



Social sharing of emotions on individual, dyadic, and group levels

*A thesis submitted for the degree of
Doctor of Philosophy by Research*

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Hilary term 2013

To Hayzell and Cal, who give my life joy and meaning.

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ACKNOWLEDGEMENT

I could not have completed my thesis without the help of many smart and generous individuals. My principal thanks go to Dr Brian Parkinson, who took me on as a graduate student and provided invaluable mentorship, advice, and direction throughout my studies.

Science is a team sport, and I was very fortunate to work in a research group who encouraged collaboration. Being able to work in parallel with Dr Gwenda Simons and Laura Taylor on co-rumination was very helpful as we could share ideas, data, and assistance when needed. Likewise, I am immensely grateful for the tireless efforts of Vanessa Riedel, Radka Jersakova, Susie Maugham, Swati Kanoi, and Talia Bolnik for assistance in conducting experiments and coding data. Additionally, I would like to thank Ee Wen Chen for his help with survey 3 and Justin Handy with survey 2 that contributed data to studies in Part I. I would also like to thank my brothers-in-arms, Dr Simon Lolliot, Dr Huseyin Cakal, and Dr Simon Lutterbie, for being a sounding board for ideas and a source of statistical support.

Beyond the lab group, I would like to thank Dr Karen Niven, Dr David Holman, and Dr Warren Mansell from the Emotion Regulation of Others and Self (EROS) research network for collaborating on the final social network study. I also owe a debt of gratitude to Dr Bernie Hogan from the Oxford Internet Institute whose advice on social network analysis was a great source of inspiration for studies in the final part of the thesis. I also would like to thank Per Block and Josh Lospinoso for helping me become familiar with the intricacies of RSiena analyses. Likewise, Dr Alex Kogan provided invaluable help in figuring out multilevel modelling.

This work was supported by the Medical Research Council [grant number CQ6004] and in part by the Economic and Social Research Council [grant number RES-060-25-0044], who deserve the bulk of my gratitude for funding my studies.

ABSTRACT

People turn to others for help and advice during hard times. Early psychologists suggested a ‘talking cure’ as a remedy for emotional turmoil (e.g., Freud, 1916–7/1963; Rogers, 1942). Likewise, folk psychology often sees heart-to-heart conversations as a win-win proposition that brings relief to the afflicted person and reinforces social bonds at the time of need. However, talking about problems does not always help (e.g., Rimé, 2009; Rimé, Mesquita, Boca, & Philippot, 1991; Rimé, Philippot, Boca, & Mesquita, 1992; Rose, 2002). In some cases, problem-talk can be a lose-lose proposition that drags both discussants into depression (Rose, 2002; Rose, Carlson, & Waller, 2007). This thesis examines co-rumination (Rose, 2002), a case of emotional sharing that hurts people instead of helping them, on three levels of analysis (individuals, dyads, and groups).

At the individual level, I sketch the life course of co-rumination and replicate earlier findings of gender differences. Furthermore, online survey data ($N = 464$) links co-rumination with agreeableness and neuroticism. I also demonstrate that co-rumination can be assessed with a brief measure that is 66% shorter than the original. At the dyadic level, data from recorded conversations between romantic couples show that face-to-face co-rumination influences people’s real-time emotional trajectories in complex ways. Furthermore, observer-ratings of the conversations suggest that third-parties can detect co-rumination, even from silent videos. Finally, I study how people react to others’ negative mood and co-rumination in a real social context by longitudinally following two cohorts of students and modelling their interactions with social network analysis tools. These models show that co-rumination appears to elicit social rejection from others, implying a possible pathway to depression via loneliness imposed on the co-ruminators.

EXTENDED ABSTRACT

When people encounter adversity, they seek the counsel of others for emotional support and practical advice. When the social support network works, emotional disclosure can be an avenue to explore solutions to problems, facilitate closeness, and mobilise support (e.g., Buhrmester & Prager, 1995, Parker & Asher, 1993). In addition to expressions of sympathy, social support can include a wide range of behaviors from giving tangible assistance to engaging the down-trodden friend in a fun activity (Fenlason & Beehr, 1994). From an empirical point of view, these intuitions appear valid at face value. Having a close-knit network of friends and family is one of the best predictors of well-being and health (e.g., Myers, 2003). Furthermore, close relationships serve as conduits for social support to the extent that psychological literature commonly refers to them as support networks (Barrera, 1986).

Unfortunately, there are situations in which the social support network fails to deliver relief (e.g., Cheng, Chen & LuoKogan, 2008; Rimé, 2009; Rimé, Finkenauer, Luminet, Zech, & Philippot, 1998) and help-seeking behavior may turn maladaptive. Under some circumstances, talking about negative aspects of one's life can get out of control and start to negatively impact the mental health of the help-seeker and possibly even the helpers (e.g., Hankin, Stone, & Wright, 2010; LaRocco, House, & French, 1980; Rose, 2002; Rose, Carlson, & Waller, 2007). Understanding which aspects of this process deliver the most helpful results would be an important step toward creating more effective mental health interventions and protect people from developing preventable mood disorders related to depression or anxiety.

In this thesis, I study how people talk excessively about problems and the consequences of doing so. While self-disclosure is seen as a positive aspect found in close friendships (Buhrmester, & Furman, 1987; Parker & Gottman, 1989), some types of self-disclosure can be maladaptive. Co-rumination refers to extensively discussing and rehashing problems and dwelling on negative feelings that goes beyond typical self-disclosure (Rose, 2002). Because co-rumination may exacerbate worries about whether problems will be resolved, about negative consequences of problems, and pessimistic outlook due to the consistent negative focus, it is not unsurprising that it has been linked with decreasing mental well-being (e.g., Hankin, Stone, & Wright, 2010; Rose,

2002; Rose, Carlson, & Waller, 2007). However, co-rumination does not appear to be uniformly maladaptive behavior, as it is also linked with increased friendship closeness (Rose, 2002; Rose, Carlson, & Waller, 2007).

Even though co-rumination is—by definition—an interpersonal process that unfolds in a particular relationship within a wider social context, much of the co-rumination research has focused on the individual. I will try to widen this focus, both theoretically and empirically, to include factors that make co-rumination both interpersonal (between two individuals) and social (involving multiple individuals). Specifically, I will investigate how differences in age and personality influence individuals' tendency to co-ruminate, 2) how co-rumination plays out in real-time interpersonal interaction, and 3) how co-ruminative relationships affect other relationships in a network.

The thesis uses a multi-method approach and includes a number of methodological improvements to previous co-rumination research. At the broad level, this thesis illustrates opportunities unlocked by digital collection and exponentially increasing processing power of computers. In many ways, the methodological aspects of this thesis are an ode to technology, because the work in this thesis would not have been technologically feasible until very recently. For example, many of the experiments presented here involved the creation of custom-made software, collection of responses from online participants, refinement of data with crowdsourced labour market, and computationally demanding statistical analysis of longitudinal social network evolution. I hope that the way in which I apply these ideas and advanced analysis tools to co-rumination generalises to other topics as well. Even if the reader's research interests should not include co-rumination, I hope that the discussion of these broader principles is useful and that the practical information offers a useful template for other studies.

This thesis investigates co-rumination in intrapersonal (e.g., age, gender, and personality), interpersonal (e.g., face-to-face dyadic interaction), and social (e.g., the network of relations among many people) contexts. This three-level analysis is informed by the four-level analytic framework for social functions of emotions (Keltner & Gross, 1999), but in order to keep the scope manageable, the cultural level of analysis will not be examined. Because the theoretically,

empirically, and methodologically most interesting section of the thesis is the social level, it is also the longest. This means that in the first two parts the follow-up analyses are kept to minimum in order to devote more pages to social-level analyses.

Each part will contain its own discussion of relevant theory, hypotheses, methods, and empirical results. While each part has its own focus, they share some common themes (such as change over time and novel methodology). For each part, I will first review the current state of co-rumination theorising through comparison to other theories, and use the overlapping theories to make predictions about co-rumination. Then, I will describe the new types of methodology that I use to test specific co-rumination hypotheses and explain the experimental findings. In addition to being directly applicable to co-rumination research, I hope that each section—in addition to contributing to co-rumination literature—demonstrates the applicability of its ideas and tools to a broader range of research questions.

At the individual level, I will discuss how individual differences in gender, age, personality, and relationship status are related to co-rumination. Specifically, Study 1.1 will sketch a picture of average levels of co-rumination by age and gender, showing that after adolescence and early adulthood, the levels of adult co-rumination appear to stabilise shortly before 30 years of age and that women appear to co-ruminate more than men regardless of age. Study 1.2 will link co-rumination with both neuroticism and agreeableness, but the connection with neuroticism is likely due to shared variance with rumination. Finally, in Study 1.3, I will develop a brief measure of co-rumination and cut down the number of required items from 27 to 9.

At the dyadic level, I will examine how conversation acts as a conduit for co-ruminative processes. I will specifically focus on the semantic content of conversations and the emotional experiences of the speakers. Study 2.1 invites romantic couples to talk about sad topics on camera and uses video-cued recall method to collect 1-second resolution data about the partners' emotional valence throughout the conversations. The results will disconfirm a linear downward effect of co-rumination and show that the participants' levels of co-rumination interact in complex ways. Study 2.2 attempts to gain an understanding of linguistic markers of co-rumination, but the results do not identify such (beyond co-ruminators appearing to use longer sentences). The last

study at the dyadic level, Study 2.3, uses third-party observers to code transcripts and silent videos of the original conversations to determine whether co-rumination is most apparent in the verbal content or the nonverbal expressions that accompany the words. The results show that one aspect of co-rumination, dwelling on negative affect, can be detected by observers from silent videos, suggesting that co-rumination might also be visible to others in real-life social settings.

At the social network level, I will examine how mood and co-rumination influence how people interact with each other. I will also present an integrated view of co-rumination as a part in a broader system of networked emotion regulation. Specifically, Study 3.1 will demonstrate that mood perception plays a role in determining with whom people communicate: people perceived to be in a positive mood appeared to attract more communication from others. In Study 3.2, I will show that the social isolation of co-ruminative dyads can be explained by social constraint (Pennebaker & Harber, 1993) as posited by the theory of social sharing of emotion (Rimé, 2009). The results show that students who scored high on measures of co-rumination were less likely to be friended by other students, suggesting that the deterioration of adolescent co-ruminators' peer-relations (Starr & Davila, 2009; Tompkins, Hockett, Abraibesh, & Witt, 2011) could be due to co-rumination eliciting social rejection.

Part I: Individual co-rumination

The intrapersonal part of my thesis focuses on individual people as co-ruminators. People differ from each other in important ways, such as gender, age, and personality—all of which could influence how people talk to and relate to each other. At the intrapersonal level, I attempt to piece together a portrait of a co-ruminator by reviewing the existing co-rumination literature using gender, age, and personality as organising themes. This part of the thesis is relatively brief and mostly serves as a preamble for research on the dyadic and social network levels.

For theoretical background, I shall review a decade's worth of co-rumination literature using individual co-ruminators as a focal concept. By using this intrapersonal lens, I consolidate current findings and point out specific gaps in the literature. Specifically, I will combine data from multiple sources and plot co-rumination levels by gender over the developmental time scale. Furthermore, I will extend current co-rumination research into the domain of one of the most fundamental of individual differences, personality.

The main methodology at the individual level is based on self-report surveys. In addition to collecting online questionnaire data from individual participants, I will also use data from other co-rumination research to plot the life-course of co-rumination. As the difficulties in this meta-analysis of the data illustrate, I will highlight the importance of shared agreement among researchers about measurement instruments. To help harmonise findings, co-ordinate research in the field, and improve co-rumination measurement, I will introduce a brief measure of co-rumination (CRQ-9). Co-rumination researchers should find the section on construct validity of Co-Rumination Questionnaire (CRQ-27) interesting, since no article to date has reported the underlying factor structure of the principal co-rumination measure in detail, despite the fact that best practices in measurement construction strongly advise it.

At the end of this part of the thesis, I review individual-level evidence that suggests that some aspects of co-rumination cannot be fully comprehended at this level alone. Before moving to the dyadic level, I will point out why intraindividual data about co-rumination is insufficient (or at least inefficient) to discover relational processes.

LITERATURE REVIEW

Although research on co-rumination spans a decade, no authoritative review of research on the topic exists. Since the seminal publication by Rose in 2002, about 20 publications that focus on co-rumination have been published. Because I cannot refer the reader to a review paper and because the number of publications to be discussed is limited, I will try to address all current papers on co-rumination.

Rumination

Ten years ago, Rose (2002) proposed that adolescent girls in particular are at risk of receiving maladaptive support from discussions with their close friends and proposed a concept to explain this observation—co-rumination. As implied by the name alone, rumination is a key component in co-rumination. Rumination is one of the best documented risk factors in depression and a common response to negative emotion. It involves thinking perseveratively about one's feelings and problems (e.g., Nolen-Hoeksema, 1991, Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Rumination is defined as way of responding to distress by repetitively and passively focusing on the symptoms of distress and its possible causes and consequences.

Rumination has been found to make depressive episodes worse and hasten their onset (Nolen-Hoeksema et al., 2008). As a risk factor for depression, rumination also predisposes people to abuse drugs and alcohol (e.g., Nolen-Hoeksema & Harrell, 2002; Nolen-Hoeksema & Morrow 1991). The hallmarks of rumination are an inward focus, dwelling on negative emotion, and brooding on the consequences of the negatively valenced state (Nolen-Hoeksema, 1991). Because rumination is closely associated with depression (e.g., Nolen-Hoeksema, 1991; Nolen-Hoeksema, Parker, & Larson, 1994), Rose (2002) proposed that it might also play a role in childhood depression, especially among girls.

Co-rumination

Co-rumination literature originated from the observation that despite having close friendships, many teenage girls experience high levels of depression and anxiety (e.g., Hankin et al., 1998; Petersen, Compas, Brooks-Gunn, Stemmler, & Grant, 1993). This finding remained

something of a paradox, because it was thought that close, intimate friendships would buffer people from emotional distress. It was observed that in some adolescent relationships, talking about problems and concerns can become a central focus of activity (Belle, 1989; Zahn-Waxler, 2000). Rose (2002) reasoned that if the majority of girls' discussions revolve around negatively focused topics, they are engaging in an interpersonal form of rumination. Co-rumination is a relationship process that involves "extensively discussing and revisiting problems, speculating about problems, and focusing on negative feelings" (Rose, 2002, p. 1830). In short, whereas rumination is about rehashing one's problems in isolation, co-rumination is verbalised and socially reinforced with another person.

Since rumination exacerbates depression whereas self-disclosure improves relationship quality (e.g., Parker & Asher, 1993), co-rumination was intended to integrate both rumination and self-disclosure into a single construct to explain why talking about one's problems with a close friend can simultaneously enhance relationship quality while increasing the risk of depression. Therefore, co-rumination and rumination are different from each other because rumination is an intrapersonal process focused on thinking about one's problems (Nolen-Hoeksema, 1991; Nolen-Hoeksema & Morrow, 1991) and co-rumination is an interpersonal process of discussing problems with others (Rose, 2002).

As a merger of depressogenic rumination and relationship-enhancing self-disclosure, co-rumination might therefore explain both poor mental health outcomes and positive relationship outcomes at the same time. Rose hypothesised that co-rumination would be one of the mechanisms predisposing adolescent girls to depression while conferring relationship benefits, thus explaining away the apparent paradox. The idea that talking about problems can have adverse outcomes is not new (e.g., Fenlason & Beehr 1994; Kaufman & Beehr 1986; Nolen-Hoeksema & Girgus, 1994), but not until Rose (2002) introduced the concept did the double-edged aspect of peer support gain traction and started to receive systematic research attention.

Co-rumination is an interesting construct because it reflects the complexity of real-world relationships. On one hand, talking about problems with others seems adaptive, and co-rumination has been linked with increased relationship satisfaction (e.g., Calmes & Roberts, 2008; Waller &

Rose, 2010). On the other hand, co-rumination has also been implicated in the development of psychopathology such as depression and anxiety (Hankin et al., 2010; Rose, Carlson, & Waller, 2007; Waller & Rose, 2010) as well as unhealthy behaviors such as binge drinking (Ciesla, Dickson, Anderson, & Neal, 2011).

To explain the adaptive aspects of co-rumination, Rose (2002) suggests that intense emotional conversations may be particularly likely to be related to feelings of closeness, regardless of whether the self-disclosure focuses on positive or negative topics or to what extent self-disclosure dominates the conversation. At face value, the ingredients of co-rumination seem adaptive and positive. To a casual observer, co-rumination might appear as a supportive process characterised by empathy, concern for others, and socio-emotional competency. Indeed, many of these constructs are important features of close relationships, including friendships (Bukowski, Newcomb, & Hartup, 1996). For example, empathy allows people to be sensitive to others' needs (Eisenberg & Lennon, 1983; Zahn-Waxler, 2000). Furthermore, concern for others is generally seen as an important relationship competency (Zahn-Waxler & Radke-Yarrow, 1990).

These theoretical intuitions have some empirical support. Bukowski, Adams, and Santo (2006) summarised that co-ruminators are more supportive and validating to others' problems, and Starr and Davila (2009) showed that co-ruminative girls rated themselves as more interpersonally competent. These findings illustrate that seemingly benign relationship processes may involve trade-offs. In fact, recent literature has pointed out that the adaptiveness of apparently positive processes cannot be taken for granted. For example, positive attributions and expectations (McNulty, 2010), expression of emotional vulnerabilities (Lemay & Clark, 2008), and self-synchronisation (Gabriel, Kawakami, Bartak, Kang, & Mann, 2010) have been associated with negative outcomes. Even happiness, one of the most positive concepts in psychology, can have its dark side (Gruber, Mauss, & Tamir, 2011). In terms of co-rumination, being sensitive to the distress of others may come at an emotional cost from the entanglement with their problems (Gore, Aseltine, & Colten, 1993). Such "costs of caring" (Kessler & McLeod, 1984, p. 620) have been suggested in the past, but the supporting evidence was limited until co-rumination research took off.

CRQ-27

Co-rumination was first operationalised with a questionnaire developed by Rose (2002), who pre-tested an initial item pool on two samples of undergraduates ($N = 194$ and $N = 272$). Item generation and selection were guided by Rose's theorised nine aspects of co-rumination, each of which was represented by three items in the final measure. Following item selection, the 27-item Co-Rumination Questionnaire (CRQ-27) was administered to adolescent students ($N = 608$). Indicators of internal consistency for the measure were excellent in child and adolescent samples across multiple measurements (Rose, 2003; Rose et al., 2007), with Cronbach's alpha values ranging from .96 to .97.

Although no one has explicitly documented the psychometric properties of CRQ-27, it appears to have desirable qualities. Most researchers using the measure site internal reliability coefficients above .90, and in longitudinal studies, CRQ-27 has demonstrated variable test-retest reliability. Rose et al. (2007) reported a correlation of $r = .54$ over the period of six months, while Hankin et al. (2010) reported $r = .22$ over the period of five months.

Review Of Empirical Findings

Research into co-rumination has picked up since 2002 and continued to accelerate recently. Unsurprisingly, typical co-rumination studies have primarily focused on the process of excessive problem-sharing within close relationships and its consequences on mental health and relationship quality. Table 1 presents an overview of co-rumination research since Rose (2002) introduced the term. There are some commonalities among the studies. For example, most research has relied on self-report methodology and focused almost exclusively on children and adolescents. The relationship that co-rumination has with depression and anxiety has received most research attention. For the review of the accumulated evidence, I will look at findings relating to depression, anxiety, gender, age, and the relationship context before moving to identifying gaps in the literature.

Table 1
Overview of co-rumination research articles since 2002

Article	Main finding	Method	Sample	N
Rose, 2002	Co-rumination was related to feelings of closeness between friends as well as depression and anxiety.	Cross-sectional self-report	3rd, 5th, 7th, and 9th graders (boys and girls)	608
Rose, 2007	Co-rumination predicted increased depression and anxiety over time for girls but not boys.	Longitudinal self-report	3rd, 5th, 7th, and 9th graders (boys and girls)	813
Byrd-Craven, Geary, Rose & Ponzi, 2008	Observed co-rumination was associated with a significant increase in cortisol.	Self-report and observational coding of interaction task	Undergraduate women	48
Calmes & Roberts, 2008	Men and women did not differ in their degree of co-rumination with parents, romantic partners, and same-sex roommates. Only co-rumination with a closest friend was related to emotional distress.	Cross-sectional self-report	Undergraduates (125 male, 220 female)	345
Starr & Davila, 2009	Co-rumination did not predict depressive symptoms, but was related to romantic relationship experiences.	Longitudinal self-report	Adolescent girls	83
Waller & Rose, 2010	Co-rumination predicted parentchild closeness, but only co-rumination about mothers' problems predicted anxiety and depression in children.	Cross-sectional self-report	5th, 8th, and 11th graders (boys and girl) and a subset of mothers	514 youth and 200 mothers
Haggard, Robert & Rose, 2010	Co-rumination predicted less depression for men under highly abusive supervisors, and increased depression under low abuse.	Cross-sectional self-report	Business school alumni (men and women)	247
Hankin, Stone & Wright, 2010	Co-rumination predicted prospective changes in depression and dependent interpersonal stressors.	Longitudinal self-report	6th10th graders (boys and girls)	350
Stone, Uhrlass & Gibb, 2010	Co-rumination were related to past diagnoses of clinical depression.	Retrospective self-report	Mothers and children between ages 8 and 12 (boys and girls)	81
Ciesla, Dickson, Anderson & Neal, 2011	Co-rumination was associated with greater alcohol consumption among women, but not men.	Cross-sectional self-report	Undergraduates (men and women)	447
Stone, Hankin, Gibb & Abela, 2011	Co-rumination predicted clinical depression onset risk as well as episode severity and duration.	Longitudinal self-report	Adolescents (boys and girls)	106
Tompkins, Hockett, Abraibesh & Witt, 2011	Co-rumination predicted depression and reduced number of friends.	Cross-sectional self-report	912th graders (boys and girls)	146
Byrd-Craven, Granger & Auer, 2011	Dwelling on negative affect component of co-rumination was associated with HPA hyperactivity and cortisol.	Self-report and observational coding of interaction task	Undergraduate women	88
Smith & Rose, 2011	Co-rumination mediated the effects of social perspective taking on friendship quality and empathetic distress.	Cross-sectional self-report	6th, 7th, and 8th graders (boys and girls)	308
Marmenout, 2011	Introduced term "collective rumination"	Group discussion	University students (men and women)	81

Gender

Co-rumination was originally proposed as an explanation for a sharp difference in mood disorder prevalence between the sexes (Rose, 2002). Women tend to ruminate more than men overall (Nolen-Hoeksema & Jackson, 2001), place more emphasis to being sensitive in social relationships (Rudolph, 2002), spend more time in dyads (Benenson, Apostoleris, & Parnass, 1997), and self-disclose at higher levels (e.g., Buhrmester & Furman, 1987; Parker & Asher, 1993). It has also been suggested that women and girls have a stronger interpersonal orientation than men and boys (Nolen-Hoeksema & Girgus, 1994).

Taken together, the higher propensity for women to both ruminate and self-disclose seem to directly translate to increased levels of co-rumination as well. Indeed, gender differences in co-rumination are one of the most robust empirical findings in this area, as almost every study has found that girls and women tend to co-ruminate at higher levels than boys or men (e.g., Calmes &

Roberts, 2008; Haggard et al., 2010; Jose et al., 2010; Rose, 2002; Rose et al., 2005; Rose et al., 2007; Smith & Rose, 2011). Although the gender difference findings in co-rumination are robust, there are some limitations. Stone et al. (2010) reported no gender differences in levels of co-rumination between the genders, and Calmes and Roberts (2008) observed that while the typical pattern of increased co-rumination with a closest friend held among the female participants, men and women did not differ in their degree of co-rumination with parents, romantic partners, and same-sex roommates. Likewise, Haggard et al. (2010) failed to find a relationships between women's co-rumination and depression.

Depression

The findings about depression and co-rumination have mostly been supportive of Rose's (2002) original hypothesis that levels of co-rumination are related to depression (e.g., Hankin, Stone, & Wright, 2010; Rose, Carlson, & Waller, 2007; Stone, Hankin, Gibb, & Abela, 2011; Waller & Rose, 2010). Because co-rumination has been suggested as a mechanism that increases depressive symptomatology, it has been studied with both cross-sectional and longitudinal designs. Rose's (2002) original study was cross-sectional, just like the majority of other studies (see Table 1). Current levels of co-rumination has been linked with a history of depressive episodes in a retrospective study (Stone, Uhrlass, & Gibb, 2010). In prospective studies, current levels of co-rumination have been found to predict nonclinical levels of future depression between two time points (Rose, Carlson, & Waller, 2007) as well as clinical episodes between multiple time points (Hankin et al., 2010; Stone et al., 2011). Schwartz-Mette and Rose (2012) found that one friend's depression at Time 1 predicted dyadic co-rumination, which in turn transferred depressive symptoms at Time 2 to the other friend.

Despite these supportive findings, not all studies unanimously support the co-ruminative hypothesis. For example, co-rumination has not always been predictive of future depressive symptoms as hypothesised (Starr & Davila, 2009), even though co-rumination was predictive of present levels of depression. Starr and Davila also levied a critique against co-rumination's role in future depression by pointing out their non-significant effect sizes were approximately similar to ones reported in Rose and colleagues' (2007) initial prospective study. They note that the predicted increases in depressive symptoms might be so small as to be of limited clinical significance.

