intersection of panic disorder nodes with the community of physiological indicators nodes suggests that test anxiety physiological indicators items may be a proxy for panic disorder nodes elicited by one type of 'problem' (i.e., examination pressures) and vice versa. Because generalized anxiety nodes did not intersect with worry nodes, they are less likely to be proxies for each other.

Direct and indirect negative edges were shown between cognitive interference and SRWB nodes (supporting Hypothesis 1d: Cognitive interference would share negative edges with SRWB). These edges replicated the previous finding by Putwain, Stockinger, et al. (2021) and studies showing negative correlations between test anxiety and well-being (e.g., Steinmayr et al., 2016). SRWB is form of subjective well-being comprising the presence of positive, and the absence of negative, experiences at school (Hascher, 2003, 2008).

As such, it is possible to see how test anxiety could either be an affective indicator of poor well-being or relative to SRWB through negative edges. The coherent community of SRWB nodes being distinct from that of test anxiety would suggest that test anxiety is not an indicator of poor well-being. Rather, they are distinct constructs linked via negative relations.

Direct and indirect positive edges were shown between worry, tension, and cognitive interference, and social anxiety nodes, and between cognitive interference and major depression nodes. Although we did not specifically hypothesize which components of test anxiety would link to social anxiety and major depression, these findings were consistent with studies showing positive relations between test anxiety and social anxiety and major depression (Weems et al., 2010). They also supported our theory that the different components of test anxiety show differential relations with emotion disorder and well-being and extend the previous network analysis by Putwain, Stockinger, et al. (2021) that was limited to generalized anxiety, panic disorder, and well-being.

The obvious conceptual overlap between social anxiety and test anxiety was confirmed by the social anxiety nodes corresponding to performance sharing positive edges with test anxiety. In addition, these social anxiety nodes were located closer to test anxiety and separated one cognitive interference node (i.e., difficulty concentrating) from the remainder of the cognitive interference community. Although test anxiety may share a focus with some aspects of social anxiety (i.e., anxieties arising in performance situations), as communities of nodes were largely distinct, test anxiety and social anxiety indicators are not proxies for each other. These close links may suggest a common mechanism for test anxiety and social anxiety characterized by ineffective emotion regulation strategies to deal with performance pressures such as rumination, social withdrawal, and self-devaluation (Keil et al., 2017; Klemanski et al., 2017).

Major depression is characterized by low mood and a loss of interest and enjoyment of typical activities (e.g., school). Major depression showed a coherent and distinct community of nodes. Test anxiety nodes were not indicators of major depression and vice versa. Major depression did, however, share positive edges with test anxiety and it is likely that features of test anxiety, including the anticipation of failure and negative judgments of one's academic ability, could contribute to features of major depression, including feelings of worthlessness and reduced interest in school. In addition, the positive edges between forgetting and difficulty concentrating (i.e., cognitive interference) and not thinking clearly (i.e., major depression) could indicate an underling issue with executive function and attention control (Snyder et al., 2019; Yang et al., 2022). There were, however, some unanticipated edges shared between test anxiety and major depression nodes that could represent antithetical facets of anxiety and MD. For example, highly anxious persons may wish to move to release muscular tension (e.g., Asmundson et al., 2013), hence a negative edge was shown between tension nodes and the major depression node representing *not* wanting to move.

4.2. The identification of test anxiety cut scores for emotion disorder

The ROC curve analysis identified cut points for MTAS total scores that showed moderate to high accuracy for generalized anxiety, panic disorder, social anxiety, and major depression, with acceptable sensitivity and specificity. Although MTAS component scores showed lower accuracy, sensitivity, and specificity, it is notable that generalized anxiety showed the strongest thresholds for worry, panic disorder for physiological indicators, social anxiety for worry and tension, and major depression for cognitive interference. The more robust accuracy, sensitivity, and specificity shown for test component scores in relation to specific emotion disorders mirrors the findings of the psychometric network analysis and supports our theorizing that the different components of test anxiety would link more strongly to some emotion disorders than others. Persons who reach the MTAS cut scores may be experiencing a level of emotional distress comparable to those of emotion disorders and hence would benefit from support, intervention, or examination adjustments (e.g., taking examinations in a small room, relaxing strict time constraints; see Zuriff, 1997). As such, MTAS cut scores may be assistive for practitioners.

