



A network analytic framework for subjective indicators of attentional control: Exploring unique associations and directed pathways

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ABSTRACT

Subjective indicators of attentional control, the Attentional Control Scale (ACS; comprising attentional focusing and shifting) and the Cognitive Failures Questionnaire (CFQ/CFQ 2.0), are related but considered to capture distinct manifestations. However, how these indicators relate to one another and to related constructs when considered simultaneously remains unclear. Using a network analytic framework, we examined these subjective indicators within a broader context of related constructs, including psychological distress (depression, anxiety, and stress) and empathy (cognitive and affective) in 592 participants. We estimated a Gaussian Graphical Model (GGM) and a Directed Acyclic Graph (DAG) to examine unique associations and potential pathways. In the GGM, cognitive failures related to both attentional focusing and shifting, but each showed distinct associations. Cognitive failures were associated with anxiety. Attentional focusing was associated with stress and affective empathy, whereas attentional shifting was associated with depression, cognitive empathy, and affective empathy. The DAG suggested three potential pathways. One linked anxiety to attentional focusing and shifting through cognitive failures; the other two linked empathy to the ACS dimensions, with cognitive empathy linked to attentional shifting and affective empathy to attentional focusing through stress. Considered together, these indicators were related but showed distinct patterns of association with psychological distress and empathy.

1. Introduction

Attentional control refers to the ability to focus on task-relevant information while resisting interference from both external and internal distractions (Burgoyne et al., 2023; Unsworth et al., 2021). Although attentional control is commonly measured using behavioral tasks based on specific paradigms (e.g., the Flanker, Stroop, or Antisaccade tasks), it is also frequently assessed using self-report measures that capture how individuals experience and evaluate their own attentional control capacity (Derryberry & Reed, 2002). The present study focuses on these subjective indicators of attentional control.

One widely used self-report measure of attentional control is the Attentional Control Scale (ACS; Derryberry & Reed, 2002). The ACS was developed to assess individual differences in attentional control and includes two key dimensions: attentional focusing (i.e., the ability to concentrate on goal-relevant information) and attentional shifting (i.e., the ability to switch between tasks or goals). Other measures include the

Cognitive Failures Questionnaire (CFQ; Broadbent et al., 1982) and its updated version, the CFQ 2.0 (Goodhew & Edwards, 2024a), both of which have been shown to correlate with objective attentional control tasks (Goodhew & Edwards, 2024a; Goodhew & Edwards, 2025). These measures capture the frequency of cognitive failures in everyday life, such as forgetting appointments, calling people by the wrong name, or misplacing objects.

Although these measures (the ACS and the CFQ or CFQ 2.0) are related, such that higher levels of cognitive failures are associated with lower attentional control capacity, particularly in focusing and shifting (Goodhew & Edwards, 2024a; Goodhew & Edwards, 2024b; Judah et al., 2014), they are considered to capture distinct aspects of subjective attentional control. Specifically, the ACS is considered to reflect more abstract evaluations or beliefs about one's attentional control capacity, largely due to inconsistent findings regarding its associations with objective attentional control tasks (Clarke & Todd, 2021; Quigley et al., 2017). In contrast, the CFQ (or CFQ 2.0) reflects more concrete or

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experiential manifestations of attentional control in everyday life (Goodhew & Edwards, 2024b; Thomson & Goodhew, 2021).

These self-report indicators of attentional control have also been linked to a range of domains, including psychological distress and social-emotional processes. For example, studies have shown that higher levels of depression, anxiety, and stress are associated with increased cognitive failures and reduced attentional control (Adamis et al., 2025; Judah et al., 2014; Kranjčev & Vukasović Hlupić, 2021; Mahoney et al., 1998; Reinholdt-Dunne et al., 2013; Sullivan & Payne, 2007; Sutin et al., 2020). In the social-emotional domain, previous studies suggest that higher levels of cognitive failures and lower attentional control are associated with reduced cognitive empathy (i.e., the ability to take others' perspectives and understand their emotional states; Reniers et al., 2011) but increased affective empathy (i.e., the ability to be sensitive to and vicariously experience the emotions of others; Reniers et al., 2011) (Goodhew & Edwards, 2021; Goodhew & Edwards, 2022; Goodhew & Edwards, 2024a).

