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Posttraumatic stress or posttraumatic growth? Using network analysis to explore the relationships between coping styles and trauma outcomes

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ABSTRACT

Trauma can produce posttraumatic stress disorder (PTSD), but may also foster positive outcomes, such as posttraumatic growth. Individual differences in coping styles may contribute to both positive and negative sequelae of trauma. Using network analytic methods, we investigated the structure of PTSD symptoms, elements of growth, and coping styles in bereaved survivors of a major earthquake in China. Hypervigilance and difficulty concentrating were identified as the most central symptoms in the PTSD network, whereas establishing a new path in life, feeling closer to others, and doing better things with life ranked highest on centrality in the posttraumatic growth network. Direct connections between PTSD symptoms and elements of growth were low in magnitude in our sample. Our final network, which included PTSD symptoms, growth elements, and coping styles, suggests that adaptive and active coping styles, such as positive reframing, are positively related to elements of growth, but not appreciably negatively related to PTSD symptoms. Conversely, maladaptive coping styles are positively related to PTSD symptoms, but are not negatively associated with growth. Future longitudinal studies could shed light on the direction of causality in these relationships and their clinical utility.

1. Introduction

Trauma is common, but posttraumatic stress disorder (PTSD) is relatively rare. Nearly 90 % of individuals will experience a traumatic event during their lifetime, based on the diagnostic criteria of the American Psychiatric Association's *Diagnostic and Statistical Manual fifth edition* (DSM-5; American Psychiatric Association, 2013; Kilpatrick et al., 2013), but less than 10 % will develop PTSD (Breslau, 2009; O'Donnell, Elliott, Lau, & Creamer, 2007; Perkonigg, Kessler, Storz, & Wittchen, 2000). In addition to PTSD and related disorders (e.g., depression; Breslau, 2009), trauma may also contribute to *positive* changes in someone's life (Tedeschi & Calhoun, 2004). Tedeschi and Calhoun (2004) define such posttraumatic growth, hereafter "growth," as a positive psychological change experienced as a result of the struggle with highly challenging life circumstances" (p. 1). Among these changes are perceptions of increased personal strength, a greater ability to relate to others, finding a new path in life, a greater appreciation of life, and deepened spiritual understanding (Tedeschi & Calhoun, 1996). Although seemingly incompatible, growth and PTSD symptoms often co-occur. Both have been reported in survivors of a tornado, plane crash,

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mass shooting, and the loss of a loved one[1] (McMillen, Smith, & Fisher, 1997; Polatinsky & Esprey, 2000; Tedeschi & Calhoun, 2007). In fact, many individuals experience growth simultaneously with considerable levels of distress, including PTSD symptoms (Cadell, Regehr, & Hemsworth, 2003; Lev-Wiesel & Amir, 2003).

However, other researchers have characterized the relation between the emotional consequences and benefits of trauma (as well as other stressful life events) in other ways. One study found that individuals who have lost a loved one usually do not experience growth unless they also experience at least moderate levels of post-loss distress (Calhoun, Tedeschi, Cann, & Hanks, 2010). Further, if the death disrupted individuals' core beliefs, they not only exhibited higher symptoms of posttraumatic stress, but also more self-reported growth. Additionally, PTSD symptoms and growth were positively correlated in reference to individuals' most difficult event in the past year (Park, Cohen, & Murch, 1996). Interestingly, Barton, Boals, and Knowles (2013) found a positive correlation between PTSD symptoms and growth in an undergraduate sample across a wide range of traumatic and stressful life events (study 1), but not in a sample of treatment-seeking women who had experienced sexual or physical assault (study 2), suggesting that stressful events of relatively moderate intensity are those most likely to foster growth. Another study found the relationship between growth and PTSD symptoms to be curvilinear, with the highest levels of growth reported among participants who experienced intermediate levels of posttraumatic stress (Butler et al., 2005). In a recent longitudinal study, Whealin et al. (2020) found that higher levels of PTSD symptoms in trauma-exposed US veterans weakly but significantly predicted higher levels of growth over the course of four years (but not vice versa), and that a curvilinear association described this relationship better than a linear relationship. In line with this, Shakespeare-Finch and Lurie-Beck (2014) conducted a meta-analysis and found a significant linear and a significantly stronger curvilinear relationship between the two phenomena, such that the highest levels of growth occurred at intermediate levels of posttraumatic stress. Liu, Wang, Li, Gong, and Liu's (2017) meta-analysis supported a positive relationship between growth and PTSD. Findings of these meta-analyses also indicate that the growth-PTSD relationship differs depending on age (Liu et al., 2017; Shakespeare-Finch & Lurie-Beck, 2014), type of index event (Liu et al., 2017; Shakespeare-Finch & Lurie-Beck, 2014), and time since the event (Liu et al., 2017). Yet other researchers have neither found a significant linear (Barton et al., 2013, study 2; Powell, Rosner, Butollo, Tedeschi, & Calhoun, 2003; Wu, 2013; Znoj, 1999; Zoellner, Rabe, Karl, & Maercker, 2008), nor a significant curvilinear relationship (Wu, 2013) between growth and PTSD symptoms. Taken together, the findings on the relation between PTSD and growth are mixed, perhaps because of other moderating variables such as the type of trauma or individual differences.

One way of interpreting the mixed findings concerning the relation between PTSD symptoms and growth concerns individual differences in styles of coping with stress. Some coping styles may be more effective than others in decreasing PTSD symptoms, promoting growth, or both. For instance, meta-analyses have consistently shown that growth is associated with religious or spiritual coping and positive reframing (Ano & Vasconcelles, 2005; Helgeson, Reynolds, & Tomich, 2006; Prati & Pietrantoni, 2009; Schroevers & Teo, 2008). Regarding posttraumatic stress, PTSD patients recruited from a psychiatric hospital engaged in more suppression compared not only to healthy controls but also to other anxiety patients (Amir et al., 1997). Suppression was positively associated with intrusions and avoidance among PTSD patients – although the connection to the latter is likely due to their conceptual overlap (Amir et al., 1997).

Another potentially important distinction is whether trauma survivors engage in active versus passive coping. Active coping strategies, such as effortful thinking and problem-solving, were more strongly associated with growth than were passive coping styles (Whealin et al., 2020; Wild & Paivio, 2004; Wu, 2013). Others found that proactive coping was negatively associated with PTSD symptoms (Vernon, Dillon, & Steiner, 2009), whereas avoidant emotional coping, such as denial or self-distraction, was positively associated with posttraumatic stress (Schnider, Elhai, & Gray, 2007). Hence, coping styles may be differentially conducive (or prohibitive) to growth and PTSD symptoms. A closer examination of how coping styles relate to both posttraumatic stress and growth may illuminate the complex relationship between these two very different, but often co-occurring trauma outcomes.

