

Extreme weather, climate change, climate action and uncertainty distress:

An exploratory study using network analysis.

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Supplementary Materials

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Ethical Statement:

In conducting this study, the authors have abided by the Ethical Principles of Psychologists and Code of Conduct as set out by the BABCP and BPS. . The study received approval from the Faculty of Medical Sciences Ethics Committee, at Newcastle University: 6737/2020.

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Appendix 1: Description of Measures in Full

Standardized Measures of Psychological Distress

The following five measures assess psychological distress, namely symptoms of worry, anxiety, depression, post-traumatic stress symptoms, and adjustment disorder.

Penn State Worry Questionnaire-3. Berle et al. (2011) developed an ultra-brief version of the PSWQ from the full 16-item PSWQ (Meyer et al., 1990). The three items measure worry on a 5-point Likert scale, from 1 (*not at all typical of me*) to 5 (*very typical of me*). Kertz et al. (2014) established a cut-score of 11 with sensitivity = 0.71 and specificity = 0.73.

Generalized Anxiety Disorder Questionnaire 2 (GAD-2; Kroenke et al., 2007, 2010). The GAD-2 consists of the first two items of the GAD-7 rated on a 0 (*not at all*) to 3 (*nearly every day*) scale over the last two weeks. The first item refers to feeling nervousness, anxious and on edge, while the second refers to worrying. Scores range from 0 to 6, and a cut-score ≥ 3 indicates clinically significant anxiety.

Patient Health Questionnaire 2 (PHQ-2; Kroenke et al., 2003). The PHQ-2 consists of the first two items of the PHQ-9 rated on a 0 (*not at all*) to 3 (*nearly every day*) scale over the last two weeks. The first item refers to little interest or pleasure in doing things, while the second refers to feeling down, depressed or hopeless. Scores range from 0 to 6, and a cut-score ≥ 3 indicates clinically significant depression.

International Adjustment Disorder Questionnaire (IADQ; Shevlin et al., 2020). The IADQ (Shevlin et al., 2020) assesses the core features of adjustment disorder (AdjD) outlined in the International Classification of Disease (ICD-11, World Health Organization, 2022). This was used both as a measure of AdjD in the present study and as a symptom severity scale. The questionnaire consists of three main sections, the first is usually a list of nine categories of stressful life events that was not used here. The second section assesses six core symptoms of AdjD, related to the index event which in this case was named specifically as “climate change”, covering both preoccupation and failure-to-adapt in the last month. Item responses are on a five-point Likert scale, ranging from 0

(*not at all*) to 4 (*extremely*). The final section of the scale assesses functional impairment caused by these symptoms in the domains of social, occupational/educational, and other aspects of daily living, using three items, once again on a five-point scale. The measure is scored algorithmically to capture each of the five criteria for AdjD; if all five are met then the person meets criteria for AdjD. In this study, criteria one, exposure to a stressor was considered met if the person considered that their life had been disrupted by climate change to any extent (score ≥ 1). The nine preoccupation, failure to adapt, and functional impairment items were also summed to provide an indicator of psychological distress in response to climate change consistent with definitions of adjustment disorder.

Primary Care PTSD Screen for DSM-5 (PC-PTSD-5, Prins et al., 2016). This measure assesses five core symptoms of PTSD in reference to exposure to a traumatic event. Each item is rated *yes* or *no*. Scores range from 0 to 5. A cut-score of 4 indicates likely PTSD. In this study, participants were presented with the questionnaire only if they had experienced extreme weather in their area in the last five years and the frame of reference was “Thinking about extreme weather, in the past month have you...”.

Psychology of climate change:

Three core concepts from the psychology of climate change literature were assessed, namely, distress, concern and action.

Climate change distress. Eleven items were rated on a nine-point Likert scale from 0 (*not at all*) to 9 (*extremely*) in response to “how you feel in response to extreme weather and climate change”. In line with broad definitions of climate change and ecological distress, five were in the anxious register (anxious, concerned, panicked, scared, worried), three were complex or self-conscious emotions that may be experienced in the transgressor role of moral injury (ashamed, regretful, guilty) while three were in the register of the transgressee role of moral injury (angry, frustrated, and betrayed).

