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Original Article

Self-focused rumination links stressful events to depressive and anxiety symptoms in older adults with depressive symptoms: path and network analyses

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Abstract

Self-focused rumination, defined as an excessive attentional focus on one's depressive symptoms and their causes, meanings, and consequences, is well-established for its role in the onset and maintenance of depressive and anxiety symptoms. However, it remains unclear how this cognitive style can be manifested in older adults and how it might bridge the influences of different stressful life events (SLEs) namely dependent SLEs (partially attributable to one's behaviours) and independent SLEs (entirely beyond personal control), with the two symptom dimensions. Data were from 1868 community-dwelling older adults (mean age=73.4; 83.1% female) as part of a territory-wide stepped-care intervention in Hong Kong for those with mild-to-moderately severe depressive symptoms (Patient Health Questionnaire–9=5–19). We investigated whether self-focused rumination would link dependent and independent SLEs to depressive and anxiety symptoms using both path and network analyses. In the path model, both SLE types were associated with self-focused rumination. Dependent SLEs were directly associated only with depressive symptoms, while independent SLEs were directly associated only with anxiety symptoms. Self-focused rumination linked SLEs on both symptom dimensions. With all symptoms accounted for in the network model, self-focused rumination also presented as the most central bridge symptom between the two SLEs and depressive and anxiety symptoms. Our study provided novel evidence to suggest the potential for targeting this cognitive response style in future interventions for reducing depressive and anxiety symptoms in older adults, particularly amid ongoing stressors.

Keywords: rumination; repetitive negative thoughts; depression; anxiety; network analysis; old-age mental health

Introduction

Rumination is a form of perseverative cognition characterised by repetitive negative thoughts, typically involving a passive fixation on information related to the self but may also encompass information related to others, social situations, and life events[1,2]. While such experiences of excessive fixation on thoughts have been described as early as the 1800s in the forms of "*idee irresistible*"[3] and "*idees fixes*"[4], it was not until the proposition of the response styles theory in 1991 that the study of rumination, particularly in the context of major depression, has been revived in research and clinical practice[5].

According to the response styles theory, rumination is defined as an excessive attentional focus on one's depressive symptoms and their causes, meanings, and consequences—and the fact that one is depressed—which can interfere with problem-solving and contribute to depressive symptoms[5,6]. This form of rumination is also referred to as self-focused rumination. The *brooding* subtype, in particular, is defined as an abstract, overgeneralised, and less adaptive form of thinking that has consistently been shown to be more predictive of prospective symptoms, the onset and duration of major depressive episodes, and poorer treatment outcomes as compared with the more evaluative, concrete thinking style[7–9]. Existing studies have shown that this subtype of self-focused rumination is associated not only with depression but also with generalised anxiety disorder and other mental health problems[10,11]. Given its modifiable and transdiagnostic nature, intervention components targeting self-focused rumination have been viewed as an 'active ingredient' for reducing depression, anxiety, and their comorbidity[6,12].

To inform the design of more effective interventions, elucidating not only the role of rumination in mental health but also the factors that contribute to its development and maintenance is crucial. Although its content is predominantly self-related, theoretical models and empirical findings have shown that stressful life events (SLEs) could trigger ruminative thoughts about not only event-related information but also various aspects of one's life [10,13]. However, little is known about whether these relationships would differ depending on the type of personal SLEs experienced.

Life stressors have generally been distinguished into dependent SLEs, which are those that are at least partially the result of one's own characteristics or behaviours (e.g., conflicts with a friend); and independent SLEs, which are those entirely out of one's control (e.g., natural disasters)[14,15]. These two SLE types may be conceptualised as lying on a spectrum, ranging from being largely extrinsic and non-self-related at one end to largely self-related at the other. Studies have shown that people with a history of depression tend to experience more dependent-type SLEs, which subsequently contribute to elevated risks of recurrent depression (stress generation and stress sensitisation[16,17]), thereby forming a vicious stress–depression cycle[15]. It may be expected that dependent SLEs would exert a greater influence on self-focused rumination, and thereby increase symptom severity. In addition to testing this hypothesised association, whether independent SLEs would also contribute to self-focused rumination and how these two SLE types would similarly or differentially relate to depressive and generalised anxiety symptom dimensions remains to be investigated. This differentiation can be crucial both for advancing our understanding of the core phenomenology of the ruminative response style and symptoms of depression and anxiety, as well as for informing future interventions.

Despite the clinical significance of examining the roles of rumination and SLEs in mental health, existing studies have largely been focused on youth populations[18–20]. Indeed, epidemiological studies have consistently shown lower prevalences of depressive and anxiety disorders in older populations compared to their younger and middle-aged counterparts[21,22]. Nevertheless, their content has been shown to differ. For instance, older adults have been reported to have more worries about health and

the welfare of loved ones[23], as well as experience more symptoms of anhedonia and appetite loss[24]. Further, studies have suggested that older adults tend to engage in fewer ruminative thoughts[25,26], although their associations with depressive symptoms are comparable to those in other age groups[26]. At the same time, the types and frequency of SLEs also likely differ across the lifespan, with older adults generally reporting fewer SLEs but more ageing-related stressors (e.g., major health problems in self or others, the loss of significant others)[27,28]. As such, it currently remains unclear whether existing observations of the associations of rumination with mental health outcomes could be generalised to older adults. To the best of our knowledge, no study has examined the influences of SLEs on rumination in older adults and their associations with depressive and anxiety symptoms, respectively.

With mental disorders being increasingly viewed as complex systems characterised by mutually reinforcing networks of symptoms and psychological, biological, and sociocultural factors[29,30], the use of a network analysis approach will be helpful to determine further whether specific symptoms of depression and anxiety would be more reactive to external stressors, and whether rumination would serve as a bridge in these relationships. The aims of the present study were thus two-fold: (a) to elucidate the associations between dependent and independent SLEs and depressive and anxiety symptoms in a large community sample of older adults with mild-to-moderately severe depressive symptoms; and (b) to examine the role of self-focused rumination as a transdiagnostic factor in bridging these associations.

We hypothesised that both types of SLEs, particularly dependent SLEs, would be associated with heightened self-focused rumination, which would subsequently be associated with higher levels of depressive and anxiety symptoms. We further anticipated that dependent SLEs would exert greater influences on depressive and anxiety symptoms as compared with independent SLEs. Nevertheless, given that anxiety symptoms generally involve worries and fear about uncertain and uncontrollable events in the future, it is possible that independent stressors have a greater impact on anxiety vs. depressive symptoms. To confirm these patterns of associations, we aimed to test these hypotheses using both the traditional path model and the symptom network model.

Methods

Participants

Participants were new service users in Phase 3 of JC JoyAge. JoyAge is a territory-wide, community-based mental health stepped-care prevention and intervention service involving 48 district-based elderly service centres and integrated mental wellness centres across all 18 districts of Hong Kong, targeting older adults aged 60 years and older with mild to moderately severe depressive symptoms (operationalised as a score of 5–19 on the Patient Health Questionnaire–9-item [PHQ-9] [31]). Those with a known history of intellectual disability, autism spectrum disorders, bipolar disorder, schizophrenia-spectrum disorders, Parkinson's disease, or dementia were excluded. Meanwhile, those identified with imminent suicidal risk were referred to local hospital psychiatric services or given additional support following standard risk management protocols of the respective organisation.

Details of Phases 1 and 2 of the service have previously been described [32–34]. Phase 3 of JoyAge began on 1 January 2024. Aside from continued evaluation of community-based psychosocial interventions for older adults, the new service phase aims at examining the effectiveness of the service model for middle-aged adults aged 45–59 years across a few service units in the primary care setting. The findings of which are beyond the scope of the present study and will be reported elsewhere [35].

Given their high comorbidity [36], generalised anxiety symptoms were also included as a key outcome of the service. To further examine the present research question in Phase 3 of JoyAge, measures of rumination and SLEs were newly added to the intake assessment. Of 1950 older adults aged 60 years and older who joined the service from 1 January 2024 to 26 January 2025, 1869 (95.8%) provided information on rumination and SLEs. Of these participants, 1 had missing data on anxiety symptoms. Five of these participants (0.3%) had a PHQ-9 score ≥ 20 but were assessed as having no imminent risk and were thus retained. The final sample included was thus 1868 in the present study. All data analysed were collected in person at baseline by trained social workers, with ongoing monitoring by the research team.

Written informed consent was obtained from all participants, with ethics approval granted by the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (UW 20-246). All procedures contributing to this work complied with the Helsinki Declaration of 1975, as revised in 2013. We followed the STROBE guidelines in reporting the present study findings.

Measures

Self-focused rumination

Self-focused rumination was assessed using the brooding subscale of the Ruminative Response Scale (RRS-Brooding), which comprises five items capturing the more maladaptive form of repetitive negative thinking [5]. All items were rated on a 4-point Likert scale (from 1 "never to 4 "nearly all of the time") and summed to generate a composite measure of self-focused rumination frequency, with good reliability demonstrated in the present sample (α=0.87). The RRS-Brooding measure has been adopted in a previous population-representative study involving older adults in Hong Kong [37].

Personal stressful life events

Personal stressful life events (SLEs) during the past six months were assessed using the List of Threatening Experiences (LTE) checklist, which is among the most adopted measures of life events [38]. A total of 12 major categories of events is captured using a binary yes/no checklist format. Based on the original development of the LTE, five events were conceived to be 'dependent' SLEs (e.g., broke off a steady relationship, separation due to marital difficulties, major financial crisis), with seven 'independent' SLEs (e.g., serious illness/injury to self or a close relative, death of a first-degree relative or close friend). The number of total SLEs, as well as dependent and independent SLEs, was aggregated to reflect 0, 1, 2, or ≥3, respectively. The Chinese version of the LTE has been adopted in community samples in Hong Kong [39], including in older adults [40].

