



The roles of coalitional threat and safety in paranoia: A network approach

Anna Greenburgh*¹ , Vaughan Bell² and Nichola Raihani¹

¹Psychology and Language Sciences, University College London, UK

²Research Department of Clinical, Educational, and Healthy Psychology, University College London, UK

Objective. Paranoia is known to vary with levels of coalitional threat and safety present in the social environment. However, it remains underexplored whether threat and safety are differentially associated with paranoia, if these relationships vary with the source of threat and safety, and whether such effects hold across the continuum of severity of paranoid thoughts.

Methods. We employed a network analysis approach with community analysis on a large dataset ($n = 6,337$), the UK Adult Psychiatric Morbidity Survey 2007, to explore these questions. We included one node to capture paranoia typical in the general population, and one pertaining to thought interference common in persecutory delusions in psychosis.

Results. Nodes reflecting paranoia in the general population as well as persecution-related concerns in psychosis shared the strongest positive edges with nodes representing threat stemming from close social relationships. Paranoia common in the general population was negatively associated with both safety stemming from the wider social environment, and safety in close relationships, where the former association was strongest.

Conclusions. Our results suggest that threat from within one's immediate social group is more closely linked to paranoid thoughts than is safety from either one's social group or the wider social environment. Further, our results imply that coalitional threat may be a particularly associated with concerns common in psychosis, whereas paranoid ideation more common in the general population is also associated with reduced coalitional safety. Overall, this network analysis offers a broad view of how paranoia relates to multiple aspects of our coalitional environment and provides some testable predictions for future research in this area.

Practitioner points

- Individuals with paranoia more typical of delusions may find threat in close social relationships most challenging

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*Correspondence should be addressed to Anna G. Greenburgh, Department of Experimental Psychology, 26 Bedford Way, London WC1H 0AP, UK (email: a.greenburgh@ucl.ac.uk).

- Variation in paranoia in the general population may be attributed to feeling safe in the wider social environment more than in close social relationships

Concerns about other people's intentions are a feature of everyday life. The exaggerated belief that others intend to harm – paranoia – is a common example. Paranoia exists as a continuum in the population, where many people experience mild paranoid thoughts and a few people experience intense persecutory delusions (Bebbington et al., 2013). Paranoia can be conceptualised as a complex network of interconnecting features, where paranoid thoughts form distinct but linked clusters of mistrust, interpersonal sensitivity, ideas of reference, and ideas of persecution (Bell & O'Driscoll, 2018).

A recent synthesis proposes that paranoia may, in part, stem from mechanisms related to *coalitional psychology*, the set of cognitive abilities that help us navigate complex social environments comprised of kin and non-kin (Raihani & Bell, 2019). These abilities enable us to detect social threat and support, track alliances, and maintain social bonds, as well as help us to understand and monitor social status, track group membership, and perceive group cohesiveness (Boyer, Firat, & van Leeuwen, 2015).

Phenomenologically, paranoia reflects these themes: paranoid concerns centre around other people and often involve identifying social threat from people who are perceived to form groups (Bell, Mills, Modinos, & Wilkinson, 2017; Raihani & Bell, 2019). Moreover, paranoia in the general population is sensitive to the level of coalitional threat in the environment. In strategic interactions, stronger attributions of harmful intent are made to others who act unfairly, have higher social status, belong to an outgroup, and who form more cohesive opponent groups (Greenburgh, Bell, & Raihani, 2019; Raihani & Bell, 2019; Saalfeld, Ramadan, Bell, & Raihani, 2018; Veling, Pot-Kolder, Counotte, Van Os, & Van Der Gaag, 2016). In addition, cues of coalitional safety reduce paranoia. For example, trust is higher in situations of low power imbalance and low conflict (Weiss et al., 2020); social identification predicts reductions in paranoia over time (Sani, Wakefield, Herrera, & Zeybek, 2017); and engaging in secure attachment imagery (where the individual feels safe in the company of others) reduces paranoia in comparison to avoidant and anxious attachment imagery (Sood, Carnelley, & Newman-Taylor, 2021). As such, paranoia in the general population can be conceptualised as reflecting a proposed component of coalitional psychology, the coalitional safety index (CSI). This index is a putative internal regulatory variable that monitors cues of social threat and safety in the environment and translates these into a coalitional stress response (Boyer et al., 2015). Understanding paranoia through a lens of coalitional psychology allows us to make predictions about risk factors for paranoia through conceptualising them as inputs to this coalitional safety index.

First, a core claim of the coalitional safety index model is that threat and safety are 'not two sides of the same coin' (Boyer et al., 2015). That is, safety cannot simply be inferred from the absence of threat, nor vice versa. This is observed in animal threat detection systems where removal of threat cues does not necessarily lead to inferring safety (Dielenberg & McGregor, 1999). Indeed, threat cues, rather than safety cues, are suggested to be of particular importance to the CSI (Boyer et al., 2015). There is some existing data to support this prediction: longitudinal data indicate that the level of threat in an individual's neighbourhood (neighbourhood disorder and stress) is more predictive of psychotic experiences – where paranoia is a common feature – than the level of safety (neighbourhood cohesion) (Solmi, Colman, Weeks, Lewis, & Kirkbride, 2017).