Climate change concerns. Ten common concerns from the literature were assessed on a 0 (*not at all*) to 8 (*extremely*) nine-point Likert scale. Three types of concerns were assessed: extreme weather (two items; affecting me or friends and family), climate change (four items; affecting me, my future, my friends and family, the planet) and measures to address climate change (four items; restrictions on me, affecting my future, the economy and society in a bad way). These items reflect a range of egoistic, altruistic and biospheric concerns (e.g., Helm et al., 2018). While these could be scored separately, the scores on the ten items were summed for the purposes of this study. Note that the instruction was “Please rate how concerned you feel about each...”, and so was framed neutrally rather than as worry or fear – one can express concern without necessarily engaging emotionally.

Climate change action. In line with the literature, positive climate change actions were assessed with 19 items covering both simple behaviours where many will engage in (e.g., Walked or taken public transport instead of driving) to those that environmental activists might do (e.g., Took part in a protest/rally about a climate change issue). The items were drawn from the Environmental Action Scale (Alisat & Riemer, 2015), two items from Brody et al., (2010) and the Pro-environmental behaviour scale (Dono et al., 2010). Items were rated on a 5-point Likert scale from 0 (*never*) to 4 (*frequently*) in answer to the question: “In the last six months, how often, if at all, have you engaged in the following environmental activities and actions?”

Disruption

Disruption was assessed with a composite measure of exposure to extreme weather and personal exposure to extreme weather and mitigation (see results for construction of the composite), and two face-valid items measuring subjective disruption.

Extreme Weather: A questionnaire was adapted from the Household Natural Hazards Preparedness Questionnaire (Williamsburg Emergency Committee, 2004) measures exposure to types of extreme weather, the number of exposures to extreme weather, and the impacts of extreme weather. The first part asks about eight types of extreme weather in their area: flooding,

strong winds, droughts, storm surges, sea level rise, landslips and landslides (due to extreme weather), wildfires, and extreme winter weather. Participants indicate *yes* or *no* to each of these types of weather. The next item asks about the number of extreme weather events in the last five years on a scale from 0 to 5, with anchor points at *0, 1-2, 3-4, 5-6, 7 or more*. Participants then answer 12 questions about impact, all answered as *yes* or *no*. The first item is about receiving weather warnings, the next seven refer to personal implications: taking precautionary measures, damage to home, properties or vehicles, insurance claim, difficulty with insurance coverage, financial loss, or injury. The final four items refer to effects of extreme weather events on family or friends, namely, precautionary measures, damage, injury and death. Five scores are derived: the number of types of extreme weather (0-8), the number of extreme weather events (0-5), receiving warnings (0-1) the number of personal impacts (0-7) and the number of impacts to family and friends (0-4). Note, these are counts of potential events or consequences that can be independent so that reliability assessed as internal consistency is not relevant.

Personal Experience of Extreme Weather: This single item measures whether participants have personally experienced extreme weather (Fownes & Allred, 2019). Participants rate their response on a 7-point Likert scale from *Strongly disagree* to *Strongly agree*.

Mitigation Measures. Mitigation measures were identified for each type of extreme weather. Brody et al. (2010) provided the model for the mitigation measure in the context of flood mitigation: ten flood mitigation measure were identified, namely, flood walls or barriers, embankments, clearing debris, channelization or dredging, flood plains, flood risk maps, flood planning, land use planning, and an open other category. Participants were shown the list only if they had reported floods on the extreme weather list and then ticked any that applied. The number of mitigation measures varied according to the type of weather (source of mitigation measures indicated in parentheses): six measures for drought (Wilhite et al., 2007), four for sea level rise and storm surges (Nicholls, 2011), five for winter weather ([Winter Weather | Ready.gov](https://www.ready.gov/winter-weather)), nine for

wildfire (Calkin et al., 2014) five for cyclones and strong winds ([Cyclones and severe storms | Emergency services and safety | Queensland Government \(www.qld.gov.au\)](#)) and four for landslips ([Landslide - Precautionary Measures, Early Warning Systems, and Slope Geometry | Britannica](#)).

