Co-Rumination in Social Networks

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Introduction

Co-rumination is a form of self-disclosure that occurs within conversations and involves frequent, repetitive, and speculative discussions of personal problems and negative feelings (Rose, 2002). Typically, co-rumination occurs and is examined in the context of close dyadic relationships, as this construct was originally proposed as a relationship process between same-sex friends (Rose, 2002). Since the concept of co-rumination was first introduced, the study of co-rumination has expanded to a diverse array of relationships. Evidence now shows that across many types of relationships, co-rumination is associated with both adaptive and maladaptive socio-emotional outcomes (Calmes & Roberts, 2008; Starr & Davila, 2009).

Co-rumination can be assessed in terms of an individual's tendency to co-ruminate with a same-sex close friend or within a typical relationship of interest (RStudio Team, 2022; Calmes & Roberts, 2008). Evidence suggests that co-rumination increases as children enter adolescence and continues to increase until about middle adolescence (Felton et al., 2019; Rose, 2002; 2007). Across all age groups, females tend to report more co-rumination than males within same-sex friendships (e.g., Balsamo et al., 2015; Rose et al., 2007; Tompkins et al., 2011), however, these sex differences do not appear to carry over to other types of relationships, e.g., parent-child, sibling, roommate, or romantic relationships (Ames-Sikora et al., 2017; Barstead et al., 2013; Calmes & Roberts, 2008). Thus, both males and females appear to co-ruminate in close relationships, however, females are more likely to make it a focus in same-sex friendships.

Co-rumination and Internalizing Symptoms

The ruminative aspect of co-rumination has been likened to depressive rumination and may therefore be associated with depressive and other internalizing symptoms (Rose, 2002). In line with this idea, longitudinal evidence suggests that co-rumination at earlier time points predicts future depressive rumination (Felton et al., 2019). Thus, co-rumination about a problem within a friendship may exacerbate an individual's distress over the problem, leading to increases in both depression and anxiety symptoms. In accord, evidence suggests that higher levels of co-rumination are positively associated with depression and anxiety symptoms within same-sex friendships (Rose, 2002). Subsequent research has replicated this finding in same-sex friendships and extended it to roommate, and romantic relationships (Ames-Sikora et al., 2017; Guassi Moreira et al., 2016). These results suggest that like rumination, co-rumination may indeed serve a similar stimulating function for individual-level depressive and anxiety-related cognitions and may help to account for gender differences in these symptoms.

An early study within the co-rumination literature found that depression and anxiety symptoms associated with co-rumination appeared only in female participants (Rose et al., 2007). Further research has indicated that co-rumination may mediate the association between gender and internalizing symptoms such that females tend to report more internalizing symptoms than males, possibly due to their higher co-rumination tendencies (Calmes & Roberts, 2008; Tompkins et al., 2011). Thus, females with a tendency to co-ruminate may be particularly at risk for the development of internalizing symptoms.

At the level of the dyad, co-rumination has also been found to mediate the contagion of anxiety and depression between dyad members (Schwartz-Mette & Rose, 2012). That is, individual-level depression and anxiety symptoms may predict co-rumination within a dyad, creating a cycle between co-rumination and further internalizing symptoms for both dyad members (Rose et al., 2007). Nonetheless, despite robust evidence that co-rumination predicts symptoms of anxiety and depression, people continue to co-ruminate. One reason why they may continue to do so is the perceived positive effects it has on individual relationships.

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Co-rumination in Relationships

Mutual positive perceptions of relationship quality have been associated with co-rumination and thereby play a role in reinforcing the behavior, despite its negative effects (Rose, 2002). For example, individuals who have a higher tendency to co-ruminate in same-sex friendships report greater feelings of closeness and positive friendship quality compared to those with a lower tendency to co-ruminate in these relationships (Rose, 2002; 2007). Moreover, these positive perceptions of friendship quality appear to be mutual within the dyad (Rose, 2002).

Within same-sex friendships, co-rumination is associated with a secure attachment style and greater levels of communication within the relationship (Starr & Davila, 2009), although this benefit may be stronger for men's same-sex friendships than for women's (RStudio Team, 2022; 2007). Interestingly, co-rumination also mediates the associations between gender and positive friendship quality, indicating that co-rumination is partially responsible for females' tendency to report higher perceptions of friendship quality compared to men (Felton et al., 2019; Rose, 2002). Thus, while the effect of co-rumination on positive friendship quality may be stronger in males, it nonetheless plays a critical role in the positive friendship quality reported by females.

Outside the context of same-sex friendships, co-rumination has also been found to be associated with positive relationship quality and satisfaction within roommate and romantic relationships (Calmes & Roberts, 2008). Moreover, individuals who report moderate-to-high co-rumination within a specific relationship (e.g., significant other, same-sex friend) indicate feeling supported by their co-ruminative partners (Ames-Sikora et al., 2017). However, individuals with a tendency to co-ruminate may lack opportunities for support outside of this relationship due to an association between co-rumination and peer dysfunction (Tompkins et al., 2011). Over time, co-rumination predicts fewer friends, as well as reduced self-perceived social competence (Starr & Davila, 2009; Tompkins et al., 2011). In addition, individuals who tend to co-ruminate are observed to be less socially accepted, and females with a higher tendency to co-ruminate report greater peer stress (Rose et al., 2017; Tompkins et al., 2011).

Peer communication may also play a role in the internalizing symptoms associated with co-rumination. Specifically, one study found that the association between co-rumination and depressive symptoms was only significant when communication with peers was low (Dam et al., 2014). Thus, it appears that co-rumination may lead to a trade-off between close, positive relationships and interpersonal problems outside of these relationships, which may contribute to internalizing symptoms. That is, individuals who tend to co-ruminate, have fewer friends (Tompkins et al., 2011), and females with this disposition report greater peer difficulty (Rose et al., 2017). One explanation may be that individuals who co-ruminate may prioritize a few close co-ruminative relationships over the maintenance of other friendships and friendship initiation.

Interestingly, co-rumination tends to occur at similar levels within both members of a friendship dyad (Schwartz-Mette & Rose, 2012). That is, individuals who self-identify as "co-ruminators" may tend to befriend other co-ruminators. Furthermore, within co-ruminative conversations, both an individual's and their partner's personal problems and negative feelings seem to be equally discussed (Calmes & Roberts, 2008). Thus, it appears that co-ruminative tendencies may be a mutually occurring friendship selection factor. Given that the association between co-rumination and friendship quality is bidirectional (Felton et al., 2019), it is likely that the equitable discussion of personal problems leads both partners to perceive the relationship as highly satisfying and particularly close, thereby reinforcing the act of co-rumination within the relationship, to the exclusion of external relationships. One outcome of this process may be that co-ruminators have smaller and more sparsely populated social networks.

Social Networks

Social networks include all the relationships within an individual's life or within a particular environment (Tabassum et al., 2018). Having a larger social network is associated with higher levels of subjective well-being (Zhang et al., 2019). Conversely, having fewer social relationships and/or being socially isolated is associated with depression and anxiety symptoms (Domènech-Abella et al., 2019; Wildes et al., 2002). Thus, there is a potential interaction between co-rumination, smaller network size, and internalizing symptoms.

Networks that are bound to specific environments or contexts such as a classroom cohort, or organization are referred to as sociocentric networks (Chung et al., 2005; Tabassum et al., 2018). To examine a bounded network, researchers analyze all individuals within a specific environmental or contextual boundary, as well as the connections between them (Hawe et al., 2004). Within organizations, sociocentric network analyses can highlight, for example, areas where network characteristics may lead to increased productivity (Reagans & Zuckerman, 2001).

Alternatively, egocentric networks are those involving a single individual and their relationships with friends, relatives, colleagues, etc. (Chung et al., 2005; Tabassum et al., 2018). Within an egocentric network, an individual is the "ego," and the people with whom they have relationships are the "alters" (Chung et al., 2005). An egocentric network can be graphically characterized as a central node representing the ego, surrounded by alter nodes. The connections or relationships between individuals, graphically represented by lines, are known as "ties" (Tabassum et al., 2018). Social network analysis allows researchers to gather information about the broad characteristics of social networks, and the quality and quantity of ties within them.

Researchers compare differences in social network sizes by examining the number of alters within those networks. They compare network density based on the proportion of ties in a network relative to the total possible ties within that network (Tabassum et al., 2018). For example, a network where all alters are connected to each other is considered highly dense. Ties within a social network can be assessed in several ways and provide a nuanced understanding of the relationships between an ego and their alters. Tie strength is most often defined as a combination of time, emotional intensity, intimacy, and reciprocity within a relationship (Granovetter, 1973). Several measurements of tie strength have been used over the years such as closeness, frequency/amount of time spent together, and relationship "multiplexity" (Marsden & Campbell, 1984). Multiplexity can refer to the number of socio-emotional roles an alter, such as a parent, friend, or colleague, fulfills (e.g., Gillath et al., 2017; Verbrugge, 1979).