The impact of threat and safety on a stress response also seems to vary according to its source: whether this stems from close others or wider society. For example, a study of

psychotic experiences in victimised adolescents revealed that safety in the close family environment was more important than safety in the wider neighbourhood context in reducing risk of psychosis (Crush et al., 2018). Further, reduced social connections and social support from close others are associated with psychosis in adults (Gayer-Anderson & Morgan, 2013) and with paranoia in the general population (Freeman et al., 2011). However, in a network analysis study, McElroy et al. (2019) found that safety and threat in the wider social (neighbourhood) environment were associated with paranoia in the general population, but, after controlling for these measures, support from close others ('social connectivity') was not. In the domain of threat, it is also unclear whether threat cues pertaining to close relationships are more predictive of paranoia than threat stemming from the wider environment. For example, difficulty in close relationships is closely associated with paranoia in both clinical and general populations (Hajdúk, Klein, Harvey, Penn, & Pinkham, 2019), but so is stress from the wider social context (Wickham, Taylor, Shevlin, & Bentall, 2014).

The nature of the association between paranoia and the coalitional environment may change across the continuum of paranoia. The coalitional perspective of paranoia suggests that, in line with the phenomenology of paranoia, different mechanisms may be involved in paranoia to different degrees along the spectrum of severity (Raihani & Bell, 2019). While paranoia across the continuum involves ideas that others (often forming groups) intend to harm the individual, the identification of groups of persecutors is particularly predictive of severe paranoia (Freeman et al., 2021). Therefore, more delusional paranoia (e.g. that experienced in psychosis) may reflect cognitive processes involved in detecting coalitions and alliances to a greater degree, whereas more general forms of paranoid ideation may be more likely to involve variation in cognitive processes involved in attributions of intent (Raihani & Bell, 2019). Some initial research indicates a dissociation in the relationship between paranoia and social functioning in general compared to clinical populations (Hajdúk et al., 2019). However, no research has yet investigated how different forms of paranoia may differently associate with detection of coalitional threat and safety. Distinguishing between different forms of paranoia may help to understand seemingly contradictory results reported above where social support from close others predicts paranoia in some cases but not others: McElroy et al. (2019) found that support from close others was not associated with general forms of paranoid ideation; whereas Gayer-Anderson and Morgan (2013) found that support from close others is an negatively associated with early psychosis.

Our study examined whether coalitional threat cues are more closely linked to paranoia than coalitional safety cues. Our resulting network also enabled us to explore whether the source of such cues impacts these relationships. Furthermore, we investigated whether these associations vary based on the nature of persecutory ideation: paranoia that is more common in the general population, compared to beliefs of thought interference that are rarer and typically present as persecutory delusions in psychosis (Spence, 2001).

We employ a psychological network analysis approach on a large dataset (the Adult Psychiatric Morbidity Survey) in this study. Network analysis is advantageous for a number of reasons. Unlike traditional latent variable approaches (Reise & Waller, 2009), psychological network analysis does not seek to identify a few underlying factors based on an *a priori* model, but instead allows for a conceptualisation of cognition as a complex web of interacting components that is derived directly from the data (Borsboom, Cramer, & Kalis, 2017). The network approach has been used to determine the network structure of cognition in paranoia (Bell & O'Driscoll, 2018), as well as how features of paranoia

relates to neighbourhood disorder, stress, and cohesion (McElroy et al., 2019) and to interpersonal functioning (Hajdúk et al., 2019). Importantly, this method serves mostly an exploratory purpose (Epskamp, Borsboom, & Fried, 2018), suitable for our purposes given the novelty of the subject matter, and the impossibility of making predictions about nodes of the network until the network constituents had been identified and the network estimated.

Method

Procedure

Dataset

We used the Adult Psychiatric Morbidity Survey 2007 (APMS; McManus, Meltzer, Brugha, Bebbington, & Jenkins, 2009) for the data analysis. This is a large dataset ($N = 7,403$, $f = 4,206$, $m = 3,197$) of adult participants aged 16–95 (mean age = 51.12) recruited from private households in the United Kingdom and commissioned by the NHS Information Centre for Health and Social Care. It contains questions covering far-ranging topics, including health, living standards, employment, and psychiatric history. Questions were administered via computer-assisted interviews and self-report questionnaires. This dataset was chosen for the current analysis as it contains measures of paranoia, as well as questions relevant to coalitional psychology. The current study follows in a tradition of paranoia research employing the APMS (Bebbington et al., 2013; Bell & O’Driscoll, 2018). Our study was pre-registered at https://osf.io/4zpsf/?view_only=c189ec7d00f5417a8c57564204aa5625

Identifying items to include in the network analysis

To study multiple components of coalitional psychology, we selected a long list ($N = 40$) of questionnaire items from the Adult Psychiatric Morbidity Survey 2007 that we deemed pertinent to coalitional psychology, representing perception of cues of safety and threat from both close alliances and the wider social environment. We invited a panel of known experts in the field ($N = 11$) to participate in a questionnaire, in which they were asked to read a given definition of coalitional psychology (see Supporting information) and rate the extent to which they thought each item on the long list of items was relevant to the construct. In line with our pre-registration, each panel member was asked to rate at least 20 items from the APMS long list, and each item therefore had ratings from at least four experts. We standardised each of the panel member’s set of ratings in order to control for rater bias, and then calculated the average z -score for each APMS item (as in Raihani & Smith (2015)). Items with average z -scores above 0 were selected for the short list of coalitional items to be included as nodes in the network analyses. This amounted to 15 items from the APMS, 2007 (see Supporting information). The intra-class correlation coefficient (ICC) was calculated to assess the agreement between experts. There was a good average absolute agreement between the raters, using a two-way random effect model: $\kappa = 0.80$ (95% CI = 0.62, 0.92; $F(11,120) = 4.9$, $p < .001$).