1.1. The network approach

Although prior research on the relationship of growth and posttraumatic stress has shown that these seemingly incompatible phenomena often co-occur, most of these studies relied on statistical models that test a suggested relationship between the two phenomena as a whole (e.g., is the relation between growth and posttraumatic stress linear or curvilinear?). Therefore, these analyses, based on sum scores for both variables, may fail to capture the complex structure of co-occurrence between specific symptoms of posttraumatic stress and elements of growth. Negative sequelae, such as PTSD, may interact with aspects of growth at the symptom level. For instance, Whealin et al. (2020) found that only heightened avoidance symptoms, hypervigilance, and lower levels of sleeping difficulties predicted higher levels of growth later on. No other symptoms predicted growth independently in this study. These results suggest that the association between PTSD severity and growth may be best explained by examining the role of specific symptoms, as relationships with growth may differ widely across symptoms. Illuminating the complex relationships between individual PTSD symptoms and aspects of growth may shed light on how these multi-faceted phenomena relate to one another.

The network approach to psychopathology holds that disorders emerge from the causal interactions among their symptoms, and is therefore particularly suited to clarify the relation between specific symptoms of PTSD and elements of growth (Borsboom & Cramer, 2013; McNally, 2016). In psychopathology networks, elements of a disorder – or symptoms – are represented by "nodes" and their relationships with one another are signified by "edges" that connect pairs of nodes. The thickness of each edge corresponds to the strength of the association between two symptoms. Nodes having many strong connections to other nodes score high on measures of *strength centrality*, and thus may potentially figure prominently in the maintenance of an episode of disorder. Deactivation of these nodes (symptoms) has predicted recovery from disorder, although the mapping between node centrality and clinical importance is far from perfect, as the former represents correlation and the latter causation (Bringmann et al., 2019; Rodebaugh et al., 2018). Alternatively, the centrality of a node can be determined by the extent to which it functions as a hub between otherwise disparate nodes (i.e., *betweenness* centrality; Robinaugh, Millner, & McNally, 2016).

Several research groups have investigated the PTSD symptom structure with network analytical approaches in various samples, and found that hypervigilance, reactivity (psychological or physiological),

[1] Whereas many challenging life events can cause distress, including PTSD symptoms, a traumatic event that can result in a diagnosis of PTSD requires "actual or threatened death, serious injury, or sexual violence" according to the DSM-5 (American Psychiatric Association, 2013, p. 271). Unlike the previous DSM, the sudden loss of a loved one does not qualify as a trauma in the DSM-5 if the death was nonaccidental or nonviolent, hence, not every bereavement is officially "traumatic" (American Psychiatric Association, 2013; Kilpatrick et al., 2013). The loss of a loved one can lead to PTSD symptoms, but also to other post-loss phenomena, such as complicated grief (CG) (Kristensen, Weisæth, & Heir, 2012; Nickerson et al., 2014). As the definition of trauma has narrowed in DSM-5, studies done preceding DSM-5 involved a less restrictive definition of trauma.

feelings of detachment, intrusive thoughts and flashbacks, nightmares, difficulty concentrating, lack of interest in activities, avoidance of reminders and thoughts/ memories, an exaggerated startle response, psychological distress, and persistent negative emotions emerged as the most central symptoms (e.g., Armour, Fried, Deserno, Tsai, & Pietrzak, 2017; Fried et al., 2018; Greene, Gelkopf, Epskamp, & Fried, 2018; McNally et al., 2015; Mitchell et al., 2017; Moshier et al., 2018; Ross, Murphy, & Armour, 2018; von Stockert, Fried, Armour, & Pietrzak, 2018). Accordingly, a review including 20 network analysis studies revealed considerable heterogeneity among the most central symptoms in PTSD networks, whereas "amnesia" was consistently among the least central symptoms (Birkeland, Greene, & Spiller, 2020).

Network methods can also illuminate the structure of positive psychological phenomena, such as growth, with nodes signifying specific elements of growth instead of symptoms. Bellet, Jones, Neimeyer, and McNally (2018) examined a growth network in a sample of college students who had lost a loved one, and found that the bereaved individual's ability to find a new path in life as well as greater perceived personal strength were most central aspects of growth.

In line with the central question of the current paper, network analytical approaches can also clarify the interplay between growth and PTSD by identifying the elements of each phenomenon that are most important for understanding the relationship between the two. In network analysis, each psychological phenomenon of interest (e.g., PTSD and growth) can be regarded as a separate "cluster." When examining two clusters of nodes, "bridge nodes" are those highly connected to nodes of another cluster (Cramer, Waldorp, Van der Maas, & Borsboom, 2010). Identifying these bridge nodes may generate hypotheses as to which symptoms from negative outcome clusters contribute to (or prevent) the occurrence of positive outcomes and vice versa. Bellet et al. (2018) performed network analyses to investigate the relationship between elements of complicated grief (CG) and post-loss growth to identify such cluster-bridging nodes. They found that a bereaved individual's perceived change in world view in response to loss, which is a feature of CG, was highly associated with the occurrence of growth. Conversely, the CG symptom of an inability to care about others was inversely associated with growth. Additionally, the ability to handle difficulty from the growth cluster showed a negative relationship with CG symptoms.

Although examining the complex relations between positive and negative sequelae is important, it is likely that a wide range of other factors affect the interplay between the two. Given the importance of coping styles to both posttraumatic stress symptoms and positive outcomes, including coping styles as a third cluster may further clarify the relationship between positive and negative trauma outcomes. Such an approach could yield clinically relevant insights, revealing specific coping styles that are strongly associated with decreased PTSD symptoms or associated with increased aspects of growth.

1.2. The current study

In this study we aimed to illuminate the relations among elements of growth, posttraumatic stress, and coping styles. First, we computed a PTSD symptom network, enabling us to compare its structure and central symptoms to those of other PTSD networks. Second, we computed a growth network to identify the structure and central features of growth. Computing a growth network also served as a cross-cultural extension of Bellet et al.'s (2018) growth network. Third, we computed a combined network with growth and PTSD to identify bridging elements between these two clusters. Fourth, we computed a network with coping styles, growth, and PTSD symptoms to identify specific coping styles that are related with each outcome while controlling for the associations between them. Hence, this study extends the one conducted by McNally et al. (2015), who ran network analyses on PTSD symptoms in these earthquake survivors, but who had not examined growth and coping in their study. Furthermore, McNally et al. (2015) did not compute regularized partial correlation networks or calculated expected influence as their centrality measure.