Subjective Disruption. This was assessed with two items, the first assessing how much the participant's life had been disrupted by extreme weather and its impacts, and the second about climate change more generally and its impacts. Each was rated on a 9-point Likert scale from 0 (*not at all*) to 8 (*extremely*).

Threat.

The concept of threat was operationalized with two measures.

Perceived Proximity of Climate Change. Perceived proximity of climate change was assessed with 19 items drawn from a 26-item scale (Jones et al., 2017) covering construal of climate change on geographic (6), temporal (8), social (5), and uncertainty distance dimensions (7). The uncertainty dimension was not used. To minimise priming effects the order of the items was randomised.

Participants indicated their level of agreement with each statement on a 7-point Likert scale from 0 (*strongly disagree*) to 6 (*strongly agree*). Each subscale scale was scored with higher scores in the direction of close proximity, i.e., climate change is happening *here, now, and to people like me*.

There is an assumption in much of the literature that the three dimensions are highly correlated, that also implies that there is a higher order unitary construct of "distance". However, Keller et al., (2020) report that the relationships between the dimensions are highly variable across studies.

Further, they suggest that in some cases distance may be relatively stable, while in others it may be transient responses to an event or information. Similarly,

Perceived Threat of Climate Change. This scale was based on two items from the cognitive model of anxiety (likelihood and severity of something bad happening) with two others assessing imminence and how dangerous extreme weather or climate change would generally be for the

participant. Participants rate each question on a 9-point Likert scale from 0 (*not at all*) to 8 (*extremely*).

Uncertainty.

The three uncertainty variables consisted of rating climate change facts as lacking or having a factual basis (actual uncertainty), agreement with statements expressing uncertainty about climate change (perceived uncertainty), and actual trust/mistrust in information sources (mistrust).

Factual Basis of Climate Change. While the facts of climate change may have received scientific consensus and be communicated in authoritative ways by credible sources, *for an individual* these established available facts may be seen as uncertain in various ways (see McCloskey, 1996). Specifically, even the best factually correct information available may be seen as uncertain by an individual in that it has missing elements (available Vs. unavailable), or may be unreliable (trustworthy Vs. untrustworthy), conflicting (consistent Vs. inconsistent), noisy (relevant Vs. irrelevant), or confusing (interpretable Vs. uninterpretable). Fourteen statements derived from climate change science (see supplemental material) were taken from the UK Meteorological (Met) Office's website (the United Kingdom's weather agency, mandated by the government but subject to independent review). The items, all stated in an affirmative but neutral manner (where predictions were concerned, words like "could" were used) and were rated on a seven-point Likert scale from 1 (*completely disagree*) to 7 (*completely agree*).

Perceived Uncertainties in Climate Change Science. Five items measured agreement with statements about the degree to which climate change science is not agreed and two items (reversed scored) that it is agreed/happening (see supplemental material). These are not conspiracy beliefs with a malicious or world-view intention to mislead in the way climate change science is presented, simply agreement with the expression that "we do not yet know". The items were rated on a seven-point Likert scale from 1 (*completely disagree*) to 7 (*completely agree*).

Mistrust in the Communication of Climate Change Science. Four items measured trust in different sources of information in climate change (governments/international agencies, scientists, traditional/mainstream media, social media), one item about trust in one's own preferential media (which could include alternative media, media communicating climate change denial, etc.) two reverse scored items, the first about mistrusting because of scientific disagreement, and the second about only trusting officially rejected or marginalized sources. Participants rated each question on a 9-point Likert scale from 0 (*not at all*) to 8 (*extremely*). The scale, initially scored as trust, was then reverse scored in the direction of mistrust for the network analysis.

Intolerance of uncertainty.