In some studies, co-rumination has failed to predict depression. For example, Haggard, Robert, and Rose (2010) found no correlation between self-reported co-rumination and depression in an adult sample. Among undergraduate students, Calmes and Roberts (2008) failed to link co-rumination to depression in parent–child, romantic, or roommate relationships. However, co-rumination with one’s closest friend was significantly correlated with depression, as hypothesised. Even among adolescent samples, some null findings were reported. For example, Stone et al. (2010) reported co-rumination was not significantly correlated with depressive symptoms ($r = .05$, $p = .640$). Likewise, in a longitudinal study by Hankin et al. (2010) co-rumination was not significantly correlated with general depressive symptoms at any particular time point later on. In the same study, however, co-rumination did predict specific aspects of depression (e.g., anhedonia) and prospective trajectories of mental health problems. Tompkins et al. (2011) reported that while self-reported co-rumination was correlated with self-reported depression, it was not significantly related to the students’ depressive symptoms estimated by their teachers. It is unclear whether these null findings are due to, for example, shared-method variance inflating the correlations observed in other studies, characteristics of these particular studies, or a true lack of causal connection.

Given the accumulated evidence about the relationship between co-rumination and depression, the majority of evidence supports the basic claims of co-rumination theory—at least among teen girls. It seems quite plausible that co-rumination plays a role in the etiology of their depression. Within the scope of the original work, co-rumination appears to be a robust phenomenon with replicated evidence that support its basic premises. Co-rumination appears to instill a negative focus in youth friendships that can cast a corrosive influence on their future mental health. Furthermore, co-rumination is linked to physiological stress responses, such as increased cortisol reactivity and HPA axis hyperactivity, which has been associated with depressive and anxiety disorders (Koenigsberg et al., 2004).

Anxiety

Depression is not the only kind of emotional distress associated with co-rumination. Anxiety has often been studied as a concomitant or consequence of co-rumination. In the original study, Rose (2002) treated both depression and anxiety as comorbid internalising symptoms and reduced her data by combining them into a single variable. In her later work, such as her 2007 prospective study and the reanalysis of its data with Schwartz-Mette (2012), Rose has treated anxiety as a separate construct. In general, findings regarding anxiety and co-rumination are similar to those between depression and co-rumination. At the basic level, co-rumination contributed to increased anxiety among girls. Schwartz-Mette and Rose (2012) found that one friend's anxiety at Time 1 predicted dyadic co-rumination, which in turn transferred anxiety symptoms at Time 2 to the other friend. This provides empirical support to the basic contagion mechanism theorised to be involved in co-rumination. Similarly, trajectories in anxious arousal have been linked to co-rumination (Hankin et al., 2010), although with the same caveat as with depression: co-rumination did not predict the overall level of anxious arousal itself. Among undergraduate students, greater friend-based co-rumination also correlated with anxiety symptoms. In a study about co-rumination between children and mothers, mothers' co-rumination about their problems with their children predicted anxiety in the children.

Social Anxiety. One particular type of anxiety—social anxiety—has been studied *vis-à-vis* co-rumination. The relationship between co-rumination and social anxiety is complicated, because rumination and self-disclosure appear to have contradictory relationship with social anxiety. For example, social anxiety makes people less likely to engage others in a conversation as it is defined by social avoidance (American Psychiatric Association, 2000). In addition, socially anxious people are hesitant to self-disclose (Alden & Bieling, 1998; Meleshko & Alden, 1993). Since self-disclosure and social contact are core components of co-rumination, it would follow that socially anxious individuals would co-ruminate less with their peers. Following this logic, Starr and Davila (2009) expected to find an inverse relationship between co-rumination and social anxiety. While the zero-order correlation between social anxiety and co-rumination was nonsignificant, the predicted pattern was discovered when depressive symptoms were controlled for: girls who co-ruminated more were less socially anxious.

On the other hand, socially anxious people are more likely to ruminate (Mellings & Alden, 2000), and it would seem likely that they might also extend this to discussions with others. From this perspective, social anxiety can be hypothesised to be associated with increased co-rumination. Contrary to the findings obtained by Starr and Davila (2009), Jose and his collaborators (2012) found that adolescents who experienced high levels of social anxiety were more likely to have co-ruminative discussions with friends. In their sample, social anxiety had a weak indirect effect on co-rumination that was mediated by solitary rumination. They explained these contradictory findings of the two studies as reflecting a potential difference in the overall levels of social anxiety between the study samples. They also noted that co-rumination predicted neither rumination nor social anxiety, and high levels of rumination were not predictive of future social anxiety.

Age

Age has been a factor in co-rumination research since the beginning. In terms of terminology, “children” have usually been participants attending fifth grade or lower, and “adolescents” have been students in the seventh grade or higher. It is a well-documented phenomenon that sex differences in emotional distress show a pronounced increase during puberty (Hankin et al, 1998). By late adolescence, girls are two to three times more likely to experience depression than boys (Nolen-Hoeksema & Girgus, 1994), which was one of Rose’s (2002) original rationales to commence research into co-rumination. The gender differences in co-rumination indeed coincide with the emergence of gender differences in depression (Nolen-Hoeksema & Girgus, 1994; Rose, 2002), which has kept the focus of co-rumination research mostly on adolescents.

In the first co-rumination study (Rose, 2002), the co-rumination scores of adolescent girls were significantly higher than those of female children, whereas co-rumination scores of adolescent boys and male children did not differ (Rose, 2002). In their longitudinal study, Rose, Carlson, and Waller (2007) reported that at each time point, girls scored higher than boys on co-rumination, with the gender difference being larger among adolescents than children. This general pattern relating to age (but not gender) has been present in other studies as well. Stone and colleagues (2010) found that older children reported higher levels of co-rumination than younger children. In addition to absolute levels of co-rumination, age seems to drive other effects as well.

For example, in the original study, co-rumination was significantly related to friend-reported positive friendship quality and closeness for adolescents, but not for children (Rose, 2002).

Relationships

In addition to emotional distress, co-rumination research has focused on the positive aspects of co-rumination, namely increased closeness and satisfaction in the co-ruminative relationship. The connection between co-rumination and relationships stems from the self-disclosure included in co-rumination, which has been linked with many positive aspects of relationships, such as emotional closeness (Parker & Asher, 1993) and relationship satisfaction (Jones, 1991).

Same-sex friendships. In 2006, Rose and Rudolph proposed a model suggesting that sex differences in emotional adjustment can be explained in part by sex differences in relational processes that are learned from same-sex peers. Co-rumination is one such process, which explains why it has been studied mostly in the context of same-sex child and adolescent friendships. Such relationships provide essential source of social support during puberty and beyond (e.g., Grabill & Kerns, 2000; Taylor, 2006). As hypothesised by Rose, co-rumination between same-sex adolescent friends has been linked with friendship closeness and quality (Calmes & Roberts, 2008; Rose, 2002; Rose et al., 2007).

However, the relationship between co-rumination and relationship quality is the strongest in self-reports. For example, the zero-order correlation between self-reported co-rumination and friend-reported relationship quality was not significant in the original study (Rose, 2002). In the later longitudinal study (Rose et al., 2007), the positive correlation between co-rumination and relationship quality was also based on self-reported measures. In a later study that utilised data from both members of the friendship dyad in a structural equation model, co-rumination helped to account for the effects of social perspective taking on reciprocal friendship quality.

Romantic relationships. Romantic relationships and co-rumination have only been examined in two studies (Calmes & Roberts, 2008; Starr & Davila, 2009). Among adolescent girls, romantic relationships have been seen as a source of stress that can predispose them to higher levels of co-rumination with their same-sex friends (Starr & Davila, 2009). This line of reasoning

is based on previous observations that like co-rumination, romantic experiences are associated with adolescent depression (Davila, Steinberg, Kachadourian, Cobb, & Fincham, 2004). The results indicated that having a higher number of male friends was indeed related to greater co-rumination in adolescent girls (Starr & Davila, 2009). Co-rumination in the study was associated with increases in depressive symptoms only for girls who had more romantic experiences (i.e., one standard deviation above the mean). For girls with little romantic experiences, co-rumination was associated with less depression.

Only one study to date has looked at co-rumination between romantic partners (the above study was about co-rumination between same-sex friends about romantic relationships as a topic). Calmes and Robert (2008) asked both male and female undergraduates to report on their co-rumination with their romantic partners, and found that co-rumination within heterosexual relationships was positively correlated with relationship satisfaction, but not with depression or anxiety.

Adolescents and parents. During development, communication with one's parents about emotional topics can be an adaptive strategy (Zahn-Waxler, 2000). However, it was noted that intense focus on negative emotions might create conditions that perpetuate interpersonal problems. Three studies have looked at co-rumination and parent-child relationships. However, one of these studies focused on the child's co-rumination with peers and only controlled for the mother's depressive symptoms instead of looking at co-rumination between the mother and child (Stone et al., 2010), since children of depressed parents are often themselves depressed (e.g., Field, Healy, Goldstein, & Guthertz, 1990) and individuals who live with a depressed person can become depressed (Coyne, 1976; Howes et al., 1985).

The study by Waller and colleagues (2010) examined mother-adolescent co-rumination, relationship quality, and emotional well-being. Unlike any other co-rumination study, Waller et al. paid attention to whose problems were the content of co-rumination. They reasoned that co-rumination between mothers and children could be either about the children's problems or the mother's problems. They predicted that co-rumination about the mother's problems would be particularly depressive for the children, because the children have less control over them. As

predicted, co-rumination about the children's problems was not associated with depression whereas co-rumination about the mother's problems was significantly correlated with the children's depression. In terms of relationship satisfaction, co-rumination data from both children and mothers predicted positive relationship quality, with the largest magnitude evident in self disclosure about the children's problems.

Co-workers. Only two studies have examined co-rumination in the workplace. Haggard, Robert, and Rose (2010) mailed surveys about co-rumination to alumni of a business school. Based on literature that highlights the importance of social relationships at work (Baron & Pfeffer, 1994) and the prevalence of coworkers as discussion topics (Sandelands & Boudens, 2000), Haggard et al. reasoned that co-rumination could involve similar trade-offs between relationship quality and mental health in the workplace context as it does in more intimate relationships, especially in view of the fact that talk about workplace problems has already been found maladaptive in some situations (Beehr et al. 2000).

They found that among adults, co-rumination was not directly correlated with symptoms of depression, but a three-way interaction between gender, co-rumination, and the level of abusive supervision experience by the workers linked co-rumination to depression (Haggard et al., 2010). Surprisingly, women's co-rumination had no influence on depression under any level of abusive supervision. While men's depression was found to be correlated with co-rumination, the direction was unexpected. Under highly abusive supervision, increased level of co-rumination predicted less depression in men whereas co-rumination under less abusive supervision predicted more co-rumination. As a potential explanation for their counterintuitive findings, Haggard and her co-authors suggest that the content of men's and women's co-rumination may differ and that different personality characteristics might be at play as well. They also cite small sample size, low response rate, and a possible selection bias as factors that may have skewed their results.

The other study that relates to co-rumination in a workplace context was conducted by Marmenout (2011). Although her main interest was in how coworkers might discuss impending corporate mergers and she did not specifically measure co-rumination, she introduced a term "collective rumination" in an organisational context as "repetitively and passively discussing

organisational problems and their negative consequences with a group of peers” (p. 783). She cites Rose (2002) as inspiration for the concept and found out that negative topics dominated discussions about hypothetical merger scenarios. Furthermore, following the discussions, participants held more negative attitudes about the merger than before the peer interaction (i.e., a group discussion). In many ways, the discussions among participants echoed the themes common to co-rumination: group members mostly dwelled on negative feelings, speculated about potential negative consequences, took a passive stance, and refrained from active problem solving. However, because neither depression nor co-rumination were directly measured in the study, the findings were only suggestive. Furthermore, the discussions about mergers were role-plays among university students instead of conversations between coworkers about actual events.

GAPS IN LITERATURE

In a nutshell, co-rumination appears to be both adaptive and maladaptive, but it is not yet certain which factors affect this balance. Despite a broad research push by multiple researchers, many issues with co-rumination need further clarification. In the following section, I will identify three specific gaps in the literature. The first relates to co-rumination past adolescence, the second to personality factors in co-rumination, and the last to the way co-rumination is measured across studies.

Lifespan

Very little is known about co-rumination beyond adolescence. Figure 1 visually summarises findings from studies that reported the mean level of co-rumination in their sample by gender (Haggard et al., 2010; Hankin et al., 2010; Rose, 2002; Rose et al., 2007; Smith et al., 2011; Starr & Davila, 2009; Tompkins et al., 2011; Waller & Rose, 2009). It is immediately obvious from the graph that very little is known about co-rumination in samples older than 18 years—the gap in the literature is literally a “gap” in the graph itself. One study (Calmes & Roberts, 2008) included participants from the missing age range ($M = 19.7$, $SD = 3.1$), but the researchers measured co-rumination using a modified version of the CRQ and the scores were not reported on a 1 to 5 scale. Therefore, their data could not be included in the graph.

Researchers have already suggested reasons why this gap should be addressed. Rose (2002) herself called for longitudinal research into co-rumination. Similarly, Haggard et al. (2010) observed that life stage might influence the co-rumination over the course of a lifetime, while Starr and Davila (2009) speculated about whether co-rumination might occur differently across age groups. Aiming toward the lower end of the age spectrum, Calmes and Roberts (2008) suggested that parent–child co-rumination might play a stronger role among younger individuals. At the other end of the spectrum, Haggard and her colleagues (2010) suggest that men might become more co-ruminative in adulthood as their social life becomes centred more around conversations instead of activities.

As demonstrated by longitudinal studies (Hankin et al., 2010; Rose et al., 2007; Stone et al., 2010), co-rumination appears to shape future interpersonal dynamics and adjustment outcomes in a cumulative and transactional manner. Hankin and his coauthors suggest that co-rumination could lead into a vicious cycle of interpersonal stress generation and emotional distress that perpetuates depressive symptoms over time. Since co-rumination was linked to spikes in cortisol (Byrd-Craven et al., 2008) and HPA axis hyperactivity (Byrd-Craven et al., 2011), habitual co-rumination might have unknown long-term effects. This could be a physiological basis for the scar hypothesis (Lewinsohn, Steinmetz, Larson, & Franklin, 1981; Rodhe, Lewinsohn, & Seeley, 1990), which suggests that depressed individuals acquire lasting characteristics that shape their interactions during later life. Calmes and Roberst (2008) suggest that future studies should seek to elaborate the role of co-rumination in the onset, maintenance, and recovery from more severe forms of depression. Since adults also suffer from depression, understanding the lifetime course of co-rumination in adulthood is clearly important.

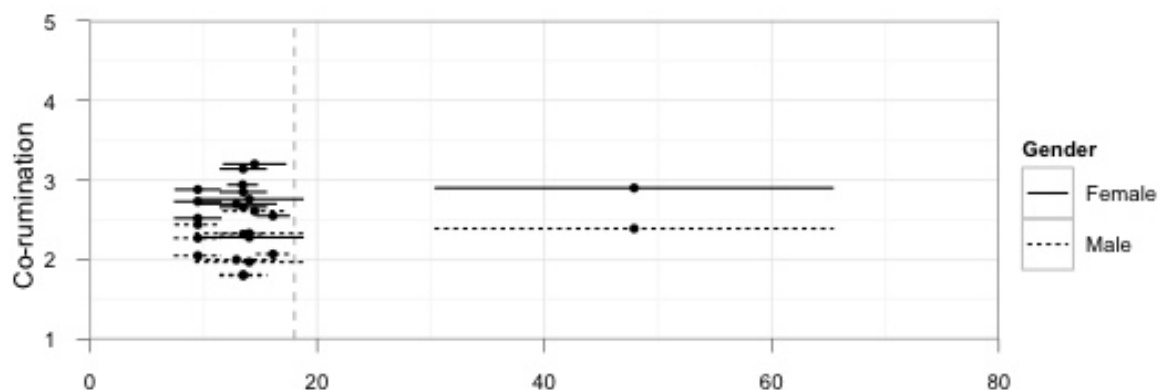


Figure 1. Mean levels of co-rumination by study, gender, and age.

Personality

From the beginning, Rose encouraged researchers to identify “other individual difference characteristics related to co-rumination” (Rose, 2002, p. 1840). Later on, Haggard et al. (2010) speculated that agreeableness and neuroticism might predispose some individuals to engage in co-rumination.

Co-rumination and personality could be related in at least two ways. First, personality characteristics could make someone more likely to engage in co-ruminative behavior. For

example, because within-person rumination correlates with neuroticism (Teasdale & Green, 2004; Trapnell & Campbell, 1999), neuroticism might also correlate with between-persons co-rumination. In short, it is possible that personality-related factors can dispose some individuals to co-ruminate. Another causal direction is possible, too. Since adolescence is a period of personality development (e.g., Bloom, 1964; Costa & McCrae, 1994), it is possible that early co-ruminative communication patterns may shape the development of the co-ruminators' emerging personalities.

To date, only one article on co-rumination has included a measure of personality. In their laboratory study about the biological mechanisms involved in co-rumination, Byrd-Craven (2011) and her co-authors included a short version of the Rothbart Adult Temperament Questionnaire, a 77-item scale measuring four general personality factors: extraversion/surgency, negative affect, effortful control, and orienting sensitivity (Rothbart et al., 2000). None of the subscales significantly predicted either self-reported or observed co-rumination. However, because the sadness subscale almost reached significance in predicting self-reported co-rumination and the sample size was relatively small ($N = 88$), the relationship between personality and co-rumination warrants more research.

Methodology

In the same way that co-rumination can be “too much of a good thing,” the 27-item Co-Rumination Questionnaire (CRQ-27) might suffer from similar ailments. First of all, the measure may have too many items. This is a problem, because 27 items may artificially inflate the measure's apparent reliability (Clark & Watson, 1995). In addition to statistical reasons to reduce the item count, there are other reasons as well. Because long questionnaires are time-consuming to complete and co-rumination research often requires data-intensive longitudinal research protocols, participant fatigue, reduced data quality, and attrition may become issues that could be avoided if a shorter measure were used.

Second, too many variants of the measure are being used, which suggests that researchers are adjusting the measure because the 27-item version is too long for their purposes. Table 2 lists the different measures that have been used to operationalise co-rumination across studies. Many researchers have already shortened the measure for their own purposes, but this has been done on

improvised basis, creating undocumented differences between the measures. Ideally, results should be comparable across studies, and variability in co-rumination measurement may compromise the basic compatibility of the findings.

Table 2
Overview of different co-rumination measure variants used in research

Study	Measure variant	Items	Cronbach's α
Rose, 2002	CRQ-27	27	.96
Rose, Carlson, & Waller, 2007	CRQ-27	27	.97
Byrd-Craven, Geary, Rose & Ponzi, 2008	CRQ-27	27	.96
Calmes & Roberts, 2008	Unpublished manuscript	16	.94 to .98
Starr & Davila, 2009	CRQ-27	27	.95
Waller & Rose, 2010	Ad hoc modification	16	.91 to .94
Haggard, Robert & Rose, 2010	Ad hoc modification	9	.91
Hankin, Stone & Wright, 2010	Appendix from Rose (2002)	9	.89 to .91
Stone, Uhrlass & Gibb, 2010	CRQ-27	27	.97
Ciesla, Dickson, Anderson & Neal, 2011	CRQ-27	27	.96
Stone, Hankin, Gibb & Abela, 2011	Appendix from Rose (2002)	9	.89
Tompkins, Hockett, Abraibesh & Witt, 2011	CRQ-27	27	.96
Byrd-Craven, Granger & Auer, 2011	CRQ-27	27	.96
Smith & Rose, 2011	CRQ-27	27	.97

SUMMARY OF KNOWN AND UNKNOWN

In the literature review above, several recurring themes became evident. Taken together, the findings suggest that co-rumination has strong links to depression and increased relationship quality, and these effects are most robust among adolescent girls. As suggested by Thompkins et al. (2011), the positive effects of co-rumination may lock girls into a vicious cycle of increased closeness that engenders increased levels of depression. Co-rumination also demonstrates a notable gender difference: girls and women tend to consistently co-ruminate more than boys and men.

Whether these findings also generalise to older populations is still unclear. Findings among undergraduates (Calmes & Roberts, 2008) and working adults (Haggard et al., 2010) seem to suggest that the relationship-enhancing aspects of co-rumination are still in effect, but the link with depression is more complicated. However, the more complicated findings among adults may be an artifact of insufficient data from post-adolescent populations, as the bulk of co-rumination research has focused almost exclusively on children and adolescents. Therefore, one big gap in the literature concerns the course of co-rumination over a lifetime.

Beyond gender and a limited range in age, very little is known about individual differences that influence co-rumination. For example, only one study (Byrd-Craven et al., 2011) addressed personality—a key construct in social psychology—with inconclusive results. Because personality can have far-reaching influence on social behavior, it is important to elucidate whether co-rumination is associated with personality dimensions.

Finally, co-rumination measurement methodology varies from study to study, which makes meta-analyses of the findings difficult. Furthermore, there may be structural problems in the Co-Rumination Questionnaire (Rose, 2002) that should be addressed.

STUDY 1.1: CO-RUMINATION OVER THE LIFESPAN

As mentioned above, most co-rumination findings are based on research on adolescents. Co-rumination as a concept, however, has been applied beyond its original domain of depression among youth (Haggard et al., 2010; Marmenout, 2011). Before extending the concept to other populations and research questions, it is important to know the baseline levels of co-rumination across the lifespan, because it might operate differently in youth than in later life.

Likewise, findings based on data from children and adolescents may be misleading when applied to adults. For example, given that longitudinal studies about co-rumination have identified an age-related increase in co-rumination from childhood to adolescence (Hankin et al., 2010; Rose et al., 2007) and that depression has strong continuity from adolescence to adulthood (Schulenberg, Sameroff, & Cicchetti, 2004), does this mean that age has a linear relationship with co-rumination? Although this would be a logical extrapolation of the current findings, it sounds very unlikely. Because none of the previous studies have addressed whether co-rumination could decrease in adulthood and the increasing linear trend is based only on adolescent samples, I conducted a brief survey to chart the lifetime course of co-rumination.

Method

Participants

The present study merged data from two separate surveys into a single dataset. For both surveys, participants were recruited online by placing invitations to participate to various social media outlets from Facebook to Twitter, which attracted participants from diverse backgrounds and age groups to complete an online survey. Of the participants, 168 were women (mean age = 26.4 years, $SD = 8.72$) and 144 were men (mean age = 28.0 years, $SD = 9.23$). For ethical reasons, people under 18 were excluded from participation. The eldest participant was 72 years of age.

Measures

Co-rumination. Participants' tendency to co-ruminate with a close friend was assessed using the original 27-item Co-Rumination Questionnaire (CRQ-27; Rose, 2002). They responded to statements about their problem-talk behaviour on a five-point Likert-type scale (1 = Not at all

true, 5 = Really true). As in the original measure, the items were separated into two parts. Items 1–12 were associated with a prompt “When we talk about our problems...” whereas items 13–27 were preceded by “When we talk about a problem that one of us has...” The Cronbach’s alpha values for the measure in both surveys were very high (0.95 and 0.97).

Results

The mean level of co-rumination across the entire sample was 2.38 ($SD = 0.86$). As found in most other co-rumination studies, women scored significantly higher in co-rumination ($M = 2.53$, $SD = 0.84$) than men did ($M = 2.19$, $SD = 0.84$), $t(310) = -3.5836$, $p < .001$. Among women, age was negatively correlated with levels of co-rumination, $r = -.23$, $p = .002$. Among men, the correlation between age and co-rumination was close to zero, $r = -.06$, $p = .460$. However, because co-rumination and age might have a different relationship with each other during different periods of development (cf. differences between children and adolescents in, e.g., Rose et al., 2007), a straight line may not be sufficient to capture the dynamics of co-rumination over age. Figure 2 summarises the lifetime course of co-rumination using locally weighted scatterplot smoothing (LOESS; Fox, 2000; Wickham, 2009).

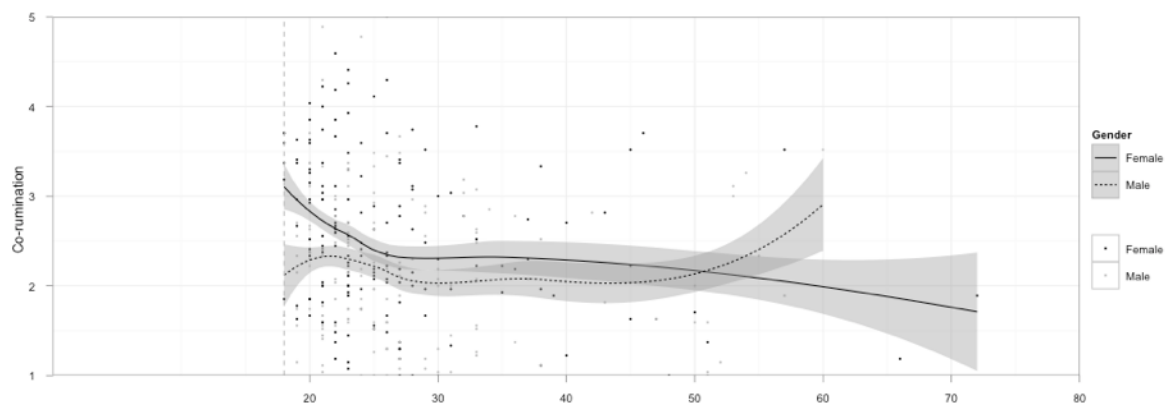


Figure 2. Co-rumination scores over the lifespan by gender.

Discussion

Consistent with past studies on co-rumination with adolescent samples, there was a marked gender difference in co-rumination among the youngest participants. From late 20s until late 40s, the course of co-rumination seemed fairly stable. Although Figure 2 shows a marked increase in male co-rumination after the age of 50, I am hesitant to take this as a meaningful finding, because the sample size in that age group was very limited: only two male participants over the age of 55 were present in the sample. Therefore, the upswing in co-rumination was based on very limited data and could very well be spurious, especially as the linear correlation between male age and co-rumination was essentially flat. Haggard and her colleagues (2010) postulated that some men might become more co-ruminative in adulthood through with interacting with women. Although their study was in the context of co-rumination with a coworker, I think that their logic is easy to extend to long-term romantic relationships.