Items selected for inclusion in the network largely pertained to coalitional threat or safety. As such, we were able to pursue our pre-registered aim to examine whether paranoia was more strongly related to items reflecting coalitional danger rather than coalitional safety.

Paranoia

Two items from the Psychosis Screening Questionnaire (Bebbington & Nayani, 1995) within the APMS were selected to represent paranoia in the network analysis: PSQ2 and PSQ3. This selection was based on a previous study on the network structure of paranoia in the general population (Bell & O’Driscoll, 2018), which identified these two items as forming a distinct sub-community of *ideas of persecution*. PSQ3 (‘Over the past year, have there been times when you felt that people were against you?’) represents common paranoid thoughts that often occur in the general population as well as in persecutory delusions. PSQ2 (‘Have you felt that your thoughts were directly interfered with or controlled by some outside force or person?’) represents thoughts that are less frequent and are typically present in persecutory delusions involving the belief that others are intending to harm the individual by interfering with their mind or externally controlling them (Bebbington et al., 2013; Bebbington & Nayani, 1995; Spence, 2001). Therefore, our selection of these two items allowed us to examine one measure of ideation typical in persecutory delusions in psychosis alone (PSQ2) and another measure more likely to also capture general paranoid ideation (PSQ3). While delusions of thought inference can occur outside of paranoia, the PSQ2 measures these experiences where they relate to ideas of persecution (Bebbington et al., 2013; Bell & O’Driscoll, 2018): a loss of control over one’s thoughts and actions due to intentional action by other agents, where this is likely to be experienced as harmful and frightening.

Statistical analyses

The network analysis was pre-registered, and codes to reproduce analyses are openly available online. The datasets used are available upon application to the UK Data Service. The statistical software *R* (version 3.4.4) was used to carry out all analyses. Discrete variables from the APMS were first recoded into ordered categorical variables where higher values signified stronger responses to the question item, and, consequently, ordered categorical variables with four or more levels were treated as continuous variables, as is common procedure in psychological network analysis when relationships are expected to be linear. Answers of ‘unsure’ or ‘I don’t know’ were excluded from the analysis, such that items such as PSQ2 and PSQ3 were treated as binary (yes/no) variables. Skewed continuous variables were log-transformed, where skew was determined using the skewness function within the Moments package in *R* (Komsta & Novomestky, 2015).

Network analysis. We estimated a network to investigate the structure of paranoia and coalitional psychology from a partial correlation matrix of the selected short-list of coalitional and paranoia items. Variables were represented in the network as nodes, and the edges between these nodes signify their conditional dependence relations. Our data contained continuous and categorical variables, so we estimated a Mixed Graphical Model using the *mgm* package in *R* (Haslbeck & Waldorp, 2020). This method of network estimation employs the least absolute shrinkage and selection operator (LASSO), which is a form of regularisation. This shrinks all edge-weights towards zero and sets all small weights to zero by limiting the total sum of absolute parameter values (Epskamp & Fried, 2018). The level of penalization involved – in other words how conservative the estimated network is – is determined by the parameter lambda, selected using Extended Bayesian Information Criterion (Epskamp & Fried, 2018). EBIC model selection also involves a tuning parameter, gamma, which we set to 0.5 (Foygel & Drton, 2010). Together these

methods produce conservative estimates and a sparse network where non-significant edges are minimised.

We performed two analyses to confirm the stability and accuracy of features of the network. First, to assess how stable the centrality metrics (see Supporting information) estimated were, we performed a *case-dropping subset bootstrap* using the *bootnet* function in R. Here, we bootstrapped the model 1,000 times where increasing numbers of cases are removed from the dataset and the centrality metrics (strength, expected influence, betweenness and closeness) are recalculated with each iteration to give a correlation stability coefficient (Epskamp et al., 2018). Of particular value is the centrality measure of strength (the sum of all absolute edge weights a node is connected to) as it is less susceptible to fluctuation based on removal of nodes in the network compared to other centrality measures, namely, betweenness and closeness (Bringmann et al., 2019). Second, to assess the accuracy of the estimated edge-weights, we bootstrapped the model 500 times to construct *bootstrapped confidence intervals* (CIs), where in 95% of cases the CI contains the true value of the edge-weight parameter. We computed predictability for each node in the network using the *mgm* package (Haslbeck & Waldorp, 2020): predictability reflects how well any given node can be predicted by the other nodes in the network.

Main hypotheses -

Q1. Does paranoia relate more strongly to items reflecting coalitional threat than coalitional safety? (pre-registered)

We conducted bootstrapped difference tests of on edge-weights in the network. Significant difference tests are achieved by taking the difference between bootstrap values of two edge-weights and constructing a bootstrapped CI around the difference scores, where a null-hypothesis test can then be conducted by determining whether zero is in the bootstrapped CI. It is important to note that these significance tests do not control for multiple testing, which is not possible to do in psychological network estimation and has been noted as a topic for future research (Epskamp et al., 2018).

Support for our hypothesis would be given by a result that edges between nodes reflecting paranoia and coalitional threat are significantly stronger than edges between paranoia and coalitional safety.

Q2. Do the relationships between cues of coalitional threat or safety and paranoia vary based on the source of such threat and safety?

We performed a community analysis to determine whether different types of coalitional cues cluster together. Here, the *spinglass* algorithm was used to identify sub-communities in the estimated network using the package *igraph* in R (Csárdi & Nepusz, 2006). Sub-communities are clusters of nodes that share many edges within the sub-community and few edges with nodes outside it (Yang, Algesheimer, & Tessone, 2016). We also ran a community analysis using Exploratory Graph Analysis using the package *EGAnet* in R (Golino et al., 2021) to test whether the same communities were found using a different statistical method.