2. Material and methods

2.1. Participants

The participants were 362 Chinese adult survivors (female = 266, male = 96) of the Wenchuan earthquake in 2008 who had lost at least one child in the disaster. A large minority had either been injured (38.1 %), temporarily been buried under rubble (33.4 %), or helped to rescue other victims (41.4 %) during and after the earthquake. Their mean age was 44.8 years at the time of data collection, and most were married (84.5 %). Most participants had an education level of either junior high school or elementary school and below (77.62 %), representative of the residents of this rural region. The data were collected 5 years and 6 months after the earthquake had occurred. The Harvard Committee on the Use of Human Subjects and the ethics committee of the Institute of Psychology at the Chinese Academy of Sciences (CAS) approved the protocol and informed consent of the original data collection.

2.2. Measures

2.2.1. PTSD checklist – specific, Chinese version (PCL-S; Weathers & Ford, 1996; Weathers, Litz, Herman, Huska, & Keane, 1993)

The PCL is a widely used questionnaire that consists of 17 items with each item representing one PTSD symptom, according to the DSM-IV-TR diagnostic criteria (Blanchard, Jones-Alexander, Buckley, & Forneris, 1996). Participants indicated on a 5-point Likert scale how bothered they were by each symptom in the past month in response to the earthquake. The PCL, Chinese version, was provided by the Institute of Psychology, CAS, where the translation, back-translation and reliability and validity evaluation took place. The PCL, Chinese Version, is reliable and valid in various populations (Li et al., 2010), including our sample of Wenchuan earthquake survivors ($\alpha = .94$).

2.2.2. Posttraumatic growth inventory- Chinese (PTGI-C; Tedeschi & Calhoun, 1996)

The PTGI is a 21-item self-report questionnaire that assesses posttraumatic growth in five domains: relating to others, new possibilities, personal strength, spiritual change, and appreciation of life. This questionnaire has good internal consistency ($\alpha = .90$) and acceptable test-retest reliability over two months ($r = .71$) and is widely used in trauma and growth research (Tedeschi & Calhoun, 1996). It was also reliable in our sample ($\alpha = .81$). Each item was assessed on a 6-point Likert scale that measured how much participants experienced the described change as a result of the earthquake. Participants completed the Chinese version of the PTGI, which was translated, back-translated and edited by Dr. Li Wang and his team at the Institute of Psychology, CAS. For the purposes of our analyses, we used the short form of the PTGI (PTGI-SF) in Chinese, which includes a total of ten items from the original PTGI with two items for each of the five domains. The two items of the PTGI chosen to represent each domain in English were selected based on their loadings of the original factors from which the domains were derived, as well as breadth of item content. This short form's reliability and factor structure was validated in a separate sample of 186 participants (Cann et al., 2010).

2.2.3. Brief version of the coping orientation to problem experiences (brief COPE; Carver, 1997; Carver, Scheier, & Weintraub, 1989)

The Brief COPE is a 28-item questionnaire that assesses participants' tendency to use each of 14 coping styles, including active coping, positive reframing, acceptance, emotional support, denial, distraction, and substance abuse. Each scale is assessed by two items on a 4-point Likert scale, ranging from (1 = *I usually don't do this at all,* 4 = *I usually do this a lot).* Carver (1997) demonstrated acceptable internal reliability for the

Brief COPE and the measure was reliable in our sample (α = .86). Translation and back-translation were performed by Dr. Li Wang and his colleagues.

2.3. Data analysis

2.3.1. Missing data

There were very few missing values (0.72 %) among the entire data set, including demographics. Participants with missing values were excluded from the calculation of statistics when necessary (e.g., for the calculation of mean and standard deviation of participants' age). All participants were retained for the network analysis. Partial correlations among nodes were estimated based on pairwise complete observations. Percentages of missing data for the PCL, PTGI, and Brief COPE items were 0.77 %, 0.35 %, and 1.28 % of all total items across all participants, respectively.

2.3.2. Regularized partial correlation networks

First, we computed descriptive statistics of demographic variables for our sample. We then calculated regularized partial correlation networks of both PTSD symptoms and growth elements, in which the relationship between two nodes controls for the influence of all other nodes in the network (Epskamp & Fried, 2018). To compute the regularized partial correlation networks, we used a graphical LASSO (Least Absolute Shrinkage and Selection Operator) algorithm with the "qgraph" (Epskamp, Cramer, Waldorp, Schmittmann, & Borsboom, 2012) package in R (R Core Team, 2018). The graphical LASSO computes a sparse inverse covariance matrix by applying a lasso (L1) penalty. The L1 penalty omits edges with trivially small partial correlations between nodes and hence returns a sparse network in which visible edges are unlikely to have occurred by chance. The thickness of each visible edge indicates the magnitude of the partial correlation between any two nodes; the thicker the edge, the higher the magnitude.

2.3.3. Expected influence

We used "expected influence" (EI) to assess the centrality of each node in a network (Robinaugh et al., 2016). A node's strength centrality is the sum of absolute weights of edges that it shares with other nodes in the network. The EI of a specific node is the summed weight of edges that it shares with the remaining nodes in the network, taking negative associations into account (Robinaugh et al., 2016). Therefore, EI can be preferable to strength centrality in some cases, because it reflects the net influence that a given node might have on a network when the sign of its associations with other nodes are considered (Robinaugh et al., 2016). For example, a node with many positive but also many negative edges connecting it to other nodes would have a high strength centrality, but an EI close to zero. We used the "networktools" package (Jones, 2017) in R to compute EI. Even though highly central nodes likely figure as important for mutual interactions within a network, it is crucial to note that EI does not indicate any causality; our analyses were strictly correlational.