Taken together, previous research suggests that subjective indicators of attentional control (the ACS and the CFQ/CFQ 2.0) reflect related but distinct manifestations of attentional control and are linked with a range of domains, including psychological distress (i.e., depression, anxiety, and stress) and empathy (i.e., cognitive and affective). However, how these indicators are related to one another and to psychological distress and empathy when considered simultaneously remains unclear. Examining these indicators within a network framework may therefore provide insight into their interrelations and the extent to which they exhibit shared and distinct patterns of association with psychological distress and empathy.

1.1. The present study

The present study aimed to examine how subjective indicators of attentional control (cognitive failures measured by the CFQ 2.0 and the focusing and shifting dimensions of attentional control measured by the ACS) relate to one another and to psychological distress (depression, anxiety, and stress) and empathy (cognitive and affective) when considered simultaneously within a network analytic framework. Cognitive failures were assessed using the CFQ 2.0 (Goodhew & Edwards, 2024a), a contemporary revision of the original CFQ that includes updated content and a clearly supported unidimensional structure. As no Turkish adaptation of the CFQ 2.0 was available, we adapted the scale into Turkish and examined its psychometric properties within the present study. See the Supplementary Material, *Psychometric Evaluation of the Turkish Version of the Cognitive Failures Questionnaire (CFQ 2.0)*, for details.

In line with our aim, we employed a two-step network analytic approach. First, we estimated an undirected network model using a Gaussian Graphical Model to identify unique associations among the study variables. Unlike traditional correlation analyses, the associations estimated in undirected network models represent regularized partial correlations, indicating relationships that remain after accounting for all other variables in the network (Epskamp et al., 2018). This approach is particularly informative when multiple constructs are interrelated, as it allows the identification of unique associations between variables after accounting for the influence of the rest of the network.

Although undirected network models provide important information about the structure of associations among variables, they do not capture the potential direction of these relationships. Accordingly, as a second step, we employed Bayesian network analysis (Briganti et al., 2023; Pearl, 2009), in which relationships among variables are represented as a directed acyclic graph. This approach allows the exploration of potential directional pathways among the study variables and provides a basis for generating hypotheses regarding the positioning of subjective attentional control indicators within the broader network of related constructs.

2. Method

2.1. Participants

A total of 646 participants were recruited via convenience sampling. After excluding participants reporting neurological or psychological disorders ($n = 52$) and those under 18 years of age ($n = 2$), the final sample consisted of 592 participants (48.3% male) aged 18–70 years ($M = 37.52$, $SD = 13.45$). Additional demographic information is presented in Table 1.

2.2. Materials

2.2.1. Cognitive Failures Questionnaire 2.0 (CFQ 2.0)

Developed by Goodhew and Edwards (2024a), the CFQ 2.0 is a revised version of the original CFQ (Broadbent et al., 1982). As in the original CFQ, the CFQ 2.0 assesses the frequency of cognitive failures in everyday life. The scale consists of 15 items rated on a 5-point Likert scale ranging from 0 (never) to 4 (very often). Higher total scores indicate a greater frequency of everyday cognitive failures. The Turkish version of the CFQ 2.0, adapted for this study, demonstrated good psychometric properties; internal consistency was high ($\alpha = 0.898$; $\omega = 0.899$), and the unidimensional structure was confirmed via Confirmatory Factor Analysis (CFI = 0.914, RMSEA = 0.074 [90%CI: 0.065, 0.082], SRMR = 0.052). See Supplementary Materials for full details.

2.2.2. Attentional Control Scale (ACS)

The ACS (Derryberry & Reed, 2002) is a self-report measure of attentional control and assesses two dimensions of attentional control: focusing and shifting. The validated 17-item Turkish version (Altan-Atalay et al., 2024) was used in the present study. Items are rated on a four-point Likert scale (1 = almost never, 4 = always) and include nine reverse-coded items. Higher scores indicate greater attentional control.

2.2.3. Questionnaire of Cognitive and Affective Empathy (QCAE)

The QCAE (Reniers et al., 2011) is a 31-item self-report measure assessing cognitive and affective empathy. Items are rated on a four-point Likert scale (1 = strongly disagree, 4 = strongly agree) and include four reverse-coded items. Higher scores indicate higher levels of empathy. The validated Turkish version (Gica et al., 2021) was used in the present study.