Depressive and anxiety symptoms

Depressive and anxiety symptoms during the past two weeks were assessed using the 9-item Patient Health Questionnaire (PHQ-9) [31] and the 7-item Generalised Anxiety Disorder Scale (GAD-7) [41], respectively. Both scales are widely adopted in routine care settings and are publicly available for assessment and treatment planning. Items on the PHQ-9 and GAD-7 correspond to symptoms of major depressive disorder and generalised anxiety disorder under the DSM framework. All items are rated on a 4-point Likert scale (from 0 "not at all" to 3 "nearly every day") and summed to reflect overall symptom severity. Both measures are widely adopted, including in prior studies that used the symptom network approach, and have been validated in the general population of Hong Kong [42,43] and among Chinese older adults [44,45].

Sociodemographics and prior diagnosis

Sex (male/female), age (in years), marital status, education level, and any diagnosis of major depressive disorder or anxiety disorder. The six response options provided for assessing marital status were collapsed into two levels, namely single, separated, divorced, or widowed, and married or cohabited. Education level was defined as having no formal education, primary or below, secondary, or tertiary or above.

Statistical analysis

All analyses were carried out using *R*. Descriptive statistics of variables were first generated. Prior to applying path and network analyses, a series of correlation analyses was conducted to examine the general pattern of associations among the variables of interest.

Path analysis

The *lavaan* package was used for the path analysis. Bias-corrected and accelerated 95% confidence intervals (CIs) were generated with 5000 bootstrapped samples to test the hypothesised indirect effects of self-focused rumination, wherein CIs without overlapping a value of zero represent statistical significance. The model fit was evaluated using the following indices: comparative fit index (CFI)≥0.95, root mean squared error of approximation (RMSEA)≤0.05, and standardised root mean squared residual (SRMR)≤0.08[46,47]. Sex, age, marital status, education level, and any major depressive disorder/anxiety disorder diagnosis were adjusted for. Standardised coefficients with their standard errors were reported for the path coefficients, while unstandardised coefficients, standard errors, and 95% CIs were reported to reflect indirect effects.

Network analysis

A network model was then constructed with all individual symptoms of depression and anxiety included. All variables are referred to as "nodes". Meanwhile, the associations between two nodes are referred to as "edges", which reflect conditional independence associations (or partial correlations) whilst accounting for all other nodes and associations within the network.

Network estimation

As our main interest was in the overall network structure and inter-associations among the variables, we estimated an undirected, weighted network using regularised Graphical Gaussian Models (GGM) with the package *bootnet*[48]. The graphical least absolute shrinkage and selection operator (LASSO) algorithm was applied in combination with Extended Bayesian Information Criterion (EBIC) model selection for network estimation (hypertuning parameter set to 0.5), wherein parameters are estimated using the penalised maximum likelihood estimation method. This *EBICglasso* algorithm is among the more widely adopted procedures for network estimation using non-binary psychological and psychiatric data[49–51]. Weak edges are shrunk to zero to reduce the number of spurious edges, thereby yielding a more parsimonious network structure[48]. Spearman correlations were used to account for the non-normal distribution of individual symptom data. The package *qgraph*[52] was used to visualise the network structure. The layout of the network follows the Fruchterman and Reingold algorithm[53], in which nodes with stronger and more connected edges are placed closer to the centre of the network and closer to one another, with thicker lines reflecting stronger edges.

Centrality analysis

To examine the relative importance of each node, we computed node *strength*[54] and *expected influence* (EI)[55] as the main centrality indices. Previous work has shown that node *strength*, defined as the absolute sum of edge weights of all direct connections between one node and all other nodes, is a more robust index as compared with two other common indices, namely *betweenness* and *closeness* (the findings of which are in **Supplementary Material**) [48]. We additionally computed one-step EI[55],

which is similar to node strength except that positive/negative values of individual edges are also accounted for (for instance, negative edges would increase a node's strength but reduce its EI, which is in line with the interpretation of positive and negative associations being reflective of increased and reduced symptom activation, respectively[55,56]).

To test the hypothesised role of self-focused rumination as a bridging factor, the bridge centrality of all nodes was also investigated using the package *networktools* [56], which is a more reliable approach than visual inspection of network structures. Bridge strength and EI were computed, which reflect a node's overall connectivity with nodes in other communities in the network without and with consideration of positive/negative values of edges [56].

Network stability

Accuracy and stability tests were applied to examine network robustness using the *bootnet* package[48]. Non-parametric bootstrapping with 1000 samples was performed to generate 95% CIs of edge weights to test the stability of edge weights, while a case-drop bootstrapping procedure was applied to test the stability of centrality measures. The correlation stability coefficient (CS-C) was generated to evaluate the stability of node and bridge centrality, which reflects the maximum proportion of cases that can be dropped to maintain a correlation of 0.7 or above in the centrality indices between the original and case-subset networks with 95% probability. A CS-C of ≥0.50 is recommended[48]. Bootstrapped difference tests were applied to investigate the extent to which the edges and centrality estimates significantly differed from one another.

Community detection

Community detection of nodes in the network was examined using the *CliquePercolation* package [57]. The Clique Percolation method is one of the few community detection algorithms that allows nodes to belong to more than one community, which is particularly relevant in the study of psychopathology [58,59]. Community detection using this method was performed by optimising values of *k* (the minimum clique size) and *I* (the strength of the average relations among nodes in a community) (see Lange, 2022 for more detail [57]). With the algorithm applied at *k* values of 3 to 5 and *I* values of 0.04 to 0.01 in steps of 0.005, the optimal values identified for the weighted network were *k*=4 and *I*=0.075.

Sensitivity analysis

As JoyAge was designed for older adults with mild-to-moderately severe depressive symptoms, a proportion of participants presented very minimal anxiety symptoms. As a sensitivity analysis, we performed a subgroup analysis in those with mild or above levels of generalised anxiety symptoms (GAD-7 ≥ 5).

According to the network theory of psychopathology, stronger network connectivity is posited to result in greater symptom spread and, in turn, the emergence and maintenance of psychopathology [60]. We therefore also investigated differences in the patterns of associations between SLEs, self-focused rumination, and both symptom dimensions between those with no-to-mild symptoms (PHQ-9 < 10 and GAD-7 < 10) and those with elevated symptoms (PHQ-9 ≥ 10 or GAD-7 ≥ 10) using the Network Comparison Test [61]. Lastly, given the large proportion of female participants in this study, we conducted supplementary analyses to examine possible gender differences in the network structures between a subset of 316 female participants and the 316 male participants.

Results

Table 1 provides the sample characteristics. The sample had a mean age of 73.4 years (SD=7.9) and comprised 83.1% (n=1552) females. 44.6% were married or cohabited and 86.9% (n=1623) had at least a primary level of education or above. 23.9% (n=447) of them received a diagnosis of major

depressive disorder or anxiety disorder. Details of symptom severity on each PHQ-9 and GAD-7 item are provided in **Supplementary Table S1**. Female participants were more likely than males to have a lower education level, not be married or cohabited, and show more severe anxiety symptoms than males, while gender differences were observed in depressive symptom severity, levels of self-focused rumination, and the number of SLEs (see **Supplementary Table S2**).

In the whole sample, overall SLEs, as well as both dependent and independent SLEs, were associated with higher levels of self-focused rumination, depressive symptoms, and anxiety symptoms (r=0.18–0.20; r=0.17–0.19, and r=0.11–0.15, respectively), all $p < 0.001$ (see **Supplementary Table S1**). Self-focused rumination also showed moderate positive associations with depressive symptoms (r=0.35) and anxiety symptoms (r=0.53), both $p < 0.001$.

Table 1. Sample characteristics

	Whole sample (n=1868)
	mean (SD) / n (%)
Female sex, n (%)	1552 (83.1%)
Age	73.4 (7.9)
Marital status, n (%)	
Single/Separated/Divorced/Widowed	1034 (55.4%)
Married/Cohabited	834 (44.6%)
Education level	
No formal education	245 (13.1%)
Primary or below	695 (37.2%)
Secondary	762 (40.8%)
Tertiary or above	166 (8.9%)
Has a depression/anxiety diagnosis	447 (23.9%)
Stressful life events (LTE)	0.58 (0.85)
Dependent SLEs	0.18 (0.49)
Independent SLEs	0.42 (0.68)
Self-focused rumination (RRS–Brooding)	4.43 (3.41)
Depressive symptoms (PHQ-9)	9.66 (3.55)
None (0–4)	0 (0%)
Mild (5–9)	962 (51.5%)
Moderate or above (≥10)	906 (48.5%)
Anxiety symptoms (GAD-7)	6.99 (4.69)
None (0–4)	631 (33.8%)
Mild (5–9)	724 (38.8%)
Moderate or above (≥10)	513 (27.5%)

Note. GAD-7=7-item Generalized Anxiety Disorder scale; LTE=List of Threatening Experiences; PHQ-9=9-item Patient Health Questionnaire; RRS=Ruminative Responses Scale; SLEs=stressful life events.

Path model

In the path model without self-focused rumination, significant direct associations were observed between dependent SLEs and both symptom dimensions (depressive: β=0.15, SE=0.17; anxiety: β=0.11, SE=0.25; both $p < 0.001$). Significant direct associations were observed between independent SLEs and anxiety symptoms (β=0.11, SE=0.17, $p < 0.001$), with weak associations observed with depressive symptoms (β=0.05, SE=0.13, p=0.032). Fit indices indicated acceptable model fit: CFI=0.93, RMSEA=0.06, SRMR=0.04.

With self-focused rumination included in the model (**Figure 1**), both types of SLEs were directly associated with rumination (dependent SLEs: β=0.15, SE=0.18; independent SLEs: β=0.08, SE=0.12), which was in turn associated with both depressive (β=0.30, SE=0.02) and anxiety (β=0.48, SE=0.03) symptoms, all $p < 0.001$. Meanwhile, dependent SLEs remained directly associated with depressive symptoms (β=0.11, SE=0.17, $p < 0.001$) but not anxiety symptoms (β=0.04, SE=0.21, p=0.091), and independent SLEs remained directly associated with anxiety symptoms (β=0.07, SE=0.14, p=0.001) but not depressive symptoms (β=0.03, SE=0.11, p=0.21). In this model, self-focused rumination explained 29.5% and 64.8% of the variance in the relationships between dependent SLEs and depressive and anxiety symptoms (B=0.32, SE=0.06, CI=0.20–0.45; B=0.67, SE=0.12, CI=0.44–0.91), and 47.9% and 37.7% of the variance in the relationships between independent SLEs and depressive and anxiety symptoms (B=0.13, SE=0.04, CI=0.05–0.21; B=0.27, SE=0.08, CI=0.12–0.43), respectively. Improved model fit was observed: CFI=0.96, RMSEA=0.05 (90% CI=0.04–0.06), SRMR=0.04. Similar findings were observed in those with mild or above levels of anxiety symptoms (**Supplementary Figure S1**).

