Article details

McWilliams L.A. & Fried E.I. (2019), Reconceptualizing adult attachment relationships: A network perspective, Personal Relationships 26(1): 21-41.
Doi: 10.1111/pere.12263

Received: 12 July 2017 | Revised: 11 August 2018 | Accepted: 26 October 2018

DOI: 10.1111/pere.12263

Personal RELATIONSHIPS WILEY

ARTICLE

Reconceptualizing adult attachment relationships: A network perspective

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This article explores attachment relationships from a network theory perspective: Correlations among behaviors, beliefs, and feelings related to attachment are hypothesized to stem from causal relations. The authors used two data sets that assessed relationships with four attachment figures (mother, father, romantic partner, and best friend) using the Relationship Structures Questionnaire. Separate networks (Gaussian Graphical Models) were estimated based on 10 items for each attachment figure. Across networks in Study 1 ($N = 310$), items related to anxiety, seeking support, and discomfort disclosing feelings clustered with other items from their respective domains; a trust-related item bridged the clusters. Study 2 replicated these findings in a larger and more diverse sample ($N = 3{,}710$). The potential of network analysis for advancing the study of attachment is discussed.

KEYWORDS

attachment, centrality, network analysis, relationship structures questionnaire, replicability

1 | INTRODUCTION

Attachment theory (Bowlby, 1969, 1982) is one of the most highly researched psychological theories (Mikulincer & Shaver, 2007) and is one of the major theoretical frameworks used in contemporary psychological research on close relationships (Reis, 2012). The earliest research based on attachment theory focused on interactions between infants and their caregivers, and identified three stable styles (viz., secure, avoidant, and resistant) adopted by infants when interacting with caregivers (Ainsworth, Blehar, Waters, & Wall, 1978). In contrast to this focus on patterns of interaction within dyads, research on adult attachment has tended to conceptualize attachment characteristics as involving trait-

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like latent variables. In this study, network analysis (Schmittmann et al., 2013) is introduced as an alternative perspective for understanding the nature of attachment. In contrast to the reflective latent variable approach where a common cause gives rise to correlations in data, the network perspective raises the possibility that correlations among behaviors, beliefs, and feelings captured by the items of self-report measures of attachment may stem from causal connections between them.

1.1 | Attachment theory and measurement

Attachment theory (Bowlby, 1969, 1982) posits that an innate attachment behavioral system evolved to ensure that infants maintain proximity to their caregivers, which are referred to as attachment figures. Enduring cognitive schemas that guide behavior and expectations in other relationships are thought to develop in response to the behavior of attachment figures. Attachment figures that consistently recognize and respond appropriately to a child's need for comfort, security, and independent exploration are thought to foster a sense of security characterized by a model of self as valued and self-sufficient and a model of others as caring and trustworthy. Less responsive and/or rejecting behavior from attachment figures is thought to lead to attachment insecurity characterized by negative internalized models of self and others. Although individual attachment characteristics are shaped during infancy, they continue to guide behavior and expectations in interpersonal relationships throughout life, both having a relative degree of stability and incorporating temporary or long-lasting changes depending on life context and new attachment-relevant experiences (Mikulincer & Shaver, 2007).

Self-reports are the most commonly used method of assessing individual differences in adult attachment characteristics. The first self-report measure of attachment widely used with adults was developed by Hazan and Shaver (1987). It assessed attachment characteristics in romantic relationships and required respondents to categorize themselves into one of three specific attachment styles based on those identified in earlier research with infants (Ainsworth et al., 1978). This initial research prompted the development of numerous multi-item measures of attachment, such as the Adult Attachment Questionnaire (Simpson, 1990). These new measures had stronger psychometric properties than the earlier categorical measures. However, it is important to note that they varied substantially in terms of the type of attachment relationship assessed (i.e., a specific relationship, general close relationships, or romantic relationships), the number of constructs assessed, and the names of the constructs assessed (Ravitz, Maunder, Hunter, Sthankiya, & Lancee, 2010).

The diversity of attachment measures used in the early research on adult attachment made it difficult to identify relationships between attachment characteristics and other psychological phenomena that were consistent across different conceptualizations of attachment security and insecurity. This issue was largely resolved by Brennan, Clark, and Shaver (1998). In a factor analytic investigation of all the self-report measures of attachment available at the time, they identified a two-factor solution in which most scales loaded on one of the two factors they labeled anxiety and avoidance. Based on these findings, they used the pool of items in existing measures to create the 36-item Experiences in Close Relationships Questionnaire (ECR). It is a measure of attachment in intimate or romantic relationships and includes scales assessing the two attachment dimensions. These dimensions were originally posited to be orthogonal to each other, but numerous studies with the ECR have found the anxiety and avoidance scales to be positively correlated (Cameron, Finnegan, & Morry, 2012). The ECR and the revised version of it (ECR–R; Fraley, Waller, & Brennan, 2000) are by far the most frequently used self-report measures of adult attachment.

Most research on adult attachment has used measures intended to assess general attachment-related tendencies that apply to numerous relationships. However, there has also been an interest in assessing adult attachment in specific relationships. The Relationship Structures Questionnaire (RSQ; Fraley, Heffernan, Vicary, & Brumbaugh, 2011) was created for this purpose. It also conceptualizes

attachment as being defined by two dimensions and uses a subset of ECR items that were adapted to assess relationships with four attachment figures. These figures include respondents' mothers, fathers, romantic partners, and best friends. The initial RSQ had 10 items per attachment figure. Fraley et al.'s (2011) factor analytic study of the RSQ indicated that the anxiety item focused on trust ("I don't fully trust this person") had large cross-loadings with the avoidance factor across all four attachment figures; as a result, it was removed from the questionnaire. It should also be noted that there were several other instances in which items had substantial cross-loadings, but there was not a consistent pattern across attachment figures. For example, Fraley et al. found a reverse-scored avoidance item (Item 4; "I find it easy to depend on this person") had a salient loading on the anxiety factor for both the mother and father scales, but not for the partner and friend scales. This issue is not just applicable to the RSQ; a factor analytic study of the ECR-R indicated that some items related to depending on romantic partners intended for the avoidance scale also had salient cross-loadings on the anxiety factor (Sibley & Liu, 2004).

1.2 | The network perspective on psychological constructs

Although the foundational issue of the *meaning* of attachment dimensions has been largely ignored in the literature, the use of attachment scales assessing two dimensions implies that attachment insecurity involves two latent variables that represent two types of attachment-related experiences. That is, the behaviors, beliefs, and feelings assessed in self-report scales of attachment are viewed as co-occurring because they are the results of latent anxiety and avoidance. The correlational pattern in the data, along with Fraley et al.'s (2011) factor analyses of the RSQ scales showing that some items have considerable cross-loadings, also allow for a different conceptualization of attachment relationships.

In this article, we present network theory (Schmittmann et al., 2013) as an alternative perspective for understanding the nature of attachment. The network perspective proposes that correlations among self-report items are due to causal connections between the behaviors, beliefs, and feelings captured by the items. This contrasts with the traditional "common cause" conceptualization that attributes correlations among items to one or more latent variables (e.g., attachment anxiety and avoidance) that cause the behaviors, beliefs, and feelings captured by the items in the way an infectious disease like measles causes symptoms. Recently developed statistical methodology allows: (a) the estimation of such *psychological networks*, (b) the visualization of the network estimation results as graphs, and (c) the description of network characteristics, such as centrality estimation (Costantini et al., 2015; Epskamp, Borsboom, & Fried, 2018). In such psychological network models, individual variables are termed "nodes" and the connections between them are termed "edges." In other fields of network science, this often works differently. For example, social networks usually feature specific individuals as nodes, and edges often represent relations between these individuals. In figures illustrating networks, the position of nodes is usually based on an algorithm that accounts for the strength and frequency of the connections between the nodes. Pairs of nodes with strong connections are usually placed relatively close together, and characteristics of the edges reflect the strengths of the relationships (i.e., thicker and darker lines reflect stronger connections). Several measures of "centrality" are commonly used to provide estimates of the connectedness of nodes in the network.