2.2.4. Depression, Anxiety and Stress Scale (DASS21)

The DASS21 (Lovibond & Lovibond, 1995) is a 21-item self-report measure assessing depression, anxiety, and stress symptoms experienced over the past week. The scale comprises three subscales (depression, anxiety, and stress). Items are rated on a four-point Likert scale (0 = never, 3 = almost always), with higher scores indicating greater symptom severity. The validated Turkish version (Yildirim et al., 2018)

Table 1
Demographic characteristics of participants.

Demographic characteristics	<i>n</i>	%
Gender		
Male	286	48.3
Female	306	51.7
Education level		
Primary/middle school	84	14.2
High school	131	22.1
Undergraduate (university)	311	52.5
Graduate (master/Ph.D.)	66	11.2
Relationship status		
Married	303	51.2
Single	249	42.1
Divorced	24	4.1
Widowed	16	2.7

Note. *n* = number of participants.

was used in the present study.

2.3. Procedure

Ethical approval was obtained from the Ethics Committee of Istanbul Sabahattin Zaim University prior to the current study (Approval No. E.202528725). Data collection was conducted online via Qualtrics. Participants were first presented with an informed consent form, which informed them that participation was voluntary and that they could withdraw from the study at any time without penalty. Those who provided consent proceeded to a demographic information form, followed by the administration of the CFQ 2.0, ACS, QCAE, and DASS21. The order of these scales was randomized across participants. Within each scale, items were presented in their standard order, and a forced response format was employed for all items.

2.4. Data analysis

The data were processed and analyzed using R (R Core Team, 2025) in RStudio (Posit Team, 2025). Due to the forced-response format, no missing data were present in the dataset. Prior to the network analyses, potential outliers and the distributional characteristics of the total or subscale scores of all study variables were examined. These included cognitive failures (the CFQ 2.0 total score); attentional focusing and attentional shifting (subscale scores of the ACS); depression, anxiety, and stress (subscale scores of the DASS21); and cognitive and affective empathy (subscale scores of the QCAE). No extreme outliers were detected, and all variables were approximately normally distributed; all data were therefore retained. Full details of these preliminary analyses, together with descriptive statistics and Pearson correlations among all study variables, are reported in the Supplementary Material (Figs. S2–S4 and Tables S4–S5). Additionally, VIFs (1.08–2.95) and tolerance values (0.34–0.92) indicated no problematic multicollinearity.

First, an undirected network model, a Gaussian Graphical Model (GGM), was estimated using the bootnet package (Epskamp et al., 2018) to examine unique associations (i.e., edges) between study variables (i.e., nodes). In the model, edges represent regularized partial correlations between nodes after controlling for all other nodes within the network. To ensure a sparse and interpretable network, the EBICglasso algorithm was applied, based on graphical LASSO regularization (gLASSO; Friedman et al., 2008), with model selection guided by the Extended Bayesian Information Criterion (EBIC; Chen & Chen, 2008). A conservative tuning parameter ($\gamma = 0.5$) was used to reduce spurious edges (i.e., false positives; Foygel & Drton, 2010), and estimated edges were additionally thresholded. The resulting network was visualized using the qgraph package (Epskamp et al., 2012), and the estimated edge weights are reported in the Table S6.

For the estimated network, centrality analysis was conducted to evaluate the relative importance of individual nodes. All centrality indices were obtained (Fig. S5 and Table S7), but the interpretation focused on the Expected Influence (EI) metric, which retains the sign of edge weights and is therefore more appropriate in networks containing negative associations (Robinaugh et al., 2016), as observed in our estimated network structure. In addition, node predictability was estimated using the mgm package (Haslbeck & Waldorp, 2020) to examine the extent to which each node's variance was explained by the remaining nodes in the network (see Table S7).

The accuracy and stability of the estimated network model were assessed using bootstrap methods (1000 iterations) via the bootnet package (Epskamp et al., 2018). Edge-weight accuracy was evaluated with a non-parametric bootstrap, and the stability of EI with a case-dropping bootstrap, quantified using the correlation stability (CS) coefficient, which should preferably exceed 0.50 and not fall below 0.25 (Epskamp & Fried, 2018). Both bootstrap plots are presented in Figs. S6 and S7.