Starr and Davila (2009) suggested that having a boyfriend may engender problems to adolescent girls. They reasoned that since adolescents are still inexperienced with relationships, teen girls encounter interpersonal problems (or generate them, as suggested by Hankin et al., 2010) that are hashed over with girlfriends, who play an important role in early romantic processes (Brown, 1999; Connolly & Goldberg, 1999). The same might apply to men, but in the context of long-term relationships in adulthood. During early adulthood (or “emerging adulthood,” Arnett, 2000, p. 469) between 18–24 years of age, heterosexual men typically commit to long-term relationships, including cohabitation, domestic partnerships, engagements, and marriages. In such relationships, men might encounter qualitatively different kinds of problems to discuss with their male friends or receive a quantitatively larger dose of female communication. Because early- to mid-twenties initiates a time period during which the male and female co-rumination essentially move in tandem, long-term heterosexual romantic relationships might provide an interesting context for co-rumination studies. It is possible that men at this age become more co-ruminative due to romantic engagement with women. However, this research question will not be explored in detail here, but left for future research.

STUDY 1.2: PERSONALITY CORRELATES OF CO-RUMINATION

It is surprising that the extant literature has not yet discussed co-rumination in the context of personality. Since neuroticism is associated with negative emotional states, pessimism, moodiness (John & Srivastava, 1999), and, most importantly, individual rumination (see Trapnell & Campbell, 1999, for a review), co-rumination might have significant overlap with neuroticism. Likewise, co-rumination might also be related to agreeableness as a function of being attuned to others' feelings.

Neuroticism

The direct conceptual link between neuroticism and co-rumination is ruminative response style (Nolen-Hoeksema, 1991). If neuroticism has been shown to correlate with rumination, neuroticism can be expected to correlate with co-rumination as well. Therefore, I predict that a correlation between co-rumination and neuroticism will be observed. Such an association could be explained in at least two ways.

One possibility is that co-rumination is synonymous with neuroticism and CRQ-27 does not measure what Rose (2002) intended. Clark and Watson (1995) advised measure-makers to word items very carefully to avoid tapping into the broad individual differences in affect and cognition that characterise neuroticism. They also warn that inclusion of negative affect-laden terms in a measure “virtually guarantees” a substantial neuroticism component in it. This is a valid concern for CRQ-27, because many of its items contain negatively valenced terms (e.g., “problems” and “bad things”). Furthermore, one of CRQ’s content areas focuses specifically on negative emotion. An illustrative item from this content area is “When we talk about a problem that one of us has, we talk a lot about how bad the person with the problem feels.” Therefore, it is important to demonstrate that CRQ-27 does not unintentionally index the neuroticism personality dimension due to item wording by establishing that items in CRQ-27 do not cross-load on both co-rumination and neuroticism factors. One way to provide evidence that co-rumination measure does not unintentionally measure neuroticism is to show that the items load onto a different factor in a factor analysis.

A second possibility is that co-rumination and neuroticism are linked by an intermediary variable. For example, a possible correlation between neuroticism and co-rumination could be explained by rumination, if both co-rumination and neuroticism shared variance with it. In other words, rumination could be a go-between variable that links co-rumination and neuroticism. In this case, co-rumination and neuroticism could be legitimately separate constructs while being correlated. Therefore, if both neuroticism and co-rumination are linked together by rumination, neuroticism should not predict co-rumination after controlling for rumination.

Agreeableness

Co-rumination is associated with increased relationship quality (Calmes & Roberts, 2008; Waller & Rose, 2009) and co-ruminative relationships are characterised by closeness and affection. Because the agreeableness personality dimension involves many traits conducive to relationship maintenance, such as warmth and sympathy (John & Srivastava, 1999), the co-rumination measure should share variance with agreeableness. Since ruminative response style should be unrelated to agreeableness, I expect that any correlation between co-rumination and agreeableness would remain significant even after controlling for rumination.

Method

Five online surveys were conducted and data from each were combined for factor analyses. All surveys were a part of a larger research program into interpersonal emotion regulation with an emphasis on co-rumination. Because data from these surveys were analysed in aggregate and the procedures for each survey were similar, the surveys are discussed together.

Participants

Survey 1 participants (18 women and 20 men) were undergraduates who participated in a separate experiment with a close friend. Surveys 2 (65 women and 42 men) and 3 (103 women and 102 men) recruited participants online from diverse backgrounds and age groups (these data were collected for the previous study about co-rumination over the lifespan). Survey 4 data were collected from undergraduates taking a class (27 women and 23 men). Survey 5 sampled undergraduate participants (44 women and 20 men) similar to survey 1. The mean age for all 464 participants was 25.08, ($SD = 8.34$).

Measures

Co-rumination. As in the previous study, co-rumination with a close same-sex friend was assessed with the 27-item Co-Rumination Questionnaire (Rose, 2002). The Cronbach's alpha values for the full measure in each survey were very high and ranged from 0.95 to 0.97. The aggregate internal consistency coefficient for all of CRQ-27 data was 0.97.

Rumination. Participants in survey 3 completed a 22-item measure of ruminative response style (Nolen-Hoeksema & Morrow, 1991). Participants were asked to indicate how often they engage in ruminative thoughts or behaviors when they feel sad. Each item was rated on a Likert-type scale anchored at 1 ("never") and 4 ("always"). The measure demonstrated high internal reliability (Cronbach's alpha = .92).

Personality. Surveys 2 and 3 included a 20-item "Big Five" personality measure (mini-IPIP; Donnellan, Oswald, Baird, & Lucas, 2006). The personality dimensions assessed were openness to experience, conscientiousness, extroversion, agreeableness, and neuroticism. Participants completed the measure by indicating, on a 5-point scale, how well each statement described them. In total, 339 participants completed the measure. The least reliable personality dimension in the sample was openness to experience ($\alpha = 0.66$) and the most reliable was conscientiousness ($\alpha = 0.78$).

Procedure

All data were collected online from adult or young adult participants either via standalone surveys or in conjunction with laboratory experiments. In all cases, after giving their informed consent, the participants completed CRQ-27 as a part of a longer survey. The survey was always completed before the participants were exposed to other experimental tasks. Answers to all items of CRQ-27 from the five surveys were used as a single data set.

Results

Of the five personality dimensions measured, as predicted only agreeableness and neuroticism correlated with co-rumination. In Table 3, I report the results of a partial correlation analysis assessing correlations between co-rumination and personality dimensions after controlling for rumination. The previously observed correlation with neuroticism dropped almost to zero (and became nonsignificant) while the correlation between co-rumination and agreeableness remained virtually the same. This suggests that, as predicted, the relationship between neuroticism and co-rumination depends on their shared variance with rumination.

Table 3
Correlations between personality dimensions and co-rumination

	<i>Co-rumination only (correlation)</i>	<i>Co-rumination and rumination (partial correlation)</i>
Openness to experience	.07	.07
Conscientiousness	.01	.07
Extroversion	.06	.13
Agreeableness	.25***	.26***
Neuroticism	.20**	.04

Note. ** $p < .01$. *** $p < .001$.

Factorial distinctness

If co-rumination is factorially free of a substantial neuroticism or agreeableness component, co-rumination and personality factors should also remain distinct in factor analyses. This was tested with a confirmatory factor analysis (CFA) on a pool of items consisting of 27 co-rumination items and eight mini-IPIP items, of which four indexed neuroticism and four agreeableness. The CFAs were performed in MPlus (version 6; Muthén & Muthén, 2006) using the robust maximum likelihood estimates to explore model fit. In the model, four neuroticism items loaded onto a single latent variable, four agreeableness items onto another, and the 27 co-rumination items divided into four parcels that loaded onto a third latent variable. Each parcel contained six to seven items chosen by their factor loadings. To populate the parcels, first items

with the highest and lowest loadings were included, then the second highest and second lowest loadings, and so on to reduce the number of observed variables. The three-factor model fit the data well, $\chi^2(51) = 99.245$, $\chi^2/df = 1.946$, $RMSEA = .055$, $CFI = .98$, $SRMR = .04$, suggesting that co-rumination, neuroticism, and agreeableness are factorially distinct. To summarise, the correlation between neuroticism and co-rumination is most likely due to some intervening variable—rumination, very likely—and not because neuroticism and co-rumination measure the same latent construct.

Discussion

Co-rumination was shown to be correlated with neuroticism and agreeableness, as predicted. After controlling for rumination, only the correlation with agreeableness remained significant. Subsequent factor analyses of the items corroborated the argument that the shared variance between neuroticism and co-rumination was due to their overlap with rumination, not neuroticism contamination in CRQ-27 items.

STUDY 1.3: A BRIEF MEASURE OF CO-RUMINATION (CRQ-9)

Aggregating findings from many co-rumination studies was complicated by the fact that many researchers had modified the co-rumination measure. While CRQ-27 is a common choice in co-rumination research (e.g., Byrd-Craven et al., 2008; Rose et al., 2007; Starr & Davila, 2009; Stone, Uhrlass, & Gibb, 2010), it is often shortened due to practical demands (Calmes & Roberts, 2008; Haggard et al., 2010; Hankin et al., 2010; Stone, Hankin, Gibb, & Abela, 2011; Waller & Rose, 2010). Sometimes the original CRQ-27 questionnaire is shortened to include 16 items (Calmes & Roberts, 2008; Waller & Rose, 2009), sometimes nine items (Haggard et al., 2010, Hankin et al., 2010, Stone et al., 2011). Whenever a measure is substantially shortened, modified, or used in a new context, reliability and validity must be re-established with substantial psychometric work (Switzer, Wisniewski, Belle, Dew, & Schultz, 1999).

Need for a shorter measure

The present diversity of CRQ-27 variants is an indication that there is an unmet need for a standard short version of the measure with confirmed psychometric properties. This need for short measures is especially pressing for longitudinal research, because co-rumination is a relational process that unfolds over time between people, which necessitates data collection from multiple people over multiple periods of time. In order to understand the short-term fluctuations in co-rumination as well as its within-person developmental trajectory from childhood to adulthood, data would need to be collected both frequently and for long periods of time.

There are two main empirical reasons why shorter measures should be favored in general. First, measures with high number of items may have inflated indices of internal reliability that may make the measure appear unidimensional despite a more complex factor structure (Cortina, 1993). Second, participant compliance and data quality deteriorates with longer questionnaires (Galesic & Bosnjak, 2009). Both these problems can be avoided by using shorter measures.

In psychology, Chronbach's alpha is generally understood to represent the unidimensionality of a measure, although it was never presented as such (Cronbach, 1951). There is a subtle difference between *internal consistency* and *homogeneity*: internal consistency refers to

the *interrelatedness* of a set of items, whereas homogeneity refers to the *unidimensionality* of the set of items. Consistency is necessary—but not sufficient—for homogeneity (Schmitt, 1996). While CRQ-27 has consistently been reported to have high Cronbach's alphas in varied samples, it does not automatically follow that the measure is unidimensional, because alpha is not a measure of unidimensionality (Cortina, 1993; Schmitt, 1996; Sijtsma, 2009). Another problem with Cronbach's alpha as a measure of unidimensionality is that it increases as a function of the test length (Nunnally, 1978, pp. 227–228). In plain language, alpha is not related to unidimensionality, because different measures of varying factorial composition may have the same alpha value (Sijtsma, 2009). Given that CRQ-27 has a relatively high number of items, reducing the number of items would be an improvement for both practical and psychometric reasons.

Short measures are preferable for other reasons, too. Ethically, researchers are required to consider the wider implications of requesting participants to volunteer their time and effort to the research enterprise (British Psychological Society, 2007). It is the researcher's responsibility to make sure the participants' time is used in an efficient way and to ensure that the participants know all relevant information about the research before participating—including details such as the average length of time taken to complete the study. Asking participants to complete redundant items when a smaller set of items would do is an inefficient way to conduct research.

In order to quantify how long it takes to complete CRQ-27, I conducted a very brief online survey that included 27 co-rumination items (i.e., CRQ-27) and five administrative and demographic items. All items except two (participant's password and the participant's relation to the co-rumination partner) were multiple-choice questions with a maximum of five response options each. After excluding one participant who started the questionnaire and finished it 22 hours later as an outlier, the average completion time for the entire questionnaire was 224.9 seconds ($SD = 83.81$ seconds), which means the average completion time per item was seven seconds. Therefore, the CRQ-27 by itself takes participants approximately three minutes and nine seconds complete. In comparison, a nine-item brief measure would require only one minute and three seconds. Since studies in Part III of this thesis require repeated assessment of co-rumination, it would be beneficial to have a brief measure that does not unduly strain participants.

CRQ-9

Despite a range of ad hoc modifications to CRQ-27, some researchers have converged on the same set of items. The original paper that coined the term co-rumination and described CRQ-27 contained a list of nine representative items for each content area of co-rumination (appendix I of Rose, 2002, pp. 1841–42). These items are listed in Table 4. They have already been used as a 9-item measure of co-rumination (Hankin et al., 2010; Stone et al., 2011) while others have used item sets based on additional analyses of the original 27 items (Haggard et al., 2010; Waller & Rose, 2010). Although Rose (2002) did not specify the nine representative items to form a stand-alone measure, it is possible that a shorter scale based on these items may have sufficient reliability and validity for wider adoption. Since the nine items listed by Rose (2002) have been published as prototypical co-rumination items and used by other researchers in their unaltered form, these items will be referred to as CRQ-9 in this thesis. As the other brief measures used by other researchers have items in common with CRQ-9, and because the CRQ-9 items should be representative of co-rumination concept as it was defined by Rose (2002), CRQ-9 has potential to be a successful, standardised brief measure of co-rumination. However, if CRQ-9 were to function as a suitable replacement, it must fulfil various psychometric criteria.

Table 4
Co-rumination content areas and representative items (as published in Rose, 2002)

<i>Content area</i>	<i>Item</i>
<i>Frequency of discussing problems (“frequency”)</i>	<i>We talk about problems that my friend or I are having almost every time we see each other.</i>
<i>Discussing problems instead of engaging in other activities (“priority”)</i>	<i>When we see each other, if one of us has a problem, we will talk about the problem even if we had planned to do something else together.</i>
<i>Encouragement of the friend’s discussing problems by the focal child (“urging by ego”)</i>	<i>When my friend has a problem, I always try really hard to keep my friend talking about it.</i>
<i>Encouragement of the focal child’s discussing problems by the friend (“urging by alter”)</i>	<i>When I have a problem, my friend always tries to get me to tell every detail about what happened.</i>
<i>Discussing the same problem repeatedly (“repetition”)</i>	<i>When we talk about a problem that one of us has, we’ll talk about every part of the problem over and over.</i>
<i>Speculation about causes of problems (“causes”)</i>	<i>When we talk about a problem that one of us has, we talk about all of the reasons why the problem might have happened.</i>
<i>Speculation about consequences of problems (“consequences”)</i>	<i>When we talk about a problem that one of us has, we try to figure out every one of the bad things that might happen because of the problem.</i>
<i>Speculation about parts of the problem that are not understood (“unknowns”)</i>	<i>When we talk about a problem that one of us has, we spend a lot of time trying to figure out parts of the problem that we can’t understand.</i>
<i>Focusing on negative feelings (“negativity”)</i>	<i>When we talk about a problem that one of us has, we talk a lot about how bad the person with the problem feels.</i>

Score equivalency. The most important criterion for the brief measure is that it taps into the same construct as the original co-rumination measure. Therefore, any brief form of CRQ-27 should yield scores that correspond to scores that would have been obtained with the full version. Therefore, if CRQ-9 were an acceptable substitute to CRQ-27, its scores should strongly correlate with CRQ-27 scores.

Factor structure and reliability. Because of the reduced number of items, it is important to establish the internal consistency of CRQ-9 both across participants and measurements. In order to replace CRQ-27, CRQ-9 should have a psychometric profile that is either equivalent to or better than the original in terms of unidimensional factor structure and reliability. Specifically, it should have a clearly unidimensional factor structure, an adequately high internal consistency coefficient (i.e., Cronbach's $\alpha > .80$), and a test–retest performance comparable to CRQ-27. Because there are no theoretical grounds to specify how co-rumination scores are expected to change over time, our aim is to establish that CRQ-9 test–retest reliability are comparable to that of CRQ-27 instead of demonstrating that the across-measurement consistency reaches a predetermined value.

Method

Data from Study 1.1 and 1.2 were combined for factor analyses and comparing scores between CRQ-27 and CRQ-9. Confirmatory factor analysis was used to investigate the factor structure of both CRQ-27 and CRQ-9. Correspondence of scores between CRQ-27 and CRQ-9 was established using Pearson's correlation coefficient.

For analysis of test–retest reliability, a subset of participants in Survey 3 completed CRQ-27 twice: once before a lab visit and once as part of Survey 3.

Participants

Participants whose data were used to establish the factor structure of CRQ-9 and score equivalency were the same as in the previous study. These participants reported on co-rumination with a same-sex friend.

The participants whose data were used for the test–retest analyses ($N = 64$) were heterosexual partners in long-term relationships partaking in a laboratory experiment (for details, please refer to Part II of this thesis). Among these participants, the women’s mean age was 26.65 ($SD = 7.03$), and the men’s was 28.06 ($SD = 8.09$). Unlike the participants who only took one survey on co-rumination with a friend, these participants reported on co-rumination with their long-term romantic partner.

Procedure

All measures were collected online (see Studies 1.1 and 1.2 for details). For assessment of test–retest reliability of co-rumination in a romantic relationship, a two-part survey was conducted. At T1, the participants completed an online survey prior to participating in a lab experiment. At T2, the participants again completed CRQ-27 online (i.e., Survey 3 of the previous study). On average, participants took the retest 233 days after the initial survey ($SD = 70$). All couples who were still together at the time of the follow-up ($N = 29$) completed the survey at T2.

Measures

Co-rumination with a friend. Co-rumination with the participant’s closest friend was assessed using CRQ-27 (see Study 1.2 about personality and co-rumination as the data were the same). CRQ-9 contained the representative items listed in the appendix of the paper introducing CRQ-27 (Rose, 2002, also listed in Table 4). Since all CRQ-9 items are included within CRQ-27, there was no need for the participants to take two separate co-rumination measures. Instead, CRQ-9 was scored from a subset of CRQ-27 items. Cronbach’s alpha values for the nine-item measure in each survey ranged from .86 to .93. The aggregate internal consistency coefficient for all of CRQ-27 data was .97. The average inter-item correlation was .52. For CRQ-9, the corresponding numbers were .92 for internal reliability and .55 for average inter-item correlation.

Co-rumination with a partner. Individuals in long-term romantic relationships reported on co-rumination with their partner. To this end, the CRQ-27 items were rephrased to replace “my friend” with “my partner.” Summary scores were calculated for CRQ-27 and CRQ-9 as the mean of the item ratings in each measure (see Table 5 for descriptive statistics).

Table 5
Descriptive statistics of co-rumination test–retest data

	T1 (<i>N</i> = 64)	T2 (<i>N</i> = 58)
CRQ-27		
Mean (<i>SD</i>)	2.94 (0.49)	2.50 (0.65)
Cronbach's alpha	0.88	0.94
Interitem correlation	0.21	0.36
CRQ-9		
Mean (<i>SD</i>)	2.94 (0.49)	2.37 (0.71)
Cronbach's alpha	0.60	0.84
Inter-item correlation	0.14	0.37

Results

Score equivalency

Pearson's correlation coefficient was used to test the correspondence between CRQ-27 and CRQ-9 scores (same-sex friendship). The correlation between CRQ-27 and CRQ-9 scores was strong, $r = .98$, $p < .001$. A similarly strong correlation was observed for co-rumination within romantic relationships, $r = .97$, $p < .001$. Despite only having a third of the original measure's items, CRQ-9 captured 94–96% of co-rumination variance both within same-sex friendships and romantic relationships.

Factor structure

CRQ-27. To establish the CRQ-27 factor structure, confirmatory factor analyses (CFA) with latent variables were performed, because past exploratory factor analyses (e.g., Rose, 2002) have already suggested unidimensionality. Although CFA has already been applied to modified co-rumination measures to establish discriminant validity of friend-based co-rumination and rumination (Calmes & Roberts, 2008) and validate a measurement model (Haggard et al., 2010), it has not yet been used to directly examine the internal factor structure of CRQ-27. Therefore, CFA was needed to test the CRQ-27 unidimensionality hypothesis. Latent variables allowed us to retain all observed variables in the CFA, which, in turn, allowed us to estimate and control for measurement error (Byrne, 2006). The CFAs were performed in MPlus (version 6; Muthén & Muthén, 2006) using robust maximum likelihood estimates to explore model fit. Models were compared using a scaled chi-square difference test (Satorra & Bentler, 2001) to see which model provided the best fit. The fit criteria suggested by Hu and Bentler (1999) were used: Comparative

Fit Index (*CFI*) of .95 or larger, Root Mean Square Error of Approximation (*RMSEA*) equal to, or smaller than .06, and a Standardised Root Mean Square Residual (*SRMR*) of .08 or smaller.

Furthermore, to attenuate for the effects of large sample sizes on the chi-square statistic, a chi-square to degrees of freedom ratio of 3:1 was assumed to indicate acceptable model fit and a ratio of 2:1 to indicate good model fit. Although there is no commonly accepted standard for the ratio, smaller values indicate better fit (Springer, Kamata, & Abell, 2009).

In model 1, the simplest form of unidimensionality was tested, in which all CRQ-27 items load onto a single latent factor (items were combined into parcels as in Study 1.2). Model 2 represented co-rumination with the nine distinct content areas outlined by Rose (2002). For this model, all 27 items were loaded onto their respective nine content areas, and then each content area was loaded onto the superordinate latent variable, co-rumination (see Figure 3 for model 2 structure). These models did not fit the data well. The unqualified unidimensional model 1 fit the data worst, $\chi^2(324) = 2529.339$, $\chi^2/df = 7.806$, *RMSEA* = .121, *CFI* = .73, *SRMR* = .078 with model 2 faring only marginally better, $\chi^2(315) = 1414.658$, $\chi^2/df = 4.491$, *RMSEA* = .087, *CFI* = .87, *SRMR* = .064. Since the confirmatory factor analyses did not support the expected factor structure of CRQ-27, the hypothesis of unidimensionality of the measure in our sample had to be rejected.

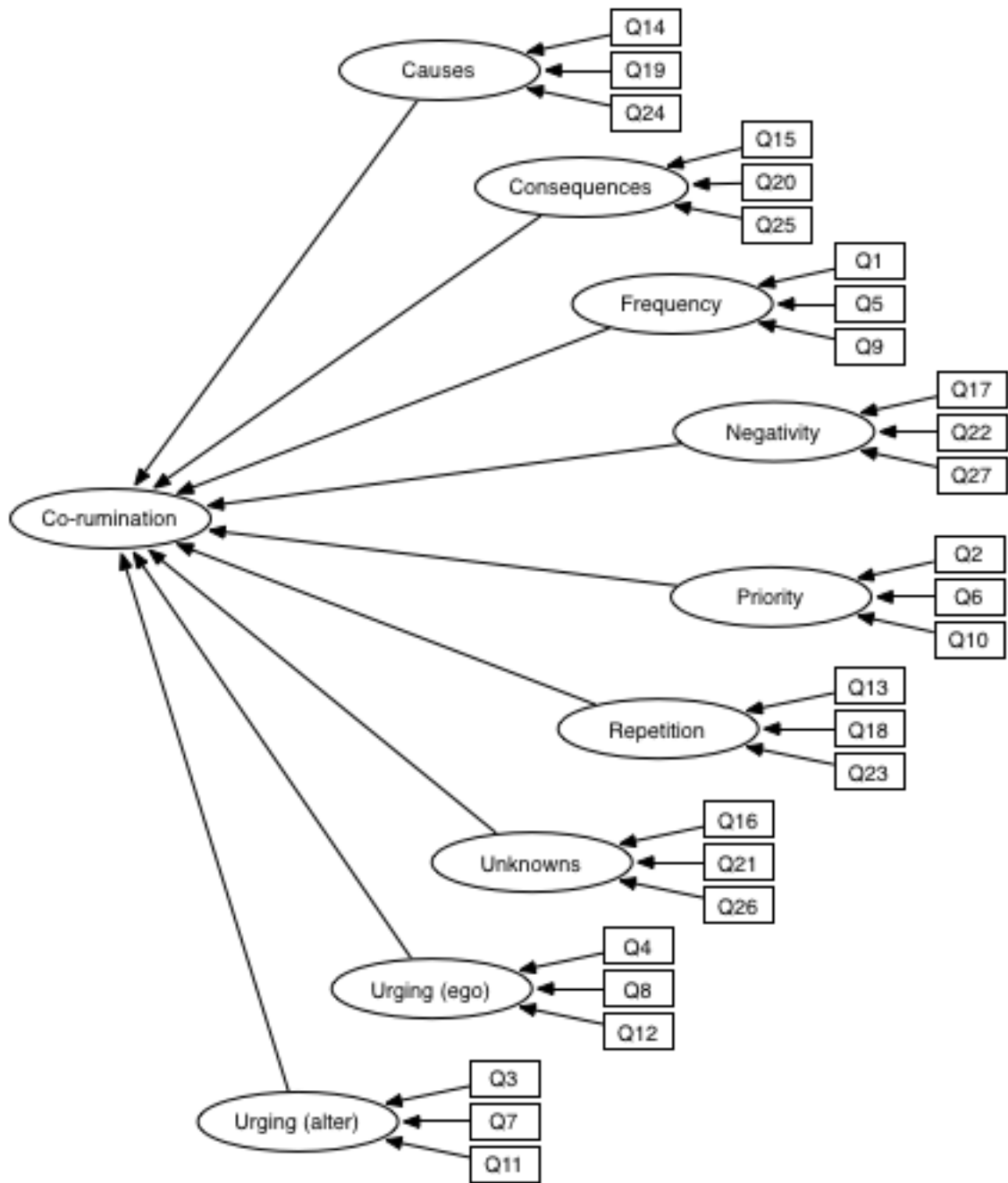


Figure 3. Model of co-rumination with each content area as a latent variable.