Mappings of alters and ties within egocentric networks are typically used to examine associations between an individual's traits, such as characteristics, behaviors, and attitudes, and the social effects of those traits. For example, large, dense networks and strong social ties are associated with positive outcomes such as greater life satisfaction and subjective well-being (Zhang et al., 2019; Zou et al., 2015). However, in an environment where sparse networks are the norm, having or striving for a high-density network may have negative outcomes (Kane, 2011). Taken together, this research indicates that network density may be associated with positive or negative outcomes, depending on the broader social context. Additionally, the presence of strong ties indicates close relationships, which may provide individuals with greater opportunities to receive social support. Because characteristics such as network size, density, and tie strength are associated with both positive and negative outcomes, it is important to understand how individuals form social networks, whether the presence of a co-ruminative interpersonal style predicts network management behaviors, and whether differences in network size or density are associated with more positive or more negative outcomes for individuals.

Most people actively manage and maintain their social networks. Network management behaviors include the initiation, maintenance, and dissolution of network ties (Gillath et al., 2017), measured in terms of people's tendencies to engage in these behaviors. An individual's tendency to initiate, maintain and dissolve ties may be influenced by individual factors such as gender (Bleske-Rechek & Buss, 2001), attachment (Gillath et al., 2011), or personality (Shipilov et al., 2014). Network management behaviors affect network characteristics such as network size, tie strength, and multiplexity (Gillath et al., 2017). Individuals who initiate many relationships may have larger networks with lower density while those who cultivate closer friendship groups may have smaller, denser networks. Thus, network management skills may play an important role in understanding how co-

ruminators build their networks and how those networks relate to social outcomes. Understanding the effects of co-rumination on social networks and network management may be particularly pertinent during the transition to college or university, when people typically leave their old social environment and enter a new one.

Transition to University

Many students entering their first year of university are either older adolescents or young adults and are thus entering the early or emerging stages of adulthood. During emerging adulthood (late adolescence to mid-twenties), individuals experience a variety of challenges relating to the determination of identity in new social, work/academic and community contexts (Arnett, 2007). The first year of university may be particularly stressful for many young adults because they must manage the demands of a rigorous academic program while transitioning to independent living. Indeed, both men and women report increases in internalizing symptoms and stress during the first year in university, along with decreases in perceived support (Conley et al., 2020). Co-rumination tendencies may critically affect the degree to which young adults successfully navigate this transition, as co-rumination has been shown to play a role in stress generation (Hankin et al., 2010), internalizing symptoms (e.g., Carlucci et al., 2018; Felton et al., 2019; Rose, 2002), and social relationships (Starr & Davila, 2009; Tompkins et al., 2011). This volatile life-stage may therefore, place individuals entering their first year of college or university at an increased risk for co-rumination and its negative consequences. Thus, it is important to examine how the presence of co-rumination affects this life-transition.

Current Study

The current study examines how co-ruminative tendencies relate to an individual's relationships within their social network via social network analysis. Previous research indicates that individuals who co-ruminate have close relationships in which they co-ruminate, yet have fewer friends overall (Tompkins et al., 2011). While there is extensive research on the impact of co-rumination at the dyadic level, few researchers have sought to examine how co-rumination impacts an individual's overall network structure. To our knowledge, this is the first study to examine associations between co-rumination and social factors through social network analysis. Additionally, we examined how co-rumination relates to network management behavior, including the tendency to initiate, maintain, and dissolve relationships. The results of this study provide insight into the potential mechanisms that may cause both the adaptive and maladaptive outcomes associated with co-rumination.

Here, we used egocentric social network analysis to determine how co-ruminative tendencies relate to various social

network characteristics. Specifically, we examined both the size and density of an individual's network in relation to their tendency to co-ruminate. We also examined how co-ruminative tendencies associate with depression symptoms and network management behaviors. We proposed the following specific hypotheses:

I. Because co-rumination is associated with mutual and enhanced perceptions of relationship quality (Rose, 2002), we anticipated that greater levels of co-rumination within a particular relationship would be associated with greater tie strength (i.e., a composite of self-reported relationship closeness, relationship quality and satisfaction with that quality; Hypothesis IA) and socio-emotional multiplexity (Hypothesis IB).

II. In line with the evidence that co-rumination is associated with fewer friends (Tompkins et al., 2011), we expected that a greater tendency to co-ruminate in general (across relationships) would be associated with smaller network size and lower network density. The association between co-rumination and network size would at least be partially mediated by a unique pattern of network management behaviors (i.e., a greater self-reported tendency to prioritize the maintenance of close ties, a greater self-reported tendency to dissolve ties, and a lower self-reported tendency to initiate new ties).

III. Both co-rumination and smaller network size are positively associated with internalizing symptoms (Domènech-Abella et al., 2019; Schwartz-Mette & Rose, 2012; Wildes et al., 2002). We therefore predicted that a greater tendency to co-ruminate in general would be associated with greater levels of depressive symptoms. This association between co-rumination and depressive symptoms would be at least partially mediated by network size.

Methods

Participants

Participants were undergraduate students participating in a large-enrolment (~3000 students) introductory psychology course at Western University in Ontario, Canada. They completed the study in exchange for partial course credit. Western University is a large institution with ~25,000 undergraduate students (Western University, 2019-2020). In the current sample, 88.9% of participants reported having moved away from home to attend university. Thus, most participants in our sample were experiencing the transition to independent living and university studies simultaneously. Data were collected during the first semester of students' first year of university (between 29 September 2021 and 22 November 2021), because we were interested in social network development as individuals enter this new life stage (i.e., emerging adulthood and the beginning of post-secondary education). To maximize the likelihood that study participants were making the transition to university from living at home, we only

analyzed data from participants that were enrolled in year one of their undergraduate programs at the time of the study and aged 17–22 years[1]. While many studies examining emerging adults have focussed on individuals aged 18 and above, we included 17 year-olds in our study, as many students (14% of our final sample) entering university in Canada begin the year aged 17 and turn 18 before the end of first semester. Importantly, analyses showed few meaningful differences between 17 year-olds and those 18 and older in our sample (see Supplemental Table 3). We therefore included the 17 year-olds in our analyses.

Consistent with literature assessing personal factors on social network characteristics, this study aimed to have a sample of 500 participants, before exclusions. To determine sample size, we used a Monte Carlo power analysis toolkit for indirect effects (Schoemann et al., 2017). We used a single mediator model for our power analysis, which aligns with our hypothesis (HIII) assessing co-rumination, network size and depressive symptoms. We set the confidence level at 95% and the target power at 90%. Associations between co-rumination and depressive symptoms (Spendelow et al., 2017), co-rumination and number of friends (Tompkins et al., 2011), as well as network size and depression (Santini et al., 2015), have small-to-moderate effect sizes. Thus, we set correlation values at 0.2 for all paths. We used the following standard deviations for the variables: $SD_{co\text{-}rumination}=0.73$ (White & Shih, 2012), $SD_{depression}=8.16$ (Rose et al., 2017) and $SD_{networksize}=3.94$ (Gillath et al., 2017). This analysis suggested that 378 participants would provide a statistical power of 0.90. To ensure that we achieved this sample with exclusions, we oversampled and stopped data collection once we obtained 549 participants.

We excluded 62 participants that were either outside of our desired age bracket (17–22 years old), were not in their first year of university or failed to participate in the network interview. Of the remaining 487 participants who completed the survey, we excluded 5 participants who failed 2 or more of the 4 attention check items built into the online survey, as well as those with invariant responses on the co-rumination questionnaire (defined as answering the same response for the entire survey; 1 participant) and those who had more than 20% missing responses on the survey (3 participants). Individuals who failed to complete the Network Interview and/or those that failed to provide information on key variables of interest were also excluded (2 participants), as well as those that had network sizes outside of our instructed maximum of 35 (8 participants). Finally, we excluded statistical outliers, i.e., those with scores on either the Co-rumination Questionnaire (CRQ; Rose, 2002), Network Management Inventory Short-Form (NMI-SF; Guassi Moreira et al., 2016) or the Hospital Anxiety-Depression Scale (HADS; Zigmond & Snaith, 1983) that were three or more standard deviations above or below the mean (14 participants; included in the raw data file on the study's OSF page). All materials, measures and analysis scripts were uploaded to a preregistration document on the

Table 1. Demographic characteristics of final sample.

	n	%
Age		
17	65	14.19
18	361	78.82
19	27	5.90
20	5	1.09
Gender identity		
Woman	335	73.14
Man	117[a]	25.32
Non-binary	1	0.22
Genderqueer	1	0.22
Other gender identity	1	0.22
Prefer not to say	3	0.66
Sexual orientation		
Heterosexual	398	86.90
Gay/Lesbian	8	1.75
Bisexual	41	8.95
Other orientation	4	0.87
Prefer not to say	7	1.53
Ethnicity		
White	184	40.17
Asian	196	42.79
Black	8	1.75
Latin american	4	0.87
Arab	19	4.15
Indigenous	0	0
Mixed ethnic/racial background	41	8.95
Another ethnicity not specified	6	1.31
Did you move away from home to attend university/college?[b]		
Yes	406	88.84
No	51	11.16

[a]This sample includes both cisgender (n = 116) and transgender (n = 1) men. All women identified as cisgender.
[b]One *participant chose not to answer.*

OSF (https://osf.io/mube4/). De-identified raw data have also been uploaded onto the study's OSF page. To de-identify raw data, we used random and anonymous participant IDs for each individual and their alters.