In recent years, network models have been used extensively to study relations between symptoms of mental disorders (Borsboom & Cramer, 2013; Fried et al., 2017). This research warrants a brief discussion here because it highlights conceptual and empirical questions that can be raised by the network perspective. First, network analysis can be used to generate hypotheses regarding relations between variables. For example, a network analysis of depression symptoms reported by patients participating in a chronic pain rehabilitation program indicated that difficulty concentrating had a high

level of centrality (i.e., interconnectivity; McWilliams, Sarty, Kowal, & Wilson, 2017). Based on that finding and the compromised attentional capacity of those experiencing chronic pain, the authors speculated that difficulty concentrating might be a common starting point for the development of other symptoms of depression, particularly anhedonia with which it shared a strong edge. Second, network characteristics such as centrality may provide insights into adverse outcomes. For example, a longitudinal study of adults found that symptoms with higher levels of centrality at baseline were more predictive of the development of a depressive disorder than symptoms with low centrality (Boschloo, van Borkulo, Borsboom, & Schoevers, 2016). This suggests the future study of network parameters, such as centrality, to increase prediction of psychopathology onset. Third, network theory implies that changes in highly central nodes will have a larger impact on changes of the network structure as a whole than change in less central nodes (Robinaugh, Millner, & McNally, 2016). Related to this idea, it has been suggested that targeting highly central symptoms may enhance psychological treatments (van Borkulo, Borsboom, Penninx, Waldorp, & Schoevers, 2015). Finally, network analysis can help identify potential mechanisms accounting for associations between constructs. Cramer, Waldorp, van der Maas, and Borsboom (2010) proposed that clusters of symptoms, such as depressive and generalized anxiety disorder symptoms, may co-occur because of "bridge symptoms" that are included in the diagnostic criteria for both disorders and connect one cluster of symptoms to the other. For example, the experience of sleep problems and fatigue in the domain of anxiety disorders could trigger the development of depressed mood and subsequently lead to additional depressive symptoms, which may result in comorbid anxiety and mood disorders (Beard et al., 2016). This idea has led to numerous network articles on the comorbidity of mental disorders (Fried et al., 2017).

The network approach has also been applied to other psychological areas such as cognitive abilities (van der Maas et al., 2006), attitudes (Dalege et al., 2015), and personality research (Costantini et al., 2015; Cramer et al., 2012; Mõttus & Allerhand, 2017). When applied to self-report measures of personality traits, the network perspective suggests that items assessing a personality construct, such as extraversion, are correlated because of mutual causal connections, and not because the latent construct leads to the behaviors captured in the items. Take, for example, extraversion items about liking to be around others and enjoying talking to people at parties. These two items would be expected to be correlated with each other because liking being around people could lead to greater enjoyment when talking to people at parties, and because the capacity to enjoy talking to people at parties could make it more likely one would like being around others. This contrasts with the perspective that items are passive measurements of the underlying dimension of extraversion.

1.3 | Overview and objectives

In this study, we extend the network framework to adult attachment relationships and suggest that it may provide a compelling alternative model to the reflective latent variable or common cause approach that has informed past research on attachment. The first objective of this study is to demonstrate the application of network analysis to the study of adult attachment relationships. For example, usually discussing problems with a person (i.e., content of RSQ Item 1) could lead to feeling comfortable opening up to that person (i.e., content of reverse-scored RSQ Item 6) and subsequently finding it easy to depend on that individual (i.e., content of reverse-scored RSQ Item 4). An underlying avoidance variable is not necessary to account for associations between items capturing these experiences.

The second objective is to use network analysis to study the connection between attachment anxiety and avoidance. Factor analytic studies of attachment self-report measures (e.g., Sibley & Liu,

2004) support the continued use of scales assessing separate attachment anxiety and avoidance dimensions. However, it is also important to note that self-reports of anxiety and avoidance are often positively correlated (Cameron et al., 2012). This overlap between the scales raises the possibility that some components of one attachment construct may have causal relationships with components of the other attachment construct. Consistent with this suggestion, factor analytic studies of the RSQ (Fraley et al., 2011) and ECR–R (e.g., Sibley & Liu, 2004) have found that some items have salient loading on both anxiety and avoidance factors. Similar to so-called "bridge symptoms" that connect two clusters of symptoms in psychopathology networks, these cross-loading items may capture important aspects of attachment experiences that bridge between the two forms of attachment insecurity. For example, not trusting an individual (i.e., the content of the anxiety item dropped from the RSQ) could lead to feeling uncomfortable opening up to this individual (i.e., the content of a reverse-scored avoidance item on the RSQ). Reconceptualizing cross-loading items as bridge items has important implications for attachment theory and measurement. Eliminating items with cross-loadings is a reasonable method for creating scales that are pure measures of anxiety and avoidance. However, the network perspective highlights the potential value of these items as they may capture the mechanism by which changes in one attachment dimension result in changes in the other dimension.

The third objective of this study is to empirically evaluate the similarity of attachment networks across attachment figures (i.e., mother, father, romantic partner, and best friend). The nature of one's relationships with different attachment figures is likely to vary, so variations across the structures of these attachment networks would not be surprising. However, it is also possible that similar attachment-related dynamics may operate across various attachment relationships and result in similar networks across attachment figures.

A final objective is to examine the replicability of the findings. The large majority of network articles in psychology have estimated network models only on a single sample and have, therefore, not examined the replicability and generalizability of the networks. This has been identified as major limitation of the literature (Fried & Cramer, 2017), and only a few empirical investigations exist to date (Fried et al., 2018). We, therefore, want to address the issue of replicability thoroughly in this very first investigation of attachment networks. To that end, we investigate all research questions presented above in two studies. In Study 1, attachment networks are estimated using data obtained with the RSQ from a sample of university students ($N = 310$). In Study 2, the same network methods are used to estimate the attachment networks of an older, more diverse, and larger sample ($N = 3{,}710$). As part of Study 2, we formally compare all results across the two samples and, therefore, test the replicability of the results of Study 1.

2 | STUDY 1

2.1 | Method

2.1.1 | Participants and procedures

Study 1 utilized data (total $N = 310$) from two previously published studies that assessed attachment with the RSQ. Due to some additional data collection after the original studies were completed, slightly more data were available for the current study than in the originally published studies. Both previous studies utilized convenience samples of university students as participants. The largest study (McWilliams, Murphy, & Bailey, 2010) included 218 participants that completed an online survey during one of the several group data collection sessions. In the other study (McWilliams & Brodeur, 2016), 92 participants completed paper-and-pencil versions of self-report measures during individual data collection session. The average age of participants was 20.6 years

(*SD* = 3.83). A majority of the sample was female (58.7%). In terms of racial/ethnic identity, the majority of participants were White (83.9%), followed by Asian (5.8%), Black (5.2%), and Native or Indigenous (1.3%). The "other" option was endorsed by only 3.9% of the sample.