In the second step of the network analysis, Bayesian network analysis

was conducted to estimate a directed acyclic graph (DAG). The DAG structure was estimated via the bnlearn package (Scutari, 2017) using the constraint-based PC-Stable algorithm (Colombo & Maathuis, 2014). We applied the PC-Stable algorithm across 1000 bootstrap samples and retained edges with edge strength >0.85 and edge direction >0.50 (Briganti et al., 2023). The resulting thresholded DAG was considered the final model, and all subsequent interpretations were based on its structure. Edge strength and direction values for all edges are provided in Table S8.

3. Results

3.1. Gaussian Graphical Model (GGM)

The estimated GGM is presented in Fig. 1A. In this model, the two subjective indicators of attentional control were directly associated: cognitive failures showed direct negative associations with both attentional focusing and attentional shifting. Among the psychological distress variables, only anxiety showed a direct positive association with cognitive failures, whereas depression and stress were not directly associated with cognitive failures. In addition, no direct associations were observed between cognitive failures and empathy-related variables (i.e., cognitive empathy and affective empathy). Attentional focusing showed direct negative associations with stress and affective empathy. No direct associations were observed between attentional focusing and depression, anxiety, or cognitive empathy. In addition, attentional shifting showed direct negative associations with depression and affective empathy and a direct positive association with cognitive empathy. However, no direct associations were observed between attentional shifting and anxiety or stress.

As shown in Fig. 1B, anxiety was the node with the highest EI in the estimated network. In contrast, the highest predictability was observed for stress. Node predictability values ranged from 0.27 to 0.66, indicating that, on average, 42% of the variance in each node was explained by its neighboring nodes (Table S7). Predictability estimates for the subjective indicators of attentional control were 0.30 for cognitive failures, 0.29 for attentional shifting, and 0.27 for attentional focusing. Accuracy and stability analyses indicated adequate edge-weight estimation and centrality stability (CS-coefficient = 0.75; Figs. S6 and S7).

3.2. Directed Acyclic Graph (DAG)

Fig. 2A presents the thresholded DAG, with edge strength and direction thresholds set at 0.85 and 0.50, respectively. Fig. 2B presents the full DAG structure prior to thresholding (Table S8 for detailed bootstrap results).

The final model (i.e., the thresholded DAG) suggested three potential directed pathways involving the subjective indicators of attentional control. One pathway involved both subjective indicators of attentional control, extending from anxiety to cognitive failures and further to the ACS dimensions of attentional focusing and attentional shifting. The remaining two potential pathways involved the ACS dimensions rather than cognitive failures and originated from different empathy components, with one extending directly from cognitive empathy to attentional shifting and the other extending from affective empathy to stress and further to attentional focusing. Edge strength estimates for the potential pathways ranged from 0.90 to 1.00, and support for edge direction ranged from 0.53 to 0.76 (Table S8).

4. Discussion

This study examined how the subjective indicators of attentional control relate to one another and to psychological distress and empathy-related variables using a two-step network approach. The GGM showed that although cognitive failures, attentional focusing, and attentional shifting were interrelated, they exhibited distinct patterns of association