Four measures cover dispositional IU, situational IU, information seeking, and uncertainty reducing behaviours.

Dispositional Intolerance of Uncertainty. This is measured with a brief version of the Intolerance of Uncertainty Scale (IUS-5, Bottesi et al., 2020), a five-item version of the Intolerance of Uncertainty Scale (IUS; Freeston et al., 1994), the gold standard measure for IU. The five items include two items measuring desire for predictability, two items describing aversiveness of uncertainty, and one item assessing uncertainty paralysis (Bottesi et al., 2020). Participants rate each item on a 5-point Likert scale from 1 (*not at all characteristic of me*) to 5 (*extremely characteristic of me*). The IUS-5 is psychometrically sound and correlates highly with the IUS-12 across a range of samples (Bottesi et al., 2020).

Situational Intolerance of Uncertainty. This scale was based on Pepperdine et al. (2018) and consists of four pairs of items, the first of each pair refers to the uncertainty of a target item and the second is how bothered or upset the participant is by the uncertainty. The four target items are (the uncertainty of) not knowing enough about climate change, not knowing what is being done in response to climate change, not knowing what will happen in the future with climate change, and not knowing the longer-term impact of climate change on you. The scale consists of eight questions

in total, and participants rate each question on a nine-point Likert scale from 0 (*not at all*) to 8 (*extremely*).

Information Seeking. Four questions asked about time per day engaging with the information sources about climate change concerns within a typical day, namely, traditional media, social media, other sources (e.g., friends, colleagues, etc), and alternative media sources (e.g., media sources which challenge or oppose the mainstream viewpoint). These items were rated with respect to on a 1 to 10 scale from 1 (*not at all*), through 2 (*less than 15 mins*) and 3 (*15-30 mins*), up to 10 (*> 7 hours*).

Uncertainty Reducing Behaviours. The short version of the Intolerance of Uncertainty Behaviours in Everyday Life (IUBEL, Clifford et al., 2015) consists of the original six items with one additional item developed within the context of the pandemic (I am acting as if the worst is happening right now). The items are rated on a nine-point Likert scale from 0 (*not at all*) to 8 (*extremely*).

Composite measure of extreme weather and mitigation

Local mitigation measures are put in place in areas where there is greater likelihood of material damage, threat of injury or to life, or greater disruption to day-to-day life by a given type of extreme weather. They thus provide an indicator of risk or of the likelihood of extreme weather may occur and could have an impact. From a psychological standpoint they increase the salience of extreme weather. The number of local mitigation measures varied according to the type of extreme weather and the total varied according to the number of types of extreme weather experienced. The total number of mitigation measures varied from 0 to 18 ($M = 1.84$, $SD = 2.77$) and was highly positively skewed (2.42) and kurtotic (7.80). Consequently, a ranking was attributed that reduced skew and kurtosis to acceptable levels but still correlated highly with the original total (Spearman's $\rho = .991$).

Composite Extreme Weather Index

Initial inspection of the extreme weather variables showed correlations between them varying from .2 to .7. To facilitate the network analysis, a composite extreme weather index was created by conducting a principal components analysis on the extreme weather variables described above. The item about receiving weather warnings did not load on the single factor so was not included. For the six retained scores, the Kaiser-Meyer-Olkin measure of sampling adequacy was .77, indicating the correlation matrix was suitable. The scree plot and Kaiser's rule indicated a single component. A single component was extracted with an eigenvalue of 2.89 and accounted for 48.9% of the total variance. A component score was generated by the regression method. The component loadings can be seen in Table 3; all six variables loaded strongly in the range of .60 to .77, indicating a strong degree of unidimensionality.

Enter table 1 about here

Table 1. Composite extreme weather index showing loadings on the extracted component for each variable.