Separate analyses were conducted for each of the four RSQ scales. In the case of the romantic partner items, data provided by individuals reporting no current or past dating/romantic relationships were not included. This resulted in a sample of 272 for this scale. Given the information collected in these studies, it was not possible to select only those reporting on a current relationship. This is one small methodological difference with Study 2, which focuses on current romantic relationships. A few participants did not respond to all of the scales, so the sample sizes for the analyses for each scale were slightly lower than the total sample size (i.e., $N = 301$ for the best friend and father scales and $N = 303$ for the mother scale). These few missing values were dealt with by using pairwise complete observations (i.e., participants were not deleted listwise, but rather all available information was used to estimate each correlation; cf. Santos, Fried, Asafu-Adjei, & Ruiz, 2017).

2.1.2 | Measures

The RSQ (Fraley, Niedenthal, Marks, Brumbaugh, & Vicary, 2006; Fraley et al., 2011) is a shortened version of the ECR that was modified to assess attachment characteristics in four specific relationships: mother or mother-like figure, father or father-like figure, dating or marital partner, and best friend. The instructions for each version of the measure specify the relationship respondents are to consider when completing the items. A set of 10 almost identical questions (6 avoidance and 4 anxiety) about "this person" are posed for each relationship using a response format ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Those not currently in a dating or marital relationship were asked to respond with respect to a former partner or a relationship they would like to have with someone. An early version of the RSQ originally available online was administered. The more recent version presented in Fraley et al. (2011) utilized a different sequence of items than the earlier version. To facilitate interpretation of current findings, the numbers used to identify the items have been altered to match with the content of the scale as presented in Fraley et al. (2011). For example, the original Item 1 ("It helps to turn to this person in times of need") has been labeled as Item 3 as it is in Table 1 of Fraley et al. Four of the avoidance items are reverse scored. In the current study, the reverse scoring was applied prior to the analyses being conducted.

2.1.3 | Statistical analyses

Descriptive statistics regarding the demographic characteristics and responses to the RSQ items were calculated using IBM SPSS Statistics 23. All network analyses were computed with version 3.3.1 of R, a free software environment for statistical computing and graphics.

Network estimation

A separate network was estimated for the 10 RSQ items related to each of the attachment relationships (i.e., mother, father, partner, and best friend). The network structure of the four attachment scales was estimated using the R-packages qgraph (Epskamp, Cramer, Schmittmann, & Borsboom, 2012) and bootnet (Epskamp et al., 2018). A network analysis examines relationships (edges) between variables (nodes). In the current study, we used the Gaussian Graphical Model that estimates the regularized partial correlations among items (i.e., the statistical association of two items after controlling for all other relationships in the network). This method also addresses the risk of false positive connections by applying the graphical least absolute shrinkage and selection operator (GLASSO; Friedman, Hastie, & Tibshirani, 2008), a technique that sets very small (i.e., spurious) coefficients to

TABLE 1 Relationship Structures Questionnaire (RSQ) items and item-level descriptive statistics across attachment figures in Studies 1 and 2

	Study 1/Study 2 means (standard deviations in parentheses)			
Item numbers and wording	**Mom**	**Dad**	**Partner**	**Best friend**
1. I usually discuss my problems and concerns with this person.	2.88/3.73 (1.81/2.06)	3.69/4.65 (1.98/2.01)	1.99/2.17 (1.24/1.44)	2.33/ 2.28 (1.47/1.50)
2. I talk things over with this person.	2.68/3.60 (1.83/2.03)	3.43/4.40 (2.00/2.06)	1.88/2.19 (1.15/1.50)	2.07/2.21 (1.20/1.44)
3. It helps to turn to this person in times of need.	2.21/3.14 (1.63/2.07)	2.86/3.82 (1.86/2.16)	1.84/2.17 (1.19/1.47)	2.06/2.15 (1.30/1.45)
4. I find it easy to depend on this person.	1.97/3.15 (1.61/2.15)	2.66/3.68 (1.97/2.27)	2.22/2.67 (1.43/1.75)	2.20/2.70 (1.32/1.71)
5. I prefer not to show this person how I feel deep down.	2.99/3.87 (1.93/2.13)	3.57/4.36 (2.03/2.10)	2.45/2.79 (1.55/1.90)	2.19/2.74 (1.36/1.79)
6. I do not feel comfortable opening up to this person.	2.89/3.60 (1.92/2.11)	3.50/4.27 (2.00/2.11)	2.47/2.71 (1.65/1.87)	1.95/2.61 (1.33/1.77)
7. I am afraid that this person may abandon me.	1.33/ 2.04 (1.14/1.80)	1.68/ 2.41 (1.56/2.03)	2.57/ 3.21 (1.77/2.10)	1.65/2.39 (1.29/1.74)
8. I worry that this person will not care about me as much as I care about him or her.	1.27/2.07 (0.88/1.78)	1.53/2.41 (1.20/1.96)	2.85/3.29 (1.94/2.19)	1.80/2.52 (1.36/1.79)
9. I often worry that this person does not really care for me.	1.48/2.23 (1.20/1.90)	1.74/2.56 (1.53/2.06)	2.41/2.87 (1.73/2.04)	1.64/2.34 (1.15/1.66)
10. I do not fully trust this person.	1.56/2.59 (1.33/2.13)	1.92/2.87 (1.73/2.25)	2.26/2.77 (1.52/1.99)	1.66/2.23 (1.18/1.64)

Note. Items 1–4 are reverse scored, Items 1–6 are avoidance items, Items 7–9 are anxiety items, and Item 10 is a cross-loading item.

zero. As a result, it yields parsimonious network structures that encode only the relevant relationships between variables. The Gaussian Graphical Model requires as input the correlation matrix of items; given multivariate normal data, we estimated Pearson correlations. The network estimation results in an adjacency matrix that encodes the conditional dependence relationships of all items. For a tutorial article on estimating regularized partial correlation networks, we refer the reader to Epskamp and Fried (2018). We use qgraph to visualize these matrices. In the network graphs, thicker lines denote stronger connections between nodes. The Fruchterman–Reingold algorithm (Fruchterman & Reingold, 1991) was used to place the nodes with stronger and/or more connections closer together. In the current study, an equalized presentation based on the average of all four networks was used to place the nodes in the same position across the networks. This method is preferred because it facilitates a visual comparison of the networks (Rhemtulla et al., 2016).

The adjacency matrices and correlations among the items for each network are included in the Supporting Information. As well, the R-codes are available on the Open Science Framework (see https://osf.io/d6jhz/). These materials are sufficient to make the results of the network analyses fully reproducible.

Network inference

Many different centrality metrics have been used in the recent literature on psychological networks. For this present article, we are interested in two of these metrics: node strength (or strength centrality)

and betweenness. Both assess the connectedness of a given variable with all other variables in the network but highlight different aspects of interconnectedness (Borgatti, 2005; Opsahl, Agneessens, & Skvoretz, 2010). Strength centrality is the overall degree of the associations between a node and all other nodes, and is defined as the sum of all absolute associations (i.e., edge weights) a specific variable exhibits with its neighbors. We are interested in strength because it is a straight forward, intuitive, commonly used, and robust metric of node interconnectedness. Betweenness places importance on the shortest path length connecting any two nodes; nodes with high betweenness centrality are ones that often lie along the shortest paths connecting other nodes to each other, like a railway station through which many trains need to travel to get from any location to any other location. This measure of centrality was included because it can be useful in identifying nodes that lie on the intersection of two or more clusters of nodes (conceptually: nodes through which information "travels" when it goes from one to the other cluster).