CRQ-9. Confirmatory methods were used to test a model of CRQ-9 with all nine items loading onto one latent variable, similar to Model 1 with CRQ-27 mentioned above. The error variances were allowed to covary for two items: “When my friend has a problem, I always try really hard to keep my friend talking about it” and “When I have a problem, my friend always tries to get me to tell every detail about what happened.” This was done because the items’ wording suggested content overlap (Byrne, 2006), the measurement error covariances were more likely

systematic rather than random (Byrne, 2006), and because uncorrelated error variances are unlikely in empirical data (Bentler & Chou, 1987). Due to the parceling process used for Model 1, the same could not be implemented with it, possibly restricting the model fit (as allowing covarying error variances can facilitate achieving a better model fit, thus stacking the odds in favour of the CRQ-9 model). However, the parceling process also facilitates a better model fit, reducing a potential bias in favor of the CRQ-9 model.

This model fit the data better than either of the CRQ-27 models, $\chi^2(26) = 97.918$, $\chi^2/df = 3.766$, $RMSEA = .077$, $CFI = .96$, $SRMR = .040$. However, it is important to point out that 1) a model with fewer items is more likely to fit the data by default, 2) the assumptions regarding error covariances were relaxed, and that 3) CRQ-9 factor structure has not been established before, which limits the CFA findings.

Test-retest reliability

To test the stability of co-rumination measurement over time, the scores from both CRQ-27 and CRQ-9 were correlated across both time points. The results showed a high level of agreement among the scores (see Table 6). Furthermore, the pattern of correlations between scores recorded at T1 and T2 was nearly identical for both CRQ-27 and CRQ-9.

The correlations of co-rumination scores within romantic relationships over time (i.e., $r = .72$ for CRQ-27 and $r = .68$ for CRQ-9) were somewhat higher than those reported for co-rumination within a same-sex friendship over similar time-spans. Rose et al. (2007) reported a correlation of $r = .54$ over the period of six months, while Hankin et al. reported $r = .22$ over the period of five months.

Table 6
Correlations of CRQ-27 and CRQ-9 scores across two time points

	<i>Time 1</i>		<i>Time 2</i>	
	CRQ-27	CRQ-9	CRQ-27	CRQ-9
<i>Time 1</i>				
CRQ-27		.94***	.72***	.72***
CRQ-9			.67***	.68***
<i>Time 2</i>				
CRQ-27				.97***

Note. *** $p < .001$

Discussion

Results from five questionnaire-based studies (combined $N = 464$) demonstrated that the Co-Rumination Questionnaire (Rose, 2002) can be shortened by 66% and that the simplified measurement model fits the data better. The short-form measure is suggested for wider adoption in order to 1) improve data quality by reducing participant fatigue, 2) encourage theoretical work by facilitating longitudinal social network data collection, and 3) make results across growing number of studies in the field comparable with each other by offering a standardised measure over ad hoc modifications.

These results demonstrated that the psychometric properties of the nine-item measure of co-rumination were very similar to those of the full co-rumination measure. Although CRQ-27 boasts impressive indices of internal reliability, neither confirmatory nor exploratory factor analyses supported the previously reported unidimensionality of CRQ-27 in our sample, which underlines the danger of inflated reliability due to high item counts. In comparison, CRQ-9 showed more convincing evidence of unidimensionality in both exploratory and confirmatory factor analyses. The scores from the two measures were almost perfectly correlated, suggesting that the nine items of CRQ-9 capture most of the variance in CRQ-27. In short, CRQ-9 performs well as a unidimensional measure of co-rumination among adults who are reporting on a close, same-sex friendship. While performing on equal footing with the full measure, CRQ-9 is three

times shorter, making it a feasible replacement for the CRQ-27 in research protocols that require brevity, such as longitudinal social network data collection.

In terms of temporal stability, scores for both CRQ-27 and CRQ-9 were relatively stable over a time-span of up to seven and a half months, suggesting either that co-rumination is an enduring characteristic of the relationship or that people co-ruminate about chronic issues that do not change over time. In either case, the performance of CRQ-9 compared well with the original measure, as there was hardly any difference in the temporal stability of the measures. Although the size of correlations between CRQ-27 and CRQ-9 measures at T1 and T2 was large, it is also worth noting that it does leave room for some changes in co-ruminative patterns as a relationship progresses.

Limitations

Some limitations should be acknowledged. First, all participants were largely a self-selected sample acquired through recruitment ads. As a consequence, this may have resulted in less variance for most of our measures and may have attenuated some of the correlations. However, this should not have affected the overall pattern of results, as many aspects of the findings (e.g., internal reliability estimates of the scales) were largely in line with findings from other research. The test–retest survey may also have been influenced by the variable time-frame between measurements, although when time difference between the two surveys was entered as a predictor of T2 co-rumination scores (and set to interact with T1 scores), only co-rumination scores at T1 was a significant predictor. It is also possible that different relationships have different temporal stability. The present survey only measured co-rumination in a romantic partnership and thus it is not possible to say whether co-rumination with close same-sex friends would fluctuate more over time or remain more stable.

BEYOND INDIVIDUAL CO-RUMINATION

In review, my findings suggest that co-rumination has interesting dynamics over the lifespan beyond teenage years. However, very little is known about co-rumination in adults. Only one study included an adult sample, looking at co-rumination between coworkers (Haggard et al., 2010). Therefore, trying to extend co-rumination into adulthood would be an important research direction. I also demonstrated that personality—one of the most fundamental individual differences after gender—bears an interesting relationship with co-rumination and should be taken into account. Finally, I provided evidence that co-rumination can be quickly measured with only nine items.

Co-rumination research has already been conducted almost exclusively through survey methodology and at individual level of analysis, and there are yet undiscovered research opportunities at a higher level of analysis. Because co-rumination—by definition—is impossible without another person, the dyadic level is a more natural level to study co-rumination, in my opinion. I am not alone holding this opinion, because many co-rumination researchers have discussed fruitful directions for future research, and dyadic issues feature prominently on the list. Some of the common suggestions are: observational assessment of co-rumination, paying more attention to the co-ruminative dyads, and using more diverse samples. I will briefly discuss each in turn as a warm-up and rationale for the next part of the thesis.

Observational Methods

One of the more frequently suggested direction for co-rumination research is to augment the methodology beyond self-reports to observational assessments (e.g., Hankin et al., 2010; Stone et al., 2010; Waller & Rose, 2009). This direction is important, because exclusive reliance on self-report measures creates problems with recall biases and shared method variance.

In current co-rumination literature, only three studies (Byrd-Craven et al., 2008, 2011; Rose et al., 2005) observed actual co-ruminative interactions between participants. In these studies, close same-sex friends were asked to discuss one of their current problems as they normally would. These conversations were then coded by observers on four dimensions of co-

rumination (mutual encouragement of problem talk, rehashing problems, speculating about causes and consequences of problems, and focusing on negative affect) according to a coding scheme devised by Rose and her colleagues (2005). In these studies, observed co-rumination predicted increased cortisol responses (Byrd-Craven et al., 2008; 2011), suggesting that co-rumination can amplify, rather than mitigate, physiological stress responses to stressors.

So far, only one project has attempted to analyse the specific conversational content in co-ruminative encounters (Rose et al., 2005). In this study, conversational responses to problem statements were coded into categories and participants were given a score that represented the frequency with which they used each category to respond to a friend's problem. The findings showed that co-ruminators responded with a lot of support and acknowledgment to their friend's problem—a pattern that is likely to maintain co-rumination. In 2007, Rose and her co-authors, suggested that future research should assess what co-ruminators disclose and how they act upon the content of the disclosure. Likewise, Stone et al. (2010) called for additional research to better understand the dyadic context of co-rumination. They particularly pointed out that the processes by which co-rumination operates within a friendship should be studied more. Unfortunately, despite stated interest and obvious benefits, no research in the last seven years has attempted to analyse the content of co-ruminative conversations. This is a problem I will tackle in the next part of the thesis by collecting data from naturalistic, real-time conversations.

Dyadic Data Analysis

Another challenge is that intra-individual data alone is insufficient to discover relational processes in co-rumination, because when only one person is reporting on a relationship, the unit of analysis is then that person's perception of the relationship instead of the relationship itself. In simple terms, every story has two sides and relying on only one can be misleading. Given that co-rumination is an inherently dyadic process, including data from self- and peer-reports will be vital according to Tompkins et al. (2011). In similar vein, Calmes and Roberts (2008) note that because the impact of co-ruminative processes may vary between individuals within the same dyad, it is important to include the perspective of both members of the relationship dyad. Therefore, a

prudent co-rumination researcher should collect dyadic data. Only with such data can one hope to gain a more nuanced understanding of co-rumination as a dyadic phenomenon.

Diverse Samples

The final point in the individual level of analysis part of my thesis is that co-rumination is ripe to be extended from the realm of teenage commiseration to a more varied range of relationship contexts. This call for the use of different samples has been made by a number of researchers (Calmes & Roberts, 2008; Haggard et al., 2010; Rose et al., 2007). Haggard and her colleagues postulated that some men might become more co-ruminative in adulthood through interacting with women, and my preliminary findings suggest that men and women converge in co-rumination during early- and mid-twenties, which hints at the influence of long-term romantic relationships.

Heterosexual romantic relationships have already been implicated as causes for same-sex co-rumination during adolescence, but only one study to date has looked at co-rumination within romantic relationships. Our entire knowledge of co-rumination between romantic partners is limited to one survey of undergraduates (Calmes & Roberts, 2008). This woeful state of affairs has not gone unnoticed, as Schwartz-Mette and Rose (2012) urged studies of older adolescents or young adults to examine co-rumination in heterosexual romantic relationships. They point out that co-rumination in romantic relationships might differ from co-ruminative processes in the same-sex same friendships of the romantic partners. In the next part of my thesis, I will look at the dyadic co-rumination between long-term romantic partners in heterosexual relationships as well as relationship partners' co-rumination with their respective same-sex friends.

Part II:
Co-ruminative dyadic
conversations

Part II shifts the perspective from individuals to relationships and considers co-rumination as an inherently dyadic phenomenon. In comparison to the developmental timescales involved in the previous part, this part deals with real-time interaction. In my literature review, I will go over the sparse literature on interpersonal aspects of co-rumination. I also point out that although problem-talk is one of the defining characteristics of co-rumination, very little is known about co-ruminative conversations themselves. Because talking is an observable real-time social behaviour, naturalistic conversations offer a promising platform for research.

The centrality of talking serves to underline another important aspect of co-rumination. Co-rumination is relational by definition, because it is impossible to co-ruminate alone. The core behaviour in co-rumination is to talk with someone else. This alone makes co-rumination dyadic, and I argue that the relational nature of the subject matter necessitates real-time, dyadic, and naturalistic data: human relations—the natural habitat of emotions—are nigh impossible to manipulate experimentally. Thus, the best we can do is to unobtrusively observe them.

At the dyadic level, my empirical work aims to answer whether co-ruminators converse in a different manner than people who do not co-ruminate. To find out, I invited long-term romantic couples to talk about sad topics on camera. In contrast to typical content/conversation/discourse analysis methods, my analyses rely on statistical analyses of real-time quantitative data sampled directly from these interactions. This approach differs from subjective, qualitative techniques that are common in humanities (e.g., grounded theory; Glaser & Strauss, 1967). For data, I focus on the “*what*” and “*how*” of the dynamic interactions that unfold between people. A transcribed text corpus of the conversations constitutes the “*what*” of the conversations, which will be distilled into quantified language features. The “*how*” consists of continuous video-cued recall data and video recordings. The relation between co-rumination and 1) the emotional trajectories of the conversations, 2) language use, and 3) others’ perceptions will be examined over three studies.

At the end of the interpersonal part of the thesis, I will review evidence that suggests that co-rumination cannot be fully comprehended at the dyadic level, either. Specifically, I will point out that co-ruminative conversations could influence the state of other relationships as well.

LITERATURE REVIEW

It is difficult to tell from literature whether co-rumination is meant to represent an individual trait or a special kind of a relation between individuals (or a quality of such a relation). On one hand, co-rumination is measured as an individual trait (Rose, 2002), but co-rumination theory assumes a dyadic context in which it unfolds. In terms of findings, the depressive aspect of co-rumination (e.g., Rose, 2002; Rose et al., 2007; Starr & Davila, 2009) is exclusively assessed at the level of individuals, but the positive aspect of co-rumination, increased relationship satisfaction (Rose, 2002; Rose et al., 2007), depends on the existence of a dyadic relation by definition. Because of this definitional ambiguity, co-rumination literature is not possible to categorise into neat intra- and interpersonal categories. The following section reviews extant co-rumination literature using interpersonal interaction as a lens through which to interpret the findings.

Interpersonal Emotion In Co-rumination

While emotion does involve within-person internal states, many researchers have argued that emotion can be more fruitfully understood as a relation between persons (e.g., de Rivera, 1977; de Rivera & Grinkis, 1986; Parkinson, 1996; Parkinson, Fischer, & Manstead, 2005). Most emotions take place in a social context, operate on social input, and serve various social functions (Parkinson, 1996; Parkinson, Fischer & Manstead, 2005). From this interpersonal viewpoint, emotions are not mere subjective responses to an external situation. Instead, they are part of transactions between persons and situations (which often include other people). Emotions are dynamic and embodied modes of engagement that reconfigure relations in the shared environment, conveying information both to self and others about these relations and shaping them at the same time. As such, emotions are both a way to understand these relations and a tool to shape them (e.g., Parkinson, 2009).

The interpersonal theory of depression (Coyne, 1976) suggests that interacting with a depressed person can be a risk factor for depression. Social referencing in co-rumination may cause the co-ruminators to adopt each other's negative orientation to the object of problem-talk. In a way, the conversation may become an echo chamber of negative emotion that amplifies the

negative emotion within the dyad. In interpersonal situations, people use emotion to communicate important information to others about who they are, how they wish to be treated, and how they feel about the situation (Hareli & Hess, 2010; Keltner & Kring 1998). As speakers, we use the whole gamut of our emotional expression capabilities by supplementing our spoken words with facial expressions, vocal intonation, hand gestures, and body postures. As listeners, in addition to the words being spoken, we take in cues through all conduits of emotion to decide how to appropriately respond to behaviour (van Kleef, De Dreu, & Manstead, 2004). Thus, in addition to the spoken content, nonverbal emotion expression may be another conduit through which co-rumination operates. However, because only a few studies have focused on co-ruminative processes in general, it is uncertain how co-ruminative processes work during face-to-face interactions and how excessive dwelling on the negative emotions in the present nudges people toward depression in the future. Ciesla and Roberts (2007) suggest that the process of rumination (i.e., repetitive pondering) is separate from the content of rumination (i.e., the specific negative cognitions), suggesting that one possible research avenue is to try and separate what is being said from how it is said.

Dyadic co-rumination

Despite the fundamentally dyadic nature of co-rumination, the construct has mostly been analysed as an individual trait (see the literature reviewed in the previous part of the thesis). Because literature on ruminative response style is mostly a matter of personality psychology, it is natural that Rose (2002) used individuals as her primary unit of analysis and focused on individual differences in co-rumination. However, the importance of the interpersonal context and processes is inescapable in co-rumination. For example, one of the key assumptions of co-rumination is that the co-ruminators emotionally converge on mutual negative emotion (Rose, 2002). Thus, the downward spiral toward depression involves a kind of “empathic depression,” in which two people become depressed due to each other’s sadness or problems (for a similar phenomenon regarding empathic worry, see Parkinson and Simons, 2012).

Despite calls to conduct research with observational data at the dyadic level of analysis (Calmes & Roberts, 2008; Tompkins et al., 2011), the real-time interaction involved in co-rumination has not been a popular research topic. The lack of empirical and theoretical focus on

real-time processes could be due to the difficulties in analysing dyadic, time-indexed data. The complex, interrelated data required to investigate dyadic data has only recently become available (Butler, 2011; Kenny, Kashy, & Cook, 2006). In terms of research that incorporates a time-dimension, co-rumination has been investigated longitudinally with time scales ranging from multi-month prospective studies (Hankin et al., 2010; Rose et al., 2007) to day-to-day variation (White & Shih, 2012). Overall, Rose (2002) suggests that persistent negative emotion gives rise to the negative aspects of co-rumination, but does not specify which real-time mechanisms are implicated.

In the context of a social interaction or an interpersonal relationship, emotion forms a system in which components interact both within the individuals and across the partners as well (Butler, 2011). These temporal interpersonal emotion systems (TIES) are built on the idea that emotion in one person is connected directly to a parallel emotion in another person. Since TIES apply to repeated emotional observations taken over time from at least two partners in a relationship or interaction, Butler's framework should be of interest for co-rumination research as well. According to Butler, the elements in TIES can covary with each other in either morphostatic (stable) or morphogenic (changing) patterns. This means that people's emotions can become coupled in such a way that they mutually influence each other's patterns. Some systems are drawn towards states that recur over time and become increasingly predictable. In terms of TIES, the longitudinal slide toward depression observed among co-ruminators fits the description of morphogenic covariation following a decreasing trend (between-partner emotional covariation around a downward trajectory). Butler (2011) also points out the importance of investigating under what circumstances tighter emotional covariation or coupling represents healthy versus unhealthy functioning. Another point that she brings up is that it is important to pay attention to the appropriate time scale: for example, interpersonal transmission of negative emotion may be uncomfortable in the short term, but may enable better functioning in the longer term.

A notable exception in the dearth of dyadic studies was carried out by Schwartz-Mette and Rose (2012), who tested the hypothesis that co-rumination plays a role in depression and anxiety contagion. Their work built on the interpersonal theory of depression (Coyne, 1976), but extended it to also include anxiety contagion. More importantly, their data analyses accounted for dyadic

interdependence between co-ruminators. Using data from a previous experiment (Rose et al., 2007) for structural equation modeling, they found that mere self-disclosure was not enough for negative emotion contagion. Instead, only co-rumination (i.e., extensive, repetitive, and speculative conversations) mediated the contagion effect. However, how exactly co-rumination accounts for contagion was left for future studies, although the researchers suggested two possible causal paths. As one of the possible mechanisms, Schwartz-Mette and Rose suggested that unintentional mimicry of partner's expression of high negative affect could contribute to the effect. However, they also suggest that co-rumination about ambiguous topics—for which there are no clear solutions—might be particularly distressing and conducive for contagion. Thus, co-rumination could be contagious through the content being discussed or the manner in which it is talked about.

Relationship context. Another key insight that flows from the dyadic nature of co-rumination is that it may be closely linked to the relational context in which it unfolds. If co-rumination were a purely intrapersonal construct (i.e., co-rumination was not sensitive to the dyadic context), parent–child co-rumination would be indistinguishable from co-rumination between identically aged student–teacher pairs and romantic partners should co-ruminate just like adolescent best friends. Although intuition tells that this may not be the case and co-rumination is likely to vary by relationship type, research that takes the relationship into account is so scant that many researchers have called for future research to tackle different relationship types (e.g., married couples) to establish whether co-rumination is uniquely associated with child and adolescent friendships (e.g., Schwartz-Mette & Rose, 2012; Starr & Davila, 2009).

Observational Coding

In 2005, Rose, Schwartz, and Carlson ran an experiment that attempted to collect better texture and detail about the conversations that co-ruminators have with each other. In addition to relying on observational methods, Rose and her colleagues focused on conversational processes that may foster co-rumination. Their data were collected directly from actual problem talk in 24 tenth-grade same-sex friend dyads (twelve of the dyads were boys). The friends participated in the experiment in an observation room. While alone, each friend listed a problem he or she had. When

united, the dyads were reminded of the problems and prompted to talk about them. Specifically, the friends were asked to talk about each other's problem, but told that it did not matter whose problem they discussed first. They were instructed to talk about anything they wanted to relating to the problems. Furthermore, the participants were told to talk about the problems as long as they wanted for up to 16 minutes when the experimenter would return to the observation room. Should the friends finish before 16 minutes, they were instructed to talk about something else or, if they wanted to, work on a puzzle placed on the table between the participants. At the end of the experiment, the youths completed questionnaires about the interaction.

After the experimental data collection, the video recordings of the problem talks were coded at two levels of analysis. The micro-level analysis involved "thought units," and the process of coding them required four steps: 1) identifying the thought units; 2) coding individual thought units to own- problem-statements, friend-problem-statements, or neither; 3) coding responses to own-problem-statements; and 4) coding the topic of each own-problem-statement. This coding did not assign co-rumination scores, but was used to gain information regarding how the friends talked about their problems. To enable thought-unit coding, the researchers transcribed the conversation speech to text format using an extensive transliteration scheme. (In fact the bulk of the coding instructions consider notations for various features of speech.) Co-rumination scores for each friendship dyad were assigned by global coding. For this, trained coders rated the videos on a 5-point Likert-type scale, representing the coders' judgment of 1) how much the participants rehashed problems, 2) encouraged problem talk, 3) speculated on problems, and 4) dwelled on negative affect. An additional global score was given for overall co-rumination and the coders estimated the number of minutes the dyad spent on discussing problems.

Rose et al. (2005) found that higher co-ruminators were especially likely to respond to friends' own-problem-statements with responses involving agreements and acknowledgements. These findings suggest that co-ruminators may communicate in ways that foster and maintain problem talk. By extension, this could be one of the ways in which individuals prone to depressive symptoms lack the necessary skills to provide appropriate closeness and support (Coyne, 1976). In terms of overall levels of co-rumination, the gender difference was similar in magnitude to the effect sizes reported in previous, survey-based studies. Also consistent with the past studies,

observed co-rumination was positively related to both the friendship and emotional outcomes (i.e., increased friendship quality and depression). The magnitude of the effect was somewhat reduced for friendship quality, however. This reduction could be due to shared method variance that might have confounded the past survey studies.

The observational coding paradigm (Rose et al., 2005) has since been implemented by Byrd-Craven et al. (2008; 2011) and Landoll et al., (2011). Of these, both of the articles by Byrd-Craven and her colleagues were focused on the hormonal correlates of co-rumination and found that it was associated with increased salivary cortisol and alpha-amylase (Byrd-Craven et al., 2008; 2011). In addition, Byrd-Craven et al. (2008) included a control condition, and were able to show that dwelling on negative affect predicted increased cortisol only when personal problems were discussed. The researchers thus suggest that co-rumination must be about personally meaningful topics in order to elicit a stress response. The later study by Byrd-Craven et al. (2011) suggests that the adjustment tradeoffs in co-rumination are due to dual activation of both hypothalamic-pituitary-adrenal axis (HPA) and sympathetic nervous system (SNS), as their results showed that co-rumination produced increased levels of salivary cortisol (indicator of HPA activity) and alpha-amylase (indicator of SNS activity). The researchers suggest that while the initial HPA activity may facilitate bonding between friends by fostering affiliative behaviours, the dual system activity may contribute to internalizing symptoms.

Landoll et al. (2011), on the other hand, confirmed that girls disclose more than boys and that only girls demonstrated increased depression vulnerability six months after the disclosure. Although the researchers hypothesised that girls would discuss more interpersonal problems, evidence failed to support this as an explanation of gender differences in depression. However, other researchers have suggested other possible conversational mechanisms. Haggard et al. (2010) pointed out that the co-rumination measure does not measure the degree to which individuals focus on problem solving. Since men are more inclined to interpret problem-talk as a puzzle to be solved, the researchers suggest that men might introduce a problem-solving aspect to their co-rumination, which would protect them from its negative effects.

GAPS IN LITERATURE

Because there are so few studies that have directly focused on the dyadic aspects of co-rumination, the gaps in the literature are wide and deep. In the following section, I will attempt to provide a narrative that reshapes co-rumination into a fundamentally relational concept and suggests promising topics for study by bringing together co-rumination and other literature on negative conversations.

Co-rumination As Conversation

The greatest gap in co-rumination literature may be metaphorical. According to Lakoff and Johnson (1980), people understand ideas in terms of others. For example, people can express quantity in terms of directionality and say that a stock is going “down the drain” or that food prices are “through the roof.” Lakoff and Johnson argue that the terms of the source domain (i.e., the other idea used as an aid) can prime people and bias how they reason. Thus, the choice of how something is worded influences how people think about it (e.g., love as either a journey or war). Whether co-rumination is conceptualised as an individual or relational phenomena is reflected in language used to describe it. Thus, we must be careful how we talk about co-rumination, as our paradigm could constrain how we think about it (Kuhn, 1962/2012).

The predominant metaphor in the literature for co-rumination is an infectious agent like a virus. In the medicalised language of this metaphor, co-rumination is contagious between dyad members (cf. Schwartz-Mette & Rose, 2012) and leads to symptoms. Thus, co-rumination places people at risk, but could be diagnosed. From this point of view, co-rumination is like a common cold—and thinking of it in epidemiological terms can bias our thinking. Unlike a cold virus, however, co-rumination does not have a physical carrier. There are no “co-rumination cooties” to catch.

I propose that co-rumination is better understood in terms of communication. Instead of being an exchange of germs, co-ruminative tendencies centre around conversational processes. If the distinguishing characteristic of co-rumination is the tendency to engage in negatively valenced conversations, perhaps we are better off focusing on the dynamics of the information exchange?