We tentatively hypothesized (Hypothesis 2) that cut scores would be around the 72nd to 75th percentiles on the MTAS scale. The range of cut scores identified (50–58; 63rd–75th percentiles) were lower than the scores of 58 and 60 (72nd and 75th percentiles for generalized anxiety and panic disorder respectively) previously identified by von der Embse et al. (2021). Like von der Embse et al.'s (2021) earlier study, the highest cut score was for panic disorder. Hypothesis 2 was partially supported. Although it was not a primary consideration to identify what proportion of the sample was showing evaluated symptoms of emotion disorder, if the RCADS-derived cut scores were applied, this would result in between 41.8% (using a cut score of 58) and 63% (using a cut score of 50) of the sample being considered at risk. Are these percentages too high to be plausible? Can nearly two thirds of the sample really be considered as showing a level of test anxiety to present a possible clinical risk? The range of percentages (41.8%–63%) is a substantial increase on the 35% implied by a MTAS cut score of 60 in von der Embse et al. (2021).

Based on the present sample, the specificity values for MTAS total scores suggested the cut points would correctly identify between 75% and 86% of persons as showing RCADS-derived emotional distress (i.e., evaluated symptoms of emotion disorders that indicate a likely risk of diagnosis). The highest true positive value was for panic disorder (86%) and the lowest for major depression (75%). The specificity values of the MTAS total score cut points could correctly identify between 70% and 77% of persons without RCDADS-derived risk. The highest true negative value was for generalized anxiety (77%) and the lowest for major depression (70%). Thus, MTAS total cut scores are not a definitive judgement of whether a person will show clinical risk; there will be between 14% to 25% of persons incorrectly identified as showing no risk and 23% to 30% of persons incorrectly identified as showing risk. These cut points should be considered as indicative of risk. Nonetheless, even with these parameters of error, the proportion of the sample showing clinical risk was higher than that showed by von der Embse et al. (2021).

Three factors may be important in contextualizing the ROC curve findings. First, in von der Embse et al.'s (2021) study, data were collected pre-pandemic. Post-pandemic, the mental health of many adolescents has worsened (e.g., Daumiller et al., 2023; Pedrini et al., 2022). Epidemiological analysis showed that in 2022, 16.7% of 7–16-year-olds and 22% of 17–24-year-olds in England showed a probable mental health disorder (Newlove-Delgado et al., 2022). The damaging legacy of the Covid pandemic may have contributed to the high percentage of students identified as showing clinical risk.

Second, the ROC curve analyses used existing RCADS cut scores for elevated symptoms that could indicate risk for diagnosis. Rates of elevated symptoms for emotion disorders are far higher than actual diagnoses (Bosman et al., 2019) and it may be the case that our findings align with a sub-threshold risk. Notably, Putwain, Stockinger, et al. (2021) indicated that although 21.5% of participants showed elevated test anxiety and symptoms of generalized anxiety and panic disorder combined with low SRWB, a much smaller group (7.9%) showed substantially raised test anxiety and symptoms of generalized anxiety and panic disorder and markedly lowered SRWB.

Third, there may be characteristics of our sample that result in an elevated degree of emotion disorder symptoms. Demographically, there were more female participants than males and a smaller proportion of non-white and FSM-eligible participants than is typical of English schools. Although ethnic differences in test anxiety have been shown to be small (e.g., Putwain, 2007), females (e.g., Robson et al., 2023) and those from low-income backgrounds typically report higher test anxiety (e.g., King et al., 2024). Furthermore, females also report higher symptoms of emotion disorder than males (e.g., Chaplin & Aldao, 2013). These demographic differences may have contributed to the relatively high proportion of students identified as being at clinical risk. Additionally, one may speculate that the choice of school leaders to participate in this project may indicate recognition of anxiety issues within their respective cohorts.