Network stability

The R-package bootnet (Epskamp et al., 2018) was used to estimate the accuracy and stability of the estimates of strength and betweenness centrality. This method uses a bootstrapping approach to produce 95% confidence intervals of the edge weights, which serve as an estimate of the accuracy of the edges in the network. Bootnet also assesses the stability of the order of the strength centrality estimates for each item and produces a centrality stability coefficient. These coefficients indicate the % of subjects that can be dropped to retain with 95% certainty a correlation of 0.70 between the centrality of the network estimated on original data and the centrality of the network estimated on the subsampled data. For example, a centrality stability coefficient of 0.10 indicates that after only dropping 10% of the sample, the correlation of the original findings with those of the subsampled data drops below a coefficient of 0.70. A coefficient of 0.25 is considered the minimum for the centrality measures to be considered stable, and a coefficient of 0.5 is considered a more robust indicator of stability (Epskamp et al., 2018).

Network comparisons

To compare the four resulting graphs, we used the R-package NetworkComparisonTest (van Borkulo et al., 2017). It utilizes a series of permutation tests designed to compare networks on several metrics. A network comparison test (NCT) cannot currently compare four networks simultaneously, so a series of pairwise comparisons was conducted, with 2,000 iterations each. We used a dependent version of the NCT that accounts for the same people having been queried four separate times for responses to the four attachment scales. The NCT involves an omnibus test that determines whether the network structures differ from each other. To violate structural invariance, it is sufficient if one single edge is different enough across two networks. This is a very stringent test; a significant difference between two networks can mean that networks differ in one edge or that they are completely different. As suggested by Fried et al. (2018), it is, therefore, useful to also investigate the degree of *similarity* between networks. To do so, we used Spearman correlation coefficients to correlate the adjacency matrices (i.e., the regularized partial correlations) between all networks.

2.2 | Results and discussion

Descriptive statistics regarding each item for each attachment figure are presented in Table 1. Differences on the items across the attachment domains were not formally tested. However, it is noteworthy that the avoidance items (1–6) received the highest level of endorsement for the father versions of the

items, and that anxiety items (7–9) and the trust item (10) received the highest level of endorsement for the partner versions of the items.

2.2.1 | Network estimation

All four networks are presented in Figure 1. There are several important similarities across the four networks. First, the connection between Items 1 ("I usually discuss my problems and concerns with this person") and 2 ("I talk things over with this person") is consistently strong across all four networks. Second, the graphs are suggestive of three clusters of items within each network. The three anxiety items (7–9) are strongly connected with each other. The four reverse-scored avoidance items (1–4) reflecting a willingness to seek help from and turn to the attachment figure are all connected with each other. The two avoidance items (5 and 6) focused on discomfort disclosing feelings to the attachment figure and that are not reverse scored have a strong connection with each other. Third, Item 10 ("I don't fully trust this person"), which was deleted from the final measure used by Fraley et al. (2011) because it had high loadings on both the anxiety and avoidance factors, appears to serve as a bridge between all three clusters of nodes.

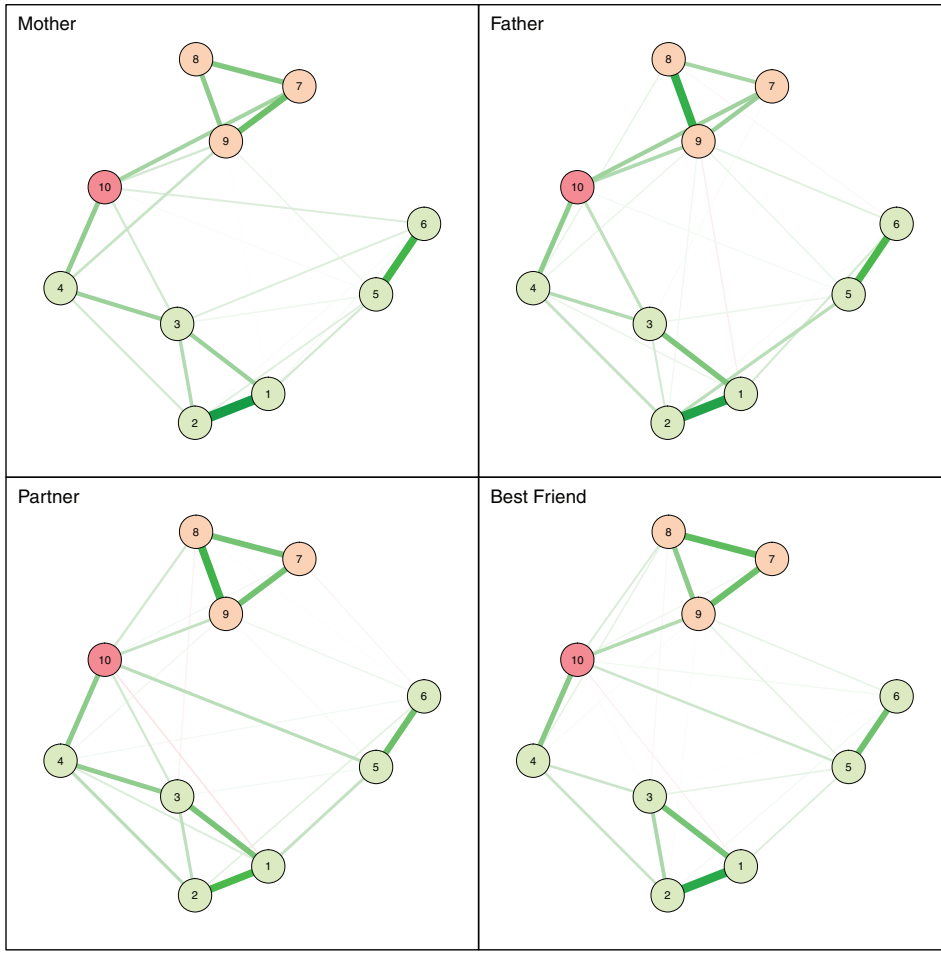

FIGURE 1 Networks of Relationship Structures Questionnaire items across four attachment figures in Study 1

Note. For details of the item content, refer to Table 1. Green lines depict positive edges, red lines negative edges, and strength of edge weights is depicted by the width and saturation of the edge.

It should also be noted that there are several negative edges in Figure 1 (i.e., red lines). These edges are weak—the strongest negative edge weights are −0.05, −0.07, and −0.04 in Networks 2, 3, and 4, respectively (there were no negative edges in Network 1). Nonetheless they are interesting, given that the *correlations* among all items are positive (all correlation tables are available in the Supporting Information). There are several explanations for negative edges in regularized partial correlation networks. A negative edge between A and B could represent a genuine conditional dependence relationship, implying that when controlling for all other nodes, the higher A the lower B (and vice versa). The negative edge could also be spurious (i.e., a "false positive," which in this case is an edge with a negative partial correlation). However, LASSO regularization was used and it tends to remove spurious edges reliably (Friedman et al., 2008), so it is unlikely but possible that spurious edges survived. The negative spurious edge could also be the result of conditioning on a collider. This happens when in the true model, A → C and B → C; in this case, C is called a collider, and controlling for C will induce a negative edge between A and B.