After data quality and outlier exclusions listed above, the final sample consisted of 458 (335 women) first year students aged 17 to 20 years-old ($M = 17.94$, $SD = 0.49$). Most individuals were heterosexual ($n = 398$) and cisgender ($n = 451$). Any participant who identified as either a man or woman regardless of being cisgender or transgender were included in our subsamples of men and women used for gender analyses. Within the sample, about 83% of individuals identified as either white ($n = 184$) or Asian ($n = 196$) while the other 17% of the sample identified as one of the following ethnicities: Black, Latinx, Arab, Indigenous, mixed ethnic/racial background or preferred not to specify. Further information regarding the sample demographics can be found in Table 1.

Measures

This study was part of a larger Master's Thesis project examining how co-rumination and personality factors influence people's network structure and the relationships amongst alters within networks. Thus, in addition to the measures listed below, participants completed a five-factor personality inventory (Big Five Inventory; John & Srivastava, 1999) that has not been included in the hypotheses/analyses for the present report but is included with other study materials on the study's OSF page. Excluding the Network Survey, participants completed all questionnaire measures on Qualtrics.

Demographics

At the beginning of the study, participants answered several demographic questions assessing the following variables: age, gender identity, race/ethnicity/cultural identity, year of study, whether they moved away from home for university and sexual/gender orientation.

Co-rumination Questionnaire (CRQ)

The Co-rumination Questionnaire (Rose, 2002) includes 27 statements assessing the discussion of personal problems and negative feelings between an individual and a close same-sex friend. For this study, the term "same-sex friends" from the original questionnaire was replaced with "confidant(s)" to account for the fact that participants may co-ruminate with friends, acquaintances, or romantic/sexual partners. (e.g., "We spend most of our time together talking about problems that my confidant(s) or I have."). Participants rated statements on the questionnaire using a 5-point Likert scale ranging from "not true at all" (1) to "really true" (5). The CRQ had excellent internal consistency ($\alpha = .91$).

Network Survey

After completing the demographic and co-rumination questionnaires, participants were directed to the Network Canvas Interviewer, which collects social network data. The Network Canvas Interviewer is part of the freely available Network Canvas Software Suite (Data Collective, Complex, 2016) https://networkcanvas.com. Participants completed the network survey with the help of video-based instructions/examples at key interview stages. A trained interviewer was available to answer questions throughout the process. The interview included the following components.

Name Generator

Participants listed individuals in their social network with whom they interact (either in-person or virtually) on a regular basis (ranging from multiple times a year to multiple times a
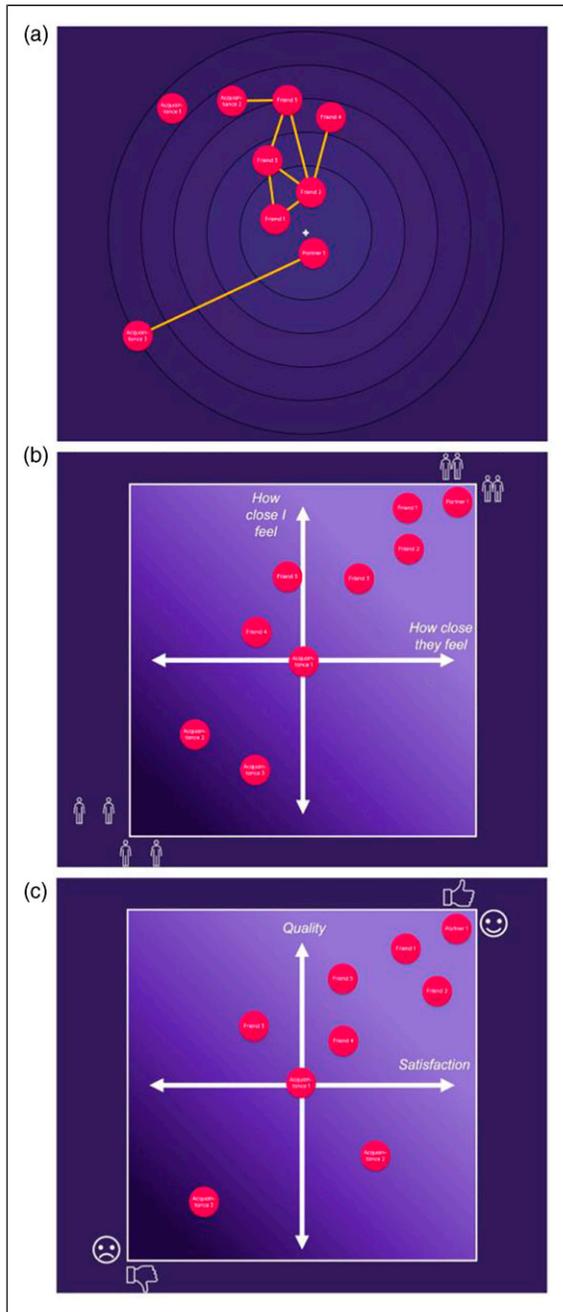
Figure 1. Network Canvas Tasks. *Note.* (A) Participants placed each of their alters on a sociogram. The closer an alter was placed to the cross, the closer the participant viewed their relationship with that alter. (B) Relationship Closeness: Participants placed each alter in the diagram quadrants based on how close they feel towards that alter, and how close they think the alter feels towards them. (C) Relationship Quality and Satisfaction: Perceived relationship quality and satisfaction with relationship quality.

Day) in a social network name generator. Name generators are used in egocentric network analysis to obtain a list of alters relative to the ego (Perry et al., 2018). Research indicates that using multiple name generators reduces the chance of

participants forgetting individuals in their life (Carrington et al., 2005). Thus, the name generator portion of the survey was broken into three parts in which participants were instructed to list up to 5–20 individuals in the following categories: (1) friends [maximum 20 individuals] (2) acquaintances [maximum 10 individuals] (3) romantic/sexual partners [maximum 5 individuals]. A definition was provided for each relationship of interest (i.e., friend: "an individual with whom one has a mutual bond of affection/liking" [Oxford English Dictionary, 2021]; acquaintance: "an individual that one knows casually or is familiar with but who is not considered a friend" [Merriam-Webster, 2020]; and romantic partner/sexual partner: "an individual with whom one is romantically intimate and/or engages in sexual activity with"). In total, the size of social networks that participants were instructed to report on ranged from 0 to 35 alters. We capped the maximum number of alters to 35 to reduce demands on participants, who were asked follow-up questions about each alter.

Participants identified individuals with unique names, nicknames, or initials and were instructed to avoid listing relatives. After naming an alter, participants were asked demographic questions (e.g., gender) about their alter, these data were not examined in present study.

Name Interpreters

Name interpreters refer to questions asked to an ego about their alters (Perry et al., 2018). A combination of questions from previous social network analysis studies, as well as supplementary items assessing our specific research questions were used as name interpreters. In this study, several survey stages were used to assess the nature of the participant's relationship with their alters. These stages assessed both broad network characteristics (network size, network density) and tie-level characteristics (where they met each individual, frequency of interactions, duration of each relationship, closeness of the tie, relationship quality, satisfaction with quality and socio-emotional multiplexity). Several of these variables (where participants met their alters, frequency of interactions and duration of each relationship) are a part of a larger research project and thus were not included in the present analyses.

Network Size and Density. Calculation of both network size and network density was conducted using R 4.1.1. (RStudio Team, 2021) and the 'egor' 1.21.1 package (Krenz et al., 2021). Network size was defined as the sum of all the alters (friends, acquaintances, and romantic/sexual partners) an individual listed in their social network. The sociogram template provided through Network Canvas allowed participants to make connections between alters who know each other to assess network density (Figure 1(a)). During the sociogram task participants were instructed to place all individuals they listed in the name generators section on the diagram and to

"connect any two people that would spend time together without you being there". Calculating network density involves dividing the number of reported ties (i.e., "edges") between alters over the total number of possible ties within the network.

Tie Strength. In addition to assessing network density, the sociogram task (Figure 1(a)) allowed participants to sort their alters based on how close they felt towards each one. As such, we edited the sociogram to include a cross in the center. Participants were informed that closer placement of an alter to the center cross would indicate a closer ego-alter relationship. Closeness of each tie was also measured using a quadrant task (Figure 1(b)) in which participants were instructed to place individuals on a diagram based on (1) how close they feel towards each alter and (2) how close they THINK each alter feels towards them. For the purposes of the present study, analyses focus on how close the participant (ego) feels toward each alter. Relationship quality and satisfaction with that quality was assessed using a second quadrant task (Figure 1(c)). Our measure of tie strength is a composite score of self-reported relationship closeness, relationship quality and satisfaction with that quality (see Data Analysis below).