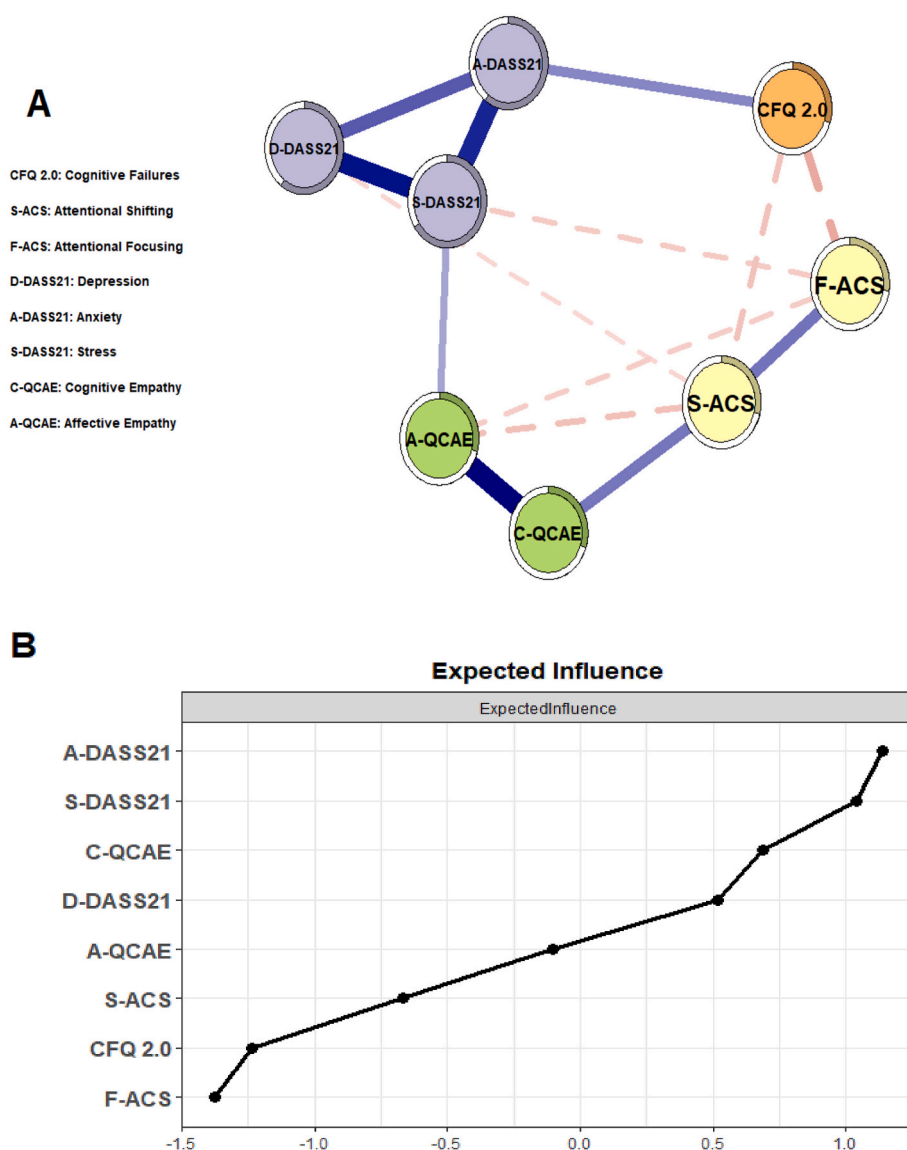


Fig. 1. (A) GGM. Nodes represent study variables, and edges represent regularized partial correlations. Blue solid lines indicate positive associations, whereas red dashed lines indicate negative associations. The thickness of the lines reflects the weight of the edge between two nodes after controlling for all other nodes in the network. The ring-shaped pie charts around the nodes indicate the predictability of each variable. Node placement was determined using the Fruchterman–Reingold algorithm (Fruchterman & Reingold, 1991). (B) EI plot. Higher EI indicates relative importance of that node within the network. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

with psychological distress and empathy-related variables. The estimated DAG suggested three potential directed pathways involving the subjective indicators of attentional control. We first consider these distinct patterns of association and then the potential directed pathways suggested by the DAG.

The subjective indicators of attentional control showed broadly similar correlations with depression, anxiety, and stress at the bivariate level (see Table S5). However, after controlling for all other variables in the network, the GGM showed a distinct pattern of associations between the subjective indicators of attentional control and the distress variables. Attentional shifting was uniquely associated with depression, consistent with earlier findings (Judah et al., 2014; Ólafsson et al., 2011), whereas attentional focusing was uniquely associated with stress, with neither ACS dimension showing a direct association with anxiety. Cognitive failures, however, were uniquely associated with anxiety, with no direct associations observed for depression or stress. Notably, the unique association between cognitive failures and anxiety is in line with Goodhew and Edwards (2024b), who found that cognitive failures explained

anxiety-related variance beyond that captured by the ACS dimensions.

The subjective indicators of attentional control also differed in their associations with empathy-related variables. In the estimated GGM, attentional shifting was positively associated with cognitive empathy and negatively associated with affective empathy, whereas attentional focusing was negatively associated with affective empathy. Cognitive failures, by contrast, retained no unique associations with either empathy component, despite being correlated with cognitive empathy at the bivariate level (Table S5). The associations involving the ACS dimensions are broadly consistent with previous findings (Goodhew & Edwards, 2021), although attentional shifting was also negatively associated with affective empathy in the present network. No unique associations involving cognitive failures were observed after accounting for the broader network of variables included in the present study, in contrast to previous findings (Goodhew & Edwards, 2022).