2.2.2 | Network inference

The standardized estimates of strength and betweenness centrality are reported in Figure 2. The values of strength and betweenness centrality indices are generally consistent across the four attachment figures. Of particular note, Item 9 ("I often worry that this person doesn't really care for me")

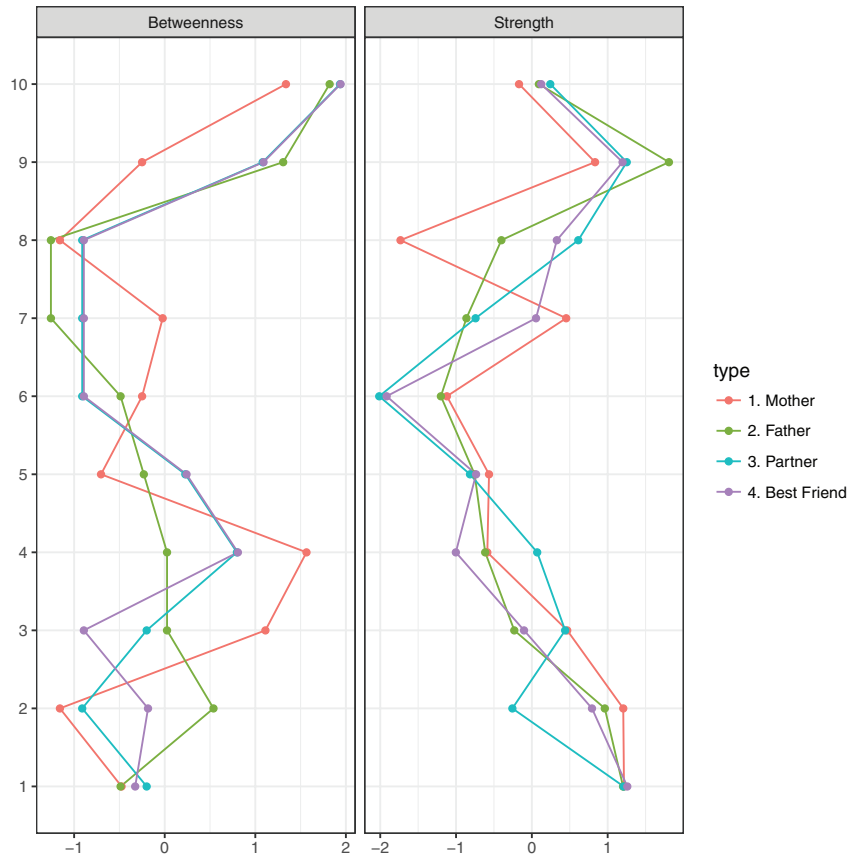

FIGURE 2 Measures of betweenness and strength centrality derived from the networks of the four attachment figures in Study 1

from the anxiety scale and Item 1 ("I usually discuss my problems and concerns with this person") from the avoidance scale both have high levels of strength centrality. As a reminder, the high strength centrality of these items means that they have the most and strongest connections within the networks. From the perspective of a network theory of attachment, these findings can be interpreted as the two constructs captured by these items potentially having the strongest putative causal relations in the complex system of attachment relations. Item 10 ("I don't fully trust this person") consistently has a high level of betweenness centrality. This means that it more often than others lies on the shortest path between all nodes in the network. From a psychological network perspective, this can be interpreted as putative causal chains of attachment item activation often going through this trust item. Arguably the most noteworthy inconsistency across networks is that Item 8 in the mother network ("I worry that this person won't care about me as much as I care about her") is only connected with two other nodes and, therefore, also has a much lower level of strength centrality compared to what is found in the other networks. Of all 40 items included in the RSQ, this item has the lowest variance ($SD = 0.88$), which could contribute to its low strength centrality (Terluin, de Boer, & de Vet, 2016).

2.2.3 | Network stability

Results of the stability and accuracy analyses are summarized as follows. The confidence intervals around the edge weights are moderately large, as expected for a sample of several hundred participants, and the edge weights difference tests indicate that the strongest 10 edges in the networks are significantly stronger than the weaker edges. This means that these edges can be reliably interpreted to be larger than the weaker edges. The centrality stability coefficients for strength centrality are 0.23, 0.49, 0.46, and 0.49 for the mother, father, partner, and best friend networks, respectively. For betweenness, they are 0.08, 0.00, 0.11, and 0.17, respectively. The centrality stability coefficients for strength therefore meet the recommended cutoff for moderately stable estimation of 0.25, except for the mother network. For betweenness centrality, none of the coefficients exceeds 0.25, which means the general order of betweenness should be interpreted with care. However, additional bootstrap analyses reveal that Item 10 ("I don't fully trust this person") consistently has the highest level of betweenness centrality even when subsetting the data sets, implying that Item 10 can be interpreted as having a higher betweenness than all other items across all four networks. Results of all stability analyses are described in detail in the Supporting Information, including supplementary figures. For further details on network stability, we refer the reader to a recent tutorial article (viz., Epskamp et al., 2018).

2.2.4 | Network comparisons

Consistent with the similarities in the networks illustrated in Figure 1 and the similarities of centrality reported in Figure 2, the NCTs indicate that the four attachment networks do not significantly differ from each other in terms of network structures (P-values between 0.16 and 0.59; all coefficients are included in the Supporting Information). To complement these tests of absolute differences between network structures, their similarity was examined by correlating the adjacency matrices of all network structures. These correlations range from 0.70 to 0.82, suggesting a high level of similarity across the networks. Details of the findings of the NCTs and the adjacency matrix correlations are included in the Supporting Information.

3 | STUDY 2

Study 1 demonstrated the application of network analysis to the study of adult attachment relationships. For example, Item 10 concerning trust ("I don't fully trust this person.") was identified as a

bridge between clusters of anxiety and avoidance items. Furthermore, there was empirical support for the similarity of attachment networks across attachment figures (i.e., mother, father, romantic partner, and best friend). The primary objectives of Study 2 are to examine the replicability of these findings in a separate sample and to determine whether or not the findings obtained from a primarily young and White student sample will generalize to a larger and more diverse sample.

3.1 | Method

3.1.1 | Participants and procedures

Study 2 utilized data collected via the webpage used by Fraley et al. (2011) to obtain data for the original psychometric study of the RSQ. It included the same version of the RSQ used in Study 1 and the sequence of items was altered for the analyses in the same manner as in Study 1. A sample of 3,710 individuals 18 years of age or older that had not been utilized by Fraley et al. was used. The average age of participants was 30.09 years of age ($SD = 12.15$) and a majority were female (77.9%). Most participants lived in the United States (58.3%). The other participant locations most commonly reported were the United Kingdom (8.3%), South Africa (6.8%), Canada (5.6%), and Australia (3.5%). In terms of racial/ethnic identity, the majority of participants were White (66.1%), followed by Black (10.1%), Latino (2.7%), Indian/Pakistani (2.7%), Chinese (2.4%), and Filipino (2.3%). The "other" option was endorsed by 5.3% of the sample, but no other specific racial/ethnic category was endorsed by more than 2% of the sample.

All analyses were conducted in the same way as in Study 1. However, in the case of the romantic partner items, analyses were conducted on data provided by individuals reporting they were currently in a relationship. This approach was selected to enable us to investigate the partner network based on reports of specific relationships, which is consistent with the approach taken with the other attachment figures. This resulted in a sample of 2,136 for this scale. Some participants did not respond to all of the scales, so the sample sizes for the analyses for each scale were slightly lower than the total sample size (i.e., 3,620 for the best friend scale, 3,704 for the mother scale, and 3,663 for the father scale). Consistent with Study 1, missing values were dealt with by using pairwise complete observations.

3.1.2 | Statistical analyses

The statistical methods used were the same as those used in Study 1. In the network figures, the same layout as in Study 1 was used to facilitate comparisons. In addition, we also compared the corresponding networks of Studies 1 and 2 (e.g., mother with mother, father with father, etc.) in the same way we compared networks within each data set: first, using the structural NCT (in the case of cross-data comparisons, for independent data), and second, by correlating the respective adjacency matrices as measures of similarity. The information necessary to make the results of the Study 2 network analyses fully reproducible is also included in the Supporting Information and on the Open Science Framework (see https://osf.io/d6jhz/).