By investigating which community paranoia items were included in, and the significant difference tests of edges between paranoia items and items within each sub-

community, we were able to investigate whether the strength of association between paranoia and different clusters of coalitional psychology items.

Q3. Do the relationships between paranoia and coalitional threat and safety depend on the form of paranoia: that which is more common and typical in the general population, compared to thoughts that are rarer and more reflective of persecutory delusions in psychosis?

This was investigated by the bootstrapped difference tests, determining if there were significant differences in the strength of edges shared between PSQ2 and other nodes in the network with edges shared between PSQ3 and those nodes.

Results

Main network analysis – APMS, 2007

Sample characteristics

The final sample ($n = 6,337$, after excluding missing data) consisted of 57% women and 43% men, ranging between 16 and 95 years of age, with a mean age of 50.6. A significant minority reported having experiences relating to paranoia (Bell & O’Driscoll, 2018): 8% reported paranoid concerns involving thought interference measured by PSQ2 and 18% reported paranoid concerns involving the feeling that ‘people were against you’ as measured by PSQ3.

Network analysis

The estimated network (Figure 1) had high accuracy and stability (see Supporting information). Paranoia items shared edges with multiple nodes in the network (Table S1). The network is regularised meaning that all edges near 0 are minimised to 0; therefore, the resulting edges illustrated in the network are sufficiently strong to be included in the conservative network (Epskamp & Fried, 2018).

Main hypotheses

Q1. Does paranoia relate more strongly to items reflecting coalitional threat more than coalitional safety?

Bootstrapped difference tests of edge-weights revealed that some coalitional factors had significantly stronger relationships paranoia than others (Tables S1-S3).

In particular, the paranoia item involving delusional thought interference (PSQ2) only shared edges with items reflecting social threat. In contrast, the paranoia item describing the feeling that ‘others are against you’ (PSQ3) was more closely positively associated with items reflecting social threat than it was negatively associated with those reflecting safety. For example, we found a stronger relationship between paranoia as measured by PSQ3 and the node coding for close relationships having lots of ups and downs (PD74) than for that coding having close and reliable family and friends (DLSS3) (CI: $-0.37, -0.07$; $p < .05$) or for CloseRI3 (which codes for relatives you feel close to) (CI: $-0.46, -0.21$; $p < .05$). Moreover, paranoia (measured by the PSQ3) was more closely related to becoming frantic at the thought of someone you cared about leaving you (PD73) than with

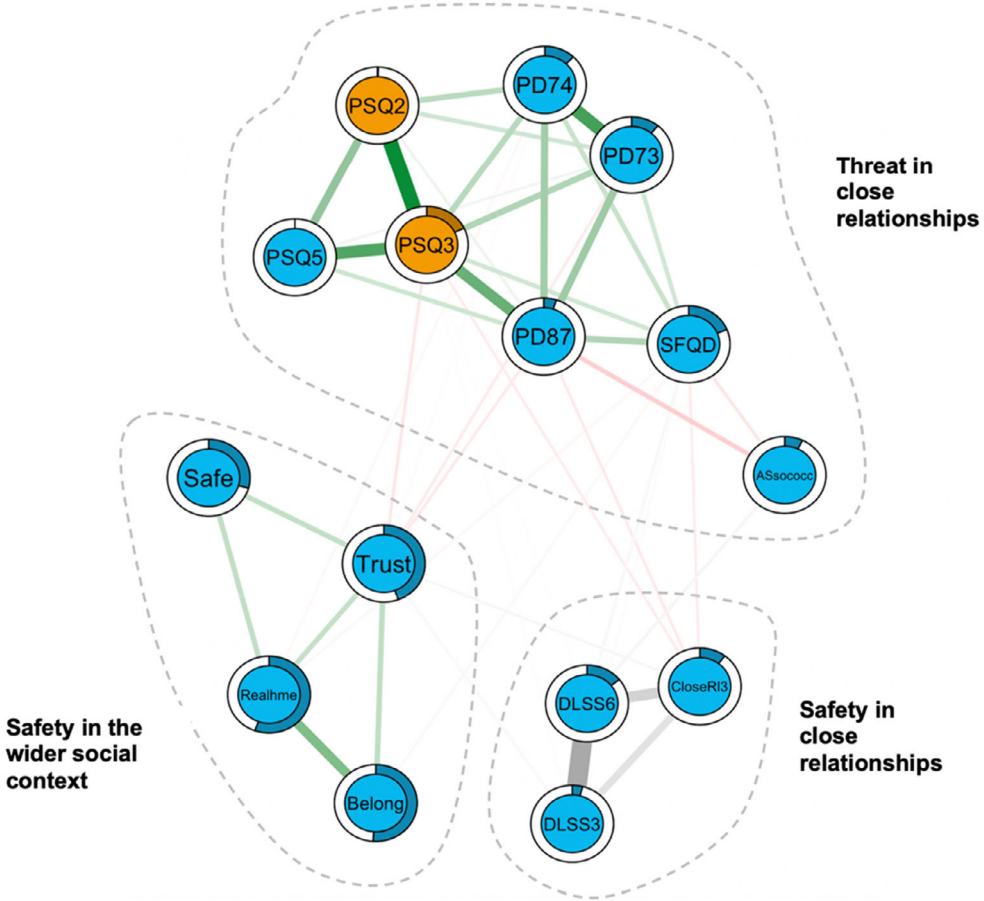


Figure 1. Estimated network with node item key. Orange node colour highlights nodes pertaining to persecutory ideation (PSQ3 and PSQ2). Dashed lines encircle sub-communities in the network. The strength of edges are represented by the width of lines between nodes. See Table S1 for the full numerical results. Edge valence is represented by edge colour, where red indicates a negative relationship and green indicates a positive relationship. Ties between categorical variables with more than two levels are depicted in grey as it is not possible to depict the valence of ties as relationships may be non-linear. Predictability estimates are represented by the pie bar surrounding each node.

measures of social safety coded by DLSS3 and CloseRI3 (CI: $-0.38, -0.07$; $p < .05$; CI: $-0.48, -0.22$; $p < .05$).