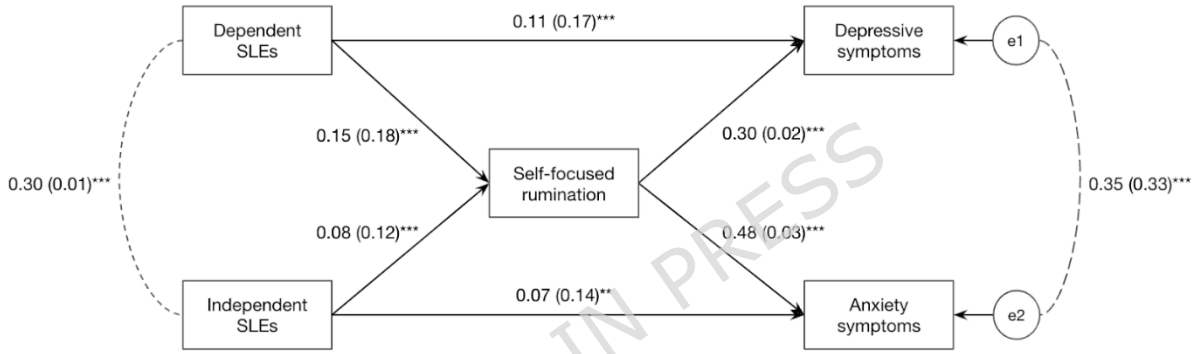


Figure 1. Path analysis with self-focused rumination as a factor linking two types of stressful life events to depressive and anxiety symptoms

Note. Standardised coefficients are presented, with standard errors in parentheses. Paths not statistically significant at the p < 0.05 level are not presented. SLEs=stressful life events.

** $p < 0.01$, *** $p < 0.001$

Network structure

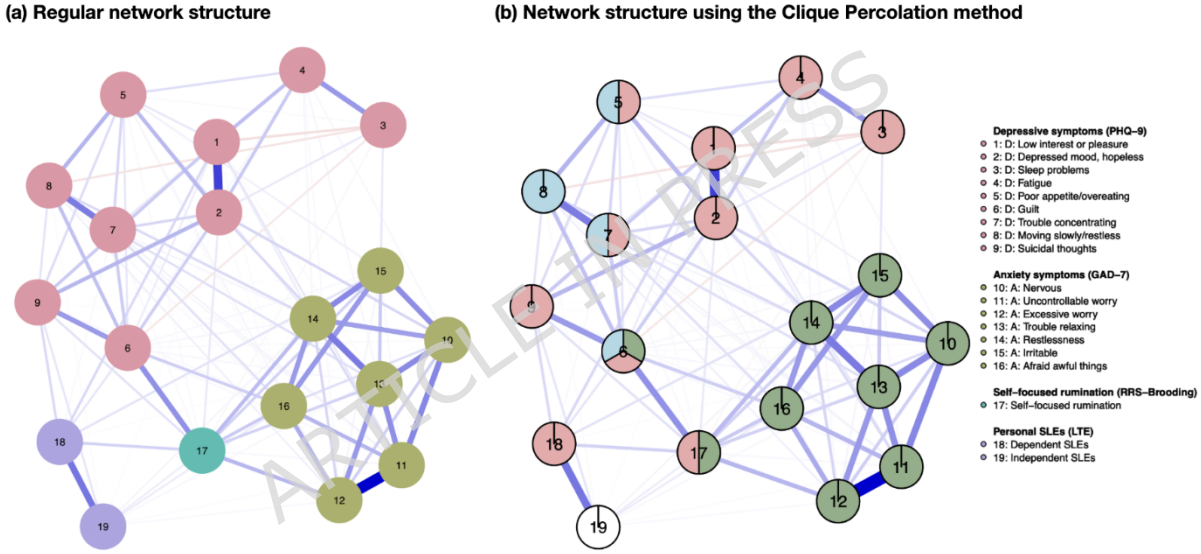
The network structure is shown in **Figure 2**. Results of the network stability and accuracy tests are presented in **Supplementary Figures S2–5**. 36.8% of all edges (63/171) were set to zero when both dependent and independent SLEs, self-focused rumination, and all symptoms were accounted for. Overall, the strongest edges observed were within-symptom domain: uncontrollable worry (GAD11) and excessive worry (GAD12) (edge weight=0.41), followed by anhedonia (PHQ1) and depressed mood (PHQ2) (edge weight=0.31). Both of these edge pairs were significantly stronger than the majority of other edges in the network (see **Supplementary Material**). Regarding cross-domain associations in the regular network structure (**Figure 2a**), the strongest edge pair was self-focused rumination and guilt (PHQ6) (edge weight=0.18), followed by excessive worry (GAD12) and restlessness (GAD14) (edge weight=0.11 for both).

Interestingly, the additional use of the Clique Percolation method revealed three communities reflective of (i) depressive symptoms–emotional and neurocognitive; (ii) depressive symptoms–neurovegetative; and (iii) anxiety symptoms (**Figure 2b**). Self-focused rumination was assigned to two communities (*depressive symptoms–emotional and neurocognitive,* and *anxiety symptoms*), while

guilt was assigned to all three communities. Dependent SLEs were assigned to *depressive symptoms–emotional and neurocognitive* community, while independent SLEs were an isolated node and were not assigned to any community. These observations were also in line with findings from the centrality analysis, which showed that self-focused rumination was among the most central bridge nodes, followed by guilt, while restlessness was among the most central nodes (**Figure 3**). Centrality plots for betweenness and closeness are given in **Supplementary Figure S6**.

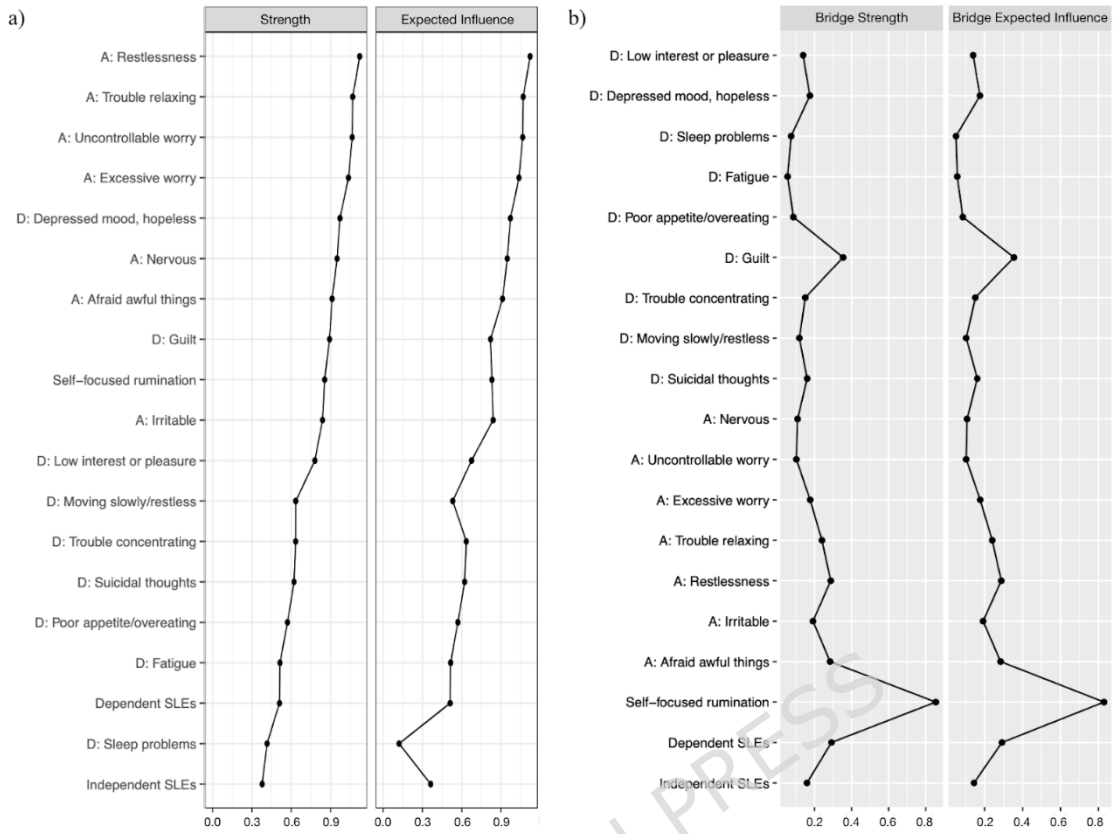
Similar to findings from the path models, relatively more edges were retained among individual depressive symptoms and dependent SLEs (44.4%) than independent SLEs (11.1%), whilst more edges were retained among individual anxiety symptoms and independent SLEs (71.4%) than dependent SLEs (14.3%) (**Supplementary Table S4**). The associations between dependent and independent SLEs and self-focused rumination were maintained in the network (edge weights=0.07 and 0.03, respectively). As in the path model, the network structure was similar in the subgroup with mild or above anxiety symptoms (**Supplementary Figures S7–11**).

Figure 2. Network structure of dependent and independent stressful life events, self-focused rumination, and symptoms of depression and anxiety



Note. (a) Regular network structure of dependent and independent SLEs, self-focused rumination, and individual symptoms of depression and anxiety using PHQ-9 and GAD-7 items, respectively, and (b) using the Clique Percolation method. Nodes with stronger and more connected edges are placed closer to the centre of the network. Thicker lines in the network reflect stronger edges (associations between two nodes). Blue lines reflect positive edges, while red lines reflect negative edges. GAD-7=7-item Generalized Anxiety Disorder scale; LTE=List of Threatening Experiences; PHQ-9=9-item Patient Health Questionnaire; RRS=Ruminative Responses Scale; SLEs=stressful life events.