Network Canvas outputs the *x*- and *y*-coordinates for the placement of each alter on a diagram. The center of the sociogram diagram receives the coordinates (0.5, 0.5). The distance of each alter node from the center coordinate was calculated using the following formula (1)

$$D = \sqrt{dx^2 + dy^2} \quad (1)$$

The distance of the alter from the center coordinate (*D*) on the sociogram task was calculated in R.4.1.1. (RStudio Team, 2021) by finding the square root of the sum of the squared difference between the *x*-value of a particular alter and *x*=0.5 (*dx*) and the squared difference between the *y*-value of a particular alter and *y*=0.5 (*dy*). This process generated one score for each alter. These data were then reverse scored to produce scores in which higher values indicate greater closeness. In the closeness quadrant task and relationship quality quadrant task, closer and higher quality relationships were placed closer to the top of the screen and therefore received smaller values on the *y*-axis. To aid in the interpretation of these data, on these tasks, *y*-axis values were reverse-scored so that higher *y*-values indicate closer relationships and greater satisfaction with relationship quality. In the relationship quality quadrant task, more satisfying relationships were placed closer to the right of the screen and thus received greater values on the *x*-axis. Thus, higher *x*-values indicated greater satisfaction with a given relationship's quality.

Socio-emotional Multiplexity. Social-emotional multiplexity was determined by calculating the total number of social-emotional roles an alter fulfills. Role selection for the social-emotional multiplexity question included: (1) sharing social activities (2) discussing personal matters (3) emotional support (4) non-emotional support [e.g., helping you study for a Test, driving you somewhere, loaning you money] (5) sharing success and happy events (6) sharing failures and unhappy events. The first four roles were assessed during the sociogram task in which participants were instructed to select alters that fulfilled a particular role (e.g., "Select **ALL** individuals you share social activities with"). For the last two roles, participants were directed across 2 different pages on the network survey that asked them to indicate which alters fulfil each role by placing that alter in a bin. A total socio-emotional multiplexity score was calculated to determine the total number of roles each alter fulfills (ranging from 0 to 6). Ego-alter relationships in which the alter fulfills more than one role are considered socio-emotionally multiplex with a greater number of roles fulfilled indicating greater multiplexity.

Co-rumination Questionnaire Follow-up

The last section of the network survey included 2 follow-up questions to the CRQ that participants completed in Qualtrics before beginning the network survey. Participants were given the following instructions "How much time do you spend discussing negative feelings, personal problems, and issues with other people with each of the individuals in your network? Place each person into the category that best describes how often this happens when you chat." Participants then had the opportunity to place the alters they listed in the name generator within one of five categories ranging from [1] "Never" to [5] "Almost always". As a part of the larger master's thesis project, participants were also asked about the topics they typically address when discussing personal problems and negative feelings with their alters.

Network Management Inventory – Short Form (NMI-SF)

The shortened version of the Network Management Inventory (Guassi Moreira et al., 2016 was used to assess network management behavior. The full Network Management Inventory has been previously used in a sample of young adults (Gillath & Selcuk, 2008) and has been used to compare network management skills in both young and old adults (Gillath et al., 2011). In this

Questionnaire, participants are instructed to think about how they typically behave during major life changes (e.g., going to a new school) when answering questions that assess their tendency to maintain, initiate and dissolve social ties. The NMI-SF contains 15 items that assess each of the three facets of network management: (1) initiation (2) maintenance (3) dissolution. To better assess our hypotheses, participants answered network maintenance questions in two parts (see Supplemental material) to assess individual scores for maintenance of *close* old network members and maintenance

of *distant* old network members (e.g., "I regularly get in touch with my… (a) closer old social network members (b) more distant old social network members). This modified version of the NMI-SF thus included 20 items. There were four questions assessing relationship initiation, five questions assessing maintenance of close network ties, five questions assessing maintenance of distant network ties, and six questions assessing dissolution of ties. Participants responded using a 7-point Likert scale ranging from strongly disagree (1) to strongly agree (7) with the middle value (4) representing neutral/mixed viewpoints. Higher scores indicated greater initiation, prioritization, or dissolution. Acceptable internal consistency was found across all four subscales of the revised questionnaire with alphas ranging from .75 to .87.

To examine the extent to which participants prioritize the maintenance of close ties over more distant ties we determined the difference between total scores on the close-alter maintenance subscale and the distant-alter maintenance subscale of the NMI-SF (*maintenance prioritization*). Total distant-alter maintenance was subtracted from total close-alter maintenance. The computed variable was identified as *maintenance prioritization* where higher values indicated a greater tendency to prioritize the maintenance of close ties over more distant ones. Several participants had negative values on this measure.

Hospital Anxiety and Depression Scale (HADS)

The Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983) is a 14-item self-report questionnaire assessing anxiety and depression symptoms. The questionnaire includes seven statements that assess anxiety (e.g., "I get sudden feelings of panic") and seven statements that assess depression (e.g., "I feel as if I am slowed down"). Participants rated each statement using a 4-point Likert scale to describe how often they experience a particular symptom. Our current hypotheses focus on depressive symptoms. We therefore limited analyses to the depressive symptom subscale of the HADS. Higher totals on this subscale indicate greater depressive symptoms. The HADS-D shows high correlations (Bjelland et al., 2002) with other depression measures.

Procedure

All measures were completed via Qualtrics and the Network Canvas Interviewer in individual rooms in a laboratory setting to allow participants to receive help from a trained experimenter during the task. After providing informed consent, participants were directed to the demographics questionnaire and CRQ on Qualtrics. Participants were subsequently guided through the network survey by the Network Canvas Interviewer. Once the network survey was complete, participants were redirected to Qualtrics where they completed the NMI-

SF, a personality measure and the HADS, before being thanked and dismissed.

Data Analysis

In the current study, results were considered statistically significant at $p < 0.05$. Effect sizes were interpreted when applicable using the guidelines outlined by Conley et al. (2020). Data analysis was conducted in R 4.1.1. (RStudio Team, 2021). The analysis scripts are available on the study's OSF page.

Missing Data

Listwise deletion was used when individuals had more than 20% missing data across the entire study ($n = 3$) or did not provide information on key network-level variables (e.g., relationship quality; $n = 2$). For self-report measures, missing data was handled using case mean substitution as suggested by Fox-Wasylyshyn & El-Masri (2005) for self-report measurements. The average rate of missing data across self-report measures in this study was 0.23 items per person (SD=0.58). In case mean substitution, a participant's average score on the items they have completed within a measure is used to replace missing values on that measure. Mean substitution was only used when fewer than 60% of the items on a measurement for a given participant was missing and when fewer than 15% of the cases within a variable were missing. After conducting the listwise deletion mentioned above, all remaining participants with missing data met the requirements for mean substitution. Utilization of case mean substitution, given these constraints, has shown correlations of .95 between original and estimated data (Fox-Wasylyshyn & El-Masri, 2005).

Covariates

Females appear to be at an increased risk of co-rumination and depressive symptoms (Calmes & Roberts, 2008; Tompkins et al., 2011). Moreover, males tend to report greater social isolation during their first semester of university (Liu, Zhang, Yang, & Yu, 2020). For this reason, we examined potential gender differences within our sample concerning the following key variables: co-rumination, network management skills (initiation, dissolution, and prioritization), network size/density, tie strength, multiplexity and depressive symptoms. We conducted several t-tests to compare means between participants identifying as men versus women (see Supplemental material [Table 2; Figure 1]). We only used male and female categories for gender identity, as the sample of individuals who selected other gender identities (e.g., genderqueer, non-binary, etc.)

was too small ($n = 6$) to analyze. Women and men significantly differed across total co-rumination and average tie strength assigned to alters in their network. Women reported a significantly greater tendency to co-ruminate across relationships (t [450] = −2.55, $p = 0.01$, $d = 0.27$) than did men. Additionally, men had a significantly higher average ego-alter tie strength within their network (t [450] = 3.23, $p <$ 0.001, $d = −0.35$) compared to women. Thus, gender was a covariate in analyses that included either co-rumination or tie strength as a variable.

Multilevel Models: Hypothesis I

Tie Strength

To calculate tie strength, we converted participants' perceptions of relationship quality, satisfaction with that quality and relationship closeness to z-scores. These items were then summed to gain an overall measure of tie strength and a constant was added to ensure positive values and thus scores ranged from 0 to 16 with higher values indicating greater tie strength. This variable appears in all subsequent analyses that include tie strength.

Co-rumination and Relationship Characteristics

To assess whether individuals with a greater tendency to co-ruminate view their co-ruminative ties as particularly close, high quality, satisfying (HIA) and fulfilling (HIB) we used a multilevel modelling approach to compare characteristics between egos and their relationships (see Perry et al., 2018). As such, the multilevel model involved relationships nested within an ego. Typically, multilevel modelling in social network analyses involves an independent variable at the alter level (Level 1) and an independent variable at the ego level (Level 2). In this study, an ego's tendency to co-ruminate (ego co-rumination) served as the Level 2 variable and the frequency of co-rumination within a particular relationship (co-rumination with tie) was the Level 1 variable. As significant gender differences exist across co-rumination scores, gender was treated as an additional Level 2 predictor. The first model examined the influence of both Level 1 and Level 2 predictors on tie strength. We hypothesized (HIA) that individuals with a greater tendency to co-ruminate tend to do so with individuals they view as particularly strong ties. We also examined how socio-emotional multiplexity relates to co-rumination using the same set of Level 1 and 2 predictors, along with our measure of tie strength. We hypothesized (HIB) that individuals with a greater tendency to co-ruminate tend to do so in relationships that they find more socially and emotionally fulfilling (i.e., multiplex).