Q2. Do the relationships between cues of coalitional threat or safety and paranoia vary based on the source of such threat and safety?

Spinglass community analysis revealed three sub-communities in the network – highlighted in Figure 1. We labelled the three sub-communities according to their constituent nodes: (1) *Threat in close relationships*, (2) *Safety in the wider social context*, and (3) *Safety in close relationships*. We note that these labels reflect subjective experiences rather than objective threat and safety in the social environment. Each sub-

community contains nodes from multiple questionnaires. This indicates that the sub-communities do not simply reflect underlying latent variables that have been previously identified by psychological questionnaires. These results were replicated when community analysis was conducted using Exploratory Graph Analysis (see Supporting information) (Golino et al., 2021).

Both paranoia nodes were included in the *Threat in close relationships* sub-community, sharing a higher proportion of edges with nodes in this sub-community compared to those in the other sub-communities. In fact, the paranoia item reflecting more delusional concerns only shared edges with other nodes within this sub-community. This is supported by the bootstrapped significance difference tests that indicate the edges between paranoia nodes and other nodes in the *Threat in close relationships* sub-community were stronger than between paranoia nodes and nodes outside of this community (Tables S2 and S3).

We can also consider the bootstrapped test of edge-weights to investigate whether paranoia (as measured by PSQ3, as PSQ2 did not share any edges with nodes in other communities) differentially related to nodes based on the source of safety they describe: to nodes in sub-communities 2 compared to 3 (*Safety in the wider social context* and *Safety in close relationships*, respectively). Only two difference tests reached significance in comparing edge weights between paranoia and items in sub-community 2 with paranoia and items in sub-community 3. The negative relationship between paranoia and trust in local community (PSQ3-Trust) was significantly greater than the negative relationship between paranoia and items indicating a close social support (PSQ3-DLSS3 (CI: 0.05, 0.30, $p < .05$), and PSQ3-DLSS6 (CI: 0.04, 0.23, $p < .05$) (see Table S2), that is, (1) how many people the individual can rely on (DLSS3) and (2) how many people close to the individual makes them feel an important part of their lives).

Q3. Do the relationships between paranoia and coalitional threat and safety, respectively, depend on the form of paranoia: that which is more common and typical in the general population, compared to thoughts that are rarer and more reflective of persecutory delusions in psychosis?

PSQ2 shared no significant edges with any item outside of sub-community 1 whereas PSQ3 did share significant negative edges with items both in sub-community 2 and 3: Trust, DLSS3, CloseRI3 (see Table S1).

Discussion

This study explored how cues of coalitional threat and safety are differentially related to paranoia, how this may vary depending on the source of such cues, and whether these relationships depend on the form of paranoid ideation. We estimated a network of items pertaining to coalitional psychology extracted from the *Adult Psychiatric Morbidity Survey* (APMS, 2007), as determined by a panel of experts; and two measures of paranoia of varying severity. Spinglass analysis revealed three sub-communities in the estimated network, which we interpreted as reflecting participants' perceptions of (1) *Threat in close relationships*, (2) *Safety in the wider social context*, and (3) *Safety in close relationships*. Both items pertaining to paranoia were included in the first category, where PSQ2 (reflecting thought interference often accompanying persecutory delusions) shared no edges with nodes outside of this sub-community, and PSQ3 (reflecting general paranoid ideation) was more closely related to items contained within the second

category (safety in the wider social context) than the third category (safety in close relationships).

Cues of coalitional threat and safety formed distinct sub-communities in the network: nodes in sub-communities 2 and 3 reflected perception of cues of safety, whereas nodes in sub-community 1 most commonly reflected threat detection. These findings support the hypothesis that threat and safety are distinguishable entities – safety cannot necessarily be inferred by absence of threat, nor vice versa (Boyer et al., 2015). Importantly, it was not simply the case that threat and safety cues, respectively, clustered together. Nodes reflecting perception of coalitional safety formed two separate sub-communities in the network: one representing the wider social environment and the other reflecting social support from close others.

Our results support our prediction that paranoia is associated with detection of certain coalitional cues more than others. Unsurprisingly, where they existed, edges between PSQ3/PSQ2 and nodes reflecting threat were positive; and edges between PSQ3 and nodes reflecting safety were negative. Both PSQ2 and PSQ3 shared the strongest edges with nodes reflecting coalitional threat as indicated by their inclusion in sub-community 1 in Spinglass community analysis as well as bootstrapped significant difference tests. This suggests that perceiving threat from within one's immediate social circle is more closely linked to paranoid thoughts than perceiving safety from both one's immediate social circle or from the wider social environment.