This suggestion should not sound far-fetched, because it is a good match with the empirical reality. Of the items in CRQ-27 (Rose, 2002), 85% contain either the word “talk” or “tell,” of which both are verbs that directly refer to face-to-face conversations. The benefit of thinking of co-rumination in terms of conversation is that it better captures its dyadic features. A good indication of the relational foundation included in the conversation metaphor is that conversations are relation-specific. People converse differently with different people: many conversations are meant only for a very specific pair of ears. When co-rumination is thought of as a conversational dialogue between people, new kinds of questions become apparent. What kind of information is being communicated and through which channels does this information flow? What do co-ruminators talk about? What is the role of nonverbal body language in co-rumination? How does a co-ruminative conversation make the co-ruminators feel? As evident by the scant interpersonal literature, these questions have not been addressed in detail before.

Conversations also better capture the co-ruminative tradeoff between depression and relationship intimacy. Consider, for example, the findings about increased relationship satisfaction—the adaptive aspect of co-rumination. A Swedish proverb says that “shared joy is double joy and shared sorrow is half-sorrow,” expressing the idea that it is natural for people to share their problems with others in order to find solutions or to soothe their negative feelings. Talking can be therapeutic. High-quality conversations involve sharing the ups and downs of life as well as personal thoughts and feelings. Heart-to-heart conversations are the currency of strong emotional attachment (Collins & Miller, 1994), so it is natural that co-rumination should lead to improved relations with one’s confidant. The dark side of co-rumination is that these conversations do not seem to bring relief to either of the co-ruminators. Instead, the repeated negative discussions appear to drag down the mood of both conversation partners.

Interpersonal Processes In Co-rumination

The conversational perspective suggests that the contagious aspects of co-rumination are rooted in face-to-face interactions. If one wishes to research conversation as a dynamic system, one must treat a conversation as a continuous flow of emotional information that determines the subsequent flow of the conversation, possibly even the course of the relationship. As pointed out

by Schwartz-Mette and Rose (2012), very little is known about real-time processes in co-rumination and depression contagion, but two channels appear as likely conduits: the verbal content of the conversations and the nonverbal behaviour that accompanies the words. In short, co-rumination could be reflected in what people say and how they say it.

Verbal processes

Talking about problems in a non-constructive way could be one of the ways in which individuals who are prone to depressive symptoms lack the necessary skills to provide appropriate closeness and support (Coyne, 1976). This suggests that co-ruminators may communicate in ways that foster and maintain problem talk. In other words, perhaps co-ruminators have a certain way of verbalising their problems that gets the conversations stuck on unhealthy trajectories.

Social sharing is a theory that describes how people talk about negative emotion (Rimé, Mesquita, Boca, & Philippot, 1991; Rimé, Philippot, Mesquita, & Boca, 1992). According to this line of research, social sharing is a process that follows an emotion episode and in which the emotional events, their circumstances, and the experiencer's own feelings and emotional reactions are described to another person in socially shared language (Rimé, 1989; Rimé et al., 1991). Social sharing literature has accumulated over 20 decades worth of findings about the way people share negative emotion by talking with each other. The findings from this line of inquiry are largely complementary to those of co-rumination literature. Rose (2002) argues that normative self-disclosure—which co-rumination literature often refers to as social sharing without making a reference to Rimé and colleagues' work—is at least in part responsible for the findings regarding improved relationship quality among co-ruminators. While the social sharing of emotion literature (e.g., Rimé, 2009 for summary) has not placed particular emphasis on relationship quality, it has observed that people engage in frequent conversations about negative emotion and that in some cases they might end up “stuck” sharing without receiving relief.

Despite considerable overlap in the subject matter, the social sharing and co-rumination branches of the literature have not yet intertwined. It is quite surprising that these lines of inquiry have not yet met, given that Rimé has pointed out that research into rumination and social sharing could integrate “a number of research topics which, up to now, have remained isolated from each

other” (Rimé, Philippot, Boca, & Mesquita, 1992, p. 255). Furthermore, Rimé hints directly at a concept that is very similar to co-rumination. While discussing why some people fail to recover from negative emotion, Rimé (2009) speculates that some people may “keep talking about it without limit” (p. 71). Unfortunately, he neither attaches a specific label to the situation nor points to particular literature for empirical support. However, the hypothesised outcome—excessive, repetitive talk about negative emotion—seems functionally equivalent to co-rumination, since Rose’s (2002, p.1830) definition of co-rumination includes “excessively discussing personal problems within a dyadic relationship.”

After an emotional event, people almost invariably talk about the event with others (Rimé et al., 1991). The early findings (as summarised in Rimé et al, 1998) demonstrate that social sharing of emotion is almost universal: emotion was shared in 88-96% of the cases, independent of age, gender, cultural heritage, type of basic emotion (fear, anger, joy, sadness), or the valence of the emotional experience. Sharing took place most often on the day of the emotion episode, and continued in a repetitive manner over extended durations (up to years). The recipients of social sharing were most typically people very close to the sharer: parents, close family members, best friends, and romantic partners, which matches the pattern observed in co-rumination as well. The pattern of findings held across various research methodologies, including recall, follow-up, diary, and experimental studies.

A Portuguese saying says that “you have five friends, and the rest is landscape.” Research shows that people most commonly share their negative emotion with five people per emotional episode (Rimé et al., 1998), but it is unclear whether people would share with the same five people every time. In anthropology, the number of individuals’ support cliques (which are defined as all the individuals from whom one would seek advice, support, or help in times of severe emotional or financial distress), averaged 4.72 in a United Kingdom and 3.01 in a United States sample (Hill & Dunbar, 2003). The process of social sharing distributes the cognitive burden across many individuals. Even sharing with one other person seems to be better than going at it alone: empirical research has shown that two heads do indeed think better than one—as long as they are given a way to communicate (Bahrami et al., 2011).

Whereas co-rumination theory has not focused on the causes of self-disclosure, social sharing literature has paid more attention to why people have an urge to share their emotions. According to Rimé and colleagues (1991), the driving force behind social sharing is emotional intensity. A precipitating event elicits an emotion in an individual, and there is a positive relation between the intensity of the emotion felt by the person and the extent of sharing (as long as the emotional intensity exceeds a certain threshold, because low-intensity emotions do not appear to trigger social sharing).

The paradox of social sharing—similarly to co-rumination—is that although intuition tells us that talking about emotion is good, empirical evidence regarding the benefits of social sharing is mixed. After reviewing over two decades worth of empirical data, Rimé (2009) concluded that merely sharing an emotion cannot change its residual intensity. To resolve this apparent paradox, he points out that social sharing has both cognitive and socio-affective benefits and that only cognitive benefits yield emotional relief over time. In short, people seek both emotional comfort and cognitive advice from others. Rimé's (2009) reasoning is based on the destabilising effects of negative emotion. According to him, negative emotion is a signal to the individual that his or her progress towards relevant goals has been disrupted and cognitive models of how the world works need to be re-evaluated. Thus, the negative emotion and mental processes associated with it persist until the discrepancy between the invalidated mental models and the observed state of the world has been resolved.

Social sharing theory postulates that negative emotional experiences have two kinds of destabilising effects on people (for summary, see Rimé, 2009). First, there are effects that Rimé calls "obvious." These include three kinds of cognitions that give the memories of the event their emotional punch: representations of blocked goals, disconfirmed expectations about the self and the world, and persistent initial appraisal of the event. These obvious effects activate memory-sustaining processes such as rumination and intrusive thoughts, which prompt the individual to engage in cognitive effort to reorganise their priorities, re-evaluate their schemas, and so on. In terms of co-rumination, the obvious effects could fuel the excessiveness and dwelling on negative emotion.

The “subtle” effects of emotion relate to the experience of failure, symbolic losses, and defeated self, and activate feelings of anxiety, insecurity, helplessness, and loneliness among others. To address the attachment-related socio-affective needs prompted by the subtle effects of the emotional experience, social sharing gives the talker an opportunity to receive comfort, support, and validation. However, social sharing can only provide temporary relief from the subtle effects of negative emotion. According to Rimé, the way to recover is to address the cognitive needs of the obvious effects by reframing or re-appraising the experience, reorganising the hierarchy of motives, and adjusting models, schemas, and goals. Thus, the comfort brought about by the socio-affective benefits is not interchangeable with advice in the same way that one cannot cure vitamin C deficiency by taking more vitamin D. Thus, Rimé posits that if social sharing fails to stimulate sufficient cognitive work, the residual emotional intensity keeps the person wanting to share the emotion until it is resolved.

Given the findings from social sharing literature, maybe co-rumination is fuelled and sustained by an overdose of emotional content or a “cognitive work deficit.” If co-ruminators focus too much on talking about the negative emotion at the expense of engaging in problem-solving, the relief from the conversations could be short-lived and lead to recurring co-rumination over the long term. This mechanism is quite feasible, as many co-rumination researchers have suggested that problem-solving orientation may help mitigate the negative influence of co-rumination (e.g., Calmes & Roberts, 2008; Hankin et al., 2010; Starr & Davila, 2009) and individual rumination has been shown to interfere with problem-solving (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). However, I am not aware of any co-rumination experiment that provided empirical evidence on whether cognitively simplistic or overly emotional language predicts prolonged co-rumination. Therefore, examining the role of verbal content of co-rumination conversations would address an obvious gap in the literature.

Nonverbal processes

Conversations are made of more than words alone. Alongside the verbal discussion, a conversation unfolds as a mutually responsive nonverbal dialog that is conducted through multiple channels such as facial expressions, intonations, gaze directions, posture, and other subtle—or not so subtle—signals of emotion. During face-to-face interaction, people adjust to each other

dynamically without having to stop and pause to take in the explicit meaning of the information being communicated (Parkinson, 2001, Parkinson, Fischer, & Manstead, 2005). Interestingly, when people offer support in highly emotional situations, they tend to favour nonverbal behaviours, such as hugging or touching, over verbalisation (Christophe & Rimé, 1997), which suggests that the nonverbal channel could play an important part in real-time co-rumination.

The involvement of nonverbal expressions in co-rumination seems plausible, because past research has linked nonverbal behaviour with both relationship satisfaction and contagion of negative emotions. During social interaction, nonverbal engagement can signal interest and approach motives (Cegala, 1981), which have been associated with increased intimacy (Burgoon et al., 1984). In terms of negative emotions, Schwartz-Mette and Rose (2012) suggest that during co-rumination, the less-distressed partner may unintentionally mimic the nonverbal expressions of high negative emotion in the other partner and internalize the distress over time. Nevertheless, this suggested mechanism remains unexplored in the context of co-rumination.

The studies that have observed real-time co-rumination (Byrd-Craven et al., 2008, 2011; Rose et al., 2005) have not paid attention to the possible nonverbal aspect of co-rumination. In the studies to follow, I attempt to isolate co-rumination in both what is being said and how the co-ruminators say it. Luckily, for research purposes, “how” is nearly orthogonal to “what,” as a silent video of interaction carries a lot of the “how” while reducing the “what” to broad inferences of the content (unless people can lip-read, of course). On the other hand, a transcript without specific notation for nonverbal or vocal characteristics reduces the conversation to only what was said without any information on how it was said. Whether one channel correlates more with self- or observer-rated co-rumination should yield clues to the conduits of co-ruminative processes.

SUMMARY OF KNOWN AND UNKNOWN

Because of the dominant role that interpersonal communication plays in co-rumination, I have proposed that co-rumination is best understood in terms of a conversation, which draws attention to the relational nature of co-rumination. Since conversations require two interacting individuals, they—and presumably co-rumination, too—are best understood at the dyadic level. If we conceptualise the long-term depressive effect of co-rumination in conversational terms, we can say that the depressive trajectory of dyadic co-rumination should be reflected in a series of increasingly negative conversations over time. Simply put, if someone has increasingly negative conversations with others, he or she might be headed toward depression. If co-rumination has a predictable long-term downward trajectory, perhaps shorter-term increases in negativity might be observable also in real-time data as well. However, the evidence is simply lacking. It is unknown whether the dyad members feel better, worse, or the same after a co-ruminative interaction.

The depressogenic nature of co-rumination and depression suggests the existence of conduits through which co-ruminative processes operate between co-ruminators. Two principal conduits with rich research traditions are verbal expression of emotion and nonverbal expressions of emotion. Both research areas have robust theoretical and methodological frameworks that are applicable to negative emotion in co-rumination. Perhaps by researching co-rumination during face-to-face interactions, we might find clues to why it hurts people in the long run. By determining the specific conduits that lead to “empathic depression,” it might be possible to design better diagnostic tools and accompanying interventions.

The first study in this part of the thesis (Study 2.1) aims to chart the real-time trajectory of co-ruminative conversations to see whether co-ruminators end their conversations on a higher or lower note than people who are less likely to co-ruminate. Taking a cue from the TIES framework (Butler, 2011), I will employ continuous real-time data collection and use dyadic multilevel analyses. The second experiment, Study 2.2 will analyse the language used by the co-ruminators in order to understand how language could reflect co-rumination. The final study will try to establish whether verbal or nonverbal behaviour carries more weight in co-rumination by recruiting third-party raters to score the conversations through observational methods adapted from the work of Rose and her colleagues (2005). Both Studies 2.2 and 2.3 will also attempt to gather evidence of heteromethod validity for the co-rumination construct.

STUDY 2.1: CONVERSATION DYNAMICS

In an old joke, a guy points out that a businessman is losing money on every sale. The businessman shrugs it off and says “*Yes, but I’ll make it up in volume!*” In many ways, a similar mechanism might explain why co-rumination is associated with depression over the long term. Co-rumination is characterised by an excessive focus on negative emotion (a “mood loss”) and frequent repetition (“volume”). If conversations focusing on negative emotions leave people feeling worse afterwards, frequent commiseration would surely put one’s mood on a downward trajectory.

The major rationale for the study is to find out whether specific dynamics—in particular, a straight downward trajectory or a curvilinear rebound—are associated with co-rumination. At the moment, co-rumination literature has made a significant contribution by showing that certain conversational behaviours are associated with maladaptive mental health outcomes (Rose, 2002; Rose et al., 2007), but the literature is less clear about which dynamics connect present co-rumination to future mood disorders. By looking at both social sharing and co-rumination literature, two clear possibilities emerge. The first possibility is a naïve interpretation of co-rumination as a linear downward process: the more people co-ruminate and rehash negative emotion, the more depressed they get. If long-term depression cumulated like sediment of chronic negative emotion, one would expect to see high co-ruminators end up with a lower mood after the conversations than low co-ruminators, suggesting a downward slide in mood.

The other alternative is that co-ruminative people are “addicted” to the short-term emotional relief that they get from having a heart-to-heart talk with a friend. According to social sharing literature, people need to cognitively process the emotion in order to recover from it, but in the short term this integrative cognitive work can be supplanted by socio-emotional soothing from others, especially immediately after intense negative experiences (Rimé, 2009). Naturally, receiving emotional support from close others can be a significant boost to one’s mood, which suggests that co-rumination should be associated with a parabolic trajectory. If emotional succor received from others slingshots the co-ruminator to be in a *better mood* after sad conversations, co-

rumination should be associated with an interaction between co-rumination and a quadratic time term.

But if co-rumination were to leave the co-ruminators *better off* afterwards, why would this be maladaptive? In terms of social sharing of emotion (Rimé, 2009), the upswing could be due to the socio-affective benefits gained by verbalising one's feelings. Past research shows that the emotional intensity of the emotional event being talked about is associated with the amount of socio-affective benefits that people receive (Rimé, 2009), meaning that sharing of negative emotions is commonly responded to with soothing and emotional support. The key assumption is that if co-rumination elicits too much of socio-affective benefits from others at the expense of help in cognitively processing the emotion. No matter how pleasant receiving 'tea and sympathy' from friends feels, it can act like a medicine that only masks the symptoms, but has no curative powers. Thus, co-rumination could be associated with an upward emotional rebound in the short short term at the cost of a longer-term downward trend (i.e., an interaction of co-rumination and time).

It has also been suggested that the response mode of the social sharing partner is important. That is, people who are well-equipped to guide others to think about their problems in a constructive manner help others recover better from negative emotion over a few days (Rimé & Nils, 2012). Conversely, people who are only capable of delivering emotional succor should boost people's moods in the short term, but their short-acting soothing might not be able to keep the co-ruminator's mood up indefinitely. Thus, we could expect to see a three-way interaction effect between the co-ruminative dyad members' co-rumination levels and the quadratic time term: high co-ruminators might make others rebound higher in the moment.

To answer these questions, data from naturalistic conversations were collected from long-term romantic couples ($N = 32$). After the conversation, the participants traced their emotional valence during conversations, allowing me to test the hypothesis that co-rumination shapes the emotional trajectories of negative conversations. This design allows me to capture emotional trajectories of sad conversations to see if co-ruminators receive a real-time mood boost from sharing negative emotion, suggesting that the path from present co-rumination to future depression

is not a linear slide, rather than an emotional rollercoast ride of short ups followed by deeper downs. The present experiment allows me to take a snapshot of these short, hypothetical ups.

In the video-cued recall paradigm, participants retrospectively provide continuous ratings of emotion. This method has been especially popular in close relations research. As the canonical example, Gottman and Levenson (1985) collected continuous data of emotion experience by having married couples discuss an area of conflict. During the conversation, the researchers recorded on video the verbal and nonverbal displays and made physiological recordings of the couple's autonomic reactions. After the conversation, the spouses independently viewed the video of the conversation and used a bipolar rating dial to indicate how they were feeling each moment during the actual interaction. The spouses' autonomic reactions were also recorded during the video-cued rating procedure. Because the physiological response patterns were similar during the actual interaction and the viewing session, Gottman and Levenson (1985) suggested that viewing the video re-created some of the original emotional experience. Providing further validity to the measurement paradigm, Rosenberg and Ekman (1994) demonstrated that participants' recollections of specific emotions during the video playback coincided with facial expressions usually associated with those emotions.

Method

Participants

Both married and unmarried heterosexual couples ($N = 32$) in long-term heterosexual relationships were recruited (average relationship duration was 3.9 years, $SD = 3.00$). On ethical grounds, couples in acute relationship conflict or with mental health concerns were excluded. The women's mean age was 26.65 ($SD = 7.03$), and the men's was 28.06 ($SD = 8.09$). Most participants were of Caucasian descent from English-speaking countries. All participating couples were entered in a prize draw for a £100 gift certificate to a large online retail company.

Apparatus

Video recording. Real-time conversations were recorded on video with two visible video cameras and battery-powered lapel microphones. The images from each camera were spliced together with a video mixer to show the participants side-by-side on a single screen (as seen in

Figure 4). The resulting high-resolution digital video was stored in a movie file for replay later in the experiment.



Figure 4. A still image of video-recorded conversation.

Video-cued recall. The classic video-cued recall paradigm (for more information, see Measures section below) requires that participants provide a continuous stream of ratings while they watch a stimulus video. When these ratings are synchronised with the events in the stimulus video, data regarding those events can be collected.

From a technical perspective, a video-cued recall system requires three components to function: playback, ratings, and synchronisation. For video playback, the early systems used analogue videotapes played back on a TV system. For ratings, researchers have typically relied on analogue-to-digital equipment, often based on specialised devices built on resistors that control voltage output, much like dimmer-switches that control the brightness of a lighting fixture. To maintain synchronisation between the ratings and the videotape, separate time-code generators were used to superimpose the elapsed time to the TV screen to be recorded on video. In order to

work appropriately, analogue rating equipment requires precise calibration in order to map the level of output electricity to the participants' moment-by-moment self-report. Because the analogue videotape was played back mechanically, the synchronisation between the ratings and the video was also vulnerable to mechanical malfunction.

In order to side-step issues stemming from using specialised analogue-to-digital data-acquisition devices, I implemented a digital version of the video-cued recall paradigm relying on a very generic device, the humble computer mouse. For the experiment, I wrote a custom software application to collect video-cued recall data. The application presented participants with video replays of their conversations (stimulus video) and asked them to move an on-screen slider up or down depending on their emotional valence during that moment in the video (data stream). Because both the video played back to the participants and the data captured from them were both digital, they were very easy to synchronise. The software was written using Ruby language (Flanagan & Matsumoto, 2008) and the Shoes graphical user interface toolkit (Stiff, 2009) on a Mac OS X 10.4 platform.

In addition to implementing the three components required for video-cued recall, the software also took care of instructing the participants. First, the application explained the task to the participant (e.g., *"Next, we will ask you to complete tasks regarding your emotional experience during the conversations"*) and instructed him or her how to operate the software (e.g., *"On the left edge of the screen, you can see a rating scale and a lever"*). Then, the software asked the participant to place the lever to the neutral midpoint of the scale and replayed a video of one of the conversations the participant just had. During playback, ratings were collected four times per second and the values were aggregated to one rating per second. Each participant saw each of the videos (happy and sad) twice, once to rate their own emotional valence and a second time to estimate their partner's valence. The order of the videos and whose emotions were being rated were randomised by the software. Figure 5 shows an example of the software in operation.



Figure 5. Video-cued recall software in action.

Measures

Co-rumination. The Co-Rumination Questionnaire (CRQ; Rose, 2002) is a 27-item self-report inventory that assesses unipolar construct of co-rumination in close relationships. The measure was modified to make a reference to “my partner” instead of “my friend.” The measure demonstrated high internal reliability in the sample (Cronbach’s $\alpha = 0.88$). For a thorough overall explanation of the measure, please refer to Study 1.3 in Part I.

The sample was limited in the range of co-rumination scores. Figure 6 shows a scatterplot of the male and female partners’ co-rumination scores. The partners’ levels of co-rumination were not significantly correlated, $r = 0.21$, $p = .250$.

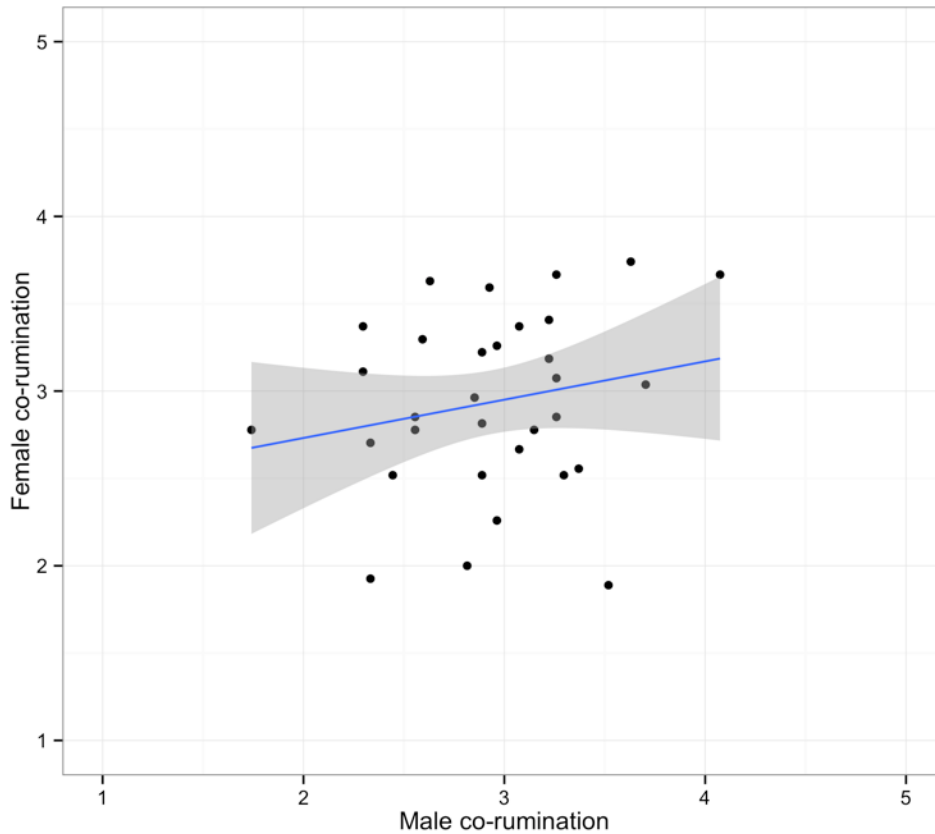


Figure 6. A scatterplot of the male and female partners' co-rumination scores.

Pre- and post-task emotions. Before and after each conversation, the participants completed a brief measure of their emotional state. The measure consisted of eight emotion words (happy, gloomy, anxious, calm, energetic, sluggish, angry, and guilty) and the participants were asked to indicate the extent to which they felt it at the moment on a scale from 1 (Not at all) to 7 (Extremely). To index the overall negative valence of the conversation, the post-conversation happy scores were reversed and averaged with post-conversation gloomy scores. For the pre-task emotions, the correlation between happy and gloomy scores was $r = -0.55, p < .001$. The post-task correlation was $r = -0.68, p < .001$.

Continuous emotional valence. Using a retrospective video-cued recall paradigm, the participants provided self-report of their emotional valence (feeling good versus feeling bad) with a computerised system operated with a mouse. The visual-analogue measurement scale was anchored to a happy face at the top of the screen and a sad face in the bottom. The scale ranged from 50 (happy) to -50 (sad), but these values were not visible to the participants.

Procedure

The study had three phases: an online questionnaire, a one-hour lab session, and a follow-up questionnaire.

Online questionnaire. Prior to the lab session, the participants completed an online questionnaire at their leisure. In addition to demographic data, the questionnaire included the 27-item co-rumination measure (CRQ-27) and various other measures not reported here.

Lab session. For the lab session, the romantic partners visited the department, one couple at a time. After being greeted, the participants were led to the laboratory where they were briefed about the purpose of the experiment and their informed consent was secured. The participants were seated face-to-face and asked to pick two topics of their own choosing—one happy and one sad—to talk about on camera. They were informed that they would discuss the topics later in the experiment, that the conversation would be recorded, and that they would have an opportunity to see the recordings before providing a further consent to allow the researchers to retain the videos for future use. The couples were free to choose a topic that was salient to them at the time and which they would feel comfortable discussing.