Figure 3. Node and bridge centrality of the Dependent-Independent SLEs–Rumination–Symptom network



Note. Centrality plots depicting the (a) strength and expected influence, as well as (b) bridge strength and expected influence, of each node in the network structure. SLEs=stressful life events. CS-C=0.75 for all four centrality indices.

Sensitivity analysis

Additional network analyses were conducted to examine any differences in the symptom networks between those with no-to-mild and elevated depressive or anxiety symptoms (**Supplementary Figures S12–17**). Results showed significant differences in network structures between the two symptom severity groups (M=0.20, p=0.010). A more detailed investigation revealed that 22 edge-pairs showed significant differences between the two groups. Specifically, stronger edge-weights within the same symptom dimension were found in the elevated symptom group (e.g., anhedonia–suicidal [0.09 vs 0.00, p=0.040], excessive worry–restlessness [0.11 vs 0.01, p=0.020]), while stronger edge-weights across symptom dimensions were found in the no-to-mild symptom group (e.g., depressed mood–nervousness [0.08 vs 0.00, p=0.050]). There was also a trend of stronger edge-weight between guilt and self-focused rumination among those with elevated symptoms (0.19 vs 0.11), p=0.050. These findings are detailed in **Supplementary Table S4**. No significant difference was found in the global strength of the two networks (5.00 *vs* 5.42; S=0.42, p=0.28). There were also no gender differences in the structure (M=0.19, p=0.39) and global strength (7.04 vs 6.95; S=0.09, p=0.87) of the two networks (**Supplementary Figures S18–22**).

Discussion

While the role of rumination in depressive and anxiety symptoms is well-established, little has yet been done to examine the factors that contribute to this response style and its consequences in an older adult population. Despite previous work having suggested a higher rumination tendency among young

people[25,26], our findings highlighted its significance in depressive and anxiety symptoms among older adults. Importantly, using both traditional path analysis and the symptom network approach, we demonstrated that self-focused rumination is a core transdiagnostic factor linking major life stressors to both symptom dimensions. The findings suggest that targeting self-focused rumination in future interventions may help reduce internalising symptoms in older adults, particularly in the current context of increasing stress

The role of rumination in overall SLEs and both depressive and anxiety symptom dimensions has been reported in previous adolescent-based studies[10]. In explaining their interrelationships, researchers have suggested that SLEs might trigger ruminative thoughts not limited to details of the event but also information related to one's personality, behaviours, and symptoms (e.g., "Why do I always react this way?"). By differentiating between the two types of SLEs in our present study, we added to this perspective by showing that dependent SLEs play a more prominent role in the manifestation of self-focused rumination as compared with the independent-type. It is thus possible that the association observed between overall SLEs and self-focused rumination may be, to a great extent, explained by the more self-related, dependent-type SLEs. Indeed, earlier work has suggested that about one-third of the association between SLEs and depression onset is non-causal and is better explained by dependent stressors [15]. Similar to the view of ideas of reference in psychotic experiences being reflective of "distinct degrees on a continuum of different possible balances of intrinsic cognitive and extrinsic environmental factors" [62,63], the phenomenological processes underlying rumination might be similar, with self-focused and event-based rumination lying at the two ends of a continuum. A more in-depth study into the different subtypes of rumination, their vulnerability factors, and their associated outcomes would provide a more comprehensive understanding of how the interplay between biological, psychological, and social factors affects mental health[62].

Using a network approach, we showed the specific symptom-level association among the variables beyond generic composite symptom scores. With all symptoms accounted for, self-focused rumination appeared to be most strongly linked to feelings of guilt, which was then connected to the rest of the depressive symptom cluster. Notably, while self-focused rumination was found to belong to both depressive (emotional and neurocognitive) and anxiety symptom communities, guilt was the only node that additionally belonged to the depressive (neurovegetative) community. Guilty feelings have previously been shown to be related to elevated rumination[64] and can be a content of ruminative thoughts[65]. Given the close associations between guilt and suicidal thoughts, reducing rumination can have important implications for mental health and suicide prevention and intervention work. Relatively strong links were observed between self-focused rumination and worries in the anxiety symptom cluster, as expected. While rumination and worries are viewed as differing in their content (e.g., focus on past events *vs* future events)[1], the two cognitive processes are generally referred to as repetitive negative thinking or perseverative cognitions and are both underpinned by attentional, interpretative, and memory biases[6,20]. While worries were captured as part of the GAD-7, worry-specific measures[66] may be considered in the future to elucidate distinctions between rumination and worry and test the pathways from the two types of SLEs to depression and anxiety symptom outcomes, respectively.

Despite the high degrees of overlap and comorbidity between depressive and anxiety symptoms[67], our study shed light on some potential distinctions between the two. This topic has, in fact, long been an area of discussion[68]. While it may be expected that dependent stressors play a more prominent role in depressive symptoms[15–17], our findings appear to suggest that anxiety symptoms may be more reactive to external influences that are entirely out of one's control. It is possible that the lack (or loss) of perceived controllability over events may contribute to a sense of uncertainty about the future, and in

turn, worries and fear that something bad might happen. Indeed, we identified one study which found more dependent stressors among adolescents with pure depression (*vs* pure anxiety disorder) [69]. To the best of our knowledge, no study has yet examined the differential associations between two types of stressors and the two symptom dimensions, or their underlying mechanisms. The present findings thus provided a novel perspective towards some overlapping yet distinct pathways to depressive and anxiety symptoms, which is crucial for further exploration in future longitudinal studies to advance understanding of the phenomenology of the two symptom dimensions and improve person-specific interventions.

Strengths and limitations

Whilst previous work has examined the pathways from external stressors to psychiatric symptoms[70] and the role of rumination as a central symptom between mental health domains[71], a major strength of the present study was the use of a large community sample of older adults to examine the role of rumination in relation to different types of external events and two common internalising symptoms in a single network model. The use of two complementary methodological approaches, alongside the consistent findings across the sensitivity analyses, provided further evidence supporting self-focused rumination as a robust bridging factor between external factors and internalising symptoms. This observation has important clinical implications.

Emerging evidence suggests that, by targeting rumination as an underlying process, both mindfulness-based cognitive therapy[72] and metacognitive training[73] are effective in reducing depressive symptoms among older adults. WhWhile rumination-focused cognitive-behavioural therapy has been shown to be effective in reducing rumination and improving mental health outcomes among young and middle-aged adults [9,74], whether it could also be adapted to target older adults remains to be further investigated. Future work may continue to build on these findings to examine the efficacy of rumination-focused interventions for older adults with heightened mood symptoms. Separately, a recent study has demonstrated the efficacy of a personalised depression prevention programme in reducing the experience of dependent stressors[75], which may be a plausible approach to weakening the stressor–depression loop and reducing depressive symptoms. While independent stressors may not be entirely preventable, supporting people in developing more adaptive cognitive, behavioural, or emotional approaches in the face of stressful life events beyond engaging in rumination or worry could be helpful.

Aside from these strengths, the present findings should be interpreted in light of several limitations and considerations. First, as in other studies on mental health services (**ref**), the sample presented to the JoyAge service was predominantly female, which might have been due to lower help-seeking intention and lower preference for emotional disclosure commonly reported in males[74]. While our exploratory analyses revealed no clear differences between genders in depressive symptoms, self-focused rumination, and the number of SLEs experienced, as well as in their network structures, female participants in our sample presented more severe generalised anxiety symptoms. Further, older men have consistently shown leading rates of suicide deaths [78]. As such, the extent to which the present findings can be generalised to a larger male population needs to be further investigated. Replicating the present research questions in other populations with more balanced gender ratios may inform more targeted intervention strategies in future services. Second, the use of a dimensional approach to evaluating the degree of dependence (e.g., with events rated by interviewers on a 4-point scale from “clearly dependent” to “clearly independent” [15]) may help further conceptualise life events on an intrinsic–extrinsic continuum of experiences. It is also possible that older adults experience more independent SLEs (e.g., health problems, loss of a significant other) as compared with young people. Testing the replicability of our findings in other age groups is crucial to determining the

validity of the postulated differences in the roles of dependent and independent SLEs and the nature of depressive and anxiety symptomatology. We also note that temporal precedence could not be established using a cross-sectional design. As shown in previous research, people with depression are more likely to encounter SLEs, particularly the dependent type [16]. It is thus possible that the associations we observed in the present study could be bi-directional in nature. While this was partially addressed in the network analysis, using a longitudinal study design to test our current hypotheses is recommended in future studies.

Lastly, we note that the study focused solely on self-focused rumination. Our previous work has demonstrated the significance of rumination *about* personal and population-level stressful events on a range of mental health problems[63,65]. The degree of overlap between self-focused and event-based rumination, their links to dependent and independent stressors, their implications for different mental health outcomes, as well as the effectiveness of interventions in reducing these two types of rumination, warrants further investigation.

Rumination is a crucial cognitive process capable of perpetuating the experience of depressive and anxiety symptoms and linking varying types of external influences to mental health states, including in older adults. Our findings suggest the need for expanding existing research and clinical practice to target ruminative experiences in the older adult population. The specificity of stress reactivity observed in depressive and anxiety symptom dimensions has theoretical and clinical implications and may be further explored in future work.

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Author Contributions
S.M.Y.W. conceived the study, while S.M.Y.W. and M.H.C.I. conducted the literature review and data analyses. All authors interpreted the findings. S.M.Y.W. and M.H.C.I. wrote the first draft of the manuscript, while D.K.Y.L., W.C.C., G.H.Y.W., and T.Y.S.L. provided comments and suggestions. All authors contributed to the revision of the manuscript and approved its final version. All authors accept responsibility for submitting the manuscript for publication.

Data Availability
De-identified data can be made available upon reasonable request and should be directed to the corresponding author.

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Declaration of Interest
The authors report no conflict of interest.

Transparency Declaration
The lead author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported and that no important aspects of the study have been omitted.