3.2 | Results and discussion

Descriptive statistics regarding the items across each measure or attachment figure are presented in Table 1. Overall, each item was endorsed more strongly in Study 2 than in Study 1. Similar to Study 1, the avoidance items (1–6) received the highest level of endorsement for the father versions of the items and the anxiety items (7–9) received the highest level of endorsement for the partner versions of the items. Inconsistent with what was observed in Study 1, the father version of the trust item

(10) had the highest level of endorsement. Given the aims of the current study, these trends were not further evaluated with inferential statistics.

3.2.1 | Network estimation

All four networks for Study 2 are presented in Figure 3. These networks are highly similar to the corresponding networks from Study 1. However, there are also numerous small differences between the Study 1 and 2 networks. For example, in the mother network from Study 2, Item 10 has weak connections with Items 8 and 5, whereas these connections are not present in the Study 1 mother network. Similar to Study 1, there are several very weak negative edges (i.e., red lines), which are different from those observed in Study 1.

3.2.2 | Network inference

The standardized estimates of strength and betweenness centrality are reported in Figure 4. The profile of the strength and betweenness centrality indices is generally consistent across the four attachment figures. Similar to what was found in Study 1, Item 9 ("I often worry that this person doesn't

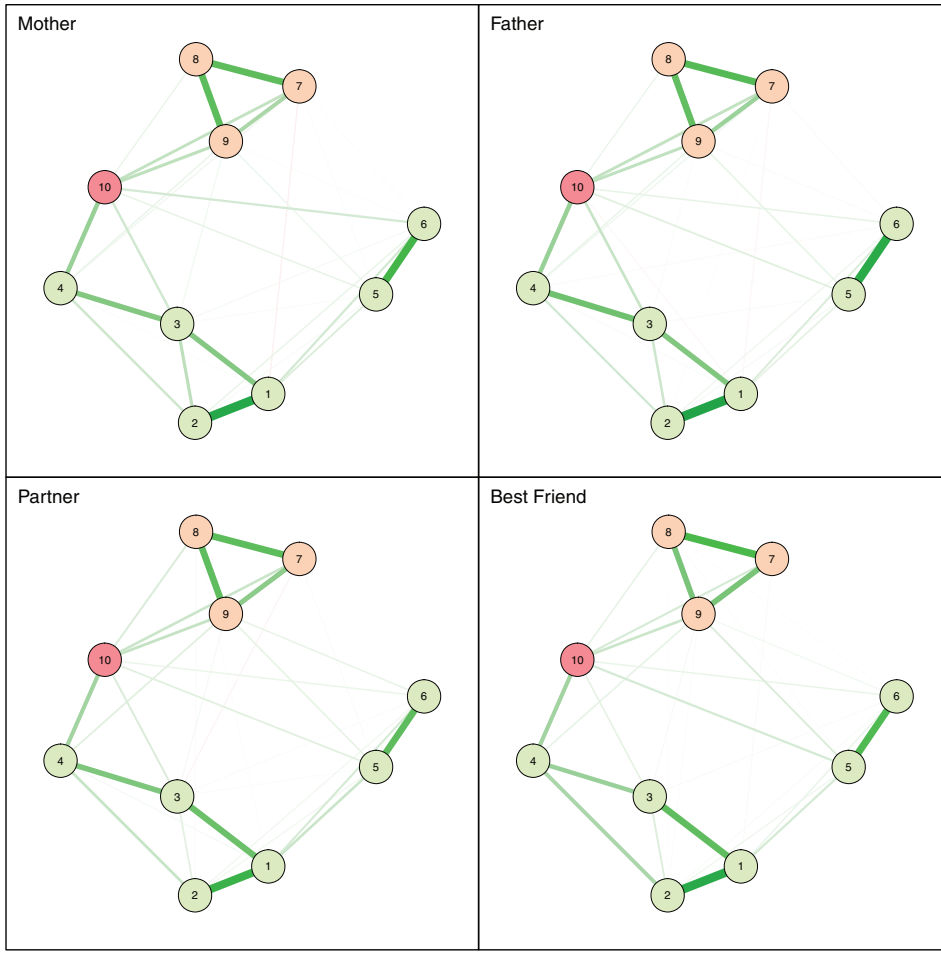

FIGURE 3 Networks of Relationship Structures Questionnaire items across four attachment figures in Study 2

Note. For details of the item content, refer to Table 1. Green lines depict positive edges, red lines negative edges, and strength of edge weights is depicted by the width and saturation of the edge.

really care for me") from the anxiety scale and Item 1 ("I usually discuss my problems and concerns with this person") from the avoidance scale both have high levels of strength centrality. Furthermore, Item 10 consistently has the highest level of betweenness centrality. In Study 1, Item 8 in the mother network has a strength centrality that is particularly low relative to Item 8 in the other networks, but this is not the case in Study 2.

3.2.3 | Network stability

The networks in Study 2 are very reliably estimated, with small bootstrapped confidence intervals around all edge weights. The centrality stability coefficients for strength centrality are all 0.75 (the maximum value of stability). For betweenness, the centrality stability coefficients are 0.64, 0.40, 0.46, and 0.52 for the mother, father, partner, and best friend networks, respectively. Thus, all coefficients exceed the criterion of 0.25 for minimal stability, and all but two exceed the threshold of 0.5 for robust estimation. In light of this level of stability, the patterns noted above reflect meaningful difference in centrality between the nodes. For example, across all the networks, the betweenness centrality of Item 10 can be considered as greater than that of the other items. Results of all stability analyses are reported in more detail in the Supporting Information.

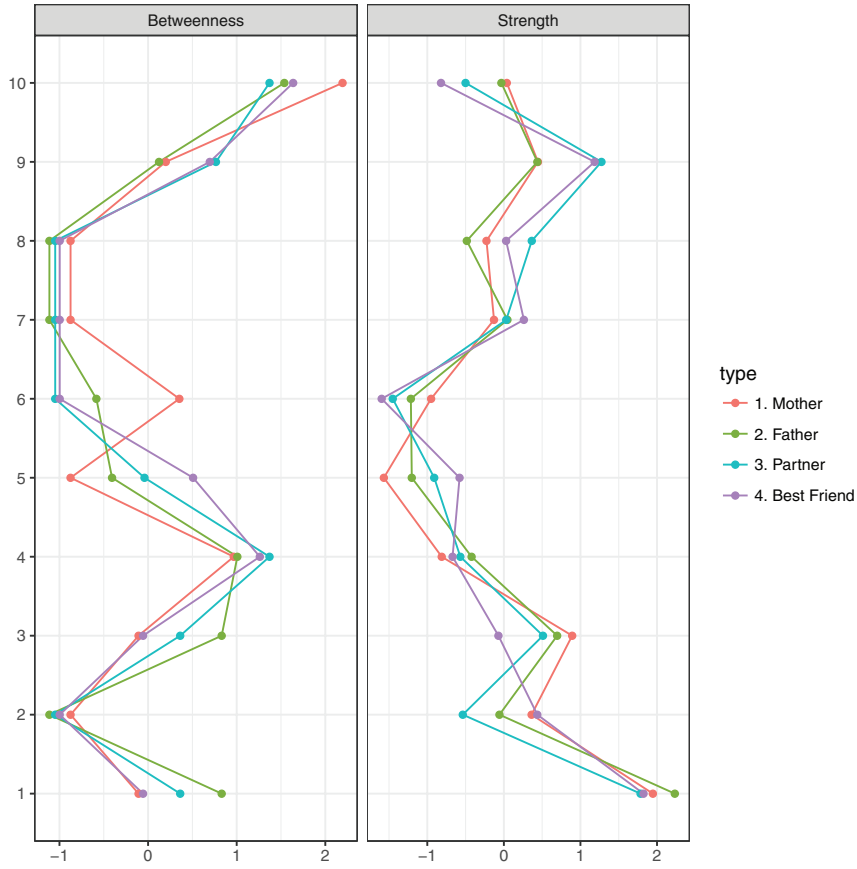

FIGURE 4 Measures of betweenness and strength centrality derived from the networks of the four attachment figures in Study 2

3.2.4 | Network comparisons

The NCTs indicate four statistically significant differences between the networks in Study 2: The mother network differs significantly from the partner ($p = 0.02$) and best friend ($p < 0.001$) networks, and the father network differs significantly from the partner ($p < 0.001$) and best friend ($p = 0.002$) networks. To complement these tests of absolute differences between global network structures, the similarity of all networks was examined by correlating their adjacency matrices pairwise. These correlation coefficients are very large (0.91–0.98) and considerably larger than those found in Study 1 (0.70–0.82).