	Extreme weather variable	Loading
1	Number of types of extreme weather	.763
2	Number of episodes of extreme weather	.748
3	Personally affected by extreme weather	.660
4	Number of impacts on self	.609
5	Number of impacts on family and friends	.595
6	Rank of number of local mitigation measures	.769

Appendix 2: Weights Matrix and Stability

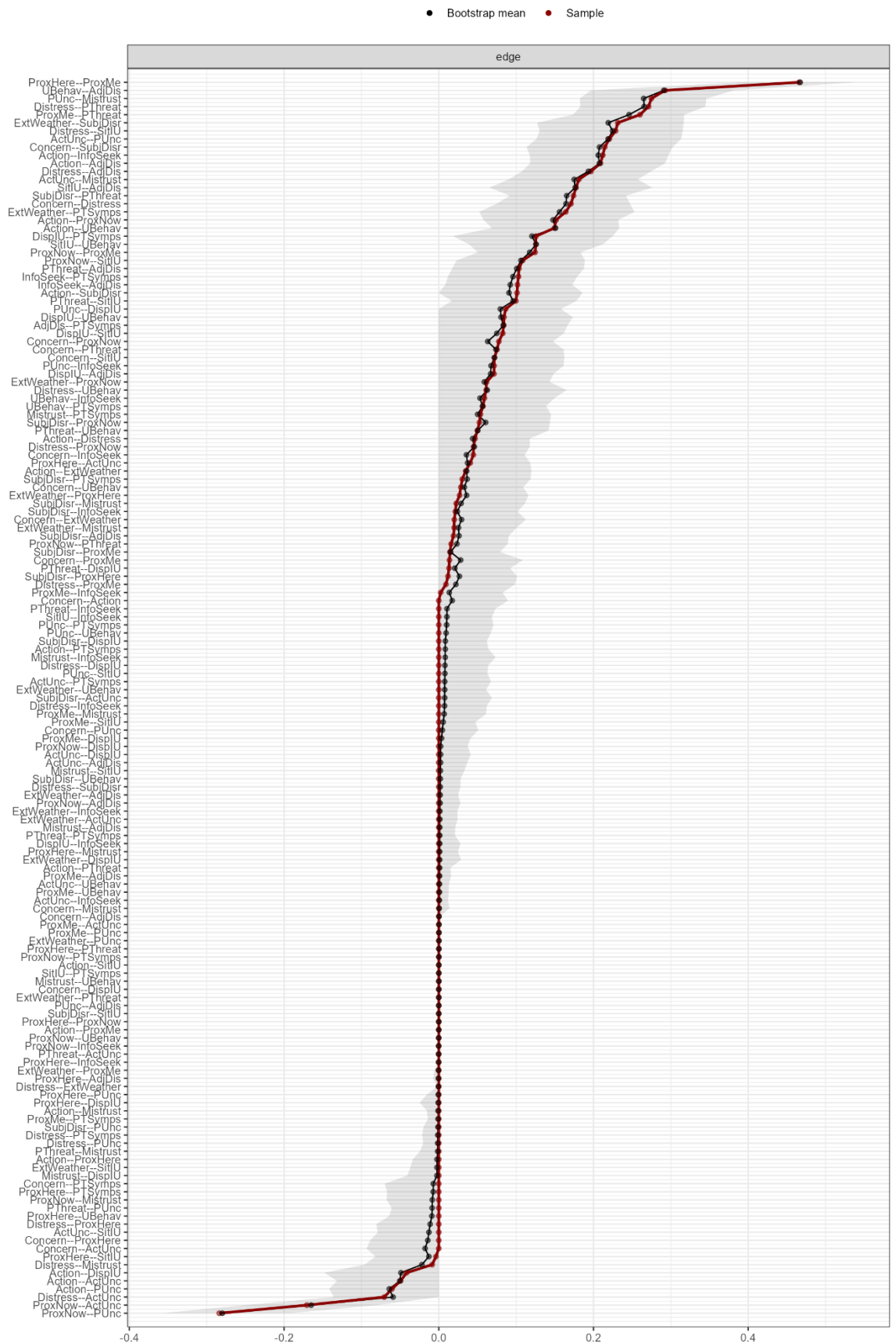
Table 2 Weights matrix - Edges > .10 in green, < -.15 in red