Original Article

Self-focused rumination links stressful events to depressive and anxiety symptoms in older adults with depressive symptoms: path and network analyses

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Abstract

Self-focused rumination, defined as an excessive attentional focus on one's depressive symptoms and their causes, meanings, and consequences, is well-established for its role in the onset and maintenance of depressive and anxiety symptoms. However, it remains unclear how this cognitive style can be manifested in older adults and how it might bridge the influences of different stressful life events (SLEs) namely dependent SLEs (partially attributable to one's behaviours) and independent SLEs (entirely beyond personal control), with the two symptom dimensions. Data were from 1868 community-dwelling older adults (mean age=73.4; 83.1% female) as part of a territory-wide stepped-care intervention in Hong Kong for those with mild-to-moderately severe depressive symptoms (Patient Health Questionnaire–9=5–19). We investigated whether self-focused rumination would link dependent and independent SLEs to depressive and anxiety symptoms using both path and network analyses. In the path model, both SLE types were associated with self-focused rumination. Dependent SLEs were directly associated only with depressive symptoms, while independent SLEs were directly associated only with anxiety symptoms. Self-focused rumination linked SLEs on both symptom dimensions. With all symptoms accounted for in the network model, self-focused rumination also presented as the most central bridge symptom between the two SLEs and depressive and anxiety symptoms. Our study provided novel evidence to suggest the potential for targeting this cognitive response style in future interventions for reducing depressive and anxiety symptoms in older adults, particularly amid ongoing stressors.

Keywords: rumination; repetitive negative thoughts; depression; anxiety; network analysis; old-age mental health

Introduction

Rumination is a form of perseverative cognition characterised by repetitive negative thoughts, typically involving a passive fixation on information related to the self but may also encompass information related to others, social situations, and life events[1,2]. While such experiences of excessive fixation on thoughts have been described as early as the 1800s in the forms of "*idee irresistible*"[3] and "*idees fixes*"[4], it was not until the proposition of the response styles theory in 1991 that the study of rumination, particularly in the context of major depression, has been revived in research and clinical practice[5].

According to the response styles theory, rumination is defined as an excessive attentional focus on one's depressive symptoms and their causes, meanings, and consequences—and the fact that one is depressed—which can interfere with problem-solving and contribute to depressive symptoms[5,6]. This form of rumination is also referred to as self-focused rumination. The *brooding* subtype, in particular, is defined as an abstract, overgeneralised, and less adaptive form of thinking that has consistently been shown to be more predictive of prospective symptoms, the onset and duration of major depressive episodes, and poorer treatment outcomes as compared with the more evaluative, concrete thinking style[7–9]. Existing studies have shown that this subtype of self-focused rumination is associated not only with depression but also with generalised anxiety disorder and other mental health problems[10,11]. Given its modifiable and transdiagnostic nature, intervention components targeting self-focused rumination have been viewed as an 'active ingredient' for reducing depression, anxiety, and their comorbidity[6,12].

To inform the design of more effective interventions, elucidating not only the role of rumination in mental health but also the factors that contribute to its development and maintenance is crucial. Although its content is predominantly self-related, theoretical models and empirical findings have shown that stressful life events (SLEs) could trigger ruminative thoughts about not only event-related information but also various aspects of one's life [10,13]. However, little is known about whether these relationships would differ depending on the type of personal SLEs experienced.

Life stressors have generally been distinguished into dependent SLEs, which are those that are at least partially the result of one's own characteristics or behaviours (e.g., conflicts with a friend); and independent SLEs, which are those entirely out of one's control (e.g., natural disasters)[14,15]. These two SLE types may be conceptualised as lying on a spectrum, ranging from being largely extrinsic and non-self-related at one end to largely self-related at the other. Studies have shown that people with a history of depression tend to experience more dependent-type SLEs, which subsequently contribute to elevated risks of recurrent depression (stress generation and stress sensitisation[16,17]), thereby forming a vicious stress–depression cycle[15]. It may be expected that dependent SLEs would exert a greater influence on self-focused rumination, and thereby increase symptom severity. In addition to testing this hypothesised association, whether independent SLEs would also contribute to self-focused rumination and how these two SLE types would similarly or differentially relate to depressive and generalised anxiety symptom dimensions remains to be investigated. This differentiation can be crucial both for advancing our understanding of the core phenomenology of the ruminative response style and symptoms of depression and anxiety, as well as for informing future interventions.

Despite the clinical significance of examining the roles of rumination and SLEs in mental health, existing studies have largely been focused on youth populations[18–20]. Indeed, epidemiological studies have consistently shown lower prevalences of depressive and anxiety disorders in older populations compared to their younger and middle-aged counterparts[21,22]. Nevertheless, their content has been shown to differ. For instance, older adults have been reported to have more worries about health and

the welfare of loved ones[23], as well as experience more symptoms of anhedonia and appetite loss[24]. Further, studies have suggested that older adults tend to engage in fewer ruminative thoughts[25,26], although their associations with depressive symptoms are comparable to those in other age groups[26]. At the same time, the types and frequency of SLEs also likely differ across the lifespan, with older adults generally reporting fewer SLEs but more ageing-related stressors (e.g., major health problems in self or others, the loss of significant others)[27,28]. As such, it currently remains unclear whether existing observations of the associations of rumination with mental health outcomes could be generalised to older adults. To the best of our knowledge, no study has examined the influences of SLEs on rumination in older adults and their associations with depressive and anxiety symptoms, respectively.

With mental disorders being increasingly viewed as complex systems characterised by mutually reinforcing networks of symptoms and psychological, biological, and sociocultural factors[29,30], the use of a network analysis approach will be helpful to determine further whether specific symptoms of depression and anxiety would be more reactive to external stressors, and whether rumination would serve as a bridge in these relationships. The aims of the present study were thus two-fold: (a) to elucidate the associations between dependent and independent SLEs and depressive and anxiety symptoms in a large community sample of older adults with mild-to-moderately severe depressive symptoms; and (b) to examine the role of self-focused rumination as a transdiagnostic factor in bridging these associations.

We hypothesised that both types of SLEs, particularly dependent SLEs, would be associated with heightened self-focused rumination, which would subsequently be associated with higher levels of depressive and anxiety symptoms. We further anticipated that dependent SLEs would exert greater influences on depressive and anxiety symptoms as compared with independent SLEs. Nevertheless, given that anxiety symptoms generally involve worries and fear about uncertain and uncontrollable events in the future, it is possible that independent stressors have a greater impact on anxiety vs. depressive symptoms. To confirm these patterns of associations, we aimed to test these hypotheses using both the traditional path model and the symptom network model.

Methods

Participants

Participants were new service users in Phase 3 of JC JoyAge. JoyAge is a territory-wide, community-based mental health stepped-care prevention and intervention service involving 48 district-based elderly service centres and integrated mental wellness centres across all 18 districts of Hong Kong, targeting older adults aged 60 years and older with mild to moderately severe depressive symptoms (operationalised as a score of 5–19 on the Patient Health Questionnaire–9-item [PHQ-9] [31]). Those with a known history of intellectual disability, autism spectrum disorders, bipolar disorder, schizophrenia-spectrum disorders, Parkinson's disease, or dementia were excluded. Meanwhile, those identified with imminent suicidal risk were referred to local hospital psychiatric services or given additional support following standard risk management protocols of the respective organisation.

Details of Phases 1 and 2 of the service have previously been described [32–34]. Phase 3 of JoyAge began on 1 January 2024. Aside from continued evaluation of community-based psychosocial interventions for older adults, the new service phase aims at examining the effectiveness of the service model for middle-aged adults aged 45–59 years across a few service units in the primary care setting. The findings of which are beyond the scope of the present study and will be reported elsewhere [35].

Given their high comorbidity [36], generalised anxiety symptoms were also included as a key outcome of the service. To further examine the present research question in Phase 3 of JoyAge, measures of rumination and SLEs were newly added to the intake assessment. Of 1950 older adults aged 60 years and older who joined the service from 1 January 2024 to 26 January 2025, 1869 (95.8%) provided information on rumination and SLEs. Of these participants, 1 had missing data on anxiety symptoms. Five of these participants (0.3%) had a PHQ-9 score ≥ 20 but were assessed as having no imminent risk and were thus retained. The final sample included was thus 1868 in the present study. All data analysed were collected in person at baseline by trained social workers, with ongoing monitoring by the research team.

Written informed consent was obtained from all participants, with ethics approval granted by the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (UW 20-246). All procedures contributing to this work complied with the Helsinki Declaration of 1975, as revised in 2013. We followed the STROBE guidelines in reporting the present study findings.

Measures

Self-focused rumination

Self-focused rumination was assessed using the brooding subscale of the Ruminative Response Scale (RRS-Brooding), which comprises five items capturing the more maladaptive form of repetitive negative thinking [5]. All items were rated on a 4-point Likert scale (from 1 "never to 4 "nearly all of the time") and summed to generate a composite measure of self-focused rumination frequency, with good reliability demonstrated in the present sample (α=0.87). The RRS-Brooding measure has been adopted in a previous population-representative study involving older adults in Hong Kong [37].

Personal stressful life events

Personal stressful life events (SLEs) during the past six months were assessed using the List of Threatening Experiences (LTE) checklist, which is among the most adopted measures of life events [38]. A total of 12 major categories of events is captured using a binary yes/no checklist format. Based on the original development of the LTE, five events were conceived to be 'dependent' SLEs (e.g., broke off a steady relationship, separation due to marital difficulties, major financial crisis), with seven 'independent' SLEs (e.g., serious illness/injury to self or a close relative, death of a first-degree relative or close friend). The number of total SLEs, as well as dependent and independent SLEs, was aggregated to reflect 0, 1, 2, or ≥3, respectively. The Chinese version of the LTE has been adopted in community samples in Hong Kong [39], including in older adults [40].