Turning to the directed network, the averaged DAG offered a complementary, exploratory perspective on the potential direction of the relationships among the study variables. Overall, its structure was

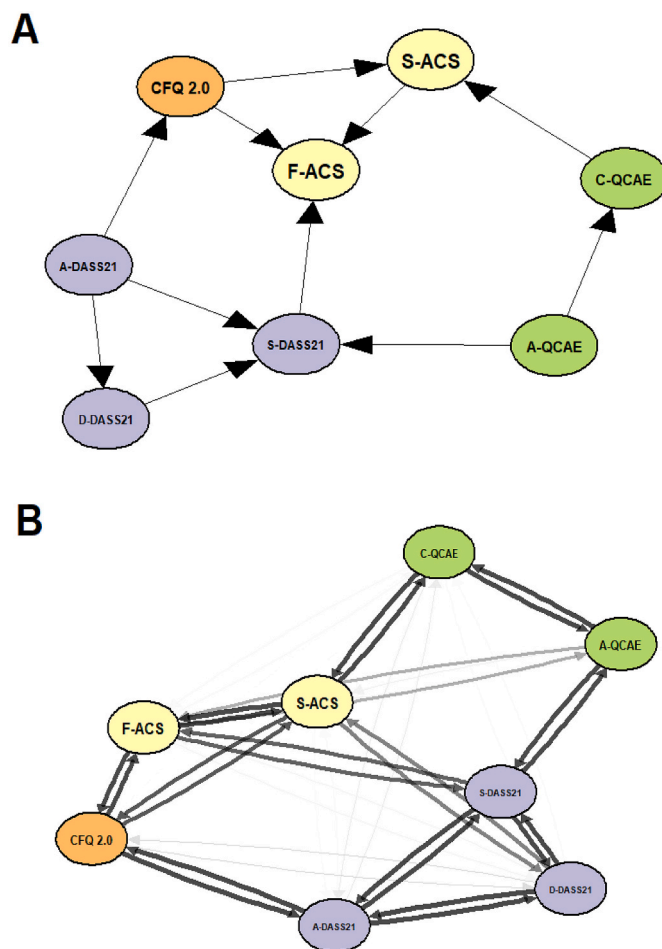


Fig. 2. (A) Thresholded DAG. Arrows indicate potential directed pathways between study variables. (B) Unthresholded DAG. This plot illustrates all identified directed pathways prior to thresholding (i.e., Panel A). The thickness of the edges represents the percentage of bootstrap samples in which a given edge appeared in a specific direction across 1000 bootstrap samples, with thicker lines indicating greater stability. CFQ 2.0 = Cognitive Failures; S-ACS = Attentional Shifting; F-ACS = Attentional Focusing; D-DASS21 = Depression; A-DASS21 = Anxiety; S-DASS21 = Stress; C-QCAE = Cognitive Empathy; A-QCAE = Affective Empathy.

largely consistent with the estimated GGM, although the direct associations of attentional shifting with depression and affective empathy were not retained. Within this overall pattern, the directed network suggested three potential pathways involving the subjective indicators of attentional control. One pathway linked anxiety to attentional focusing and shifting through cognitive failures, whereas two additional pathways connected empathy-related variables to the ACS dimensions, linking cognitive empathy to attentional shifting and affective empathy to attentional focusing through stress.

We estimated the averaged DAG using the constraint-based PC-Stable algorithm and applied bootstrapping and thresholding procedures to obtain a stable and interpretable network structure. To examine the robustness of the estimated DAG, we also estimated an alternative DAG using the Max-Min Hill-Climbing (MMHC) algorithm, which may capture different aspects of the data. The averaged DAG estimated with the MMHC algorithm revealed a pattern of associations similar to that of the averaged DAG estimated using the PC-Stable algorithm. Their directions, however, varied across estimation algorithms (see Fig. S8). Notably, the pathway linking anxiety to the subjective indicators of attentional control was largely preserved, except for attentional focusing. Although these findings are exploratory and should not be

interpreted as evidence of causal ordering, the relative consistency of the pathway linking anxiety to the subjective indicators of attentional control suggests that it may be further examined in future longitudinal studies, given the observed association between anxiety and cognitive failures and the view that both subjective indicators are considered to reflect different manifestations of subjective attentional control.