3.2.5 | Network replicability: Formal comparison of Study 1 and Study 2

The comparison of network structures in Study 1 and Study 2 reveals only one significant difference, which was between the father networks (NCT *P*-value = 0.042); the two networks for mother across studies, as well as the two networks for partner and friend do not differ from each other (*P*-values of 0.20, 0.77, and 0.51, respectively). The correlation coefficients indicate strong similarities for all four network comparisons (mother = 0.90, father = 0.81, partner = 0.84, and best friend = 0.81). All NCTs and correlation coefficients are included in the Supporting Information.

4 | GENERAL DISCUSSION

Commonly used self-report measures of adult attachment assessing general attachment characteristics and those assessing relationship-specific attachment characteristics utilize scales assessing the dimensions of attachment anxiety and avoidance. This approach understands the attachment behaviors, beliefs, and feelings assessed in self-report attachment scales as *measurements* of the two underlying dimensions. Attachment theory (Bowlby, 1969, 1982) could be used to argue that these latent variables may be generated by experiences with early caregivers. For example, unreliable or inconsistent caregivers are thought to foster attachment anxiety, whereas unavailable or unsupportive caregivers are thought to foster attachment avoidance (Mikulincer & Shaver, 2007). The behavior of specific attachment figures may also give rise to similar attachment dimensions when assessing relationship-specific attachments. Although this potential connection has not yet been investigated, several factor analytic studies of the RSQ have demonstrated that anxiety and avoidance factors are also present within self-reports of specific attachment relationships (Donbaek & Elklit, 2014; Fraley et al., 2011; Moreira, Martins, Gouveia, & Canavarro, 2015).

This study provides an alternative conceptualization of the nature of adult attachment relationships. This network approach posits that the behaviors, beliefs, and feelings captured by items on self-reports of attachment anxiety and avoidance are intercorrelated not because they are passive measurements of two shared origins (anxiety and avoidance), but because they are causally connected with each other and thus give rise to attachment anxiety and avoidance. In this study, several consistent patterns emerged across attachment figures and across studies. As anticipated, the anxiety items clustered together. Within this cluster, Item 9 ("I often worry that this person doesn't really care for me") had the highest level of strength centrality. Two clusters of avoidance items were also present. There was a cluster of items that reflected a willingness to seek support from the attachment figure. These were the four reverse-scored avoidance items. Within this cluster, Item 1 ("I usually discuss my problems and concerns with this person") had the highest level of strength centrality. There was also a smaller cluster composed of the two avoidance items that assessed discomfort with sharing feelings with the attachment figure and that arguably reflected attachment avoidance more directly.

4.1 | Main findings

The network perspective is based on the premise that the associations identified are the result of causal connections, and the Gaussian Graphical Model used can be thought to highlight such putative causal pathways (Epskamp & Fried, 2018). The first objective of the present research was to demonstrate the potential of network analysis to generate hypotheses regarding causal relationships within attachment networks. The findings of both Studies 1 and 2 are suggestive of some theoretically interesting putative causal connections. For example, within the cluster of anxiety items, Item 9 ("I often worry that this person doesn't really care for me") had the highest level of strength centrality. This finding raises the possibility that concerns about the genuineness or sincerity of an attachment figure's caring might play a central role in the development and maintenance of attachment anxiety. Such concerns could easily be expected to drive other aspects of attachment anxiety. Consistent with this idea, there were strong connections between Item 9 and those regarding fears of abandonment (Item 7) and worry about one's interest in the attachment figure not being reciprocated (Item 8). However, self-report measures often include items with a very similar content to ensure the scale has adequate internal consistency. Understanding edges as putative causal relations from a network perspective would be unwarranted in cases in which two items have very similar content. In our case, this may be particularly applicable to the strong edge between Item 1 ("I usually discuss my problems and concerns with this person") and Item 2 ("I talk things over with this person"). At present, there is no consensus on how to handle such items within the network approach, although some suggestions have been provided (see Fried & Cramer, 2017).

The second objective was to examine the possibility that there may be items that bridge between clusters of anxiety and avoidance items. Consistent with expectations, the network structures suggest that the item concerning not fully trusting an attachment figure (Item 10) serves as a bridge between the anxiety cluster and the two avoidance-related clusters. This notion is strongly supported by the results of the betweenness centrality analysis, indicating that Item 10 consistently lies along the shortest paths connecting the other nodes to each other. This pattern suggests that trust could be the mechanism by which changes in attachment anxiety affect changes in attachment avoidance, or vice versa. For example, worry about an attachment figure not really caring (anxiety; Item 9) could lead to not fully trusting the attachment figure (Item 10), which could result in difficulty depending on this attachment figure (avoidance; Item 4). This idea of a bridge between anxiety and avoidance is arguably the most theoretically interesting potential causal relationship identified in the current research. However, it is important to note that in this cross-sectional study, the edges (i.e., connections) are undirected and could, therefore, reflect relationships in the opposite directions to those suggested above. Another possibility is that they reflect bidirectional relationships.

The concept of a bridge item highlights a crucial difference between the latent variable approach and the network approach. Psychometric research based on a latent variable perspective often results in the elimination of items with cross-loadings to reduce the conceptual and statistical overlap between subscales. This was also the approach taken in the development of the RSQ, which no longer includes Item 10. The seldom acknowledged negative consequence of this approach is the potential loss of content validity (i.e., not assessing all relevant components of a construct). The network perspective not only draws attention to this loss of content validity, but also conceptualizes such items as potentially the most relevant items for understanding related psychological constructs, such as attachment anxiety and avoidance.

The third objective of the research was to empirically evaluate the similarity of attachment networks across attachment figures (i.e., mother, father, romantic partner, and best friend). The network

comparisons conducted in Study 1 indicated a high level of consistency across the four attachment networks studied, with pairwise correlations between network structures ranging from 0.70 to 0.82. In Study 2, the correlations between the adjacency matrices (0.91–0.98) indicated even higher levels of similarity. Despite these similarities, the NCT flagged four networks comparisons (out of the six) in Study 2 as significantly different from each other. This might at first glance appear contradictory, but it should be noted that the NCT, like other statistical tests, gains power to detect differences with sample size: In extremely large samples, even a miniscule difference between two network structures can lead to a significant difference. Because Study 2 featured a much larger sample than Study 1, the NCT indicated significant differences that were likely small in nature, judging from the similarity of the adjacency matrices.

The final objective was to examine the replicability of the findings across two different data sets. The results of Study 1 indicated a high level of consistency across the four attachment networks studied (mother, father, partner, and best friend), and Study 2 largely replicated the findings of Study 1 in an older and more diverse sample. However, it should be noted that in addition to the significant NCT findings noted earlier, the indices of the consistency and stability of the findings were strongest in Study 2. Formal comparisons of the network structures across studies revealed only one significant difference (viz., father network) and high similarities across all four network comparisons. The similarities of the networks across attachment figures and across studies suggest that similar attachment-related dynamics may operate across various attachment relationships. However, it is important to note that this level of similarity is likely partially due to the consistency of the items across the attachment figures. There may be a wide range of other variables relevant to a particular type of attachment relationship (e.g., sexual activity in romantic relationships) that could be highly influential within that network related to that form of attachment but irrelevant or inappropriate to consider as part of other attachment networks. The addition of such variables to network analyses of specific relationships would be expected to capture the unique features of different types of networks.