Depressive and anxiety symptoms

Depressive and anxiety symptoms during the past two weeks were assessed using the 9-item Patient Health Questionnaire (PHQ-9) [31] and the 7-item Generalised Anxiety Disorder Scale (GAD-7) [41], respectively. Both scales are widely adopted in routine care settings and are publicly available for assessment and treatment planning. Items on the PHQ-9 and GAD-7 correspond to symptoms of major depressive disorder and generalised anxiety disorder under the DSM framework. All items are rated on a 4-point Likert scale (from 0 "not at all" to 3 "nearly every day") and summed to reflect overall symptom severity. Both measures are widely adopted, including in prior studies that used the symptom network approach, and have been validated in the general population of Hong Kong [42,43] and among Chinese older adults [44,45].

Sociodemographics and prior diagnosis

Sex (male/female), age (in years), marital status, education level, and any diagnosis of major depressive disorder or anxiety disorder. The six response options provided for assessing marital status were collapsed into two levels, namely single, separated, divorced, or widowed, and married or cohabited. Education level was defined as having no formal education, primary or below, secondary, or tertiary or above.

Statistical analysis

All analyses were carried out using *R*. Descriptive statistics of variables were first generated. Prior to applying path and network analyses, a series of correlation analyses was conducted to examine the general pattern of associations among the variables of interest.

Path analysis

The *lavaan* package was used for the path analysis. Bias-corrected and accelerated 95% confidence intervals (CIs) were generated with 5000 bootstrapped samples to test the hypothesised indirect effects of self-focused rumination, wherein CIs without overlapping a value of zero represent statistical significance. The model fit was evaluated using the following indices: comparative fit index (CFI)≥0.95, root mean squared error of approximation (RMSEA)≤0.05, and standardised root mean squared residual (SRMR)≤0.08[46,47]. Sex, age, marital status, education level, and any major depressive disorder/anxiety disorder diagnosis were adjusted for. Standardised coefficients with their standard errors were reported for the path coefficients, while unstandardised coefficients, standard errors, and 95% CIs were reported to reflect indirect effects.

Network analysis

A network model was then constructed with all individual symptoms of depression and anxiety included. All variables are referred to as "nodes". Meanwhile, the associations between two nodes are referred to as "edges", which reflect conditional independence associations (or partial correlations) whilst accounting for all other nodes and associations within the network.

Network estimation

As our main interest was in the overall network structure and inter-associations among the variables, we estimated an undirected, weighted network using regularised Graphical Gaussian Models (GGM) with the package *bootnet*[48]. The graphical least absolute shrinkage and selection operator (LASSO) algorithm was applied in combination with Extended Bayesian Information Criterion (EBIC) model selection for network estimation (hypertuning parameter set to 0.5), wherein parameters are estimated using the penalised maximum likelihood estimation method. This *EBICglasso* algorithm is among the more widely adopted procedures for network estimation using non-binary psychological and psychiatric data[49–51]. Weak edges are shrunk to zero to reduce the number of spurious edges, thereby yielding a more parsimonious network structure[48]. Spearman correlations were used to account for the non-normal distribution of individual symptom data. The package *qgraph*[52] was used to visualise the network structure. The layout of the network follows the Fruchterman and Reingold algorithm[53], in which nodes with stronger and more connected edges are placed closer to the centre of the network and closer to one another, with thicker lines reflecting stronger edges.

Centrality analysis

To examine the relative importance of each node, we computed node *strength*[54] and *expected influence* (EI)[55] as the main centrality indices. Previous work has shown that node *strength*, defined as the absolute sum of edge weights of all direct connections between one node and all other nodes, is a more robust index as compared with two other common indices, namely *betweenness* and *closeness* (the findings of which are in **Supplementary Material**) [48]. We additionally computed one-step EI[55],

which is similar to node strength except that positive/negative values of individual edges are also accounted for (for instance, negative edges would increase a node's strength but reduce its EI, which is in line with the interpretation of positive and negative associations being reflective of increased and reduced symptom activation, respectively[55,56]).

To test the hypothesised role of self-focused rumination as a bridging factor, the bridge centrality of all nodes was also investigated using the package *networktools* [56], which is a more reliable approach than visual inspection of network structures. Bridge strength and EI were computed, which reflect a node's overall connectivity with nodes in other communities in the network without and with consideration of positive/negative values of edges [56].

Network stability

Accuracy and stability tests were applied to examine network robustness using the *bootnet* package[48]. Non-parametric bootstrapping with 1000 samples was performed to generate 95% CIs of edge weights to test the stability of edge weights, while a case-drop bootstrapping procedure was applied to test the stability of centrality measures. The correlation stability coefficient (CS-C) was generated to evaluate the stability of node and bridge centrality, which reflects the maximum proportion of cases that can be dropped to maintain a correlation of 0.7 or above in the centrality indices between the original and case-subset networks with 95% probability. A CS-C of ≥0.50 is recommended[48]. Bootstrapped difference tests were applied to investigate the extent to which the edges and centrality estimates significantly differed from one another.

Community detection

Community detection of nodes in the network was examined using the *CliquePercolation* package [57]. The Clique Percolation method is one of the few community detection algorithms that allows nodes to belong to more than one community, which is particularly relevant in the study of psychopathology [58,59]. Community detection using this method was performed by optimising values of *k* (the minimum clique size) and *I* (the strength of the average relations among nodes in a community) (see Lange, 2022 for more detail [57]). With the algorithm applied at *k* values of 3 to 5 and *I* values of 0.04 to 0.01 in steps of 0.005, the optimal values identified for the weighted network were *k*=4 and *I*=0.075.

Sensitivity analysis

As JoyAge was designed for older adults with mild-to-moderately severe depressive symptoms, a proportion of participants presented very minimal anxiety symptoms. As a sensitivity analysis, we performed a subgroup analysis in those with mild or above levels of generalised anxiety symptoms (GAD-7 ≥ 5).

According to the network theory of psychopathology, stronger network connectivity is posited to result in greater symptom spread and, in turn, the emergence and maintenance of psychopathology [60]. We therefore also investigated differences in the patterns of associations between SLEs, self-focused rumination, and both symptom dimensions between those with no-to-mild symptoms (PHQ-9 < 10 and GAD-7 < 10) and those with elevated symptoms (PHQ-9 ≥ 10 or GAD-7 ≥ 10) using the Network Comparison Test [61]. Lastly, given the large proportion of female participants in this study, we conducted supplementary analyses to examine possible gender differences in the network structures between a subset of 316 female participants and the 316 male participants.

Results

Table 1 provides the sample characteristics. The sample had a mean age of 73.4 years (SD=7.9) and comprised 83.1% (n=1552) females. 44.6% were married or cohabited and 86.9% (n=1623) had at least a primary level of education or above. 23.9% (n=447) of them received a diagnosis of major

depressive disorder or anxiety disorder. Details of symptom severity on each PHQ-9 and GAD-7 item are provided in **Supplementary Table S1**. Female participants were more likely than males to have a lower education level, not be married or cohabited, and show more severe anxiety symptoms than males, while gender differences were observed in depressive symptom severity, levels of self-focused rumination, and the number of SLEs (see **Supplementary Table S2**).

In the whole sample, overall SLEs, as well as both dependent and independent SLEs, were associated with higher levels of self-focused rumination, depressive symptoms, and anxiety symptoms (r=0.18–0.20; r=0.17–0.19, and r=0.11–0.15, respectively), all $p < 0.001$ (see **Supplementary Table S1**). Self-focused rumination also showed moderate positive associations with depressive symptoms (r=0.35) and anxiety symptoms (r=0.53), both $p < 0.001$.

Table 1. Sample characteristics

	Whole sample (n=1868)
	mean (SD) / n (%)
Female sex, n (%)	1552 (83.1%)
Age	73.4 (7.9)
Marital status, n (%)	
Single/Separated/Divorced/Widowed	1034 (55.4%)
Married/Cohabited	834 (44.6%)
Education level	
No formal education	245 (13.1%)
Primary or below	695 (37.2%)
Secondary	762 (40.8%)
Tertiary or above	166 (8.9%)
Has a depression/anxiety diagnosis	447 (23.9%)
Stressful life events (LTE)	0.58 (0.85)
Dependent SLEs	0.18 (0.49)
Independent SLEs	0.42 (0.68)
Self-focused rumination (RRS–Brooding)	4.43 (3.41)
Depressive symptoms (PHQ-9)	9.66 (3.55)
None (0–4)	0 (0%)
Mild (5–9)	962 (51.5%)
Moderate or above (≥10)	906 (48.5%)
Anxiety symptoms (GAD-7)	6.99 (4.69)
None (0–4)	631 (33.8%)
Mild (5–9)	724 (38.8%)
Moderate or above (≥10)	513 (27.5%)

Note. GAD-7=7-item Generalized Anxiety Disorder scale; LTE=List of Threatening Experiences; PHQ-9=9-item Patient Health Questionnaire; RRS=Ruminative Responses Scale; SLEs=stressful life events.

Path model

In the path model without self-focused rumination, significant direct associations were observed between dependent SLEs and both symptom dimensions (depressive: β=0.15, SE=0.17; anxiety: β=0.11, SE=0.25; both $p < 0.001$). Significant direct associations were observed between independent SLEs and anxiety symptoms (β=0.11, SE=0.17, $p < 0.001$), with weak associations observed with depressive symptoms (β=0.05, SE=0.13, p=0.032). Fit indices indicated acceptable model fit: CFI=0.93, RMSEA=0.06, SRMR=0.04.

With self-focused rumination included in the model (**Figure 1**), both types of SLEs were directly associated with rumination (dependent SLEs: β=0.15, SE=0.18; independent SLEs: β=0.08, SE=0.12), which was in turn associated with both depressive (β=0.30, SE=0.02) and anxiety (β=0.48, SE=0.03) symptoms, all $p < 0.001$. Meanwhile, dependent SLEs remained directly associated with depressive symptoms (β=0.11, SE=0.17, $p < 0.001$) but not anxiety symptoms (β=0.04, SE=0.21, p=0.091), and independent SLEs remained directly associated with anxiety symptoms (β=0.07, SE=0.14, p=0.001) but not depressive symptoms (β=0.03, SE=0.11, p=0.21). In this model, self-focused rumination explained 29.5% and 64.8% of the variance in the relationships between dependent SLEs and depressive and anxiety symptoms (B=0.32, SE=0.06, CI=0.20–0.45; B=0.67, SE=0.12, CI=0.44–0.91), and 47.9% and 37.7% of the variance in the relationships between independent SLEs and depressive and anxiety symptoms (B=0.13, SE=0.04, CI=0.05–0.21; B=0.27, SE=0.08, CI=0.12–0.43), respectively. Improved model fit was observed: CFI=0.96, RMSEA=0.05 (90% CI=0.04–0.06), SRMR=0.04. Similar findings were observed in those with mild or above levels of anxiety symptoms (**Supplementary Figure S1**).