Variable	Network																		
	Concern	Action	Distress	ExtWeather	SubjDisr	ProxHere	ProxNow	ProxMe	PThreat	ActUnc	PUnc	Mistrust	DispIU	SitIU	UBehav	InfoSeek	AdjDis	PTSymp	
Concern	0.000	0.000	0.171	0.020	0.215	0.000	0.078	0.014	0.075	0.000	0.000	0.000	0.000	0.072	0.029	0.045	0.000	0.000	
Action	0.000	0.000	0.047	0.035	0.101	0.000	0.152	0.000	0.000	-0.049	-0.061	0.000	-0.042	0.000	0.149	0.212	0.209	0.000	
Distress	0.171	0.047	0.000	0.000	0.000	0.000	0.045	0.009	0.271	-0.070	0.000	-0.009	0.000	0.229	0.061	0.000	0.197	0.000	
ExtWeather	0.020	0.035	0.000	0.000	0.231	0.027	0.062	0.000	0.000	0.000	0.000	0.020	0.000	0.000	0.000	0.000	0.000	0.164	
SubjDisr	0.215	0.101	0.000	0.231	0.000	0.012	0.053	0.014	0.174	0.000	0.000	0.023	0.000	0.000	0.000	0.021	0.019	0.030	
ProxHere	0.000	0.000	0.000	0.027	0.012	0.000	0.000	0.466	0.000	0.041	0.000	0.000	0.000	-0.004	0.000	0.000	0.000	0.000	
ProxNow	0.078	0.152	0.045	0.062	0.053	0.000	0.000	0.125	0.016	-0.171	-0.284	0.000	0.000	0.108	0.000	0.000	0.000	0.000	
ProxMe	0.014	0.000	0.009	0.000	0.014	0.466	0.125	0.000	0.260	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	
PThreat	0.075	0.000	0.271	0.000	0.174	0.000	0.016	0.260	0.000	0.000	0.000	0.000	0.013	0.100	0.050	0.000	0.104	0.000	
ActUnc	0.000	-0.049	-0.070	0.000	0.000	0.041	-0.171	0.000	0.000	0.000	0.220	0.181	0.000	0.000	0.000	0.000	0.000	0.000	
PUnc	0.000	-0.061	0.000	0.000	0.000	0.000	-0.284	0.000	0.000	0.220	0.000	0.275	0.086	0.000	0.000	0.072	0.000	0.000	
Mistrust	0.000	0.000	-0.009	0.020	0.023	0.000	0.000	0.000	0.000	0.181	0.275	0.000	0.000	0.000	0.000	0.000	0.000	0.054	
DispIU	0.000	-0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.086	0.000	0.000	0.083	0.084	0.000	0.071	0.126	
SitIU	0.072	0.000	0.229	0.000	0.000	-0.004	0.108	0.000	0.100	0.000	0.000	0.000	0.083	0.000	0.126	0.000	0.178	0.000	
UBehav	0.029	0.149	0.061	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.084	0.126	0.000	0.059	0.293	0.057	
InfoSeek	0.045	0.212	0.000	0.000	0.021	0.000	0.000	0.002	0.000	0.000	0.072	0.000	0.000	0.000	0.059	0.000	0.102	0.103	
AdjDis	0.000	0.209	0.197	0.000	0.019	0.000	0.000	0.000	0.104	0.000	0.000	0.000	0.071	0.178	0.293	0.102	0.000	0.084	
PTSymp	0.000	0.000	0.000	0.164	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.054	0.126	0.000	0.057	0.103	0.084	0.000	