The strength of the relationship between paranoid concerns about 'others being against you' and social support varied according to the source of that support. This item (PSQ3) was more closely related to items within the *Safety in the wider social context* sub-community compared to the *Safety in close relationships* sub-community. This result partially coincides with existing epidemiological evidence. McElroy et al (2019) found no relationship between paranoia and support from close others when controlling for safety in the wider social environment (social cohesion). Although we observed a similar direction of effect – that safety in the wider environment is more important than close social support in negatively predicting paranoia – we do still find that perception of close social support has an independent association with paranoia beyond the influence of safety of the wider environment. We suggest this may be because we included a larger range of items reflecting close social support than included in the study by McElroy et al. (2019). However, we note that these significant difference results are rather marginal and warrant further testing.

Our results suggest a partially distinguishable relationship between coalitional environment and paranoia depending on the nature of paranoia. As previously mentioned, both PSQ2 and PSQ3 items were included in sub-community 1, suggesting that thought interference that typically accompanies persecutory ideation (PSQ2) and paranoia involving broad concerns about the intentions of others (PSQ3) were closely linked with threat in close relationships. However, there were some differences in how the edges from each of these different types of paranoia related to nodes outside of this sub-community. In particular, PSQ3 shared edges with nodes reflecting safety cues from both the close and wider social environment (in sub-community 2 and 3); whereas PSQ2 only shared edges with other nodes within sub-community 1. That is, once controlling for all other relationships in the network, ideation relating to persecutory delusions in psychosis (PSQ2) was only associated with threat from the close social environment and not with measures of safety, either from close others or from the wider community. We note that, despite including PSQ2, the network estimated may not generalise to a clinical population

as participants in the APMS are selected from the general population that may have included both help-seeking and non-help seeking individuals.

We note a number of caveats in the current study. Importantly, our results cannot provide any causal conclusions as to how coalitional threat and safety moderates paranoia: our results likely both reflect biases that stem from paranoia (higher tendency to perceive coalitional threat) and risk factors for paranoia (higher levels of coalitional threat in the environment lead to higher levels of paranoia). Additionally, we note that, while we used ratings from panel of domain experts to determine what APMS items pertained to coalitional psychology, our sub-communities were interpreted by the research team. This is a common practice in network analysis research (Fried, 2016) although some finer-grained distinctions within these categories may be argued for. For example, nodes we identified as pertaining to coalitional threat might be interpreted as maintaining alliances (e.g., PD74 and SFQD). We classified such nodes as ‘coalitional threat’ as they describe turbulent and unreliable coalitional affiliations, which are a source of social threat. That fact that the ‘threat within close relationships’ sub-community comprised several nodes used to measure other psychopathological constructs (e.g., personality disorder) highlights that coalitional psychology is a potential transdiagnostic mechanism. Further, this sub-community reflected coalitional threat perception specifically rather than including all broad indicators social dysfunction. We would like to stress that our labels refer to subjective experiences (detection of coalitional threat/safety) rather than actual exposure to such environmental features. An extension to the current research might measure exposure to specific coalitional threats such as interpersonal conflict, neglect and domestic violence. Further, we note that two further items – PD87 and PSQ5 – may be argued to capture experiences common in paranoia: dissociation, suspicion, and sensed presence. However, we focussed on items that fall within ‘ideas of persecution’ defined by previous studies (Bebbington et al., 2013; Bell & O’Driscoll, 2018). Even so, these nodes show similar relationships with our other paranoia nodes: they shared the strongest ties with nodes indicating coalitional threat. Finally, unfortunately, our node list did not include any items reflecting threat from the wider social environment, so the comparison of the role of threat that comes from the wider social environment (as opposed to from close social others) remains a topic for future research.

Our results are specific to a UK sample. Familial and societal support structures are highly culture-dependent, where the influence of such structures on behaviour is far-reaching. For example, the strength of ties between individuals and kin has been linked to both mentalising and moral judgement (Curtin et al., 2020). Indeed, the emotional impact of social rejection may also be culture dependent (Kimel, Mischkowski, Kitayama, & Uchida, 2017; Yaakobi, 2021). Given that the APMS involves participants from a relatively individualistic culture, it may be unsurprising that we found paranoia to be associated with cues of safety from the wider social-context over and above those from close others. However, in cultures where the role of the in-group or kin is stronger, we might expect that this pattern is reversed or dampened.

Overall, our study investigates the relationship of a range of coalitional characteristics with paranoia. Nodes reflecting coalitional psychology clustered into three groups: those concerning threat from close others, those reflecting safety in the wider social context, and those reflecting safety in close in-groups. Paranoia involving concerns that others intend the believer harm was most strongly related to threat from close others, followed by safety in the wider social context, followed by safety from close social others. Delusional ideation (thought interference) typically relevant to persecutory delusions was only associated with threat from close others. Therefore, our results suggest that threat

may be a particularly important driver of paranoid delusions, but that coalitional safety may also play a role in variation of more general paranoid ideation. Our study is exploratory in nature but offers some testable hypotheses to progress understanding of coalitional psychology in the future.

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Conflicts of interest

All authors declare no conflict of interest.

Author contribution

Anna Greenburgh: Conceptualization (equal); Data curation (equal); Formal analysis (equal); Investigation (equal); Methodology (equal); Project administration (equal); Resources (equal); Software (equal); Visualization (equal); Writing – original draft (equal); Writing – review & editing (equal). **Vaughan Bell:** Conceptualization (equal); Methodology (equal); Supervision (equal); Writing – review & editing (equal). **Nichola Raihani:** Conceptualization (equal); Funding acquisition (equal); Methodology (equal); Supervision (equal); Writing – review & editing (equal).