2.3.4. Combined networks and bridge nodes

After computing regularized partial correlation networks for growth and PTSD symptoms separately, we computed a combined network to examine the potential interplay between elements of growth and PTSD symptoms. To pinpoint which elements of a cluster may be important to that cluster's relationship with another cluster, we computed "Bridge Expected Influence" (BEI; Jones, Ma, & McNally, 2019). BEI identifies potential bridge nodes by computing a node's EI and only considering cross-cluster nodes as potential neighbor nodes. High absolute values of BEI indicate a node's potential importance as a bridge node. For instance, the BEI of a PTSD symptom indicates to what extent this symptom is related to aspects of growth. Positive values reflect overall positive relationships (i.e., a PTSD symptom is associated with higher levels of growth), whereas negative values reflect overall negative relationships (i.e., a PTSD symptom is associated with lower levels of growth). Next, we computed a second combined network that also included coping styles to identify which ones are strongly associated with the occurrence of either PTSD symptoms or growth. To this end, we computed two BEI values for each coping style node; one for the PTSD cluster, and one for the growth cluster.

2.3.5. Stability of network models

To estimate the stability of each network, we performed 1000 case-dropping bootstraps with the "bootnet" package (Epskamp & Fried, 2017, 2018). The bootstrapping procedure returns a correlation stability (CS) coefficient that indicates which proportion of cases (i.e., persons) could be eliminated from the analyses while retaining a correlation of at least .7 with the original estimates within a 95 % confidence interval. As such, the CS coefficient assesses whether original estimates correlate with bootstrapped estimates, i.e., it examines the stability of estimated values relative to one another across bootstrapped samples. We used the default value of $r = .7$ for our bootstrapping procedure, because it reflects a very large effect size (Cohen, 1977; Epskamp, Borsboom, & Fried, 2018). We estimated CS coefficients for edge weights, EI, and BEI to assess their respective stabilities (Epskamp & Fried, 2018).

3. Results

A key of node names and their univariate statistics, as well as descriptive statistics for PTGI and PCL-S sum scores appears in the supplemental materials S1 and S2.

3.1. PTSD network

Edge weights of the PTSD symptom network were stable, *CS* (correlation [cor] = .7) = .75, as were EI values, *CS* (cor = .7) = .56 (Epskamp & Fried, 2018). The network and its EI values appear in Fig. 1. All associations in this network were positive (in this and all subsequent networks, solid green edges signify positive associations, whereas dashed red edges signify negative associations). Nodes with large EI values are indicated by capitalized blue text. Hypervigilance was the most central symptom node in this regularized partial correlation network, followed by difficulties concentrating. Amnesia was the least central symptom. Strong associations emerged between a heightened startle response and hypervigilance as well as feeling upset and physical reactions in response to stressful reminders. Edges between anger and difficulties concentrating as well as sleep and anger also had a high magnitude.

3.2. Growth network

The growth network was stable as indicated by CS coefficients for edge weights, *CS* (cor = .7) = .72, and for EI values, *CS* (cor = .7) = .72. The network and EI values for each node appear in Fig. 2. Finding a new path in life, a greater sense of closeness with others and the ability to do better things with life emerged as the most central nodes in this network. Interestingly, changing priorities about what is important in life had an EI close to zero and was not connected to other elements of growth except for a weak positive association with a greater appreciation of life. The strongest edges in the growth network emerged between a sense of closeness with others and learning how wonderful people are, religious faith and a better understanding of spiritual matters, as well as the ability to do better things with life and the ability to better handle difficulties.

3.3. Combined PTSD and growth network

The combined PTSD and growth network was stable based on the CS coefficients for edge weights, *CS* (cor = .7) = .66, and BEI values, *CS* (cor = .7) = .65. When computing this network, we found that the "change in

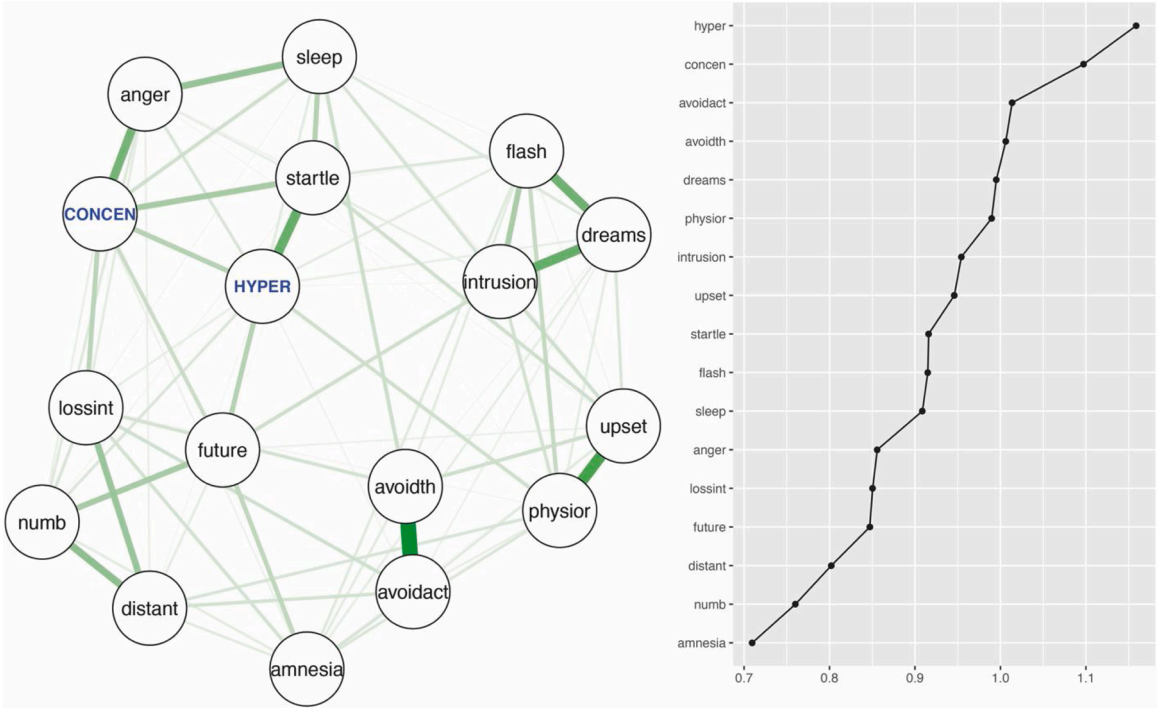

Fig. 1. Regularized partial correlation network for posttraumatic stress symptoms and expected influence (EI) values for each node. The regularized partial correlation between two nodes is represented by an edge. Edge thickness represents the magnitude of the correlation between two nodes. All relationships between nodes were positive in this network, indicated by solid green edges. Hypervigilance and difficulty concentrating, represented by capitalized blue text, had the highest EI values.