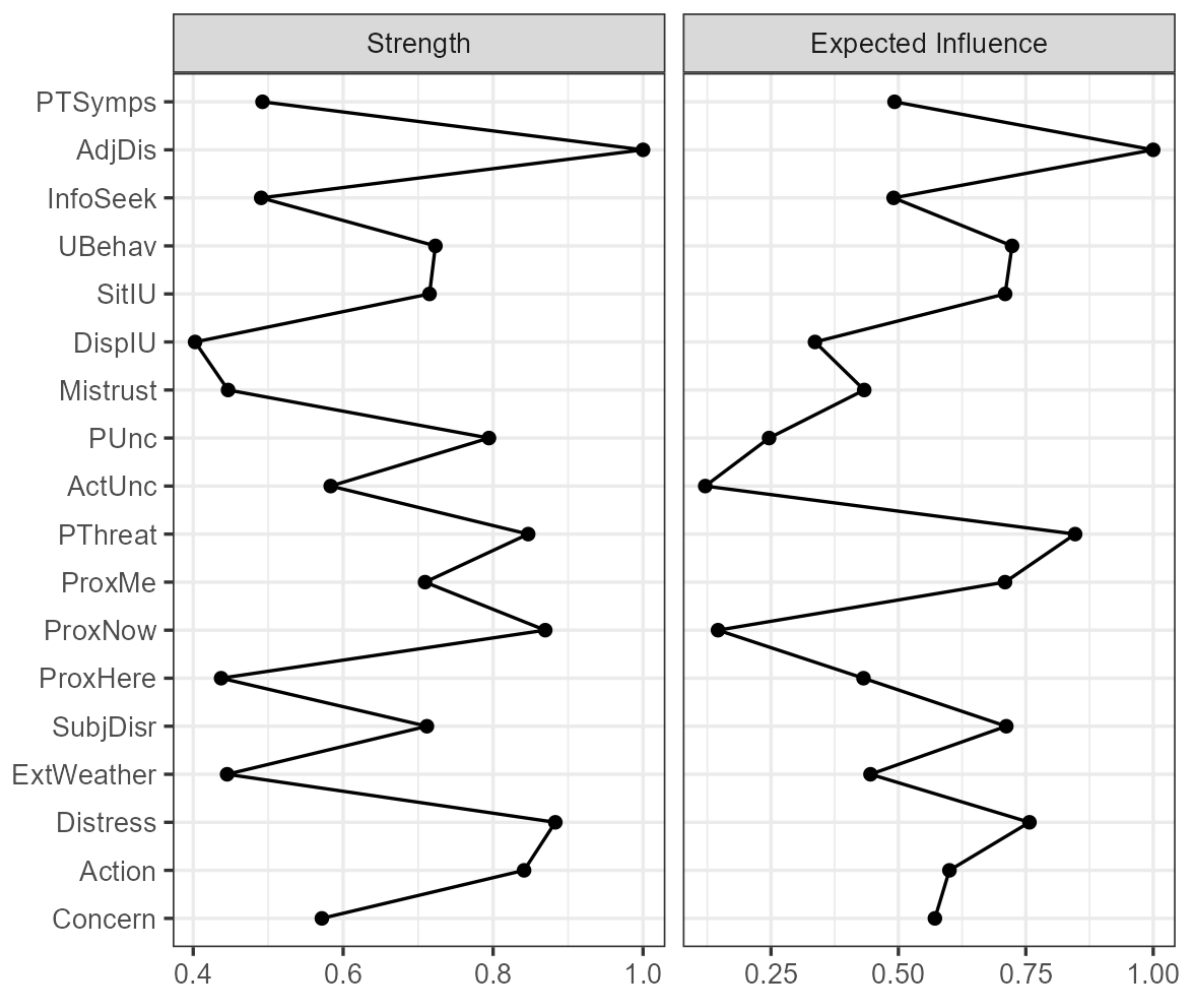
Total	>.1 or <-.15
Positive	64 27
Zero	81
Negative	8 2
Total	153 29