After choosing the topics to discuss, they completed a measure of their emotional state before the conversation. Then, the participants were instructed to talk about one of the topics (i.e., the topic order was randomised). Each dyad talked about the topic for 2.5 minutes, after which they completed a measure of their emotional state after the conversation. The dyad then talked for another 2.5 minutes about the other topic and filled another post-conversation emotional state measure.

The dyad members then completed a computerised emotion-recognition task (as a distraction) in separate rooms while the recorded video was transferred onto two laptops. After a couple of minutes, once the emotion recognition task was over, the participants were separately briefed on the video-cued recall procedure and left alone to complete the continuous emotion rating tasks. After both participants were ready, they were asked to give informed consent allowing the researchers to use their videos for further data extraction. Finally, participants were thanked and escorted out of the building.

Follow-up survey. Several months after the lab session, the participants were contacted via email and invited to complete a separate set of questionnaires. The follow-up questionnaire included various other measures that were part of a different research initiatives (Emotion Regulation in Others and Self; EROS research network), but only a co-rumination measure were included in the present analyses. Each participating couple was compensated £20. As part of the follow-up survey, the participants also retok the co-rumination measure (CRQ-27). On average, the participants took the questionnaire 233 days after the initial survey, $SD = 70$. At the time of the follow-up, 29 of the couples completed the survey (three couples had broken up).

Results

The present experiment attempted to establish whether co-rumination would shape the emotional trajectory of a conversation. Specifically, I set out to test whether co-ruminators would feel worse after sad conversations.

Post-conversational emotion state

As a simple manipulation check, the conversation topic had a measurable effect on the participants' emotions. As Figure 7 demonstrates, almost all emotions were significantly shifted by the conversations. The overall pattern was that after the happy conversations, the participants reported feeling more positively valenced emotions (i.e., calmness, energy, and happy) and less negatively-valenced emotions (e.g., angry, anxious, gloomy, guilty, and sluggish. A repeated-measures t-test comparison of the pre- and post-task emotions showed that all of the reported emotions were significantly affected by the happy conversation and almost all emotions by the sad one (only anxiety and sluggishness were unaffected). The pattern in experienced emotions after a sad conversation was the reverse of the happy condition: the conversation increased reports of negatively valenced emotion words and reduced positive ones.

This pattern was reflected in the negative valence composite as well (see Figure 8). After the sad conversation, people did feel greater amounts of negative valence. Likewise, they felt less negative after a happy conversation, although these data are not reported here as the following analyses will focus on the sad conversations. The increased negativity was also present in the continuous measure of emotional valence. On average, men ended their sad conversations at -15.2

and women at -15.0 , both significantly below the starting point, $t(31) = 5.45$, $p < 0.001$ for men and $t(31) = 5.40$, $p < 0.001$ for women. The difference in endpoint means was not significant between the genders. As a summary, it is quite clear that the choice of topic did serve as an effective mood manipulation.

In terms of co-rumination, the results were not significant. In a linear regression model that predicted negative valence from co-rumination, gender, and topic, only topic remained a significant predictor of negative valence, $R^2 = .52$, $F(4, 121) = 33.29$, $p < .001$. Against predictions, neither gender nor co-rumination—or an interaction thereof—were associated with a drop in overall post-conversation mood.

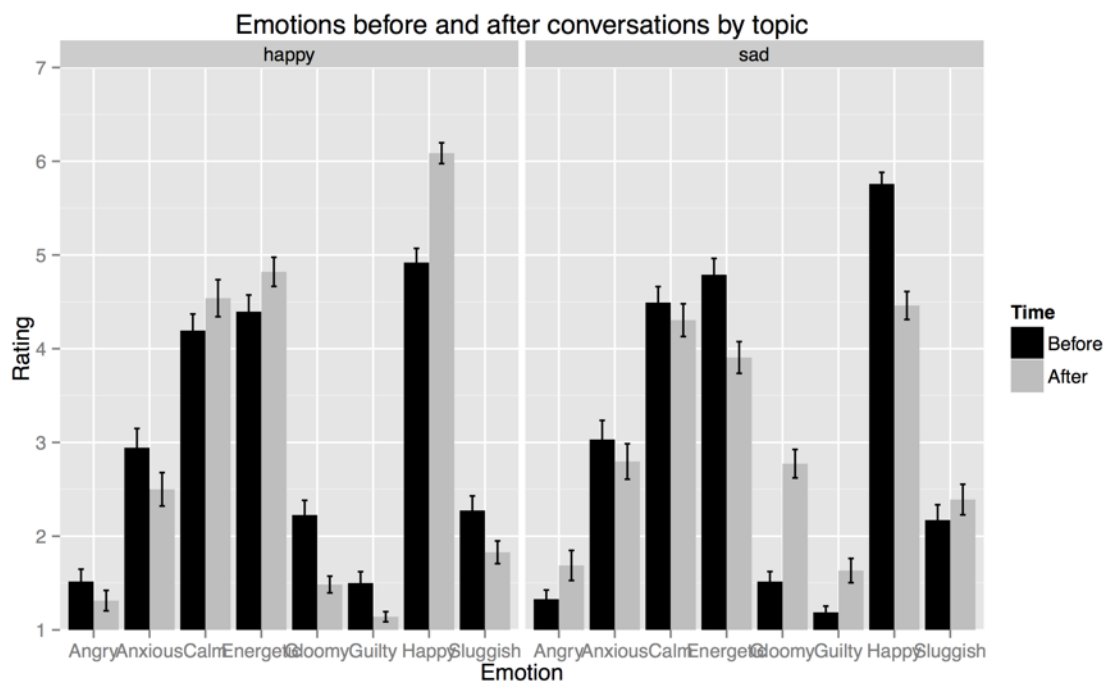


Figure 7. Participants' emotions before and after conversations by topic.

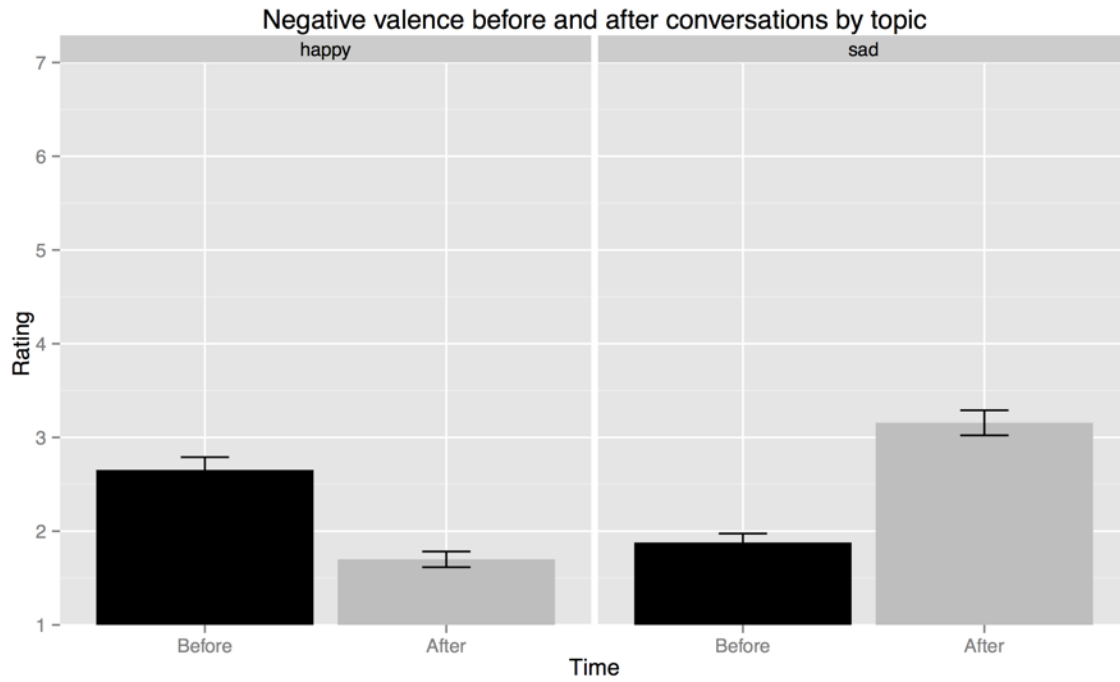


Figure 8. Overall negativity before and after conversations.

Typical emotional trajectory during conversations

The trajectories of the conversations reflected the above analyses of overall sentiment during the conversations. Figure 9 plots an average course of both sad and happy conversations, showing the marked difference between the two in terms of emotional valence. Figure 10 shows a more detailed example of the data, focusing on only one of the couples. The couple exhibits similar dynamics as the average trajectory during the sad conversation: two thirds of the conversation is dominated by a downward nosedive, followed by a rebound during the last third.

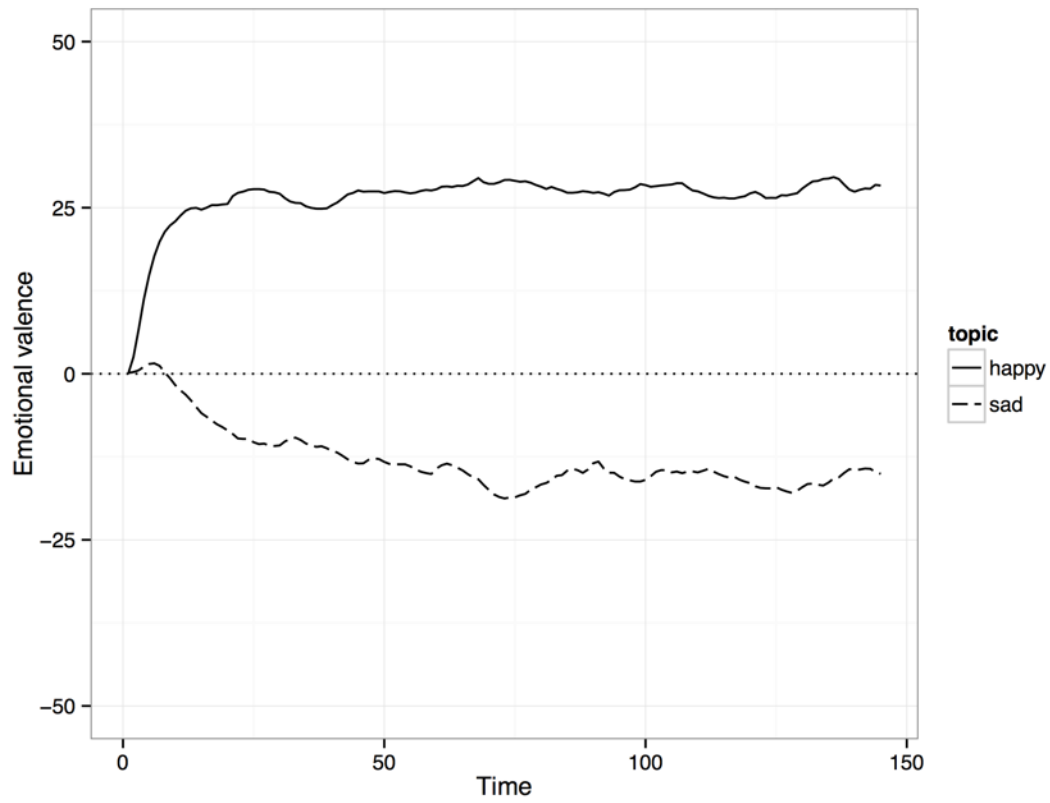


Figure 9. Average trajectories of happy and sad conversations.

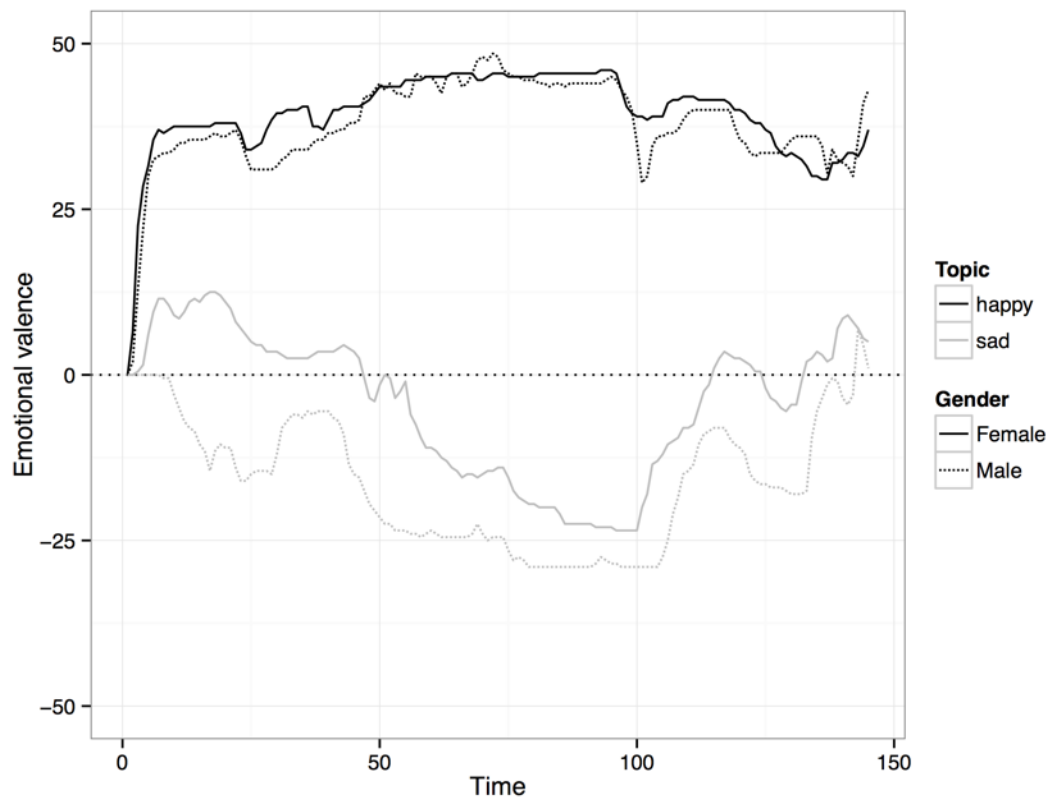


Figure 10. Example of one couple's emotional valence during sad and happy conversations.

Emotional trajectory and co-rumination

To take into account the reciprocal influence that the partners in the conversation may (and probably do) exert on each other, the data were modelled using a multilevel framework implemented with multilevel package (Bliese, 2012) in R language (R Development Core Team, 2009). Multilevel Modeling (MLM; Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2004) can be thought of as ordinary least-squares models, but with additional variance terms for dealing with non-independent data due to group membership. MLM models have a variance term that indicates how much the intercept (i.e., mean) of the dependent variable (DV) differs between groups. The second variance term does the same for the slopes between independent (IV) and dependent variables. The third variance term reflects how much individual scores differ from predicted values within a group.

I chose to implement a two-level model (time-points nested within couples) over a three-level model (time-points nested within partners nested within couples), because the dyads are distinguishable by gender. This model has been recommended for modeling within-dyad processes regarding changes over time (Gonzalez & Griffin, 2000; Kenny & Zautra, 1995; Laurenceau & Bolger, 2005; Raudenbush, Brennan, & Barnett, 1995). In the present study, level 1 models the second-to-second, self-reported emotional valence of men and women, and level 2 captures their dyad relation. Thus, emotion ratings were modeled as a function of time and each partner's co-rumination scores as well as gender, grouped by dyads. The intercept (e.g., average valence) or slope coefficient (e.g., the relationship between co-rumination, time, and valence) served as the dependent variables for models at level 2. In the model, gender, own co-rumination, partner's co-rumination, and time were entered as fixed effects. Gender and dyad membership were entered as random effects. The estimation was performed with the nlme package (Pinheiro & Bates, 2000) using steps suggested by Bliese (2012). In order to account for serial autocorrelation in the second-by-second ratings, an autoregressive integrated moving average (ARIMA) autocorrelation structure of order 1 was specified (i.e., adjacent timepoints were expected to show a statistical dependency). The full R model output is included in Appendix 1.

In step one, the assumption that within-group variation is present in the data was tested by estimating an unconditional means model or a null model (i.e., valence predicted by dyad membership alone). In effect, the only predictor of valence was an intercept term (i.e., couple mean). Intraclass Correlation Coefficient (ICC) was calculated from the results to determine how much of the total variance were between-couple variance. In the null model (i.e., only using the dyad membership as a predictor), between-couple variance was 59.9 and within-couple variance 209.0, yielding an intraclass correlation of .22. Intraclass correlations for dyads (between-dyad variance divided by total variance) are interpreted in the same fashion as Pearson correlations (Kenny et al., 2006, p. 33). Thus, if a dyad member has a high score on a measure and the intraclass correlation is positive, then the other dyad member also has a relatively high score.

In step two, the reliability of the group means was estimated. Specifically, the a_{wg} for single item measures was calculated (Brown & Hauenstein, 2005). The mean a_{wg} was 0.75. By convention, values at or above 0.70 are considered good agreement, so there was a high level of agreement within the couples in regard to emotion ratings, providing further evidence for the necessity of a multilevel model.

In step three, all hypothesised predictors and their interactions were entered into the model and the parameter values estimated using restricted maximum likelihood method.

Gender. In a model that predicts emotional valence during any second of the participants' sad conversation, gender was a significant predictor. Two dummy variables (one for male and one for female) were created for gender. For the male dummy variable, male participants were given the value of 1 and female participants 0. For female dummy variable, the values were reversed. This data arrangement allows to estimate separately the effects of each gender in a single model.

The coefficients for both variables indicate the expected value when the other predictors are zero. Because the other variables were centred around their means, the coefficients represent the average valence for average co-ruminators during the midpoint of the sad conversation. At this time, men were predicted to score -17.881 on a scale from 50 (very happy) to -50 (very sad), indicating that their emotional valence was depressed significantly below the neutral baseline,

$t(9225) = -11.19, p < 0.001$. Women, too, scored significantly below neutral: $-18.769, t(9225) = -9.24, p < 0.001$.

Time. To quantify the impact of time on emotional valence, a linear and quadratic time variables for each gender were included as predictors. All time variables were centred with zero-point indicating the midpoint of the conversation (145 seconds of data were recorded for each conversation). Since the interaction of time variables with co-rumination variables was included in the model, the interpretation of these scores is conditioned on co-rumination at zero. Since the variables for co-rumination were mean-centred, this means that the effects are interpreted with an average co-ruminator in mind.

For both men and women, the linear time variable was significant. The linear time coefficient for men was $-0.089, p < .001$ and -0.090 for women. This means that at the midpoint of the conversation, the emotional trajectory of average co-ruminators was on a downward path, dropping almost a full point for every ten seconds of the conversation. The quadratic time term was likewise significant, 0.002 for men and 0.003 for women, $p < .001$ for both. This indicates that, for average co-ruminators, the downward effects of the linear trend were counteracted by a curvilinear rebound upwards.

With these information, we can plot the expected trajectory average co-ruminators. Because the time variables were interacted with co-rumination in the model, their interpretation is conditioned on the other predictor to be at zero. Thus, the coefficients for both linear and quadratic time represent the effect of time on emotional valence *for average co-ruminators* (i.e., centred co-rumination average equals zero). For males, the predicted valence for each second can be expressed as the equation $\hat{y} = -16.362 - 0.093x + 0.002x^2$. Likewise, the trajectory for women can be expressed as $\hat{y} = -17.785 - 0.085x + 0.002x^2$. Figure 11 shows a plot for both of the equations.

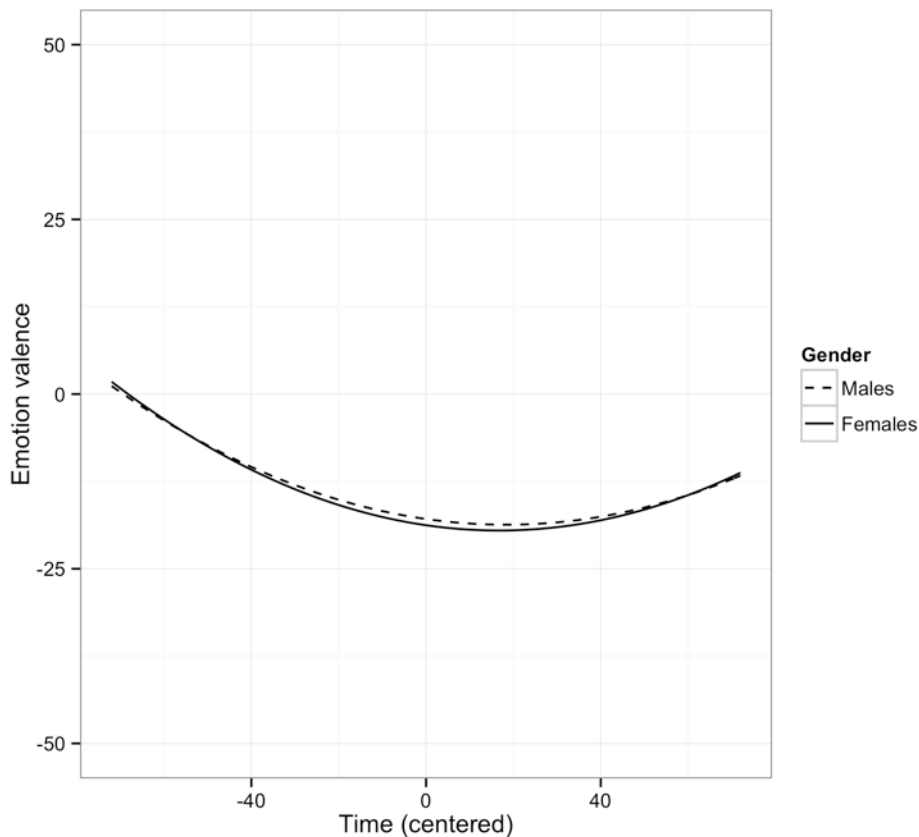


Figure 11. Predicted emotional trajectory during sad conversation for average co-ruminators.

Co-rumination. To investigate whether co-rumination has a direct impact on the sad conversation trajectory, male and female co-rumination scores (centred around the grand mean) were entered into the model. The prediction was that co-ruminative individuals would experience lower emotional valence during negative discussions, but the effect of the participants' own co-rumination was not significant for either gender. This means that in the middle of the conversation, one's own co-rumination by itself did not predict emotional valence. Furthermore, neither the partners' level of co-rumination or the interaction of both actor/partner co-rumination scores were significant. This suggests that merely being a co-ruminator—or being in a relationship with one—did not create measurable differences in absolute level of emotional valence at the midpoint of the conversation.

Co-rumination and time. Rather than focusing on differences at a single moment in time, the present study is more interested in quantifying the effect of co-rumination as time goes by. As noted above, the effect of time at the midpoint of the conversation for average co-

ruminators was negative. But would the effect be stronger for co-ruminators, meaning that the downward slope would be steeper for some participants? Looking at the interaction between linear time and co-rumination, an interesting gender difference emerges. For men, the prediction that co-rumination leads to a steeper, linear downward slope is supported, as the coefficient for the interaction term is -0.044 , $t(9225) = -5.171$, $p < .001$. This means that for average male co-ruminators, the effect of time changes to more negative with each additional point on the co-rumination measure. However, for women, the interaction term was a positive 0.021 , $t(9225) = 2.560$, $p < .001$, suggesting that for average female co-ruminators, the effect of time was positive, in part counteracting the linear downward trend for time.

For the squared time term, a compatible pattern was present. The rebound effect was not significant for men, but increased female co-rumination predicted higher valence rebound with a positive coefficient of 0.001 , $t(9225) = 5.409$, $p < .001$.

In terms of contagiousness of co-rumination, both men and women's emotional trajectories were influenced by their partner's tendency to co-ruminate (i.e., a significant interaction with linear time and partner's co-rumination score). Every one-point increase in the female partner's co-rumination score predicted a steeper linear downward trajectory for men, coefficient -0.048 , $t(9225) = -5.779$, $p < 0.001$. Likewise, having a co-ruminative male partner also meant a steeper linear decline in emotional valence for women, -0.042 , $t(9225) = -4.843$, $p < 0.001$. In terms of a rebound induced by partner's co-rumination, the effect was significant only for women, but to the opposite direction: having a co-ruminative partner was associated in a minor reduction in the curvilinear upswing, -0.0004 , $t(9225) = -2.037$, $p = .041$.

Because it is rather likely that the emotional valence trajectories are also shaped by the joint action of both partners' co-rumination scores, a three-way interaction was also added to the model for both linear and quadratic time terms (although the latter is technically a four-way interaction, because the quadratic time term in its own right can be interpreted as the changing effect of time on time itself, or time $\times$ time). The effect of time depended on the combination of the male and female co-rumination scores, but only for female participants. The *male co-rumination* $\times$ *female co-rumination* $\times$ *linear time* interaction was significant, -0.194 , $t(9225) = -11.987$, $p < .001$.

as well as *male co-rumination* $\times$ *female co-rumination* $\times$ *quadratic time*, -0.003 , $t(9225) = -6.648$, $p < .001$. Because these effects are difficult to interpret in isolation, Figures 12 and 13 show the predicted trajectories for five types of couples in which 1) both partners are average co-ruminators, 2) both partners are high co-ruminators, 3) both partners are low co-ruminators, 4) the male partner is a high co-ruminator and the female is low, and 5) the female partner is a high co-ruminator and the male is low. Low or high levels of co-rumination were calculated as sample mean of co-rumination scores ± 1 standard deviation. These cases illustrate the compound impact of gender, co-rumination, and time (including all interactions reviewed above).