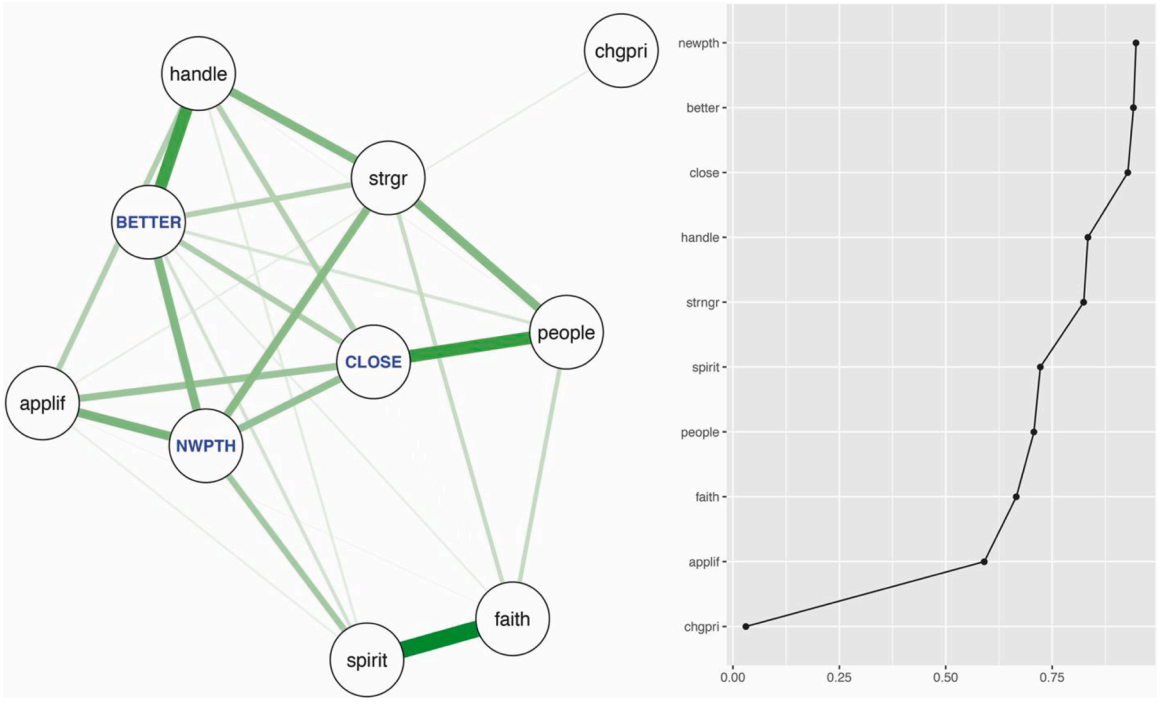

Fig. 2. Regularized partial correlation network for posttraumatic growth and expected influence (EI) values for each node. The regularized partial correlation between two nodes is represented by an edge. Edge thickness represents the magnitude of the correlation between two nodes. All relationships between nodes were positive in this network, indicated by solid green edges. Establishing a new path in life, being able to do better things with life, and having a greater sense of closeness with others, ranked highest on EI. These high-ranking nodes are represented by capitalized blue text.

priorities" node from the growth cluster was far more closely associated with the PTSD cluster than the growth cluster (see S3). The phenomenon may have obscured meaningful inter-cluster relationships. That is, some nodes from the PTSD cluster may have had high BEI values only because of their association with this node, and growth nodes' BEI values may have been decremented. In addition to the high BEI values of the

"change in priorities" item, there are potential difficulties in interpreting this item (see Discussion). Accordingly, we eliminated this node from subsequent network analyses. Networks including the "change in priorities" item can be found in the supplementary material (see S3 and S4).

Edge weights in the combined PTSD and growth network without the "change in priorities" item were stable based on an acceptable CS coefficient for edge weights, *CS* (cor = .7) = .69. However, BEI values were not stable in this network based on the suggested 0.25 cut-off (Epskamp et al., 2018), as indicated by an unacceptable CS coefficient for BEI values, *CS* (cor = .7) = .21 (see Fig. 3). Hence, the stability of bridge centrality in this two-cluster network seems dependent on the "change in priorities" item. This lack of stability means that BEI values should not be interpreted for identifying bridge nodes in this network. Our analysis indicated that there are both negative and positive relationships between PTSD symptoms and growth elements.

Importantly, zero-order correlations between the PTGI-SF and the PCL indicated that scores on these two questionnaires were not correlated overall, neither including the "change in priorities" item ($r = .04$, *ns*), nor excluding it ($r = -.03$, *ns*). However, significant edges emerged at the symptom level, as indicated by both combined networks.

3.4. Combined PTSD, growth, and coping styles network

Stability analyses of the combined network with PTSD, growth, and coping styles (without the "change in priorities" item) indicated that this network has acceptable stability based on CS coefficients for edge weights, *CS* (cor = .7) = .58, for BEI values between PTSD symptoms and coping styles, *CS* (cor = .7) = .44, and for BEI values between elements of growth and coping styles, *CS* (cor = .7) = .49. Two sets of BEI values (two values for each coping style) indicate the relationship of coping styles with PTSD and growth separately, while controlling for the influence of all other nodes (see Fig. 4). The coping styles of positive reframing and the use of religion had the largest positive BEI values with respect to the growth cluster (nodes with capitalized, bold green text in the network), followed by active coping. The coping style of the use of humor had a negative association with elements of growth. The use of self-blame, behavioral disengagement, substance abuse, venting, denial, acceptance, and emotional support seem to have no notable connection to growth based on their BEI values of 0. With respect to PTSD, the use of self-blame and substance abuse had the highest positive BEI values (nodes with capitalized blue text), whereas religion, humor, acceptance, positive reframing, planning, active coping, and instrumental support did not seem to be connected to PTSD.

The complete network including the "change in priorities" item was stable as indicated by the CS coefficients for edge weights, *CS* (cor = .7) = .51, for BEI values between PTSD symptoms and coping styles, *CS* (cor = .7) = .39, and for BEI values between elements of growth and coping styles, *CS* (cor = .7) = .45 (see S4). "Change in priorities" was positively connected to both coping styles and PTSD symptoms, but had no significant edges to its own growth cluster. Strikingly, self-blame had a high BEI value not only with respect to the PTSD symptom cluster, but also to the growth cluster in this network, which is caused by the edge that this coping style shares with the "change in priorities" node. Self-blame was not connected to any other elements of growth.