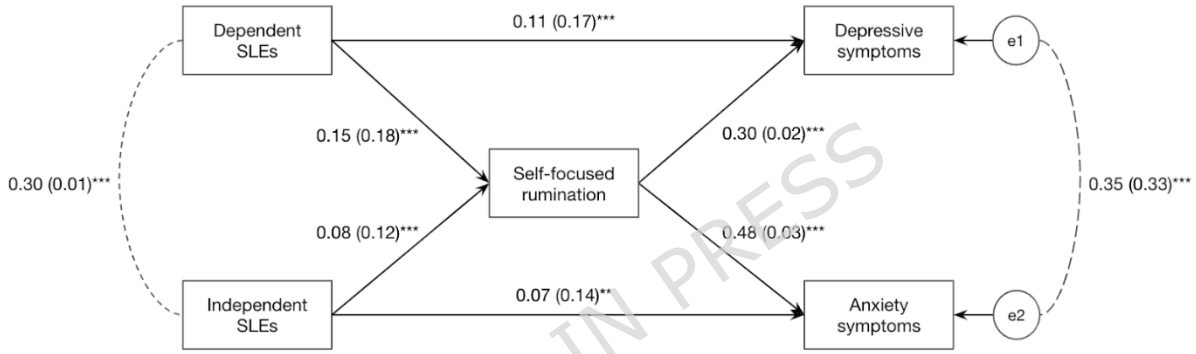


Figure 1. Path analysis with self-focused rumination as a factor linking two types of stressful life events to depressive and anxiety symptoms

Note. Standardised coefficients are presented, with standard errors in parentheses. Paths not statistically significant at the p < 0.05 level are not presented. SLEs=stressful life events.

** $p < 0.01$, *** $p < 0.001$

Network structure

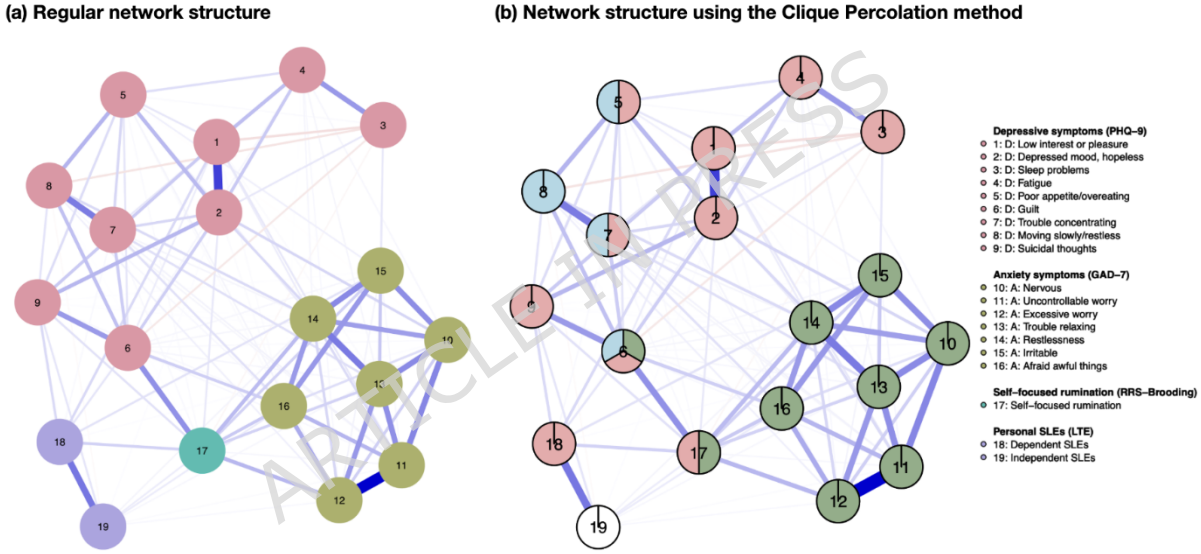
The network structure is shown in **Figure 2**. Results of the network stability and accuracy tests are presented in **Supplementary Figures S2–5**. 36.8% of all edges (63/171) were set to zero when both dependent and independent SLEs, self-focused rumination, and all symptoms were accounted for. Overall, the strongest edges observed were within-symptom domain: uncontrollable worry (GAD11) and excessive worry (GAD12) (edge weight=0.41), followed by anhedonia (PHQ1) and depressed mood (PHQ2) (edge weight=0.31). Both of these edge pairs were significantly stronger than the majority of other edges in the network (see **Supplementary Material**). Regarding cross-domain associations in the regular network structure (**Figure 2a**), the strongest edge pair was self-focused rumination and guilt (PHQ6) (edge weight=0.18), followed by excessive worry (GAD12) and restlessness (GAD14) (edge weight=0.11 for both).

Interestingly, the additional use of the Clique Percolation method revealed three communities reflective of (i) depressive symptoms–emotional and neurocognitive; (ii) depressive symptoms–neurovegetative; and (iii) anxiety symptoms (**Figure 2b**). Self-focused rumination was assigned to two communities (*depressive symptoms–emotional and neurocognitive,* and *anxiety symptoms*), while

guilt was assigned to all three communities. Dependent SLEs were assigned to *depressive symptoms–emotional and neurocognitive* community, while independent SLEs were an isolated node and were not assigned to any community. These observations were also in line with findings from the centrality analysis, which showed that self-focused rumination was among the most central bridge nodes, followed by guilt, while restlessness was among the most central nodes (**Figure 3**). Centrality plots for betweenness and closeness are given in **Supplementary Figure S6**.

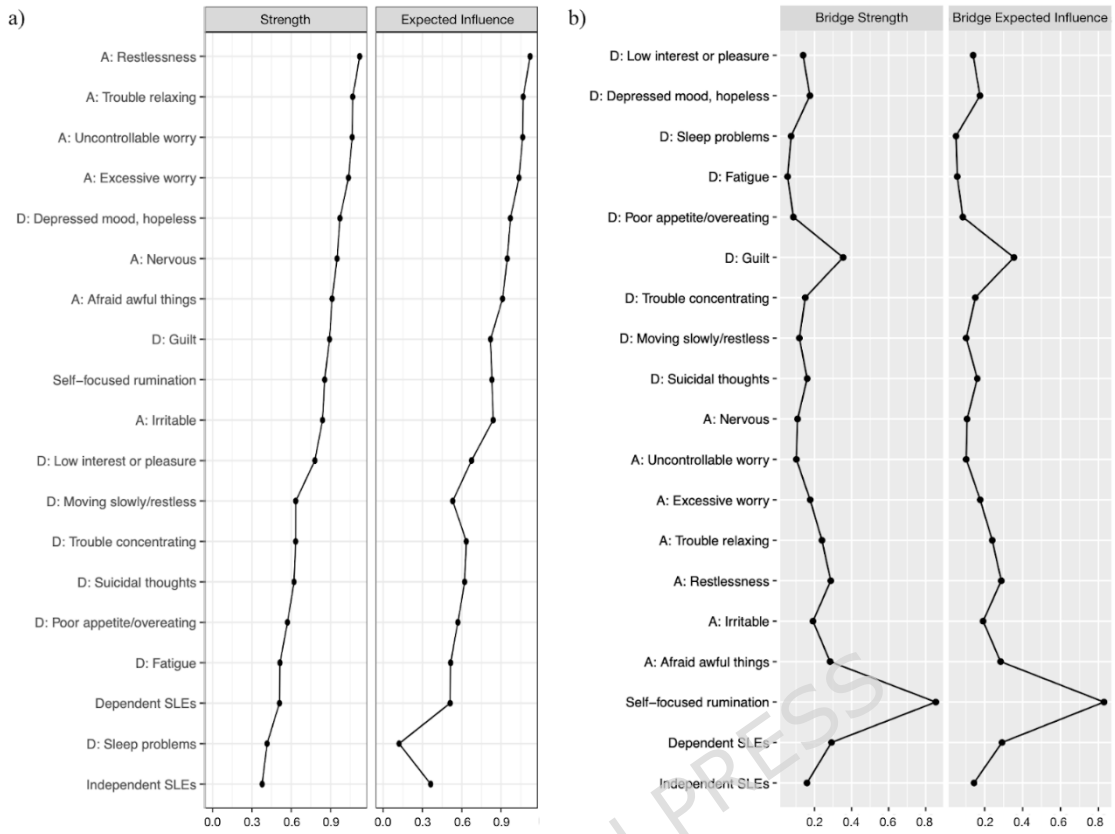
Similar to findings from the path models, relatively more edges were retained among individual depressive symptoms and dependent SLEs (44.4%) than independent SLEs (11.1%), whilst more edges were retained among individual anxiety symptoms and independent SLEs (71.4%) than dependent SLEs (14.3%) (**Supplementary Table S4**). The associations between dependent and independent SLEs and self-focused rumination were maintained in the network (edge weights=0.07 and 0.03, respectively). As in the path model, the network structure was similar in the subgroup with mild or above anxiety symptoms (**Supplementary Figures S7–11**).

Figure 2. Network structure of dependent and independent stressful life events, self-focused rumination, and symptoms of depression and anxiety



Note. (a) Regular network structure of dependent and independent SLEs, self-focused rumination, and individual symptoms of depression and anxiety using PHQ-9 and GAD-7 items, respectively, and (b) using the Clique Percolation method. Nodes with stronger and more connected edges are placed closer to the centre of the network. Thicker lines in the network reflect stronger edges (associations between two nodes). Blue lines reflect positive edges, while red lines reflect negative edges. GAD-7=7-item Generalized Anxiety Disorder scale; LTE=List of Threatening Experiences; PHQ-9=9-item Patient Health Questionnaire; RRS=Ruminative Responses Scale; SLEs=stressful life events.