As per Nezlek (2008), our Level 1 (co-rumination with tie) and Level 2 (ego co-rumination) variables were centered based on either the grand mean (ego co-rumination) or group mean (co-rumination with tie) before being entered into our models. As a first step, we analyzed the unconditional (random-intercepts) models for the maximum likelihood estimates of the dependent variable (tie strength) and variance estimates of Level 1 and Level 2. If we found variance at both the between-ego and within-ego levels, we ran the random intercept model with the addition of our Level 1 predictor (co-rumination with tie). We then ran two additional random intercept models with both the Level 1 predictor (co-rumination within tie) and Level 2 predictors (ego co-rumination and gender) as well as an interaction between our Level 2 predictors. We repeated the above procedures to examine socio-emotional multiplexity.

Mediation Models: Hypotheses II & III

Co-rumination, Network Management Skills and Network Size (HII). To our knowledge, no study has sought to examine how an individual's tendency to co-ruminate might mediate their network management behaviours. Hypothesis II therefore tests whether differences in network size and density based on self-reported co-rumination might be mediated by the tendency to prioritize close over more distant ties, the tendency to dissolve ties, and reduced tie initiation. We began by examining the conditions needed for mediation to occur (see Baron & Kenny, 1986). Specifically, we tested for the direct effects of co-rumination on the tie initiation and dissolution subscales of the NMI-SF, as well as our calculated maintenance prioritization score using regression analyses. Similar regression analyses were also used to examine the relationship between co-rumination and our network size and network density metrics.

We predicted that co-rumination would be significantly and negatively associated with tie initiation, network size and network density. Additionally, we predicted that co-rumination would be significantly and positively associated with tie dissolution and maintenance prioritization. We predicted that maintenance prioritization would also be associated with lower tie initiation and greater tie dissolution and these behaviours would be associated with smaller network size. This idea is consistent with previous research showing that both initiation and dissolution are associated with network size such that initiation is associated with a larger network and dissolution is associated with a smaller network (Gillath et al., 2017). Assuming these basic conditions were met, we predicted that the association between co-rumination and network size would be at least partially mediated by a unique pattern of network management behaviours.

Contrary to prediction, our analyses failed to reveal significant direct paths for the variables of interest. Therefore, we followed our pre-registered analysis plan and refrained from testing for mediation in the proposed pathways. The results from the regression analyses assessing associations between co-rumination, network management skills and network
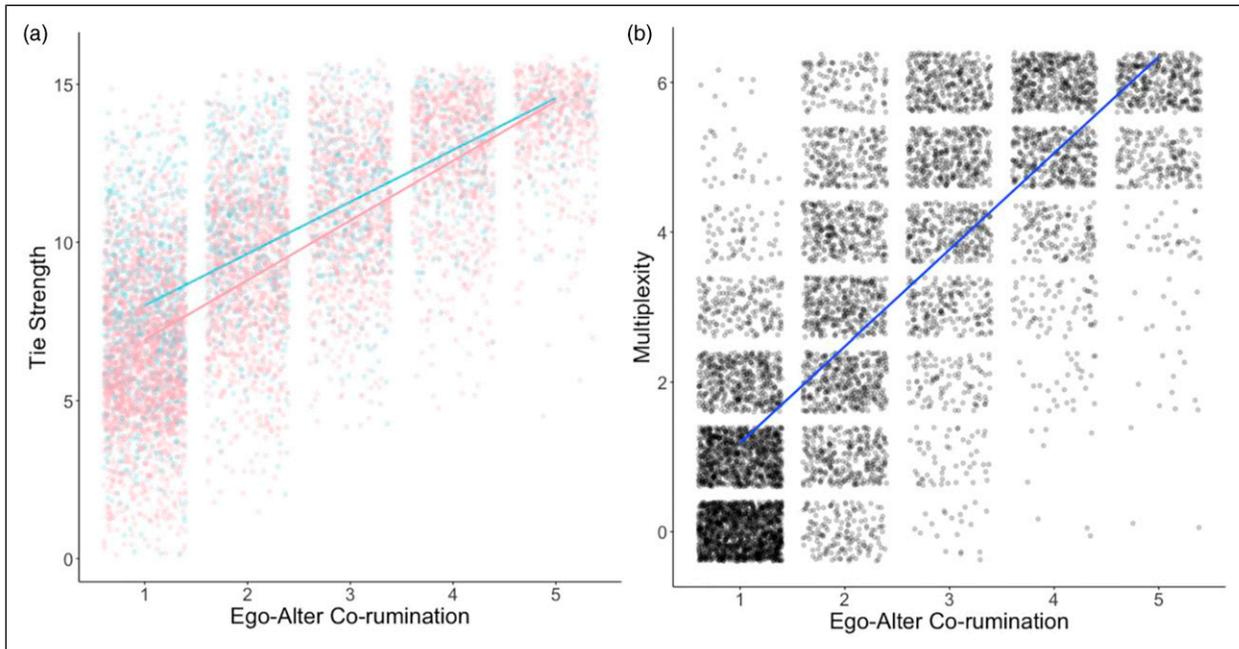
Figure 2. Associations with co-rumination levels in ego-alter relationships. *Note.* A) Association between tie strength and co-rumination within a particular relationship across gender (men = blue, women = pink); B) association between multiplexity (i.e., number of socio-emotional roles fulfilled) and ego-alter co-rumination.

characteristics can be found below. When necessary (i.e., when looking at gender as a covariate), we compared linear models hierarchically.

Co-rumination, Network Size and Depressive Symptoms (HIII). As above, we assessed the direct effects of co-rumination and network size on depressive symptoms through regression analyses. We predicted that co-rumination would be associated with greater depressive symptoms and that this effect would be partially mediated by smaller network size. Again, analyses revealed that we did not have the sufficient direct paths between variables to conduct the mediation analyses. The results from the regression analyses assessing co-rumination, depressive symptoms and network size appear below. Again, we compared linear models hierarchically when considering gender as a covariate.

Results

All hypotheses and reported analyses were preregistered and accepted in-principle in a stage 1 registered report. However, we opted to run our analyses in R 4.1.1. Instead of SPSS as R 4.1.1. Was better suited to the analysis of network-level data. As noted above, the pre-registered conditions for conducting the proposed mediation analyses were not met. Therefore, no mediation models were tested.

Tie Strength (Hypothesis IA)

To assess whether greater levels of co-rumination within a particular relationship would be associated with greater tie strength we used multilevel modelling (see Supplemental Table 4). The intercept-only model assessed the effect of the ego on tie strength without predictors. Tie strength across egos was significantly different than zero (γ_{00} = 9.55, 95% CI [9.45, 9.66], $p < 0.001$). We found variance in tie strength both between (σ^2 = 0.803) and within egos (i.e., between an ego's alters; σ^2 = 10.50), though the variance was larger at the alter level. Results suggest a correlation between alters nested within a given ego on tie strength (ICC = 0.071).

To compare models, we calculated differences in fit (-2LL) between a model and its subsequent model and then compared this to a chi-square distribution of significance. Model 1 including ego-alter co-rumination yielded better fit than the intercept-only model ($p < 0.001$) and Model 2 (including ego co-rumination) yielded a better fit than Model 1 ($p < 0.001$). Model 3 (including the interaction term) did not fit the data better than Model 2 (R^2 = 0.52, p = 0.31). Thus, in support of our hypothesis, higher co-rumination within a relationship (β = 1.99, $p < 0.001$) predicted tie strength. That is, for each unit increase in ego-alter co-rumination, tie strength increased by approximately 2. Moreover, identifying as a man positively predicted tie strength (β = −0.38, p = 0.003), such that men reported greater tie strength than women (Figure 2). An ego's general tendency to co-ruminate (β = 0.001, p = 0.62) did not predict tie strength.

Socio-emotional Multiplexity (Hypothesis IB)

To assess our hypothesis that greater levels of co-rumination within a particular relationship would be associated with greater socio-emotional multiplexity (i.e., an alter fulfills a greater number of socio-emotional support roles) we tested a similar series of models including multiplexity as the dependent variable (Supplemental Table 4). The intercept-only model assessed the effect of the ego on multiplexity without predictors. Multiplexity across egos was significantly different from zero (γ_{00} = 2.67, 95% CI [2.79, 2.94], $p < 0.001$) and variance in multiplexity occurred both between egos (σ^2 = 0.382) and within egos (i.e., between an ego's

Alters; σ^2 = 4.326), though the variance was larger at the alter level. Results suggest a correlation between alters nested within a given ego regarding multiplexity (ICC = 0.081).

We found that Model 1 including ego-alter co-rumination as a predictor fit the data better than the intercept-only model ($p < 0.001$) and Model 2 (with ego co-rumination and gender) was a better fit than Model 1 (R^2 = .58; $p < 0.001$). Model 3 (including the interaction term) did not add to the overall fit (p = 0.31). In support of our hypothesis, higher co-rumination within a given ego-alter relationship (β = 1.36, $p < 0.001$) predicted greater socio-emotional multiplexity (Figure 2). However, neither an ego's general tendency to co-ruminate (β = 0.0003, p = 0.90), nor gender (β = 0.14, p = 0.11), nor the interaction (β = −0.007, p = 0.18) predicted multiplexity.