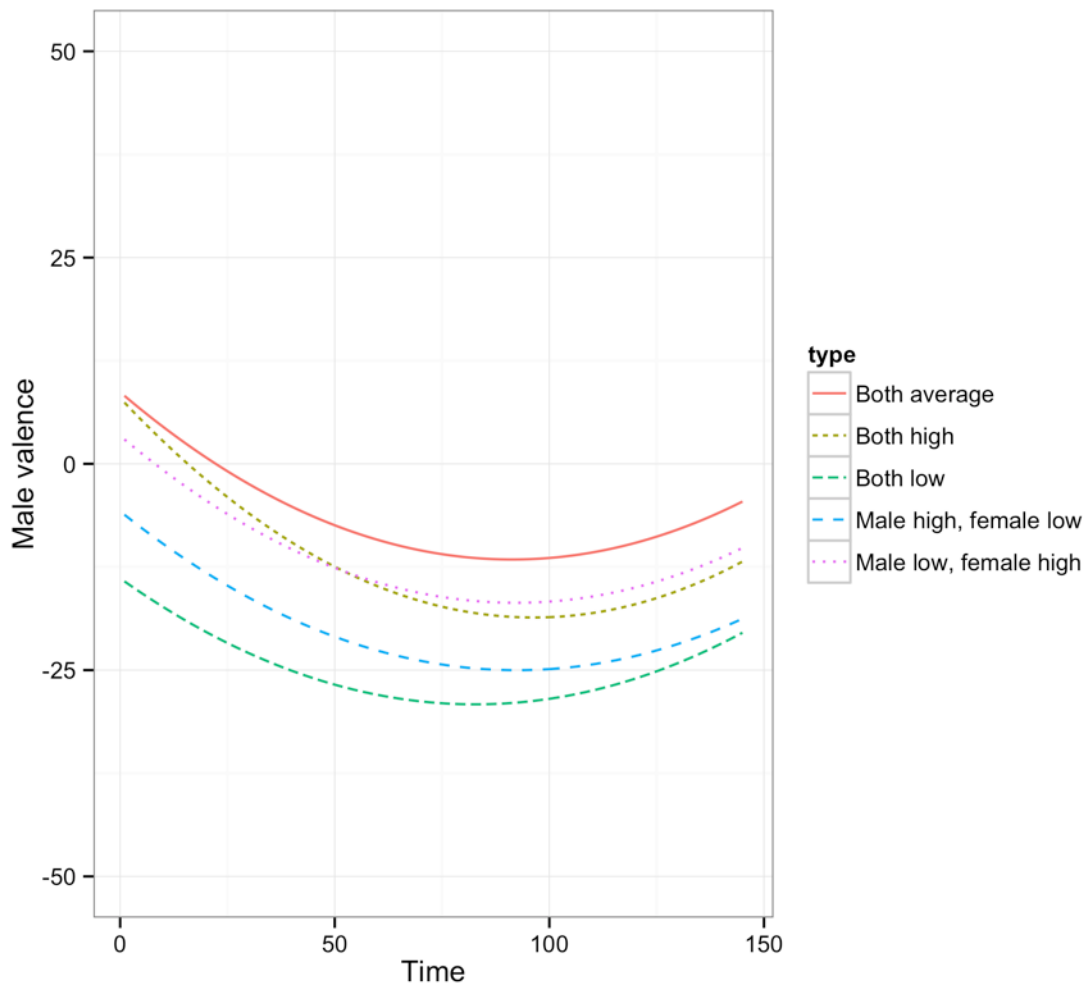


Figure 12. Predicted male valence trajectory during sad conversation for five types of couples.

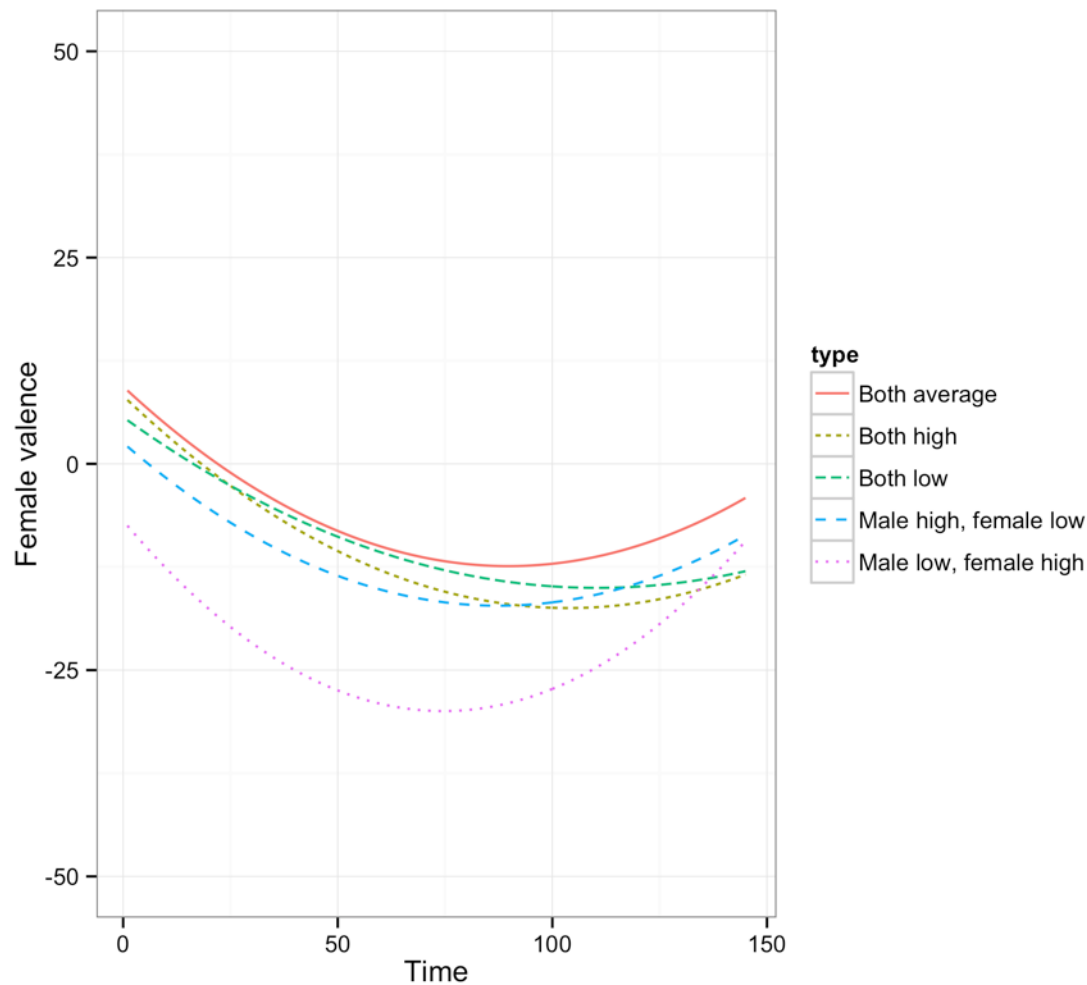


Figure 13. Predicted female valence trajectory during sad conversation for five types of couples.

Discussion

A naïve interpretation of Rose (2002) theory of co-rumination implies that co-rumination in the present leads to depressed mood in the future by focusing on negative emotion. If each co-ruminative conversation erodes the co-ruminators' mood a little, this cumulative effect could be a linear path to depression. Alternatively, co-ruminators could rebound after receiving socio-affective benefits from sad conversations (Rimé, 2009), making the long-term erosion in mood a series of short-term ups and long-term downs.

The pattern of findings is not as clear as we could hope for. On one hand, co-rumination was associated with a linear downward trend for average male co-ruminators, lending evidence to a simple effect of co-rumination on long-term mood. However, both a linear and quadratic upward trend for women, suggesting that women might be receiving emotional benefits from sharing their

negative emotions. On the other hand, having a co-ruminative partner was indicative of a steeper downward slope for both genders. Finally, for women, the steepness of their trajectory was in part determined by their partner's scores.

When all of the effects and their interactions were added together for predictions based on illustrative cases, the results portray a complex situation (see Figure 12 and 13). For both men and women, average co-ruminators fare the best by ending up nearly back to the neutral baseline after a sad conversation while all the other cases fared worse. Curiously, these also included a test case in which both partners were low co-ruminators, suggesting that some co-rumination might be better than none in terms of real-time emotional valence. For men, having either a highly co-ruminative female partner or both partners being highly co-ruminative appeared to lead to higher emotional valence at the end of the conversation. For women, being in a couple with high-low pairings leads to second-best outcomes, regardless of whether the male or the female is the more co-ruminative partner. However, the trajectory for a highly co-ruminative female paired with a man who co-ruminates very little had the most pronounced quadratic rebound and swept the lowest.

Although these results are not intuitively clear, they seem to suggest that co-rumination is associated with a significant rebound effect, although this effect is moderated by a complex set of interdependencies and gender effects (e.g., women deriving more rebound benefit from their own co-rumination while talking with their non-co-ruminative male partners). As predicted by social sharing theory (Rimé, 2009), some co-ruminators may derive socio-affective benefits from sharing their negative emotion and feel better in the moment. Although the linear downward trend was significant, the model created with the present sample rules out a simple decay in emotional valence for co-ruminators, as the rebound counteracts the downward trend. However, it appears that at the end of a sad conversation, all test cases were predicted to end on a lower note than at the outset, which leaves the door open for co-rumination to steadily reduce the co-ruminators' mood with each conversation.

Despite a confusing pattern of results, the experiment has some noteworthy implications. First of all, it provides evidence that co-rumination does appear influence emotions in real-time and shape overall trajectories of conversations. The practical implication of this is that future co-rumination research should pay attention to behaviours that unfold during face-to-face co-ruminative interactions, as they may contain the seeds of the problem. Although this experiment failed to uncover the mechanisms through which co-rumination leads to long-term mood impairment, the study does highlight an important aspect of co-rumination—its relational nature. Different combinations of high and low co-ruminating men and women had remarkably different outcomes. This suggests that examining co-rumination without reference to the other half of the co-ruminative relationship can be misleading and future co-rumination studies should account for dyadic effects.

Limitations

It is good to keep in mind that co-rumination was not associated with a worse emotional state as measured with the paper-based emotion self-report presented to participants immediately after the conversation. From these data, it appears that either the participants all returned to baseline rapidly after the conversations or the measure was not sensitive enough to detect the difference. Thus, it is possible that there is no real effect of co-rumination on post-conversation mood and that the trajectories are artifacts based on statistical noise. This is quite likely the case, as dropping just one couple from the analyses at a time leads to some of the effects to drop below significance (down to 12 significant effects from the present 14) or make others become significant (up to 17 significant effects). This instability in the results is largely due to two factors: small sample size and limited range of responses for co-rumination.

The greatest limitation of the present study is its small sample size. However, although the sample size is small in statistical terms, it is in line with other experiments that require data collection in a laboratory setting. For example, Ferrer and Helm (in press) used the exact same number of dyads for their study on physiological coregulation in dyadic interactions, although they also acknowledge their sample size is small. Although the high number of data points at the emotional valence level made the model better than just 32 data points, replicating the experiment with a larger sample size would be essential to clarify the situation.

In the Method section, Figure 6 showed the limited range of co-rumination responses (from 1.75 to 4.07 on a scale from 1 to 5), which means that the model was based on largely average scores. The sample failed to capture participants with extreme scores on co-rumination, and the dynamics of co-rumination at the low and high ends of the spectrum could be dramatically different from what can be inferred from average co-ruminators. It is also possible that the study only included people with less vulnerability to the effects of co-rumination. On ethical grounds, couples in acute relationship conflict or with mental health concerns were excluded. In effect, the couples in the experiment would, by design, have less worrisome issues on their minds and less severe mental issues than the true population, which may have skewed the results.

Even if the sample did contain “true” co-ruminators, it is likely that the video recordings only contained a facsimile of the conversations the couples would have had in real life. Conversations have an interesting “quantum” property: the mere act of measurement may cause a change in the very thing which was hope to be measured. Although the goal of the experiment was to capture naturalistic conversations, the laboratory environment may not have been very conducive to relaxed conversation. For one, the participants knew in advance that their conversation would be recorded and most likely engaged in some form of impression management. Because either amplification or suppression of emotional expressions is likely to influence the content or course of the discussion, the recorded conversations may differ in important ways from real conversations the couple has when they are in private. Some attempts were made to make the decor less office-like (e.g., the lab had a small coffee table and the computer cubicles had posters of modern art, thanks to Dr. Gwenda Simons), but the fact remains that the laboratory may not be entirely suitable for capturing true in vivo conversations. I freely admit that the captured conversations were influenced in unknown ways by the laboratory context itself, but suggest that the present studies represent a more “true to life” data than what survey measures could capture.

Another issue is that although the video-cued recall data are supposed to be about the original event itself, the actual measurement was carried out after the fact. This means that there was an unavoidable difference between when the emotional valence was experienced and when it was reported. Ideally, the measurements would be collected concurrently, so that participants

report on their actual emotional experience in the present. Unfortunately, the benefits of concurrent self-report measures must be weighed against the cost of disrupting the emotional experience or distracting the participant from it (Larsen & Fredrickson, 1999). The best-practice advice about using video-cued recall methods is that the recall of the emotions should occur shortly after the emotional experience (Larsen & Fredrickson, 1999). Because the method has been used successfully after a delay of days in between the emotional experience and the collection of the ratings, the delay of few minutes during the present experiment was probably as soon as practically possible. However, one cannot step into the same river twice: the emotional experience is likely to be different from the memory of it, as even the briefest time between emotion and its measurement allows people to reflect upon and (re)appraise their experience in unknown ways.

The final limitation of the study is that the analysis methods may smooth over important sources of variation in the data by attempting to fit a single sweeping curve through all data points. Real conversations have more ups and downs that are overlooked by the present models. It is possible that real conversations may even exhibit non-linear patterns that are not well captured by linear models.

For future research, it would be beneficial to collect both real-time and longitudinal data. It would be possible to ask participants to install an improved-upon software similar to the one used in the present study on their own computers. This would enable them to record real conversations at home and rate them for emotional valence on their own. In addition to providing more ecological valid conversations, this study design would also enable longitudinal data collection, as with minor improvements the rating software could also administer experience-sampling questionnaires. Since the installed software would not require researcher intervention, the participants could repeat the procedure daily on their own for few weeks. This kind of improved design should help researchers to monitor both participants' long-term mood and real-time emotional exchanges, which should make it easier to connect the two.

Conclusion

It appears that at the most basic level, co-rumination does influence the trajectory of conversations. However, the findings of the present study are mute on how co-rumination operates

during the conversation: if co-rumination is able to shift emotional trajectories, how does it do that? We can tell that co-rumination appears to have an effect, but whether the effect is due to *what* is being said or *how* it is being said is unclear. Thus, the next experiments try to address these questions in more detail by analysing the content of the sad conversations that the participants had.

STUDY 2.2: LANGUAGE OF CO-RUMINATION

In this study, text-analysis software Linguistic Inquiry and Word Count (LIWC; Pennebaker, Francis, & Booth, 2001) will be used to analyse the words of the participants to find out whether co-ruminators use language differently from others. I will also demonstrate how crowdsourcing can make previously costly or time-consuming research steps feasible by employing online research assistants via Amazon's online labour market, the Mechanical Turk website.

Because verbalising one's feelings is an integral part of both social sharing and co-rumination, words might provide valuable information to help us understand these processes. In general, psychology has been interested in what people say and what words might reveal about them since the Victorian times. In 1901, Sigmund Freud (1901/1975) introduced the term *parapraxis* in his book *The Psychopathology of Everyday Life*. In folk psychology, the term became to mean any accidental slip of the tongue, also known as a "Freudian slip" (i.e., when you say one thing, but mean your mother). The power of words proved difficult to harness for the benefit of research, however. While using language as a source of evidence to test psychological theories was an attractive idea, it used to be very difficult to implement in practice until few decades ago. Before computers, it required monastic patience to even calculate basic descriptive statistics (e.g., word count, personal pronoun frequencies) for a text corpus, because the work had to be done by hand—one word at a time—much like monks had to copy books by hand before the age of printing press. For these historic reasons, investigations into the meaning of words have largely been qualitative in nature.

In the recent decades, the situation has dramatically improved. Unlike people, machines can quickly process large amounts of text. This allows researchers to test statistical hypotheses on data derived from actual words that people use (Tausczik & Pennebaker, 2010). One of the pioneers in the statistical analysis of language for psychology purposes is James Pennebaker. In the 1980s, he and his colleagues demonstrated that writing about emotions is beneficial for health (e.g., Pennebaker & Beall, 1986). In his search for a more efficient method of text analysis, Pennebaker found that no suitable software existed for his purposes and Martha Francis developed

one as part of an exploratory study of language and disclosure (Francis & Pennebaker, 1992). The result was a computer program called Linguistic Inquiry and Word Count (LIWC; pronounced “Luke”). The current version of LIWC was released in 2007 (Pennebaker, Chung, Ireland, Gonzales, & Booth, 2007). It compares words in a given text to a dictionary of over 70 word categories that include standard grammar (e.g., articles, prepositions, pronouns), psychological processes (e.g., positive and negative emotion words, cognitive processes such as the use of causal words and insight words, and traditional content dimensions (e.g., sex, death, home, occupation). For example, “cried” belongs to *sadness*, *negative emotion*, *overall affect*, *verb*, and *past tense verb* categories (Pennebaker et al., 2007).

However, before LIWC can do any number-crunching, spoken word has to be captured into a suitable digital format of written text, which creates an expensive bottleneck in the language research pipeline. Although automated speech recognition keeps getting better, human labour is still required for accurate transcriptions. Although professional transcribers can almost type at the pace of a conversation, this is a rare skill and such elite transcribers command a premium price for their services. Fortunately, crowdsourcing provides a provides a low-cost, high-quality solution to this speech-to-text problem. Instead of one expert transcribing hours of conversations, thousands of amateurs could transcribe a few sentences each. In essence, tedious tasks are split into numerous tiny ones which are then completed by a large group of people. Amazon Mechanical Turk (MTurk) is an online service offered by Amazon Web Services that allows the coordinated use of human intelligence to perform tasks that computers are yet unable to do (Amazon, n.d.). It provides an on-demand workforce that has been shown to produce high quality data. In language annotation tasks, non-expert workers can equal the performance of expert annotators (Rion, O’Connor, Jurafsky, & Ng, 2008) and Buhrmester, Kwang and Gosling (2011) demonstrated that data acquired via MTurk are at least as reliable as those obtained via traditional methods.

The present study is also an opportunity to see if other operationalisations of co-rumination are supportive of it as a psychometric construct. Campbell and Fiske (1959) suggested that more than one measurement method must be used to establish the validity of a measure. Although co-rumination has already been measured via heteromethod means from real-time conversations (Byrd-Craven et al., 2008; Byrd-Craven et al., 2011; Rose et al., 2005),

unfortunately none of these articles have reported the observed correlation between self-reported and observer-coded co-rumination, although observer-rated co-rumination has been reported to be correlated with supportive and acknowledging responses to problem statements made by a friend (Rose, Schwartz, & Carlson, 2005; however, this finding was disseminated via a conference presentation and not a journal article). Working from the assumption that co-rumination could emphasise certain language features that are characteristic to it—specifically, a focus on negative emotion and excessive verbal output (Rose, 2002)—it seems logical that measures capturing these dimensions in language would share variance with self-reported co-rumination. Thus, relatively objective, computer-scored evidence for the basic features of co-rumination would be an important contribution towards heteromethod validity of co-rumination.

According to Rose (2002), “co-rumination refers to *excessively* discussing personal problems within a dyadic relationship” (p. 1830; emphasis mine). As *excess* is one of the defining characteristics of co-rumination, it sounds plausible that it also reflects in the language of co-rumination. That is, if someone talks frequently and repeatedly, it would mean that they would utter more words than someone who talks infrequently and sporadically. LIWC offers two variables to measure the number of words per conversation: total word count and average number of words per sentence. Thus, we should see a positive correlation between co-rumination and the two basic word count measures: co-ruminative people should talk more. In addition to simple word counts, LIWC also captures more nuanced linguistic data, such as words relating to psychological processes and general affect. Another hallmark of co-rumination is dwelling on negative affect (Rose, 2002), which I predict should reflect in co-ruminators’ language as an excess of negative emotion words. After all, it is rather difficult to talk about negative emotion without using sad language. Thus, a simple model of individual co-rumination could be captured by just one’s negative sentiment and verbal output during a conversation.

In addition to testing basic predictions derived from the definition of co-rumination, I will test an alternative model by integrating theory from social sharing theory (Rimé, 2009) to test the role of cognitive complexity and socio-affective soothing in predicting present levels of co-rumination (T1; co-rumination measurement prior to lab visit) as well as future levels (T2; co-rumination measurement during a follow-up survey). Language can also indicate how deeply a

person is engaging with the topic being talked about, which could yield cues into whether someone will begin to dwell on the topic and start to co-ruminate about it. For example, a person who only engages with the emotional aspects of the topic is more likely to feel the need to talk about it again, whereas a person who reappraises the meaning of the emotion through cognitive work is more likely to come to terms with the issue and put it to rest (Rimé, 2009). LIWC offers ways to quantify the relative conversational focus on cognition and emotion. As one of these measures, cognitive complexity can be thought of as a richness of detail in reasoning, and it should stand as a linguistic marker for a deeper cognitive engagement with the topic. Individuals whose language is cognitively complex use higher levels of exclusive words (e.g., “but,” “except”), tentative words (e.g., “maybe,” “perhaps”), negations (e.g., “no,” “never”), and discrepancies (e.g., “should,” “would”), combined with low levels of inclusive words (e.g., “with,” “and”; Slatcher, Chung, Pennebaker, & Stone, 2007; Pennebaker & King, 1999). Rimé (2009) suggests that only cognitive effort helps to relieve the long-term consequences of negative emotion. Based on this reasoning, cognitive complexity should predict reduced levels of co-rumination in the long run. On the other hand, language that focuses on emotion should predict increased co-rumination over time.

Method

All data for the present study are derived from Study 2.1. The audio tracks from the video recordings were transcribed to digital text files that were analysed for language usage with text-analysis software.

Apparatus

Linguistic Inquiry and Word Count. During text analysis, LIWC is given a series of text files to be processed one at a time. Then, each word in each file is compared to the dictionary file. For example, when LIWC analyses the sentence “it was a dark and stormy night”, it starts by consulting the dictionary file to see if the first word “it” has been indexed in any of the categories (Tausczik & Pennebaker, 2010). In the standard English dictionary that ships with LIWC, the word “it” is coded as a function word, a pronoun, and, more specifically, an impersonal pronoun. LIWC keeps track how many times it encounters each word category per file and processing “it” would increment the aforementioned three categories accordingly. The next word, “was,” would be

counted as a verb, auxiliary verb, and past tense verb. The software then proceeds through the entire list of text files provided to it and calculates the percentage of each dictionary category for each file. The final variables are expressed as the percentage of each dictionary category (i.e., the frequency of the observed word count is divided by the total word count in the sample). Word counts and words per sentence are not reported as percentages, but as frequency totals.

Measures

The data acquired through MTurk served as a foundation for a number of measures. In addition to the information about the participants themselves and their relationship collected in Study 2.1, the present study derived a number of linguistic and psychological measures from this corpus of text data. The MTurk transcription produced high quality results, as the transcription fragments were approximately 92% correct before merging and verification (i.e., usually only the first and last words of each fragment were incorrect, but this was expected by design). Conversations were analysed as text files that contained all transcript words attributed to a single partner during the sad conversation (i.e., if the conversations were theatre dialogue, the files would only contain lines for one actor in a single act).

Conversational turns and verbal output. In total, the participants spoke 1,693 times during the sad conversations. The conversational turns varied greatly in terms of length, as the shortest responses were made up of either a single word or a nonverbal response, such as laughing. The longest conversational turn, on the other hand, was 46 words in length. The majority of turns were than 10 words (mean = 8.03, $SD = 8.02$). However, because even brief interjections or affirmations by the speaker's partner would count as an interruption, the conversational turn is not a pure measure of individual output, rather than an indication of a dyadic dynamic.

To get a better grasp of verbal output, LIWC calculates two word count metrics. The first measure, overall word count (WC), is the total number of words (i.e., strings of characters delimited by either whitespace or punctuation characters) per file. In practical terms, this is a proxy for the total verbal output by the participant. On average, each participant spoke 208.77 words during the sad conversation, $SD = 86.72$. The second measure, words per sentence (WPS) calculates the average length of words between punctuation characters (i.e., periods, question

marks, and exclamation points). In the terms of the present study, this is the participants' verbal output regarding a single unit of language. Unlike conversational turns, this metric is not affected by interruptions by the partner, as the transcripts only contained words spoken by one participant at a time. The mean sentence length was 8.57 words, $SD = 3.43$.

Cognitive complexity. A linguistic measure of cognitive complexity can be computed by summing normalised scores for the categories of *exclusive*, *tentative*, *negation*, and *discrepancy* words and subtracting *inclusive* words (Slatcher, Chung, Pennebaker, & Stone, 2007). In the sample, the measure had a Cronbach's alpha of .67, which by typical standards of interpretation means a scale suitable for exploratory studies. However, it is uncertain whether reliability statistics developed for questionnaires can be meaningfully applied to language use, as typical theories of measurement are built on the assumption of near-perfect test-retest reproducibility of responses whereas people generally don't repeat themselves verbatim (Tausczik & Pennebaker, 2010). At the dyadic level ($N = 32$), the cognitive complexity scores were correlated between male and female partners, $r = .55$, $p < .001$.

Negative sentiment. In order to capture how much the participants focused on negative emotion in their speech, the normalised scores for *overall affect* (e.g., "emotional", "mood"), *negative emotion* (e.g., "fear", "pain"), and *sad* words (e.g., "grief", "sad") were summed using the process outlined by Slatcher and colleagues (2007). Cronbach's alpha for the sample was .84. The partners' scores on negative sentiment were correlated between men and women, $r = .43$, $p = .014$.