Appendix 3: Supplementary Figures 1 - 5

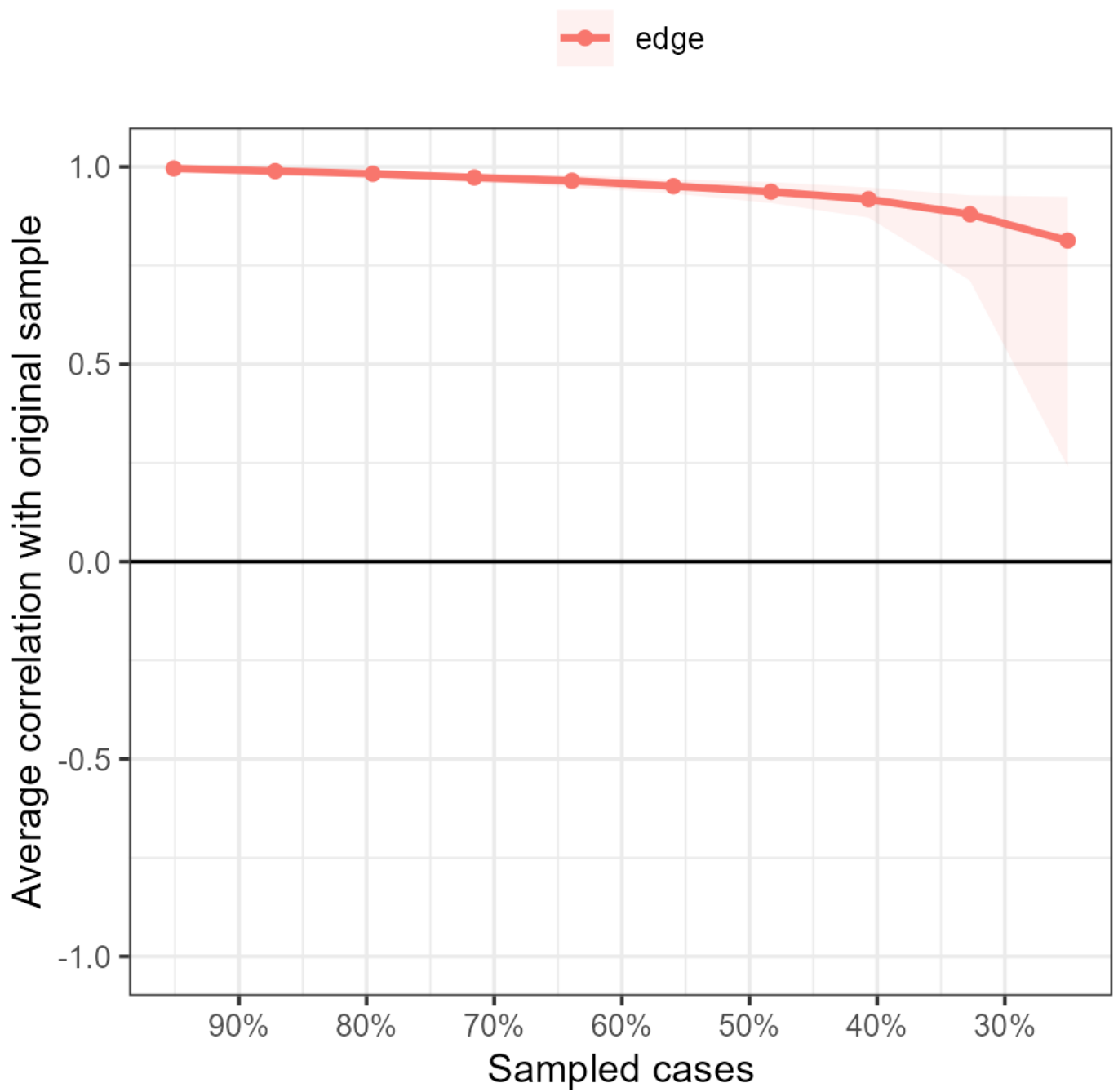
Supplementary Figure 1. Edge stability with bootstrapped CIs (1,000 resamples)



Supplementary Figure 2. Centrality plot of relative indices



Supplementary Figure 4. Edge stability with bootstrapped CIs (1,000 resamples) from 30-100% of the sample.



Supplementary Figure 5. Centrality stability with bootstrapped CIs (1,000 resamples) from 30-100% of the sample.