4. Discussion

Our findings expand the body of knowledge on the structure of PTSD and growth from a network perspective. Additionally, they shed light on how different coping styles may interact with both phenomena at the symptom level. We now turn to each set of findings and their implications.

4.1. PTSD network

The importance of hypervigilance in our PTSD symptom network and its strong association with a heightened startle response is in line with Ehlers and Clark's (2000) cognitive model of PTSD, which regards PTSD as marked by a sense of "current threat" (p. 320) accompanied by continuous reexperiencing of the traumatic event. The strong association between hypervigilance and heightened startle may indicate that these two symptoms reinforce each other and contribute to the maintenance of the disorder. Given that this strong association has been repeatedly found in previous PTSD networks, an interaction between these two symptom nodes seems likely (Armour et al., 2017; Birkeland et al., 2020; Fried et al., 2018; Greene et al., 2018; Moshier et al., 2018; von Stockert et al., 2018).

Consistent with some previous PTSD symptom networks, difficulties

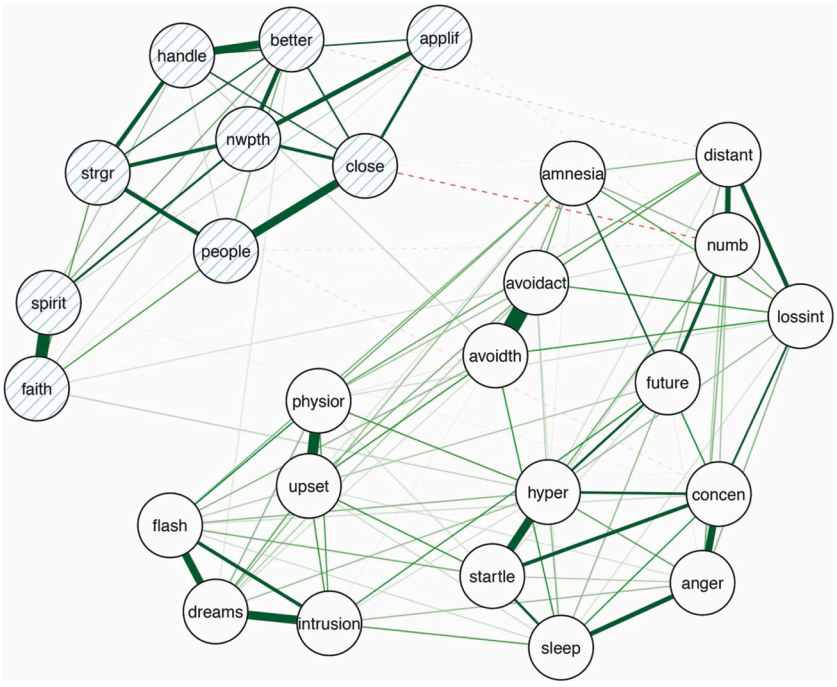

Fig. 3. Combined regularized partial correlation network for posttraumatic stress symptoms and posttraumatic growth. The regularized partial correlation between two nodes is represented by an edge. Edge thickness represents the magnitude of the correlation between two nodes. Solid green edges represent positive relationships between nodes and dashed red edges represent negative relationships. Bridge expected influence (BEI) values for this network were unstable and should not be interpreted, which is why BEI values were not included in this figure.

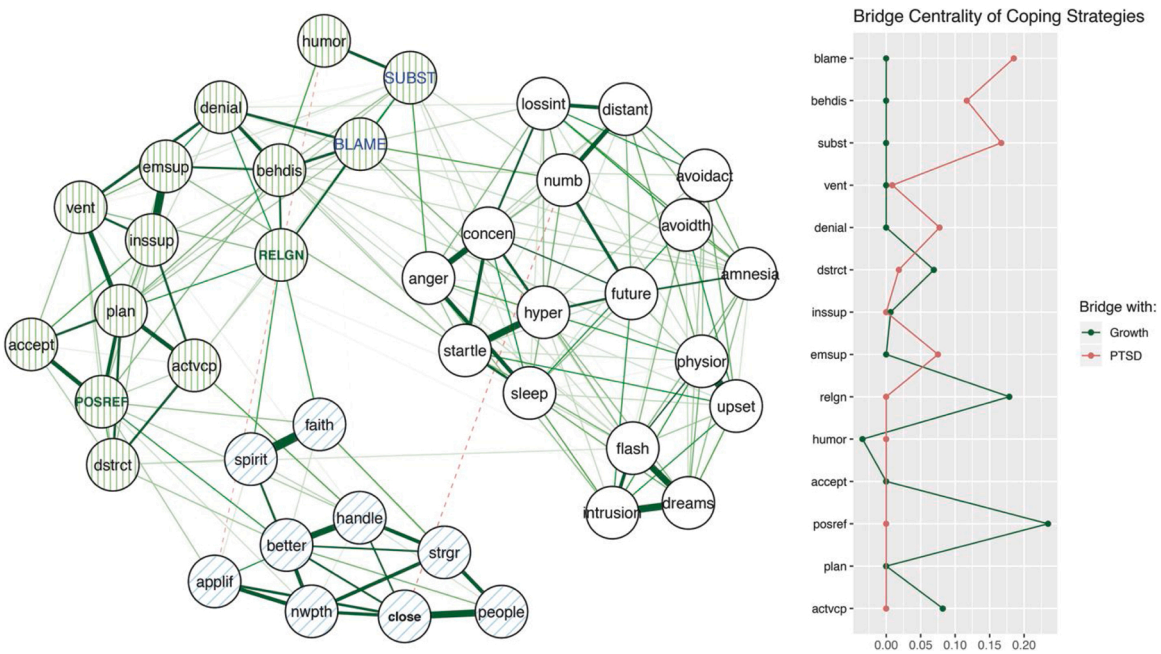

Fig. 4. Combined regularized partial correlation network for posttraumatic stress symptoms, posttraumatic growth, and coping styles. Two sets of bridge expected influence (BEI) values for each coping style node indicate the BEIs of coping styles with posttraumatic stress symptoms and elements of posttraumatic growth separately. The regularized partial correlation between two nodes is represented by an edge. Edge thickness represents the magnitude of the correlation between two nodes. Green edges represent positive relationships between nodes, dashed red edges represent negative relationships. Self-blame and substance abuse (indicated by capitalized blue text) were identified as coping styles that are most likely to act as bridge nodes with the posttraumatic stress disorder (PTSD) symptom cluster. Positive reframing and religious coping (bold, capitalized green text) were identified as the coping styles with the highest BEI values to the growth cluster.