Figure 3. Node and bridge centrality of the Dependent-Independent SLEs–Rumination–Symptom network



Note. Centrality plots depicting the (a) strength and expected influence, as well as (b) bridge strength and expected influence, of each node in the network structure. SLEs=stressful life events. CS-C=0.75 for all four centrality indices.

Sensitivity analysis

Additional network analyses were conducted to examine any differences in the symptom networks between those with no-to-mild and elevated depressive or anxiety symptoms (**Supplementary Figures S12–17**). Results showed significant differences in network structures between the two symptom severity groups (M=0.20, p=0.010). A more detailed investigation revealed that 22 edge-pairs showed significant differences between the two groups. Specifically, stronger edge-weights within the same symptom dimension were found in the elevated symptom group (e.g., anhedonia–suicidal [0.09 vs 0.00, p=0.040], excessive worry–restlessness [0.11 vs 0.01, p=0.020]), while stronger edge-weights across symptom dimensions were found in the no-to-mild symptom group (e.g., depressed mood–nervousness [0.08 vs 0.00, p=0.050]). There was also a trend of stronger edge-weight between guilt and self-focused rumination among those with elevated symptoms (0.19 vs 0.11), p=0.050. These findings are detailed in **Supplementary Table S4**. No significant difference was found in the global strength of the two networks (5.00 *vs* 5.42; S=0.42, p=0.28). There were also no gender differences in the structure (M=0.19, p=0.39) and global strength (7.04 vs 6.95; S=0.09, p=0.87) of the two networks (**Supplementary Figures S18–22**).

Discussion

While the role of rumination in depressive and anxiety symptoms is well-established, little has yet been done to examine the factors that contribute to this response style and its consequences in an older adult population. Despite previous work having suggested a higher rumination tendency among young

people[25,26], our findings highlighted its significance in depressive and anxiety symptoms among older adults. Importantly, using both traditional path analysis and the symptom network approach, we demonstrated that self-focused rumination is a core transdiagnostic factor linking major life stressors to both symptom dimensions. The findings suggest that targeting self-focused rumination in future interventions may help reduce internalising symptoms in older adults, particularly in the current context of increasing stress

The role of rumination in overall SLEs and both depressive and anxiety symptom dimensions has been reported in previous adolescent-based studies[10]. In explaining their interrelationships, researchers have suggested that SLEs might trigger ruminative thoughts not limited to details of the event but also information related to one's personality, behaviours, and symptoms (e.g., "Why do I always react this way?"). By differentiating between the two types of SLEs in our present study, we added to this perspective by showing that dependent SLEs play a more prominent role in the manifestation of self-focused rumination as compared with the independent-type. It is thus possible that the association observed between overall SLEs and self-focused rumination may be, to a great extent, explained by the more self-related, dependent-type SLEs. Indeed, earlier work has suggested that about one-third of the association between SLEs and depression onset is non-causal and is better explained by dependent stressors [15]. Similar to the view of ideas of reference in psychotic experiences being reflective of "distinct degrees on a continuum of different possible balances of intrinsic cognitive and extrinsic environmental factors" [62,63], the phenomenological processes underlying rumination might be similar, with self-focused and event-based rumination lying at the two ends of a continuum. A more in-depth study into the different subtypes of rumination, their vulnerability factors, and their associated outcomes would provide a more comprehensive understanding of how the interplay between biological, psychological, and social factors affects mental health[62].

Using a network approach, we showed the specific symptom-level association among the variables beyond generic composite symptom scores. With all symptoms accounted for, self-focused rumination appeared to be most strongly linked to feelings of guilt, which was then connected to the rest of the depressive symptom cluster. Notably, while self-focused rumination was found to belong to both depressive (emotional and neurocognitive) and anxiety symptom communities, guilt was the only node that additionally belonged to the depressive (neurovegetative) community. Guilty feelings have previously been shown to be related to elevated rumination[64] and can be a content of ruminative thoughts[65]. Given the close associations between guilt and suicidal thoughts, reducing rumination can have important implications for mental health and suicide prevention and intervention work. Relatively strong links were observed between self-focused rumination and worries in the anxiety symptom cluster, as expected. While rumination and worries are viewed as differing in their content (e.g., focus on past events *vs* future events)[1], the two cognitive processes are generally referred to as repetitive negative thinking or perseverative cognitions and are both underpinned by attentional, interpretative, and memory biases[6,20]. While worries were captured as part of the GAD-7, worry-specific measures[66] may be considered in the future to elucidate distinctions between rumination and worry and test the pathways from the two types of SLEs to depression and anxiety symptom outcomes, respectively.

Despite the high degrees of overlap and comorbidity between depressive and anxiety symptoms[67], our study shed light on some potential distinctions between the two. This topic has, in fact, long been an area of discussion[68]. While it may be expected that dependent stressors play a more prominent role in depressive symptoms[15–17], our findings appear to suggest that anxiety symptoms may be more reactive to external influences that are entirely out of one's control. It is possible that the lack (or loss) of perceived controllability over events may contribute to a sense of uncertainty about the future, and in

turn, worries and fear that something bad might happen. Indeed, we identified one study which found more dependent stressors among adolescents with pure depression (*vs* pure anxiety disorder) [69]. To the best of our knowledge, no study has yet examined the differential associations between two types of stressors and the two symptom dimensions, or their underlying mechanisms. The present findings thus provided a novel perspective towards some overlapping yet distinct pathways to depressive and anxiety symptoms, which is crucial for further exploration in future longitudinal studies to advance understanding of the phenomenology of the two symptom dimensions and improve person-specific interventions.

Strengths and limitations

Whilst previous work has examined the pathways from external stressors to psychiatric symptoms[70] and the role of rumination as a central symptom between mental health domains[71], a major strength of the present study was the use of a large community sample of older adults to examine the role of rumination in relation to different types of external events and two common internalising symptoms in a single network model. The use of two complementary methodological approaches, alongside the consistent findings across the sensitivity analyses, provided further evidence supporting self-focused rumination as a robust bridging factor between external factors and internalising symptoms. This observation has important clinical implications.

Emerging evidence suggests that, by targeting rumination as an underlying process, both mindfulness-based cognitive therapy[72] and metacognitive training[73] are effective in reducing depressive symptoms among older adults. WhWhile rumination-focused cognitive-behavioural therapy has been shown to be effective in reducing rumination and improving mental health outcomes among young and middle-aged adults [9,74], whether it could also be adapted to target older adults remains to be further investigated. Future work may continue to build on these findings to examine the efficacy of rumination-focused interventions for older adults with heightened mood symptoms. Separately, a recent study has demonstrated the efficacy of a personalised depression prevention programme in reducing the experience of dependent stressors[75], which may be a plausible approach to weakening the stressor–depression loop and reducing depressive symptoms. While independent stressors may not be entirely preventable, supporting people in developing more adaptive cognitive, behavioural, or emotional approaches in the face of stressful life events beyond engaging in rumination or worry could be helpful.

Aside from these strengths, the present findings should be interpreted in light of several limitations and considerations. First, as in other studies on mental health services (**ref**), the sample presented to the JoyAge service was predominantly female, which might have been due to lower help-seeking intention and lower preference for emotional disclosure commonly reported in males[74]. While our exploratory analyses revealed no clear differences between genders in depressive symptoms, self-focused rumination, and the number of SLEs experienced, as well as in their network structures, female participants in our sample presented more severe generalised anxiety symptoms. Further, older men have consistently shown leading rates of suicide deaths [78]. As such, the extent to which the present findings can be generalised to a larger male population needs to be further investigated. Replicating the present research questions in other populations with more balanced gender ratios may inform more targeted intervention strategies in future services. Second, the use of a dimensional approach to evaluating the degree of dependence (e.g., with events rated by interviewers on a 4-point scale from “clearly dependent” to “clearly independent” [15]) may help further conceptualise life events on an intrinsic–extrinsic continuum of experiences. It is also possible that older adults experience more independent SLEs (e.g., health problems, loss of a significant other) as compared with young people. Testing the replicability of our findings in other age groups is crucial to determining the

validity of the postulated differences in the roles of dependent and independent SLEs and the nature of depressive and anxiety symptomatology. We also note that temporal precedence could not be established using a cross-sectional design. As shown in previous research, people with depression are more likely to encounter SLEs, particularly the dependent type [16]. It is thus possible that the associations we observed in the present study could be bi-directional in nature. While this was partially addressed in the network analysis, using a longitudinal study design to test our current hypotheses is recommended in future studies.

Lastly, we note that the study focused solely on self-focused rumination. Our previous work has demonstrated the significance of rumination *about* personal and population-level stressful events on a range of mental health problems[63,65]. The degree of overlap between self-focused and event-based rumination, their links to dependent and independent stressors, their implications for different mental health outcomes, as well as the effectiveness of interventions in reducing these two types of rumination, warrants further investigation.

Rumination is a crucial cognitive process capable of perpetuating the experience of depressive and anxiety symptoms and linking varying types of external influences to mental health states, including in older adults. Our findings suggest the need for expanding existing research and clinical practice to target ruminative experiences in the older adult population. The specificity of stress reactivity observed in depressive and anxiety symptom dimensions has theoretical and clinical implications and may be further explored in future work.

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Author Contributions
S.M.Y.W. conceived the study, while S.M.Y.W. and M.H.C.I. conducted the literature review and data analyses. All authors interpreted the findings. S.M.Y.W. and M.H.C.I. wrote the first draft of the manuscript, while D.K.Y.L., W.C.C., G.H.Y.W., and T.Y.S.L. provided comments and suggestions. All authors contributed to the revision of the manuscript and approved its final version. All authors accept responsibility for submitting the manuscript for publication.

Data Availability
De-identified data can be made available upon reasonable request and should be directed to the corresponding author.

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Declaration of Interest
The authors report no conflict of interest.

Transparency Declaration
The lead author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported and that no important aspects of the study have been omitted.