Two additional issues related to the measurement and modeling of the current findings should be noted. First, across attachment figures and studies, the reverse-scored avoidance items reflecting a willingness to seek support clustered separately from the two avoidance items that assessed discomfort with sharing feelings. One interpretation for these results is that the two clusters contain items with different content. However, it is also important to recognize the items could have clustered separately, at least partially, because of acquiescence bias (i.e., the tendency to agree with statements; see Krosnick & Presser, 2010) applied to items worded in different directions. Research with items worded in the same direction, or with items structured to avoid acquiescence bias, would be required to evaluate the degree to which the two forms of avoidance noted in the current study are actually distinct from each other. Second, factor analytic methods and network analysis can be equivalent from a mathematical perspective (Kruis & Maris, 2016; van der Maas et al., 2006). This means that one data set can always be described equally well in terms of fit by a factor model and a network model. Due to the equivalence of models, some of our results could be anticipated based on previous factor analytic studies. For example, the trust item had high loadings on both factors in Fraley et al.'s (2011) study of the RSQ; in a network model, this makes it likely to be a bridge item with a high betweenness centrality. Importantly, the current findings do not challenge the continued use of scales assessing attachment anxiety and avoidance, or of factor models estimated in attachment data. What the network perspective adopted in the current study does offer is a potentially fruitful approach to *understanding* attachment from a different viewpoint.

4.2 | Implications for attachment theory and interventions

Aside from the concept of bridge symptoms noted earlier, the literature on the network approach to psychopathology offers several ideas that can be extrapolated to adult attachment, many of which we consider important for future studies on the topic. First, centrality may reflect a symptom's influence on other symptoms, so a symptom with a high level of centrality may be more likely to lead to the development of further symptoms than would a symptom with a low level of centrality (see Boschloo et al., 2016). Similarly, we hypothesize that individuals scoring high on the anxiety item with the highest strength centrality (i.e., Item 9: "I often worry that this person doesn't really care for me") may be those most likely to experience an increase in attachment anxiety over time or to maintain a high level of attachment anxiety because the aspect of anxiety captured by this highly central item might keep reactivating the behaviors, beliefs, and feelings captured by the most strongly connected items (i.e., other anxiety items). Second, it has been suggested that targeting the most central symptoms within a network may provide an effective strategy for changing the network in a positive manner (i.e., efficiently decreasing symptoms; Boschloo et al., 2016; McNally, 2016) in situations in which central symptoms are amenable to change and have causal influences on other symptoms (Fried et al., 2018). Similarly, changing behaviors, beliefs, or feelings related to the content of attachment items with the highest levels of centrality might be particularly effective in decreasing attachment insecurity. Given the high centrality of Item 1, an increase in the degree to which an individual talks with a particular attachment figure about problems and concerns (i.e., the content of Item 1) may lead to decreases in behaviors, beliefs, and feelings involved in attachment avoidance related to this attachment figure. This process of change could be directly prompted by clinical interventions that encourage an increase in these types of conversation, such as assertiveness training or couples therapy.

Although it has not received attention in the network literature on psychopathology, weakening *connections* between symptoms—in contrast to intervening directly on symptoms—could also provide an effective treatment strategy. Imagine the case of a patient who consistently consumes alcohol in response sadness (sadness → drinking): Effectively preventing sadness might not be possible for the patient, but one could aim to prevent drinking as a response to sadness. For attachment, worrying about the genuineness of an attachment figure's care (Item 9) is strongly connected with other aspects of attachment anxiety, such as fears of abandonment (Item 7). It might be possible to influence an individual's attachment network in a positive way by reducing the strength of the connection between these two constructs. For example, cognitive restructuring might help an individual worrying about the genuineness of an attachment figure's care to recognize that concerns of this nature many not be good evidence that abandonment is likely or that worry about abandonment is warranted; the goal would be to causally separate these constructs.

4.3 | Moving forward: Longitudinal and experimental research

The main goal of psychological network models applied to cross-sectional data is, in our view, hypothesis generation. Accordingly, we used the findings to develop a few directional and causal hypotheses about the relations between the behaviors, beliefs, and feelings captured by the RSQ items, and hope the ideas raised will encourage longitudinal and experimental research evaluating these possibilities. Two possibilities are discussed below.

First, advanced statistical methods based on the network perspective have been developed to study the *dynamics* of networks using experience sampling methodology where data on many variables such as emotions or symptoms are collected several times per day over an extended period of time. Studies have investigated such time-series networks both in single individuals (e.g., Bak, Drukker, Hasmi, & van Os, 2016) and groups of people (e.g., Bringmann, Lemmens, Huibers,

Borsboom, & Tuerlinckx, 2015). The use of these methods to study attachments to specific attachment figures over important relationship transitions, such as moving away from one's parents or the formation of new friendships and romantic relationships, could be used to more thoroughly investigate the dynamics of attachment. Given that attachment networks are likely to evolve at a somewhat slower pace than emotions and symptoms typically assessed in experience sampling studies, it might be necessary to collect data less frequently and over a longer period of time (e.g., 3 measures a week for half a year instead of 10 measures a day for 2 weeks).

Second, laboratory-based experimental studies involving manipulations that foster security or insecurity could shed light on attachment dynamics and potentially indicate how relationship-relevant experiences influence attachment networks. For example, the level of support during a stressful laboratory task can be manipulated via low-support and high-support messages from partners (see Collins & Feeney, 2004). This type of procedure may also create short-term changes in attachment and provide an opportunity to study attachment dynamics. Laboratory-based studies that involve procedures that promote interpersonal closeness (see Aaron, Melinant, Aron, Vallone, & Bator, 1997) could also be used to investigate the dynamics of attachment in newly forming friendships or romantic relationships. Attachment-focused clinical interventions, such as parent training used to promote the security of young children (Marvin, Cooper, Hoffman, & Powell, 2002; Steele et al., 2014) and dyadic interventions used with adolescents and their parents (Moretti & Obsuth, 2009), would also provide promising opportunities to study the dynamics of attachment in situations in which attachment security would be expected to increase substantially over a relatively long period of time (e.g., numerous weeks). These two lines of research—temporal observational studies during relationship transitions and experimental studies—might provide important insights into the mechanisms responsible for the tendency of adult attachment characteristics to remain moderately stable over time (see Fraley, 2002) as well as factors that can provoke changes in attachment characteristics.

4.4 | Summary

The current research proposes and illustrates a network conceptualization of adult attachment relationships in which the behavior, belief, or feeling assessed by an RSQ item may be causally connected to the behaviors, beliefs, and feelings assessed by other RSQ items. This perspective is suggestive of new ideas regarding: (a) the connection between attachment anxiety and avoidance, (b) potential dynamics of changes within attachment relationships, (c) the identification of individuals most likely to experience change or stability in their attachments, and (d) behaviors and environmental factors that might affect changes in attachment.

ACKNOWLEDGMENT

The authors thank R. Chris Fraley for providing archival data for Study 2.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

How to cite this article: McWilliams LA, Fried EI. Reconceptualizing adult attachment relationships: A network perspective. *Pers Relationship*. 2019;26:21–41. https://doi.org/10.1111/pere.12263