concentrating also emerged as a highly central symptom (Fried et al., 2018; McNally et al., 2015; von Stockert et al., 2018). This symptom had strong associations to anger and irritability, which in turn had strong connections to sleeping problems. In line with this finding, McNally et al. (2015) suggested that difficulties sleeping may contribute to an irritable mood during the day, which in turn may contribute to difficulties concentrating. The PTSD symptom structure of our regularized partial correlation network, which was computed by using a graphical LASSO, shows profound similarities with McNally et al.'s (2015) (unregularized) association, concentration, and relative importance networks in this sample of Chinese earthquake survivors (all four networks were computed with the same participant data). Some exceptions include the presence of several small negative edges in McNally et al.'s (2015) concentration network (removed in the regularized version) and the centrality of "future foreshortening" (identified as central in McNally et al.'s concentration network, but not in the regularized version using EI). The overall similar structure (with minor exceptions) indicates that the PTSD symptom structure is fairly robust in our sample, independent of the algorithm used to compute the network.

In line with previous PTSD symptom networks, we identified amnesia as the least central PTSD symptom (Birkeland et al., 2020), supporting that our PTSD network shows similarity to previous PTSD symptom networks despite varying sample characteristics.

4.2. Growth network

Establishing a new path in life was the most central element of growth in our network, consistent with Bellet et al. (2018), who examined growth outcomes following the loss of a loved one. Conversely, a sense of having a foreshortened future was part of the diagnostic criteria for PTSD in the DSM-IV-TR (American Psychiatric Association, 2000). Thus, our findings reinforce the importance of being capable of envisioning a future as a key process in adaptation to adverse events.

Additionally, being able to do better things with one's life was an important growth element displaying a strong connection with being able to better handle difficulties. This finding is consistent with Calhoun et al.'s (2010) idea that recovering a sense of personal agency is a precondition for the discovery of unsought benefits which characterize growth in the wake of trauma. Having a greater sense of closeness with others also emerged as a highly central node in our growth network. Indeed, some bereaved individuals report becoming more compassionate and empathetic, especially towards people who experienced a similar loss (Calhoun et al., 2010; Tedeschi & Calhoun, 2004). Feeling closer and more empathetic towards others may then contribute to the expansion of social networks and feelings of greater connectedness associated with growth.

Changing priorities about what is important in life was the least central growth element, consistent with a previous growth network (Bellet et al., 2018). Further, preliminary analyses revealed that this item was far more associated with the PTSD and coping cluster than with growth. These findings raised questions about the validity of this item in our sample as an indicator, leading us to exclude it in most of our analyses. Changing one's priorities in life may have had a drastically different connotation in our sample compared to other traumatized individuals: our participants all experienced a destructive earthquake and they lost a child. Consequently, our participants' priorities were changed involuntarily, and changes in their lives due to the destruction of the earthquake (e.g. living situation, employment) were still ongoing at the time of data collection. In contrast, changes in priorities associated with growth are usually more related to increasing the importance of "little things" that were previously taken for granted after the immediate effects of the trauma have subsided (Tedeschi & Calhoun, 2004). Although such a positive interpretation of the item is possible, it is more likely that changing one's priorities was a necessity of survival for many participants, thus changing their overall appraisal of this item to one that was expressly negative.

Moreover, it is possible that the translation of this item altered responding. Indeed, as one of the Chinese members of our group observed, this item seems more neutral than positive in the Chinese language compared to other PTGI items. Taking these difficulties of

interpretation into account, we did not include it in subsequent analyses, but networks including the "change in priorities" node can be found in the supplementary material (see S3 and S4).

4.3. Combined PTSD and growth network

The combined PTSD and growth network had stable cross-cluster edges, allowing for an interpretation of the association between any two connected nodes. However, we could not identify meaningful bridge nodes (e.g., specific PTSD symptoms that are potentially associated with higher occurrence of growth) because our BEI values were insufficiently stable after we removed the "change in priorities" element. A substantial decrease in stability after removing the only element of growth that could be identified as a bridge node in the preliminary analyses is not surprising, because it removed the strong cross-cluster partial correlations in this network.

The negative edge between the growth element of feeling closer to others and the PTSD symptom of feeling emotionally numb or being unable to have loving feelings for others is intuitive. Overall, the inter-cluster associations were low in magnitude, which is why PTSD and growth may not be as related in our sample, at least not directly. Furthermore, sum scores of PTSD symptoms and growth were not significantly related in either a linear or in a curvilinear fashion (Wu, 2013), consistent with some studies (Barton et al., 2013, study 2; Powell et al., 2003; Znoj, 1999; Zoellner et al., 2008), but not others (Barton et al., 2013, study 1; Butler et al., 2005; Park et al., 1996). Given the mixed findings in research to date, the relationship between growth and PTSD seems complex. Different cultural understandings of trauma and growth, severity and type of the traumatic event, or other unmeasured third variables could explain the lack of meaningful relations between PTSD symptoms and growth in our sample. Whereas growth is a universal phenomenon, its facets can differ across cultures and the PTGI has been criticized for construing growth chiefly in terms of Western values (Kashyap & Hussain, 2018; Splevins, Cohen, Bowley, & Joseph, 2010). Nonetheless, the current sample experienced similar levels of growth compared to previous research in this field with Western samples (e.g., Polatinsky & Esprey, 2000, which examined growth in response to the loss of a loved one), representing moderate to high mean levels of growth. Furthermore, our growth network showed structural similarities with a previous growth network of a bereaved US student sample (Bellet et al., 2018). Accordingly, it seems unlikely that the lack of meaningful relations between PTSD symptoms and growth in our sample is entirely explained by cultural differences. Alternatively, the consistently high severity of trauma in our sample may have obscured a relationship between growth and PTSD, which possibly only emerges following exposure to lower-severity traumas. This is in line with Barton et al.'s (2013) results, who found a significant positive association between PTSD symptoms and growth in an undergraduate sample (study 1), but there was no evidence for such an association in treatment-seeking women who had experienced physical or sexual assault (study 2).