Network Management Skills (HII)

To test how different network management skills related to network size and co-rumination, we conducted regression analyses (see Supplemental Figure 2 and Table 5). Contrary to hypotheses, analyses revealed a significant but weak positive association between tie initiation and co-rumination (F [1, 450] = 4.14, β = 0.03, p = 0.04, R^2 = 0.007). Despite significant gender differences in co-rumination behavior, gender did not interact with co-rumination (β = − 0.02, p = 0.48) in predicting initiation (F [3, 448] = 1.62, p = 0.18, R^2 = 0.004). As anticipated, an individual's tendency to initiate ties was weakly but significantly associated with greater network size (F [1, 456] = 12.24, β = 0.24, $p < 0.001$, R^2 = 0.024), such that tie initiation accounted for 2.4% of the variance in network size across our sample. Network size was not associated with maintenance prioritization or tie dissolution (p-values > 0.15). Neither co-rumination nor the co-rumination x gender interaction significantly accounted for variance in maintenance prioritization or tie dissolution (p-values > 0.29).

Network Characteristics (HII)

Our hypothesis that individuals with a greater tendency to co-ruminate would report smaller and more sparse networks was not supported (see Supplemental Figure 3 and Table 5).

That is, we found no significant association between co-rumination (nor any interaction between co-rumination and gender; p-values > 0.77) and network size (F [1, 450] < 0.001, p = 0.99, R^2 = - 0.002) or network density (F [1, 450] = 0.017, p = 0.90, R^2 = - 0.002).

Depressive Symptoms (HIII)

In support of our hypotheses and previous literature (Rose, 2002), co-rumination was weakly positively associated with depressive symptoms (F [1, 450] = 6.19, β = 0.02, p = 0.01, R^2 = 0.011; Supplemental Figure 4 and Table 5). The gender x co-rumination interaction did not significantly predict depressive symptoms over and above the effect of co-rumination (ΔR^2 = 0.01, p = 0.09). Thus, only co-rumination was a significant predictor of depressive symptoms. However, analysis suggested that co-rumination accounted for only 1.1% of the variance in depressive symptoms, indicating a small but significant effect. We found no significant association between depressive symptoms and network size (F [1, 456] = 1.09, p = 0.30, R^2 < 0.001).

Discussion

Since its conceptualization (Rose, 2002), research has found strong associations between co-rumination and internalizing symptoms (Spendelow et al., 2017). Moreover, research

Indicates that while co-rumination is associated with positive relationship qualities (Ames-Sikora et al., 2017), it may contribute to social difficulties outside co-ruminative relationships (Rose et al., 2017). This study expanded on findings showing that co-rumination is associated with more social difficulties (Starr & Davila, 2009; Tompkins et al., 2011) by examining the social impacts of co-rumination via social network analysis. We assessed the potential influence of co-rumination on broad social network characteristics (i.e., network size and density; HII), within particular relationships (i.e., tie strength and multiplexity; HI), and how this relates to network management skills during the transition to university (HII). We also examined potential associations between co-rumination, network size and depressive symptoms during this transition (HIII).

Relationship-level Characteristics

Evidence suggests that co-rumination is robustly associated with positive relationship-level outcomes (Rose, 2002; 2007), thus we predicted that co-rumination within a relationship would be associated with greater tie strength (HIA). Indeed, across an individual's social network, a greater tendency to co-ruminate within a particular relationship was associated with greater tie strength. That is, individuals tended to co-ruminate in relationships they viewed as particularly close, satisfactory, and high quality, supporting the idea that co-rumination is

associated with positive relationship-level outcomes (Felton et al., 2019; Starr & Davila, 2009).

Analyses also revealed that men reported greater tie strength across their network compared to women, although women showed significantly more variance in their ratings of closeness, satisfaction, and quality. One possible explanation for this finding is that the men in our sample simply did not list as many weak ties as women did. However, it is also possible that men and women evaluate their relationships differently. Women tend to have higher expectations of their friends (Hall, 2011) and are more critical of friendship rule violations (e.g., cancelling plans, sharing a secret with others, etc.; Felmlee & Muraco, 2009). Women's higher ideals for close relationships and criticism of behaviors that fail to meet them may be especially relevant to social network changes during the university transition. Moreover, given that women tend to both ruminate (Johnson & Whisman, 2013) and co-ruminate (Tompkins et al., 2011) more than men, it is possible that when women do this in the context of discussing relationship violations, it may contribute to lower relationship evaluations. Indeed, both rumination and co-rumination are associated with negative emotions and negative thinking patterns (Rudiger & Winstead, 2013; Watkins & Roberts, 2020). Thus, the potential gender differences in average tie strength across a network may in part be due to differences in relationship evaluations.

Both multiplexity and co-rumination within a relationship tend to be associated with positive relationship evaluations thus, we predicted co-rumination would occur more often in socio-emotionally multiplex relationships (HIB). Our results supported this hypothesis such that individuals tended to co-ruminate in relationships that fulfilled a greater number of socio-emotional roles. These results indicate that relationships where co-rumination occurs often provide a variety of other forms of socio-emotional support such as tangible support (e.g., helping an individual study) or sharing successes and happy events and may therefore be perceived as closer. However, previous literature suggests similarities in co-ruminative partners in terms of how they engage in this behavior (Schwartz-Mette & Rose, 2012), suggesting that co-rumination tendencies may be a friendship selection factor. As individuals in multiplex relationships tend to have similarities, our results may indicate that co-ruminative partners may be similar in ways beyond their co-ruminative engagement. Furthermore, greater multiplexity within a relationship contributes to increases in similarity over time (Mesch & Talmud, 2006). Thus, co-ruminators may share certain characteristics that signal the potential for co-ruminative conversations and eventual friendship, which may further enhance their similarity. Examining the social cues that co-ruminators send and receive while co-ruminating would allow for a better understanding of the effects of co-rumination on friendship formation.

Broad Network Characteristics & Network Management Skills

Previous literature has found that individuals with a greater tendency to co-ruminate report social difficulties outside of the relationships in which they co-ruminate (Starr & Davila, 2009; Tompkins et al., 2011). Thus, we hypothesized that individuals with a greater tendency to co-ruminate would have difficulties developing their social network during their transition to university. Specifically, we predicted that co-rumination would be associated with smaller network size and lower density (HIII), along with a greater tendency to dissolve ties, prioritization of close ties, and reduced tendency to initiate new ties (HII). However, we found no association between co-rumination, network size and network density during participants' first few months of university. Moreover, co-rumination was not associated with a greater tendency to dissolve ties or to prioritize close ties. Contrary to hypotheses, co-rumination was significantly and positively associated with tie initiation. However, because co-rumination accounted for only 0.7% of the variance in tie initiation, it is unlikely to have practical significance for network management. Tie initiation was also found to be significantly associated with greater network size, though this effect (accounting for 2.4% of the variance) was also weak. Taken together these results suggest that having a greater tendency to co-ruminate may not put an individual at risk during the flurry of network building that occurs in first few months of university.

However, given the previously established difficulties in co-ruminators' social lives (Starr & Davila, 2009; Tompkins et al., 2011), it is possible that the negative social outcomes associated with co-rumination develop over time. Given robust evidence that intimate self-disclosure is associated with liking (e.g., Collins & Miller, 1994; Sprecher et al., 2013; Tal-Or & Hershman-Shitrit, 2015), it is possible that co-ruminators make fast friends because of their willingness to discuss negative feelings and problems during a stressful university transition. However, as time goes on, their peers may grow tired of these repetitive, frequent, and negative discussions, which may result in tie dissolution. Moreover, co-ruminators themselves may dissolve ties when they find themselves unable to reciprocally co-ruminate. Longitudinal network analysis studies examining peer perceptions, co-rumination and network development over time would help uncover how co-rumination affects network development.

Depressive Symptoms

Consistent with hypotheses (HIII), co-rumination was significantly associated with higher levels of depressive symptoms, though this effect was surprisingly small. These findings, to some degree, support the well-established link between co-ruminative tendencies and internalizing symptoms (Spendelow et al., 2017). The small effect we found in this cross-sectional study may further support the notion that

the socially structured nature of the campus orientation period and frequent university-organized activities associated with residence life may reduce the effects of co-rumination, given the previously established buffering effect of social support on depressive symptoms (e.g., Grey et al., 2020; Taylor, Doane, & Eisenberg, 2014; Weber et al., 2010). The impact of co-rumination tendencies on depressive symptoms did not appear to vary across gender as some previous findings have found (Rose et al., 2007; Calmes & Roberts, 2008). However, these findings do support a recent meta-analysis suggesting that the association between co-rumination and depressive symptoms does not differ between men and women (Spendelow et al., 2017). Thus, both women and men that frequently co-ruminate with their confidants may be equally at risk for developing depressive symptoms.