The points we have made to contextualize the ROC curve analysis suggest the high proportion of students identified at risk from elevated symptoms of emotion disorder, although understandably questionable, is indeed genuine (give or take false positives and negatives). Although this high percentage is a serious cause for concern both for the students themselves as they progress in education and for their long-term mental health, it may be that this group is heterogenous and includes a smaller group with a more acute and severe clinical risk.

4.3. Co-occurrence between test anxiety and emotion disorder

If test anxiety was merely an indicator for existing emotion disorder, we would expect to see a greater intermixing of nodes for test anxiety among emotion disorder nodes than is presently the case. This possibility can be ruled out. Our findings did not, however, speak conclusively to the question of whether test anxiety should be considered as a discrete emotion disorder or whether from a transdiagnostic perspective (e.g., Caspi & Moffitt, 2018; Lahey et al., 2017), test anxiety could represent symptoms of a more general class of psychopathology, namely internalizing disorders. Nonetheless, our findings offer insight into the co-occurrence of test anxiety and emotion disorder.

Test anxiety, in contrast to emotion disorders, is situation specific. The specific setting can be one involving uncontrollable worry (i.e., generalized anxiety), panic attacks (i.e., panic disorder), embarrassment from failure (i.e., social anxiety), and lost interest and enjoyment in school (i.e., major depression). From the perspective of the Network Theory of Psychopathology (e.g., Robinaugh et al., 2020), activation of test anxiety nodes will trigger activation of emotion disorder symptom nodes. When examination pressures are ongoing, the continued activation of test anxiety nodes, combined with feedback loops that maintain activation, could result in test anxiety being a risk factor for developing an emotion disorder. The 'influential' nodes identified in the psychometric network analysis may be particularly important in spreading network activation.

In psychopathological network analyses, edges are assumed to represent bidirectional links (i.e., if data were lagged, directional relations could be established; Borsboom & Cramer, 2013). Not only could test anxiety present a risk for emotion disorder, persons with elevated symptoms of emotion disorder (e.g., sub-threshold or with a diagnosis) are more likely to become highly test anxious and experience the associated negative educational consequences. We cannot disentangle directionality due to the cross-sectional design. Previous studies have, however, shown that the relationship between test anxiety and emotion disorder risk is reciprocal (Putwain, Gallard, et al., 2021).

4.4. Limitations and recommendations for future research

Despite the relatively large sample and robust analyses that replicate and extend previous findings, there are three principal limitations to mention. The first, which we have already briefly mentioned above, is the cross-sectional design. Although it is a first necessary preliminary step to demonstrate the links between test anxiety and emotion disorder, as we have done, to establish the directionality of risk, a longitudinal design is required. Future studies could use panel models with multiple waves of data collection to model temporal psychometric networks. Relatedly, we modeled a between-person contemporaneous network. The processes that were hypothesized to link test anxiety and emotion disorder are fundamentally within-person and networks could also be examined, both contemporaneously and temporally, using within-person designs such as time series (Epskamp, 2020).

Second, we focused on just four emotion disorders, albeit those with the greatest salience for the age range of the sample. Test anxiety will likely show links with other emotion disorders, or from a transdiagnostic perspective, symptoms of internalizing disorder. To ensure as full an understanding as possible of how test anxiety relates to clinical risk, future studies should consider including additional or alternate emotion disorders or using checklists of cognitive, behavioral, and physiological symptoms that are common to internalizing disorder.

Third, our findings, along with the presence of comorbidity between emotion disorders and the grouping of internalizing disorders, suggested the possible presence of common underlying mechanisms between some, or all, facets of anxiety. Possible explanations that we highlighted earlier are cognitive attentional syndrome (Nordahl & Wells, 2019) and anxiety sensitivity (Olatunji & Wolitzky-Taylor, 2009), social withdrawal and self-devaluation (Keil et al., 2017), and problems with executive function (Yang et al., 2022). Although our findings are suggestive of these possibilities, they have yet to be widely researched for test anxiety in conjunction with other emotion disorders or internalizing symptoms and would be a fruitful avenue for future studies. Relatedly, our findings highlight the potential for a more widespread use of psychometric network analysis to deepen understanding of which other school-related variables may be co-occurring.