4.4. Combined PTSD, growth, and coping styles network

Our combined network with PTSD symptoms, growth, and coping styles identified coping methods that may affect PTSD symptoms and growth. Coping styles conducive to growth in previous research, such as positive reframing, active coping (Helgeson et al., 2006; Prati & Pietrantoni, 2009; Whealin et al., 2020; Wu, 2013), and religious coping (Ano & Vasconcelles, 2005; Prati & Pietrantoni, 2009; Whealin et al., 2020), were positively connected to growth elements in our network, but were barely connected to PTSD symptoms. Conversely, traditionally maladaptive coping strategies, particularly self-blame (Field & Bonanno, 2001; Folkman & Lazarus, 1985) and substance abuse, were positively associated with PTSD symptoms, but not with growth elements. Overall, there do not appear to be any coping styles that *both* increase growth *and* reduce symptoms. Rather, coping styles appear to be predominantly positively associated with either positive outcomes (i.e., aspects of growth) *or* negative outcomes (i.e., PTSD symptoms).

The only notable negative association that emerged in this network was between humor and growth, specifically appreciation of life. The use of humor may reflect attempts to deny the gravity of a traumatic event in one's life in interpersonal exchanges, preventing the social support key to fostering positive outcomes. Nonetheless, humor is often categorized as adaptive coping (Schroevers & Teo, 2008; Wild & Paivio, 2004; Zoellner & Maercker, 2006). However, humor is not necessarily perceived as a common, desirable trait in Chinese society as it is in Western cultures. Instead, it is a trait viewed as chiefly confined to professional comedians or actors; and public display of humor by an ordinary member of society may be regarded as inappropriate (Yue, Jiang, Lu, & Hiranandani, 2016). Yue et al. (2016) found that Canadians were more likely to use humor as a coping style than were Chinese students. This is in line with our sample, who engaged in less humor than in any other coping style (see S2).

4.5. Limitations and future directions

Network approaches allow researchers to assess the strength of associations between elements of different psychological phenomena at the symptom level, which may help to pinpoint which coping styles might be valuable clinical targets and directions for further research. However, there are several limitations to our study.

First, our data were cross-sectional and causal relationships between elements of different clusters should be interpreted as hypotheses. It is largely unknown how useful cross-sectionally derived centrality indices, including EI, will prove to be (Bringmann et al., 2019). However, some studies have indicated that such centrality indices may indeed have some predictive validity (Boschloo, van Borkulo, Borsboom, & Schoevers, 2016; Elliott, Jones, & Schmidt, 2019; Rodebaugh et al., 2018). Identifying causal relationships between nodes is highly desirable in the long run, as it could have valuable clinical implications. Cross-sectional research is only a first step; integrating causal relationships between nodes into highly developed and explicit computational theories is a long-term goal of this type of work (Robinaugh et al., 2019). Future longitudinal or experimental studies may clarify whether the key coping styles identified in the present study are more likely to be causes or consequences of the positive and negative trauma outcomes with which they were associated in our sample.

Another limitation is the fact that our BEI metrics were unstable in the combined network for PTSD symptoms and growth, preventing us from identifying which symptom-level aspects of PTSD and growth, if any, might account for their co-occurrence. Further research should be conducted to determine whether the instability of our bridge symptom metrics was due to sample-specific properties or the absence of such links altogether. Another interesting direction for future research would be to investigate whether the PTSD symptom structure differs among individuals who experience different levels of growth.

It is important to mention that our networks may not necessarily generalize to other traumatized populations, particularly due to the severity of the earthquake and its consequences in the region. Our participants experienced a specific type of traumatic event and lost a child. The sudden violent loss of a loved one in addition to experiencing a life-threatening natural disaster may result in different symptom structures than other traumatic events. Another concern regarding the generalizability of our PTSD symptom network is that we assessed PTSD symptoms based on DSM-IV criteria in the current study, preventing a direct comparison to DSM-5 PTSD symptom networks.

There may be (non-measured) coping styles that are relevant to the occurrence of PTSD and growth, but that we did not include in our analyses. For example, suppression was suggested to be positively correlated with intrusion and avoidance symptoms (Amir et al., 1997) and (intrusive) rumination was shown to predict symptoms of PTSD (Ehring,

Frank, & Ehlers, 2008; Zhou & Wu, 2016). Deliberate rumination, on the other hand, may mediate growth (Zhou & Wu, 2016).

In addition to other coping styles, future research should examine how a broader range of consequences of adverse life events relate to the three clusters we examined in the current study. Unfortunately, all participants in our study had suffered the loss of a child in the earthquake. However, their grief-related symptoms could not be assessed due to the distress associated with completing the relevant questionnaire. Other sequelae of adverse life events, which should be examined in future network studies include anxiety disorders, depression, and CG (Stroebe, Schut, & Stroebe, 2007). The principle of integrative pluralism (Kendler, 2005) suggests integrating different perspectives and levels of psychopathological research. Consistent with this principle, relationships among coping styles, posttraumatic stress, and growth are likely influenced by a wide array of social, neurobiological, cognitive, and individual difference factors that remain unexplored.

4.6. Clinical implications

Our last network provides some useful insights as to which coping styles may be of concern when treating PTSD and promoting growth. Targeting coping styles that have been identified as maladaptive in previous literature will likely alleviate PTSD symptoms overall. Targeting substance abuse may be particularly valuable for some patients, consistent with previous research (Jacobsen, Southwick, & Kosten, 2001). Additionally, targeting problematic cognitions conducive to self-blame, as is encouraged in Cognitive Processing Therapy (Galovski, Wachen, Chard, Monson, & Resick, 2015), could be valuable based on our findings. Clinicians should also encourage adaptive coping styles, such as positive reframing, but with the understanding that such modifications might not be primarily useful in alleviating symptoms of PTSD. Rather, they may be more appropriate methods for encouraging growth and enhancing quality of life in the long term, once more acute symptoms have subsided.

5. Conclusion

Our study extends the use of network analysis in examining multiple psychological phenomena while taking intra-individual characteristics into account. Our networks showed some similarities with former PTSD and growth networks. Further, coping styles have complex and distinct relationships with growth and posttraumatic stress symptoms. Adaptive and active coping styles may be particularly useful for fostering growth but may not be associated with decreased PTSD symptoms. Maladaptive coping styles that we identified may promote symptoms of PTSD and thus constitute initial treatment targets. However, this cross-sectional study was exploratory, and longitudinal studies may provide better insights about the causality of our suggested relationships and the clinical utility of our findings. Furthermore, future research should explore other constructs that may be related to growth and PTSD beyond coping styles.

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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.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.janxdis.2021.102359.

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