Contrary to our hypotheses (HIII) and previous literature (Domènech-Abella et al., 2019; Wildes et al., 2002), depressive symptoms were not associated with network size. These null findings may reflect the social conditions of the first few months of university, in which people have many structured opportunities to meet friends and make acquaintances. These network building activities may buffer the associations between co-rumination, depression and network size during the first semester of university. However, as these organized activities slow down and cease, links between depressive symptoms and network size may re-emerge.

Limitations & Future Directions

One obvious limitation of this study is its cross-sectional design, which is highly dependent on the timing of data collection and cannot show change over time. Nonetheless, this study provides valuable information about co-rumination and social network building. Specifically, although we failed to support the idea that co-rumination is a risk factor for social difficulties (i.e., challenges building and maintaining a social network), it does suggest that at least during students' first few months at university, even co-ruminators show typical network development patterns. This is important because it suggests that co-rumination does not affect initial network building, especially in the more structured environment of the first semester of university, but instead that the effects of co-rumination on network development and depression are more likely to appear over a longer timescale. Future work involving longitudinal designs would help elucidate these network processes.

Another important limitation to this study is that students may have faced relationship challenges due to Ontario's COVID-19 restrictions on social gatherings. Although the university campus supported a fully immersed on-campus experience, masking requirements and other public health measures may have interfered with at least some network management behaviors. Future research might validate these findings in the context of new samples of participants making the transition to university in future years.

Conclusions

This study provides a critical look at the impact of co-rumination on social network building during the initial transition to university. Although we found that more co-rumination within specific relationships was associated greater tie strength and multiplexity, we did not find much evidence for the anticipated network-level outcomes (i.e., small and sparse networks) associated with the tendency co-ruminate (Rose et al., 2017; Tompkins et al., 2011). Moreover, while we found a significant and positive association between co-rumination and depressive symptoms, the effect was small. Thus, at this initial network creation stage of network development, people who co-ruminate may not experience difficulties in the highly socially structured context of university residence living. This surprising finding is important because it shows that the tendency to co-ruminate may have a more developmental element to it, which unfolds over longer time periods when relationship maintenance may be placed more firmly in participants' own hands. Future research in this area should therefore focus on examining these associations from a longitudinal perspective.

Open Practices

This study has been pre-registered on the Open Science Framework (OSF; https://osf.io/mube4/). All publicly available materials are available for download on the study's OSF site. Anonymized raw data can be found on the OSF page, along with code that cleans and aggregates the raw data and produces all reported results.

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Supplemental Material

Supplemental material for this article is available online.

Note

1. Western University's Fall 2021 term included relatively minimal COVID-associated restrictions. Although Western imposed a vaccination mandate for all students, faculty and staff and required masking during indoor activities and during outdoor activities where physical distancing was difficult, in-person classroom activities were allowed at 100% capacity and other activities were allowed at 50% capacity for room size. Thus, beside the masking

policy and the fact that events were typically held in larger rooms and more frequently under tents in outdoor spaces than they might otherwise have been, the campus experience was similar to pre-covid experiences.

References

Ames-Sikora, A. M., Donohue, M. R., & Tully, E. C. (2017). Nonlinear associations between co-rumination and both social support and depression symptoms. *The Journal of Psychology*, *151*(6), 597–612. https://doi.org/10.1080/00223980.2017.1372345

Arnett, J. J. (2007). Emerging adulthood: What is it, and what is it good for? *Child Development Perspectives*, *1*(2), 68–73. https://doi.org/10.1111/j.1750-8606.2007.00016.x

Balsamo, M., Carlucci, L., Sergi, M. R., Murdock, K. K., & Saggino, A. (2015). The mediating role of early maladaptive schemas in the relation between co-rumination and depression in young adults. *Plos One*, *10*(10), Article e0140177. https://doi.org/10.1371/journal.pone.0140177

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*(6), 1173–1182. https://doi.org/10.1037/0022-3514.51.6.1173

Barstead, M. G., Bouchard, L. C., & Shih, J. H. (2013). Understanding gender differences in co-rumination and confidant choice in young adults. *Journal of Social and Clinical Psychology*, *32*(7), 791–808. https://doi.org/10.1521/jscp.2013.32.7.791

Bjelland, I., Dahl, A. A., Haug, T. T., & Neckelmann, D. (2002). The validity of the hospital anxiety and depression scale: An updated literature review. *Journal of Psychosomatic Research*, *52*(2), 69–77. https://doi.org/10.1016/s0022-3999(01)00296-3

Bleske-Rechek, A. L., & Buss, D. M. (2001). Opposite-sex friendship: Sex differences and similarities in initiation, selection, and dissolution. *Personality & Social Psychology Bulletin*, *27*(10), 1310–1323. https://doi.org/10.1177/01461672012710007

Calmes, C. A., & Roberts, J. E. (2008). Rumination in interpersonal relationships: Does co-rumination explain gender differences in emotional distress and relationship satisfaction among college students? *Cognitive Therapy and Research*, *32*(4), 577–590. https://doi.org/10.1007/s10608-008-9200-3

Carlucci, L., D'Ambrosio, I., Innamorati, M., Saggino, A., & Balsamo, M. (2018). Co-Rumination, anxiety, and maladaptive cognitive schemas: When friendship can hurt. *Psychology Research and Behavior Management*, *11*(1), 133–144. https://doi.org/10.2147/prbm.s144907

Carrington, P. J., Scott, J., & Wasserman, S. (Eds.), (2005). *Models and methods in social network analysis (28)*. Cambridge University Press.

Chung, K. K., Hossain, L., & Davis, J. (2005 November). Exploring sociocentric and egocentric approaches for social network analysis. In Proceedings of the 2nd international conference on knowledge management in Asia Pacific (pp. 1–8).

Collins, N. L., & Miller, L. C. (1994). Self-disclosure and liking: A meta-analytic review. *Psychological Bulletin*, *116*(3), 457–475. https://doi.org/10.1037/0033-2909.116.3.457

Conley, C. S., Shapiro, J. B., Huguenel, B. M., & Kirsch, A. C. (2020). Navigating the college years: Developmental trajectories and gender differences in psychological functioning, cognitive-affective strategies, and social well-being. *Emerging Adulthood*, *8*(2), 103–117. https://doi.org/10.1177/2167696818791603

Dam, A., Roelofs, J., & Muris, P. (2014). Correlates of co-rumination in non-clinical adolescents. *Journal of Child and Family Studies*, *23*(3), 521–526. https://doi.org/10.1007/s10826-012-9711-0

Data Collective, Complex (2016). *Network Canvas: Software to simplify Complex network data collection.* https://networkcanvas.com

Domènech-Abella, J., Mundó, J., Haro, J. M., & Rubio-Valera, M. (2019). Anxiety, depression, loneliness and social network in the elderly: Longitudinal associations from the Irish Longitudinal Study on Ageing (TILDA). *Journal of Affective Disorders*, *246*(1), 82–88. https://doi.org/10.1016/j.jad.2018.12.043

Felmlee, D., & Muraco, A. (2009). Gender and friendship norms among older adults. *Research on aging*, *31*(3), 318–344. https://doi.org/10.1177/0164027508330719

Felton, J. W., Cole, D. A., Havewala, M., Kurdziel, G., & Brown, V. (2019). Talking together, thinking alone: Relations among co-rumination, peer relationships, and rumination. *Journal of Youth and Adolescence*, *48*(4), 731–743. https://doi.org/10.1007/s10964-018-0937-z

Fox-Wasylyshyn, S. M., & El-Masri, M. M. (2005). Handling missing data in self-report measures. *Research in Nursing & Health*, *28*(6), 488–495. https://doi.org/10.1002/nur.20100

Gillath, O., Johnson, D. K., Selcuk, E., & Teel, C. (2011). Comparing old and young adults as they cope with life transitions: The links between social network management skills and attachment style to depression. *Clinical Gerontologist*, *34*(3), 251–265. https://doi.org/10.1080/07317115.2011.554345

Gillath, O., Karantzas, G. C., & Selcuk, E. (2017). A net of friends: Investigating friendship by integrating attachment theory and social network analysis. *Personality & Social Psychology Bulletin*, *43*(11), 1546–1565. https://doi.org/10.1177/0146167217719731

Gillath, O., & Selcuk, E. (2008 July). Attachment and social networks in young adult- hood. Paper presented at the Annual meeting of the International Association for Relationship Research (IARR). Providence, Rhode Island.

Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology*, *78*(6), 1360–1380. https://doi.org/10.1086/225469

Grey, I., Arora, T., Thomas, J., Saneh, A., Tohme, P., & Abi-Habib, R. (2020). The role of perceived social support on depression and sleep during the COVID-19 pandemic. *Psychiatry Research*, *293*(1), 113452. https://doi.org/10.1016/j.psychres.2020.113452

Guassi Moreira, J. F., Miernicki, M. E., & Telzer, E. H. (2016). Relationship quality buffers association between co-rumination and depressive symptoms among first year college students. *Journal of Youth and Adolescence*, *45*(3), 484–493. https://doi.org/10.1007/s10964-015-0396-8

Hall, J. A. (2011). Sex differences in friendship expectations: A meta-analysis. *Journal of Social and Personal Relationships*, *28*(6), 723–747. https://doi.org/10.1177/0265407510386192

Hankin, B. L., Stone, L., & Wright, P. A. (2010). Co-rumination, interpersonal stress generation, and internalizing symptoms: Accumulating effects and transactional influences in a multi-wave study of adolescents. *Development and Psychopathology*, *22*(1), 217–235. https://doi.org/10.1017/s0954579409990368

Hawe, P., Webster, C., & Shiell, A. (2004). A glossary of terms for navigating the field of social network analysis. *Journal of Epidemiology and Community Health*, *58*(12), 971–975. https://doi.org/10.1136/jech.2003.014530

John, O. P., & Srivastava, S. (1999). The Big-Five trait taxonomy: History, measurement, and theoretical perspectives. In L. A. Pervin, & O. P. John (Eds), (*2*, pp. 102–138). Guilford Press.*Handbook of Personality: Theory and Research*.