Data Availability statement

The data that support the findings of this study are openly available at <https://osf.io/4zpsf/>.

References

- APMS (2007). phase one questionnaire and phase two contents PHASE ONE 1. Household information StartDat Date interview with respondent.
- Bebbington, P. E., McBride, O., Steel, C., Kuipers, E., Radovanović, M., Brugha, T., . . . Freeman, D. (2013). The structure of paranoia in the general population. *British Journal of Psychiatry*, *202*(6), 419–427. <https://doi.org/10.1192/bjp.bp.112.119032>
- Bebbington, P., & Nayani, T. (1995). The psychosis screening questionnaire. *International Journal of Methods in Psychiatric Research*, *5*(1), 11–19.
- Bell, V., Mills, K. L., Modinos, G., & Wilkinson, S. (2017). Rethinking social cognition in light of psychosis: Reciprocal implications for cognition and psychopathology. *Clinical Psychological Science*, *5*, 537–550. <https://doi.org/10.1177/2167702616677079>
- Bell, V., & O'Driscoll, C. (2018). The network structure of paranoia in the general population. *Social Psychiatry and Psychiatric Epidemiology*, *53*(7), 737–744. <https://doi.org/10.1192/bjp.bp.112.119032>
- Borsboom, D., Cramer, A. O. J., & Kalis, A. (2017). Brain disorders? Not really: Why network structures block reductionism in psychopathology research. *Behavioral and Brain Sciences*, *42*, 1–63. <https://doi.org/10.1017/S0140525X17002266>
- Boyer, P., Firat, R., & van Leeuwen, F. (2015). Safety, threat, and stress in intergroup relations: A coalitional index model. *Perspectives on Psychological Science*, *10*(4), 434–450. <https://doi.org/10.1177/1745691615583133>

- Bringmann, L. F., Elmer, T., Epskamp, S., Krause, R. W., Schoch, D., Wichers, M., . . . Snippe, E. (2019). What do centrality measures measure in psychological networks? *Journal of Abnormal Psychology, 128*(8), 892. <https://doi.org/10.1037/abn0000446>
- Crush, E., Arseneault, L., Moffitt, T. E., Danese, A., Caspi, A., Jaffee, S. R., . . . Fisher, H. L. (2018). Protective factors for psychotic experiences amongst adolescents exposed to multiple forms of victimization. *Journal of Psychiatric Research, 104*, 32–38. <https://doi.org/10.1016/j.jpsychires.2018.06.011>
- Csárdi, G., & Nepusz, T. (2006). The igraph software package for complex network research. *InterJournal, Complex Systems, 1695*(5), 1–9.
- Curtin, C. M., Barrett, H. C., Bolyanatz, A., Crittenden, A. N., Fessler, D. M. T., Fitzpatrick, S., . . . Henrich, J. (2020). Kinship intensity and the use of mental states in moral judgment across societies. *Evolution and Human Behavior, 41*(5), 415–429. <https://doi.org/10.1016/j.evolhumbehav.2020.07.002>
- Dielenberg, R. A., & McGregor, I. S. (1999). Habituation of the hiding response to cat odor in rats (*Rattus norvegicus*). *Journal of Comparative Psychology, 113*(4), 376–387. <https://doi.org/10.1037/0735-7036.113.4.376>
- Epskamp, S., Borsboom, D., & Fried, E. I. (2018). Estimating psychological networks and their accuracy: A tutorial paper. *Behavior Research Methods, 50*(1), 195–212. <https://doi.org/10.3758/s13428-017-0862-1>
- Epskamp, S., & Fried, E. I. (2018). A tutorial on regularized partial correlation networks. *Psychological Methods, 23*, 617–634. <https://doi.org/10.1037/met0000167>
- Foygel, R., & Drton, M. (2010). Extended Bayesian information criteria for Gaussian graphical models. *Advances in Neural Information Processing Systems, 23*, 2020–2028.
- Freeman, D., Loe, B. S., Kingdon, D., Startup, H., Molodynski, A., Rosebrock, L., . . . Bird, J. C. (2021). The revised Green et al. The revised Green. *Psychological Medicine, 51*(2), 244–253. <https://doi.org/10.1017/S0033291719003155>
- Freeman, D., McManus, S., Brugha, T., Meltzer, H., Jenkins, R., & Bebbington, P. (2011). Concomitants of paranoia in the general population. *Psychological Medicine, 41*(5), 923–936. <https://doi.org/10.1017/S0033291710001546>
- Fried, E. (2016). R tutorial: how to identify communities of items in networks. Psych Networks.
- Gayer-Anderson, C., & Morgan, C. (2013). Social networks, support and early psychosis: A systematic review. *Epidemiology and Psychiatric Sciences, 22*(2), 131–146. <https://doi.org/10.1017/S2045796012000406>
- Golino, H. & Christensen, A. P. (2021). EGAnet: Exploratory Graph Analysis – A framework for estimating the number of dimensions in multivariate data using network psychometrics. (R package version 0.9, 8.).
- Greenburgh, A., Bell, V., & Raihani, N. (2019). Paranoia and conspiracy: Group cohesion increases harmful intent attribution in the Trust Game. *PeerJ, 2019*, 1–16. <https://doi.org/10.7717/peerj.7403>
- Hajdúk, M., Klein, H. S., Harvey, P. D., Penn, D. L., & Pinkham, A. E. (2019). Paranoia and interpersonal functioning across the continuum from healthy to pathological – Network analysis. *British Journal of Clinical Psychology, 58*(1), 19–34. <https://doi.org/10.1111/bjc.12199>
- Haslbeck, J. M. B., & Waldorp, L. J. (2020). mgm: Estimating time-varying mixed graphical models in high-dimensional data. *Journal of Statistical Software, VV*(li). <http://arxiv.org/abs/1510.06871>
- Kimel, S. Y., Mischkowski, D., Kitayama, S., & Uchida, Y. (2017). Culture, emotions, and the cold shoulder: Cultural differences in the anger and sadness response to ostracism. *Journal of Cross-Cultural Psychology, 48*, 1307–1319. <https://doi.org/10.1177/0022022117724900>
- Komsta, L. & Novomestky, F. (2015). moments: Moments, cumulants, skewness, kurtosis and related tests. R Package Version 0.14.
- McElroy, E., McIntyre, J. C., Bentall, R. P., Wilson, T., Holt, K., Kullu, C., . . . Corcoran, R. (2019). Mental health, deprivation, and the neighborhood social environment: A network analysis. *Clinical Psychological Science, 7*, 719–734. <https://doi.org/10.1177/2167702619830640>