The present study focused on subjective indicators of attentional control. How attentional control is assessed may itself be relevant to interpreting these findings, particularly given discussion regarding the extent to which subjective and objective measures converge (e.g., [Clarke & Todd, 2021](#); [Goodhew & Edwards, 2025](#)). Subjective and objective measures do not always show comparable associations; for instance, the association with anxiety is weaker for objective than for subjective indicators ([Shi et al., 2019](#)), and some studies have reported associations between anxiety and subjective, but not objective, measures of attentional control (e.g., [Van Bockstaele et al., 2023](#)). Although this was not examined in the present study, these differences between the present findings and previous objective-task studies can be considered in light of the view that subjective and objective measures may capture different but complementary aspects of cognitive function ([Goodhew & Edwards, 2025](#)). Future research could therefore extend the present study by incorporating objective behavioral measures. In addition, such work could also examine whether the subjective indicators investigated here show differential associations with objective measures of attentional control and sustained attention, which have recently been proposed to represent partially dissociable attentional processes ([Tsukahara & Engle, 2023](#); [Zhao et al., 2026](#)).

In line with our study aim, we used two network approaches, each with assumptions and limitations relevant to interpreting the present findings. First, the GGM was estimated using a conservative tuning parameter and additional thresholding to obtain a sparse, interpretable network; this may increase the likelihood that weak but potentially meaningful associations were not identified, so absent edges should be interpreted with caution. In addition, caution is warranted in the substantive interpretation of the regularized partial associations, given the intercorrelations among the constructs included in the estimated GGM (e.g., the DASS21 dimensions; see Table S5). Second, DAGs can provide valuable insights in psychological research ([Zhu et al., 2026](#)), but they assume acyclicity and therefore cannot represent reciprocal or feedback relationships that may be relevant for psychological variables. Also, given the cross-sectional nature of the present study, the directed results should be regarded as hypothesis-generating, and longitudinal or experimental studies are needed to test the pathways they suggest.

Furthermore, variables were selected based on theoretical relevance and to enable a direct comparison between the two subjective indicators of attentional control. Although this addressed the aims of the study, it did not include all potentially relevant constructs. Node predictability averaged 42%, but estimates for the subjective indicators ranged from 27% to 30%, suggesting that factors beyond those modelled here may contribute to these indicators. Future studies could extend the present network with other theoretically relevant constructs (e.g., personality traits, [Sutin et al., 2020](#); rumination, [Hsu et al., 2015](#)) to examine how these indicators relate to a broader range of constructs when considered simultaneously.

Finally, although the sample was balanced in gender and ranged in age from 18 to 70 years, it was recruited online through convenience sampling and consisted predominantly of highly educated Turkish participants, and individuals reporting psychological or neurological disorders were excluded. Future research should examine the present findings in clinical, more diverse, and representative samples.

In conclusion, when examined within a broader network of psychological distress and empathy-related variables, the subjective indicators of attentional control showed both shared and distinct patterns of association. The subjective indicators were interrelated, possibly reflecting partially overlapping manifestations of subjective attentional control. They nonetheless showed distinct patterns of association with

psychological distress and empathy-related variables, consistent with the view that these subjective indicators reflect distinct manifestations of subjective attentional control. The DAG suggested three potential pathways linking the subjective indicators of attentional control, psychological distress, and empathy-related variables, providing a basis for future longitudinal and experimental studies investigating the directionality of these relationships.

CRedit authorship contribution statement

Kübra Mahmut-Önalın: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Investigation, Formal analysis, Conceptualization. **Gülşah Balaban:** Writing – review & editing, Formal analysis. **Rahmi Saylik:** Writing – review & editing, Supervision.

Ethics declaration

Written informed consent to take part in the study and to publish the article has been obtained from all participants or their legal representatives. The privacy rights of participants have been observed.

This study was performed in compliance with relevant laws, regulatory frameworks and guidelines where the research took place.

This study was approved by the Istanbul Sabahattin Zaim University (Approval No. E.202528725).

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this manuscript, we used ChatGPT (OpenAI) for grammar and punctuation checking. The authors reviewed and edited the content as necessary and take full responsibility for the content of the manuscript.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.paid.2026.114068>.

Data availability

Data will be made available on request.

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