Johnson, D. P., & Whisman, M. A. (2013). Gender differences in rumination: A meta-analysis. *Personality and Individual Differences*, *55*(4), 367–374. https://doi.org/10.1016/j.paid.2013.03.019

Kane, D. (2011). The gendered transition to college: The role of culture in ego-network evolution. *Poetics*, *39*(4), 266–289. https://doi.org/10.1016/j.poetic.2011.05.003

Krenz, T., Krivitsky, P.N., Vacca, R., Bojanowski, M., Gamper, M., Herz, A., & McCarty, C. (2021). *Egor: Import and analyse ego-centered network data*. R package version: 1.21.1 https://CRAN.R-project.org/package=egor

Liu, H., Zhang, M., Yang, Q., & Yu, B. (2020). Gender differences in the influence of social isolation and loneliness on depressive symptoms in college students: A longitudinal study. *Social Psychiatry and Psychiatric Epidemiology*, *55*(2), 251–257. https://doi.org/10.1007/s00127-019-01726-6

Marsden, P. V., & Campbell, K. E. (1984). Measuring tie strength. *Social Forces*, *63*(2), 482–501. https://doi.org/10.2307/2579058

Merriam-Webster (2021). Acquaintance. In *Merriam-Webster.com dictionary*. https://www.merriam-webster.com/dictionary/acquaintance.

Mesch, G., & Talmud, I. (2006). The quality of online and offline relationships: The role of multiplexity and duration of social relationships. *The Information Society*, *22*(3), 137–148. https://doi.org/10.1080/01972240600677805

Nezlek, J. B. (2008). An introduction to multilevel modeling for social and personality psychology. *Social and Personality Psychology Compass*, *2*(2), 842–860. https://doi.org/10.1111/j.1751-9004.2007.00059.x

Oxford English (2021). Friend. In *Oxford UK English dictionary*. Retrieved June 19, 2021, from https://www.lexico.com/definition/friend

Perry, B., Pescosolido, B., & Borgatti, S. (2018). *Egocentric network analysis: Foundations, methods, and models*. https://doi.org/10.1017/9781316443255

Reagans, R., & Zuckerman, E. W. (2001). Networks, diversity, and productivity: The social capital of corporate R&D teams. *Organization Science*, *12*(4), 502–517. https://doi.org/10.1287/orsc.12.4.502.10637

Rose, A. J. (2002). Co–rumination in the friendships of girls and boys. *Child Development*, *73*(6), 1830–1843. https://doi.org/10.1111/1467-8624.00509

Rose, A. J., Carlson, W., & Waller, E. M. (2007). Prospective associations of co-rumination with friendship and emotional adjustment: Considering the socioemotional trade-offs of co-rumination. *Developmental Psychology*, *43*(4), 1019–1031. https://doi.org/10.1037/0012-1649.43.4.1019

Rose, A. J., Glick, G. C., Smith, R. L., Schwartz-Mette, R. A., & Borowski, S. K. (2017). Co-rumination exacerbates stress generation among adolescents with depressive symptoms. *Journal of Abnormal Child Psychology*, *45*(5), 985–995. https://doi.org/10.1007/s10802-016-0205-1

RStudio Team (2021). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. https://www.R-project.org/

RStudio Team (2022). *RStudio*. Integrated Development for R. RStudio, PBC. http://www.rstudio.com/

Rudiger, J. A., & Winstead, B. A. (2013). Body talk and body-related co-rumination: Associations with body image, eating attitudes, and psychological adjustment. *Body Image*, *10*(4), 462–471. https://doi.org/10.1016/j.bodyim.2013.07.010

Santini, Z. I., Koyanagi, A., Tyrovolas, S., Mason, C., & Haro, J. M. (2015). The association between social relationships and depression: A systematic review. *Journal of Affective Disorders*, *175*(1), 53–65. https://doi.org/10.1016/j.jad.2014.12.049

Schoemann, A. M., Boulton, A. J., & Short, S. D. (2017). Determining power and sample size for simple and Complex mediation models. *Social Psychological and Personality Science*, *8*(4), 379–386. https://doi.org/10.1177/1948550617715068

Schwartz-Mette, R. A., & Rose, A. J. (2012). Co-rumination mediates contagion of internalizing symptoms within youths' friendships. *Developmental Psychology*, *48*(5), 1355–1365. https://doi.org/10.1037/a0027484

Shipilov, A., Labianca, G., Kalnysh, V., & Kalnysh, Y. (2014). Network-building behavioral tendencies, range, and promotion speed. *Social Networks*, *39*(1), 71–83. https://doi.org/10.1016/j.socnet.2014.03.006

Spendelow, J. S., Simonds, L. M., & Avery, R. E. (2017). The relationship between co-rumination and internalizing problems: A systematic review and meta-analysis. *Clinical Psychology & Psychotherapy*, *24*(2), 512–527. https://doi.org/10.1002/cpp.2023

Sprecher, S., Treger, S., Wondra, J. D., Hilaire, N., & Wallpe, K. (2013). Taking turns: Reciprocal self-disclosure promotes liking in initial interactions. *Journal of Experimental Social Psychology*, *49*(5), 860–866. https://doi.org/10.1016/j.jesp.2013.03.017

Starr, L. R., & Davila, J. (2009). Clarifying co-rumination: Associations with internalizing symptoms and romantic involvement among adolescent girls. *Journal of Adolescence*, 32(1), 19-37. https://doi.org/10.1016/j.adolescence.2007.12.005

Tabassum, S., Pereira, F. S., Fernandes, S., & Gama, J. (2018). Social network analysis: An overview. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, 8(5), Article e1256. https://doi.org/10.1002/widm.1256

Tal-Or, N., & Hershman-Shitrit, M. (2015). Self-disclosure and the liking of participants in reality TV. *Human Communication Research*, 41(2), 245–267. https://doi.org/10.1111/hcre.12047

Taylor, Z. E., Doane, L. D., & Eisenberg, N. (2014). Transitioning from high school to college: Relations of social support, ego-resiliency, and maladjustment during emerging adulthood. *Emerging Adulthood*, 2(2), 105–115. https://doi.org/10.1177/2167696813506885

Tompkins, T. L., Hockett, A. R., Abraibesh, N., & Witt, J. L. (2011). A closer look at co-rumination: Gender, coping, peer functioning and internalizing/externalizing problems. *Journal of Adolescence*, 34(5), 801–811. https://doi.org/10.1016/j.adolescence.2011.02.005

Verbrugge, L. M. (1979). Multiplexity in adult friendships. *Social Forces*, 57(4), 1286–1309. https://doi.org/10.2307/2577271

Watkins, E. R., & Roberts, H. (2020). Reflecting on rumination: Consequences, causes, mechanisms and treatment of rumination. *Behaviour Research and Therapy*, 127(1), 103573. https://doi.org/10.1016/j.brat.2020.103573

Weber, S., Puskar, K., & Ren, D. (2010). Relationships between depressive symptoms and perceived social support, self-esteem, & optimism in a sample of rural. *Issues Ment Health Nurs*, 31(9), 584–588. https://doi.org/10.3109/01612841003775061

Western University (2019-2020). *Facts and figures 2019-2020*. Western University. https://www.uwo.ca/about/whoweare/facts.html

White, M. E., & Shih, J. H. (2012). A daily diary study of co-rumination, stressful life events, and depressed mood in late adolescents. *Journal of Clinical Child & Adolescent Psychology*, 41(5), 598–610. https://doi.org/10.1080/15374416.2012.706518

Wildes, J. E., Simons, A. D., & Harkness, K. L. (2002). Life events, number of social relationships, and twelve-month naturalistic course of major depression in a community sample of women. *Depression and Anxiety*, 16(3), 104–113. https://doi.org/10.1002/da.10048

Zhang, Z., Zhang, J., Zhao, N., & Yang, Y. (2019). Social network size and subjective well-being: The mediating role of future time perspective among community-dwelling retirees. *Frontiers in Psychology*, 10(1), 2590. https://doi.org/10.3389/fpsyg.2019.02590

Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta Psychiatrica Scandinavica*, 67(6), 361–370. https://doi.org/10.1111/j.1600-0447.1983.tb09716.x

Zou, X., Ingram, P., & Higgins, E. T. (2015). Social networks and life satisfaction: The interplay of network density and regulatory focus. *Motivation and Emotion*, 39(5), 693–713. https://doi.org/10.1007/s11031-015-9490-1