- McManus, S., Meltzer, H., Brugha, T., Bebbington, P. & Jenkins, R. (2009). *Adult psychiatric morbidity in England: Results of a household survey*. Health and Social Care Information Centre.
- Raihani, N. J., & Bell, V. (2019). An evolutionary perspective on paranoia. *Nature Human Behaviour*, 3(2), 114–121. <https://doi.org/10.1038/s41562-018-0495-0>
- Raihani, N. J., & Smith, S. (2015). Competitive helping in online giving. *Current Biology*, 25(9), 1183–1186. <https://doi.org/10.1016/j.cub.2015.02.042>
- Reise, S. P., & Waller, N. G. (2009). Item response theory and clinical measurement. *Annual Review of Clinical Psychology*, 5, 27–48. <https://doi.org/10.1146/annurev.clinpsy.032408.153553>
- Saalfeld, V., Ramadan, Z., Bell, V., & Raihani, N. J. (2018). Experimentally induced social threat increases paranoid thinking. *Royal Society Open Science*, 5(8), 180569. <https://doi.org/10.1098/rsos.180569>
- Sani, F., Wakefield, J. R. H., Herrera, M., & Zeybek, A. (2017). On the association between greater family identification and lower paranoid ideation among non-clinical individuals: Evidence from Cypriot and Spanish students. *Journal of Social and Clinical Psychology*, 36(5), 396–418. <https://doi.org/10.1521/jscp.2017.36.5.396>
- Solmi, F., Colman, I., Weeks, M., Lewis, G., & Kirkbride, J. B. (2017). Trajectories of neighborhood cohesion in childhood, and psychotic and depressive symptoms at age 13 and 18 years. *Journal of the American Academy of Child and Adolescent Psychiatry*, 56, 570–577. <https://doi.org/10.1016/j.jaac.2017.04.003>
- Sood, M., Carnelley, K., & Newman-Taylor, K. (2021). How does attachment imagery for paranoia work? Cognitive fusion and beliefs about self and others mediate the impact on paranoia and anxiety. *Psychology and Psychotherapy: Theory, Research and Practice*, <https://doi.org/10.1111/papt.12354>
- Spence, S. (2001). Alien control: From phenomenology to cognitive neurobiology. *Philosophy, Psychiatry, and Psychology*, 8(2), 163–172. <https://doi.org/10.1353/ppp.2001.0017>
- Veling, W., Pot-Kolder, R., Counotte, J., Van Os, J., & Van Der Gaag, M. (2016). Environmental social stress, paranoia and psychosis liability: A virtual reality study. *Schizophrenia Bulletin*, 42, 1363–1371. <https://doi.org/10.1093/schbul/sbw031>
- Weiss, A., Michels, C., Burgmer, P., Mussweiler, T., Ockenfels, A., & Hofmann, W. (2020). Trust in everyday life. *Journal of Personality and Social Psychology*, 121(1), 95–114. <https://doi.org/10.1037/pspi0000334>
- Wickham, S., Taylor, P., Shevlin, M., & Bentall, R. P. (2014). The impact of social deprivation on paranoia, hallucinations, mania and depression: The role of discrimination social support, stress and trust. *PLoS One*, 9(8), e105140. <https://doi.org/10.1371/journal.pone.0105140>
- Yaakobi, E. (2021). Can cultural values eliminate ostracism distress? *International Journal of Intercultural Relations*, 80, 231–241. <https://doi.org/10.1016/j.ijintrel.2020.10.014>
- Yang, Z., Algesheimer, R., & Tessone, C. J. (2016). A comparative analysis of community detection algorithms on artificial networks. *Scientific Reports*, 6(1), 1–18. <https://doi.org/10.1038/srep30750>

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Supporting Information

The following supporting information may be found in the online edition of the article:

Figure S1. Centrality metrics per node of the estimated network.

Figure S2. Bootstrap analysis of edge-weight accuracy.

Figure S3. Bootstrap stability analysis of centrality metrics.

Figure S4. Comparison between communities identified by Spinglass algorithm and Exploratory Graph Analysis: identical communities identified

Table S1. Edges between paranoia and coalitional psychology nodes.

Table S2. Confidence intervals associated with bootstrapped difference test between significant edge-weights involving low severity paranoia (PSQ3).

Table S3. Confidence intervals associated with bootstrapped difference test between significant edge-weights involving high severity paranoia (PSQ2).