4.5. *Implications for practice*

Our findings indicated that test anxiety should be taken seriously and not lightly dismissed as simply the stress experienced around examinations. Highly test anxious persons show elevated symptoms of emotion disorder and may present a risk for developing an anxiety disorder. It is notable that most anxiety disorders first present before the age of 18 years (Kessler et al., 2010), and after an initial episode, tend to reoccur (Liberman et al., 2015). Identifying those students who are becoming anxious about examinations and providing intervention and support has the potential to substantially reduce the health burden for both individuals and society. Such intervention need not be time consuming or costly; test anxiety has been shown to respond to low-intensity, group cognitive behavioral intervention (Putwain & Pescod, 2018; Putwain & von der Embse, 2021).

A starting point would be the identification of those students for whom test anxiety presents a possible clinical risk. The MTAS could be used for such purposes either as a standalone measure or otherwise incorporated into universal mental health screening in schools (Moore et al., 2022). If one solely wished to assess risk for emotion disorder, the RCADS would be sufficient. The MTAS, however, would allow one to identify severe test anxiety that poses an elevated clinical risk. We recommend using the MTAS total rather than component scores for two reasons. First, MTAS total scores provided the greatest accuracy. Second, although MTAS components showed stronger relations to specific emotion disorders, given the numerous direct and indirect edges within and between the communities shown in the emergent network, the total MTAS score would likely indicate the most reliable general risk.

Scores in the range of the 63rd–75th percentiles on the MTAS should be considered as a risk factor for developing an emotion disorder (MTAS scores of 52–58). An important caveat is that these cut points were identified with relatively high accuracy and are *interpretive*, rather than *definitive*, based on the balance of sensitivity and specificity. It could be argued that when using cut scores to identify persons in need of additional help, it is better to include persons for potential intervention and support who may not require it than vice versa. Conversely, the over-identification of students with high levels of test anxiety that present a clinical risk could result in limited resources that could be used elsewhere being misspent. One potential response would be to offer tiered intervention (e.g., August et al., 2018) with brief low intensity selective interventions that are less costly and time consuming to implement and offered to all persons identified as at risk. Follow-up screening combined with self- or teacher-referral using symptoms of emotion disorder could be used to identify persons in need of more intensive, costly, and time-consuming intervention.

The identification of influential nodes from psychometric network analysis as foci for intervention is controversial, unless supported by experimental manipulation (Dabalnder & Hinne, 2019). Nonetheless, the influential nodes in the present analyses correspond with well-established cognitive-behavioral interventions for anxiety (Higa-McMillan et al., 2016; Neil & Christensen, 2009). These include nodes linking test anxiety and emotion disorder that focus on perseverative worry and intense physiological panic. The links between cognitive interference and social anxiety/major depression also suggest that attention training could be a useful facet of test anxiety intervention (see Peng & Miller, 2016; Schmidt et al., 2009).

5. Conclusion

Our findings reaffirmed that test anxiety and emotion disorders are positively related and that test anxiety and SRWB are negatively related. Generalized anxiety was principally linked to worry and tension, panic disorder to physiological indicators, major depression to cognitive interference, and social anxiety and SRWB to worry and cognitive interference. Although test anxiety is related to emotion disorder and SRWB, they are largely distinct constructs; a small degree of construct overlap was shown between panic disorder and physiological indicators. In addition, test anxiety scores from the 63rd–75th MTAS scale percentile could pose an elevated risk for developing an emotion disorder.

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Declaration of competing interest

We have no known conflict of interest to disclose. The materials, dataset, and analytic code, on which analyses within this manuscript were conducted can be accessed at https://doi.org/10.17605/OSF.IO/UF8SJ.

Acknowledgements

The authors would like to thank Olivia Taylor and Shannon Watson for their help with data collection.

Appendix A. Supplementary data

Supplementary materials for this article can be found online at https://doi.org/10.1016/j.jsp.2024.101390.

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