Empathic response. A socio-affective response mode (Nils & Rimé, 2012; Rimé 2009) is characterised by appeasement, comfort, and care. To create a linguistic proxy for this kind of empathic response, the normalised scores in *affective* (e.g., "emotional", "likes"), *positive emotion* (e.g., "nice", "happy"), and *assent* (e.g., "yes", "OK") word categories were summed as above. The measure showed an acceptable level of internal reliability, Cronbach's alpha = .70, but the partners' scores were not significantly correlated with each other, $r = .23$, $p = .237$.

Co-rumination. The scores for co-rumination at the time of the experiment (T1) and several months after it (T2) were collected as part of Study 2.1. The partners' present levels of co-

rumination at T1 did not significantly correlate with each other, $r = .21, p = .250$. Partners' future levels of co-rumination were positively correlated, but with only marginal level of statistical significance, $r = .36, p = .058$.

Procedure

Although many stages of the speech-to-text process were automated, converting audio signal to machine-readable text for analysis was a complex procedure and required a multistep workflow. The process is detailed in Appendix 2.

Results

To answer whether co-ruminative processes are reflected in language, I attempted to predict present and future levels of co-rumination based on the word content and count of sad conversations recorded during Study 2.1. I started by testing two basic models of co-rumination, based on naïve interpretations of co-rumination (Rose, 2002) and social sharing (Rimé, 2009) theory.

The first model, based on a simple interpretation of co-rumination (Rose, 2002), posited that co-rumination is a linear combination of measures of linguistic excess and negative sentiment. In predicting present levels of individual co-rumination using three measures of verbal output (total output, turn length, and words per sentence) and negative sentiment, only the number of words per sentence was a significant predictor, with one more word per sentence corresponding to an increase of .067 points in co-rumination, $t(59) = 3.199, p = .002$. Contrary to expectations, negative sentiment did not reach significance. The entire model, however, was still significant, $R^2 = .11, p = .029$. The same set of predictors failed to predict future co-rumination altogether with no individually significant predictors. By itself, words per sentence were positively correlated with present level of co-rumination, $r = .33, p = .007$, and future co-rumination, $r = .26, p = .048$.

The second model took cue from an aspect of social sharing theory (Rimé, 2009), which suggests that 1) cognitive effort is required to resolve the negative consequences of intense emotion and 2) emotional support through socio-affective benefits only alleviates the short term symptoms without bringing about long-term relief. Therefore, co-rumination was attempted to predict from linguistic measures of cognitive complexity (as a proxy for cognitive work) and

empathic language (as a proxy for socio-affective response mode). However, the model predicted neither present and future levels of co-rumination.

The above models predicted co-rumination with entirely within-person analysis and thus treated participants as statistically independent individuals ($N = 64$), not as parts of a two-person conversation. Since the response mode of the partner could play a key role in how quickly people recover from emotion (Nils & Rimé, 2012), the analyses were repeated by including scores for both males and females (i.e., the same set of predictors from above analyses were entered for both partners in a single model to predict either male or female co-rumination). Because only the co-rumination measure had two longitudinal data points, the dyadic analyses were carried out as regular linear regressions (split by gender) instead of dealing with the interdependency through a multilevel model. However, none of the dyadic models reached significance.

When present levels of co-rumination were added as controls (i.e., participants' own co-rumination scores for individual level analyses and both partners' scores for dyadic analyses), both model types (i.e., one derived from co-rumination theory and one from social sharing) became significant at the individual level. However, the only significant predictor was the added co-rumination variable. In the dyadic analyses, male negative sentiment was a significant *negative* predictor, $b = -0.105$, $t(17) = -2.149$, $p = .046$, in a model that used both partners' present levels of co-rumination, total word count, words per sentence, turn length, and negative sentiment to predict future levels of co-rumination. In the model, both male co-rumination, $b = 0.930$, $t(17) = 4.619$, $p < .001$, and female co-rumination, $b = 0.481$, $t(17) = 2.261$, $p = .037$, were significant predictors of male co-rumination as well, $R^2 = .58$, $F(10, 17) = 4.725$, $p = .003$. In the corresponding female model, only present female co-rumination levels were predictive of future co-rumination, $b = 1.01$, $t(18) = 5.195$, $p < .001$. However, the p-value for female turn length was almost significant, $b = 0.26$, $t(18) = 2.011$, $p < .060$. The overall model was significant, $R^2 = .54$, $F(10, 18) = 4.317$, $p = .003$.

In the models derived from social sharing theory, adding co-rumination made all of them significant, but only participants' own levels of present co-rumination—even in the dyadic models—were significant predictors of future co-rumination.

Discussion

The present study did not provide conclusive evidence that the hypothesised language dimensions are indicative of co-ruminative processes. The only evidence towards expected direction was that words per sentence appear to be associated with co-rumination as a zero-order correlation at the individual level. If we assume that a sentence represents a coherent unit of conversation, co-ruminators in the present study expended more verbal effort to express their ideas. While co-ruminators did not speak more than others in absolute terms, perhaps increased words per sentence is an indirect measure of dwelling on a topic.

In terms of making theoretical headway in understanding co-rumination by comparing predictions made based on the original co-rumination theory (Rose, 2002) and more recent theory on the social sharing of emotion (Rimé, 2009), the results were likewise inconclusive. In the individual and dyadic models, the only credible predictor of future co-rumination was the participants' own present level of co-rumination. However, a small difference between the models could give some guidance for future research, as in the dyadic models derived from social sharing, the other partners' present levels of co-rumination were not significant like in one of the other models. This could be indirect hint that empathic and cognitively complex language do share some variance with others' co-rumination.

One possible explanation for the lack of findings is that all the conversations were sad, and perhaps co-rumination (especially at rather average levels of it) is not enough to tilt the conversation to noticeably more negative direction. The social sharing literature has discovered a relevant phenomenon, namely that the negative emotion might need to be intense enough to trigger sharing (Christophe & Rimé, 1997). If co-rumination is linked to social sharing, it is possible that the topics discussed during the conversations were not potent enough to exceed the social sharing threshold. As mentioned in the limitations for Study 2.1, perhaps no participating couple had a 'real' reason to co-ruminate upon during the conversation, although a counter-point to this argument is that many of the conversations were about seemingly weighty topics from terminal illness to ongoing, long-term unemployment.

Despite lackluster findings, the study has some strong points by demonstrating an efficient pipeline to convert participant speech into analysable text by using crowdsourced transcription via MTurk. In addition to savings in cost and time, another advantage of using MTurk is enhanced protection of participant anonymity. Giving entire conversations to dedicated transcribers allows a single individual to read entire conversations, which might give contextual clues to the participants' identity. This is especially a problem if the transcribers are recruited from the same population as the participants, which would be the case with research assistants from Oxford. On MTurk, however, each worker only gets a small fragment of the conversation, which prevents any single individual from piecing together the entire conversation and gaining access to contextual cues about the participants. Furthermore, MTurk workers are spread around the world, making any prior contact between the workers and the participants extremely unlikely.

Limitations

The most obvious short-coming of the experiment was its small sample size. Unlike in Study 2.1, the data from the present study contained so few data points that they could not be analysed with a multilevel model. Thus, the analyses presented here take into account the dyadic nature of the conversation at a very rudimentary level, as more sophisticated analyses would require a higher number of available data. Even the present analyses ran the risk of exhausting the available degrees of freedom. Thus, the pattern of findings could have been clearer (or different) with a larger sample size.

Another caveat is that the LIWC measures may not be fully accurate in capturing the intended construct. This is partly due to the way the software is built. Instead of treating words as a part of an ordered structure, like beads in a necklace, LIWC treats all words in bulk, like marbles in a bag. This “bag of words” approach to language does not retain the sequence of words, just the amount and quality of them. With LIWC, the results would be the same for actual transcripts and a list of the same words in alphabetical order.

Since meaning often hinges upon a combination and sequence of words, LIWC cannot unambiguously account for even basic grammar like negations. For example, consider how LIWC would analyse the sentence: “I am not mad, but I am not happy either.” Rather than stopping to

ponder how much conceptual overlap “not mad” and “not happy” actually have, LIWC would tally up the individuals words as two instances of negation (“not”) and a positive (“happy”) as well as a negative (“mad”) emotion words (in addition to the personal pronouns, common verbs and conjugations). But since LIWC does not keep track of which particular words went with the negation words, the scores are hard to interpret in terms of what was originally negated.

Common idioms can also accidentally increment inappropriate categories (e.g., “hit rock bottom”, “fair crack of the whip”, “as the actress said to the bishop”, “that’s what she said”). For these reasons, LIWC measures may have an unaccounted amount of fuzziness. It is also uncertain how well the language features chosen to represent the affect-focused nature of socio-affective benefits in the study actually maps onto the construct, as no baseline corpus of text and/or speech of socioaffective language exists.

For future studies, accounting for dependencies between words at the sentence- and conversation level would be welcome improvements. One possibility for future research would be to process each of the conversational turn with a context-aware sentiment analysis software, such as SentiStrength (Thelwall et al., 2010). Combined with a way to index the sentiment to an absolute time index such data could be suitable for multilevel analyses.

Conclusion

Although no language patterns were associated with co-rumination, this absence of evidence might not be evidence of absence. Therefore, to establish whether co-rumination is conveyed in language (maybe in ways that LIWC cannot detect) or whether the signal just isn’t there, the transcripts must be rated by people as well. For people, conversations hinge upon nuance and emotion as much—or perhaps even more—as the actual words spoken. Such subtle cues are lost in translation when a conversation is transcribed to a text file. This will be leveraged in the next study. The present lack of findings should not speak ill of automated language analysis, either. Accessing increasingly rich data about language use through automated software is a promising tool in the toolkit of a social psychology researcher, especially as people’s lives get increasingly broadcasted in (semi)publicly accessible text-based social media, such as Twitter and Facebook status updates.

STUDY 2.3: OBSERVER-RATED CO-RUMINATION

In many ways, the present study has similar goals as Study 2.2: to gather evidence to validate co-rumination as a construct by comparing independent operationalisations of co-rumination. As Study 2.2 failed to link co-rumination to any particular feature in the language used by co-ruminators, the present study will expand the scope to also include expressions that accompanied the words that were spoken. Additionally, by analysing how well third-party observers can detect co-rumination either in conversation content or nonverbal expressions, we can gain clues to whether linguistic content or the expressions that accompany it play a more dominant role in detectable co-ruminative processes.

The present study attempts to maximally isolate the potential effects of method-specific variance. Firstly, co-rumination will be operationalised via observational coding (Rose et al., 2005). Because co-rumination scores are established independently by different people (i.e., the co-ruminators and third-party observers), the self-reported and observed coded ratings of co-rumination should not share any common method variance. Therefore, any shared variance should be due to the construct being measured, providing evidence for heteromethod validity. Secondly, two separate sets of raters will rate the participants' sad conversations, one focusing purely on the verbal content and the other purely on the participants' nonverbal expressions.

Every face-to-face conversation consists of multiple channels of communication, including nonverbal expressions of emotion (Ekman, 1977; Parkinson, 2001). As the conversations that participants had during Study 2.1 were recorded on video, the participants' nonverbal expressions were captured for later analysis and will be utilised in the present study. In order to maximally isolate co-rumination based on language content and nonverbal expression, the video recordings were used without sound, leaving minimal cues about the actual words being spoken. To analyse the content (i.e., words that were spoken), I used the same conversation transcripts from Study 2.2 as stimuli for human raters—not for a computer software, as in Study 2.2. The plain text transcripts do not contain any cues to the nonverbal behaviour of the participants beyond simple coding of clearly audible events such as laughter and sighs. The video stimuli, on the other hand, do not contain any audible information about the words being spoken and are a visual record

of the nonverbal expressions that accompanied the words. By analysing the transcripts separately from the videos, content and expression will be maximally separated from each other.

If the observers' co-rumination ratings match the participants' own self-reports, this would suggest that co-rumination as a construct is not dependent on a particular method of measurement (i.e., heteromethod validity). Furthermore, by comparing the relative accuracies of observers rating transcripts versus observers rating silent videos, we can intuit whether linguistic or expressive processes hold more sway in co-rumination. However, if third-party observers are unable to detect co-rumination in the participants at all, co-rumination might be a process that is invisible to people who are not part of the co-ruminative dyad.

Method

Procedure

Transcript ratings. Each of the raters in the transcript condition rated each transcript as a whole and could read words spoken by both participants. After reading the transcript, the rater assigned scores for each participant separately.

Video ratings. For the observational coding of co-rumination from videos, the audio track was removed and the other participant cropped from view, meaning that each rater rated each participant one at a time without seeing or hearing the other participant. The video was displayed in its full duration.

Measures

The observational coding manual developed by Rose and her colleagues in 2005) was originally intended for use with transcripts only. For the present study, the manual was adapted for use with videos as well. Both the transcripts and videos of the sad conversations were rated for observed co-rumination by third-party observers. Six research assistants in total familiarised themselves with the observational coding manual (Rose et al., 2005).

Co-rumination. As in Study 2.2, self-reported CRQ-27 scores from Study 2.1 were used. The present levels of co-rumination refer to measurement immediately before the laboratory visit (T1) and future levels to measurements taken several months after the visit (T2).

Components of co-rumination. The observers in both the silent video and transcript conditions scored each participant on mutual encouragement of problem talk, rehashing problems, speculating about problems, dwelling on negative affect (Rose et al., 2005). Each behavioural aspect of co-rumination was rated on a 5-item Likert-type scale. Of the observers, three coded co-rumination from silent videos and the other three from transcripts.

To calculate interrater reliability for each component, intraclass correlation (ICC) was used (Shrout & Fleiss, 1979). In the case of the present experiment, a two-way model was used to compute consistency scores. Since each component was a unit of analysis, single units were used instead of averages. The null hypothesis was that $r = 0$ with 95% confidence intervals. While all co-rumination component ratings provided evidence to reject the null, the internal consistency of the rater-rated measures fell below desired levels for most measures, except for dwelling on negative affect rated from videos and for speculating about problems rated from transcripts (although dwelling on negative affect also came close). The reliability statistics are listed in Table 7.

Table 7
Reliability statistics for components of observational co-rumination by stimuli

<i>Videos</i>	<i>Transcripts</i>
Encouragement of problem talk $ICC(C,1) = .24, F(63,126) = 1.96, p < .001$ Cronbach's alpha = .51	Encouragement of problem talk $ICC(C,1) = .24, F(63,126) = 1.97, p < .001$ Cronbach's alpha = .47
Rehashing problems $ICC(C,1) = .21, F(63,126) = 1.78, p = .003$ Cronbach's alpha = .37	Rehashing problems $ICC(C,1) = .38, F(63,126) = 2.39, p < .001$ Cronbach's alpha = .55
Speculating about problems $ICC(C,1) = .28, F(63,126) = 2.17, p < .001$ Cronbach's alpha = .56	Speculating about problems $ICC(C,1) = .37, F(63,126) = 2.78, p < .001$ Cronbach's alpha = .66
Dwelling on negative affect $ICC(C,1) = .47, F(63,126) = 3.70, p < .001$ Cronbach's alpha = .74	Dwelling on negative affect $ICC(C,1) = .32, F(63,126) = 2.43, p < .001$ Cronbach's alpha = .59
Total co-rumination $ICC(C,3) = .73, F(63,126) = 3.73, p < .001$ Cronbach's alpha = .76	Total co-rumination $ICC(C,3) = .72, F(63,126) = 3.62, p < .001$ Cronbach's alpha = .72

Total co-rumination. For analyses, an overall observed co-rumination score was calculated as the mean of the behavioural aspects of co-rumination. Thus, the rating process

yielded two scores for observed co-rumination per participant: one for co-rumination observed in the transcripts and one in the silent videos. Because the measure is composed of averages of scores rather than single scores themselves, intraclass correlations were calculated slightly differently using a two-way model with random column and row effects with consistency estimated using average scores as a unit of analysis.

Results

The principal goal of the present study was to identify whether the communication channel used to express co-rumination is a verbal or nonverbal one and to collect evidence for heteromethod validity of co-rumination. Conversations recorded in Study 2.1 were split to nonverbal silent videos and verbal transcripts and rated by trained raters on four components of co-rumination and a single total co-rumination score for each participant.

Present co-rumination

At the participant level ($N = 64$), total co-rumination scores rated by observers from the silent videos was significantly correlated with participants' own self-reported co-rumination scores, $r = .29, p = .021$. However, the total co-rumination rated from the transcripts was not, $r = .14, p = .266$. To look at the predictive value of the co-rumination components (i.e., encouragement, rehashing, speculation, and dwelling), two models were constructed, each predicting present levels of co-rumination from the four components coded from either videos or transcripts. Of these models, only the one containing video-coded components was significant, $R^2 = 0.25, F(4, 59) = 4.87, p = .002$, with dwelling on negative emotion being the only significant predictor, $b = 0.52, t(59) = 3.92, p < .001$.

When self-reported co-rumination at T1 were predicted from the two total observed co-rumination scores by gender, only the female model was significant, $R^2 = .23, F(2, 29) = 4.44, p = .020$. These models are summarised in Figure 14. The final model for predicting self-reported co-rumination at T1 included the four video-rated components, four transcript-rated components, and gender. The overall model was significant, $R^2 = 0.28, F(9, 54) = 2.30, p = .030$, with video-rated dwelling being the only significant predictor, $b = 0.56, t(54) = 3.59, p < .001$.

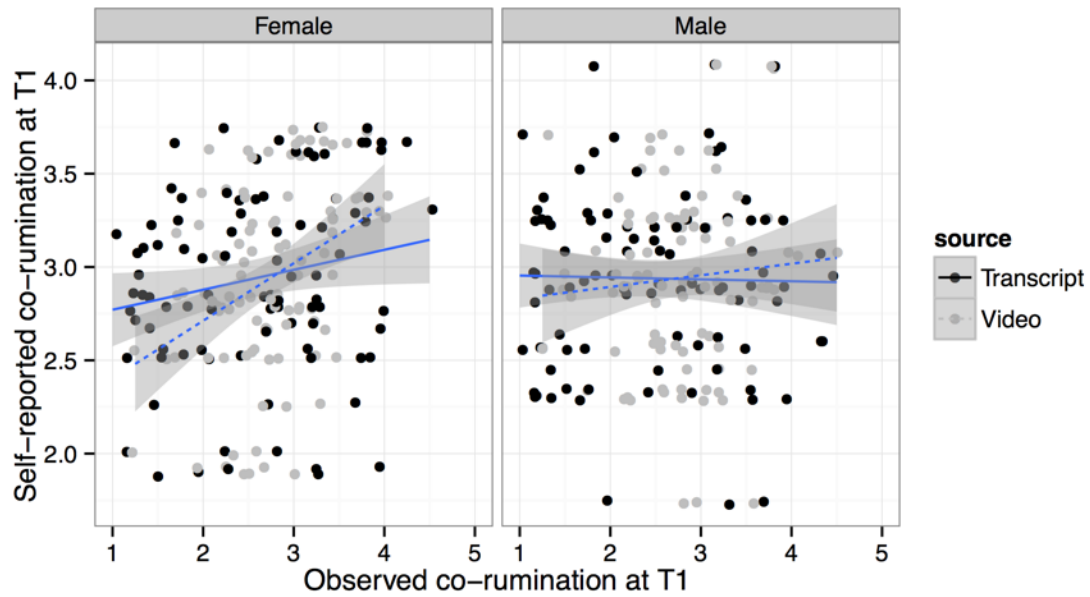


Figure 14. Observed and self-reported co-rumination by gender and stimulus.

Future co-rumination

Neither video- nor transcript-rated total co-rumination predicted future levels of self-reported co-rumination, either as single predictors or as simultaneous predictors. The models for components rated either from videos or transcripts were not significant. The model predicting self-reported co-rumination at T2 from all of the eight components was not significant, either. When co-rumination at T1 was added as a control, the model was significant, $R^2 = 0.59$, $F(10, 46) = 6.50$, $p < .001$, but the only significant predictor was present-day level of co-rumination, $b = 0.56$, $t(54) = 3.59$, $p < .001$.

Scores across raters

The observational co-rumination scores from videos and transcripts were significantly correlated, $r = .45$, $p < .001$. That is, when the participants' co-rumination were rated independently from transcripts and videos by separate raters, the raters' co-rumination ratings agreed with each other. Figure 15 shows this relation by gender, which was significant for both women, $r = .49$, $p = .004$ and men, $r = .43$, $p = .015$.

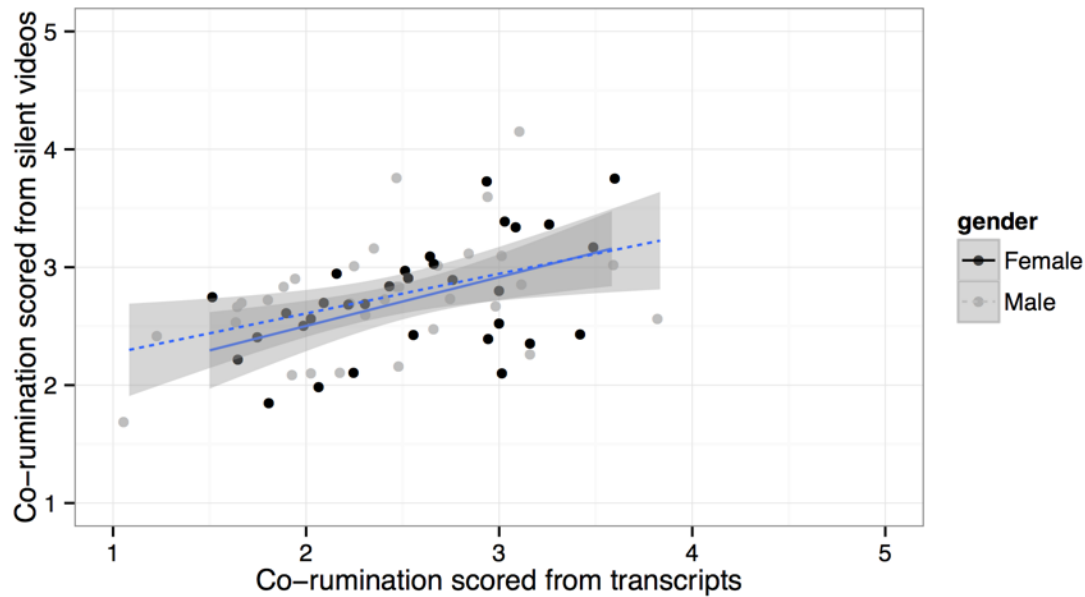


Figure 15. Scatterplot of co-rumination scored by raters from transcripts and silent videos.

Partners' scores

Since the raters scored co-rumination from videos and transcripts on a per participant basis, it is possible to compare the scores between the partners at the dyadic level ($N = 32$). When the partners' co-rumination was rated from transcripts, male and female scores were positively correlated, $r = 0.58, p < .001$. However, the partner's co-rumination scores were not correlated on video, $r = 0.22, p = .230$.

The positive correlation between male and female co-rumination on transcripts could due to rater bias, however. In these data, it is impossible to distinguish between the true effect of partners mirroring each others' co-rumination in their language and the confound of a single person giving scores to both dyad members at the same time. While videos of dyads can be cropped to show only a single person, this is harder to accomplish with transcripts: without any reference to the other participant's words and responses, the conversation can degrade beyond recognition. While it would be possible to have raters rate these "bag of sentences" on a per-participant basis, it was not attempted here, as I think there was sufficient overlap in this suggested improvement and the automated methods used in Study 2.2.

Discussion

In order to determine whether co-rumination is expressed nonverbally or verbally, videos and transcripts of sad conversations between people with known levels of self-reported co-rumination were rated by raters. Scores from the video-rated co-rumination had some success in predicting present levels of co-rumination, but the effect was driven by women's scores. Of the individual components of observed co-rumination (i.e., encouragement, rehashing, speculation, and dwelling), dwelling on negative affect as coded from videos was the only one with any predictive power on its own.

This pattern of findings is—again—both inconclusive and more complex than expected. Why would co-rumination be most reliably identified from silent videos of women who appear to be “dwelling?” On one hand, this finding lends weak evidence to the hypothesis that the conduit for co-rumination is *how* things are said, not *what* is being said. In effect, the results suggest that the most recognisable aspect of co-rumination is nonverbal. If this is the case, and the active ingredient of co-rumination is not present in language, these results are difficult to reconcile with literature focused on the importance of verbal expression in emotional recovery (e.g., Pennebaker, 1997; Rimé, 2009). In terms of evidence for heteromethod validity of co-rumination, the evidence is not as strong as could be hoped for either. However, the correlation between the participants' self-reports and raters' observational coding could have been reduced due to the instructions given to the participants about the conversation task. Because everyone was asked to talk about a sad topic, this could have induced people who are normally not prone to co-ruminate to engage in unusually co-ruminative behaviour. Thus, if co-rumination during the conversation was inflated due to task demands, it could have decoupled the state-based co-rumination that the raters picked up from the intended trait-based co-rumination reported by the participants.

The most intriguing finding might actually be the agreement between the raters who rated the videos and transcripts and not the agreement between observer-rated and self-reported scores. That is, when raters were trained to look for signs of co-rumination, their judgment tended to converge on the same individuals. The simplest interpretation of this finding is that people who are external to the situation can look in from the outside and agree upon something. Because these

ratings were given by completely independent raters from completely different source material, it lends credibility to the evidence that people are accurately reading off something they expect to correspond to excessive focus on the negative. In terms of the rated stimuli, there was no overlap: the videos had no words and the transcripts had no video. Also, the stimuli were rated by completely different groups of people with no overlap, in a randomised order. I rated neither videos nor transcripts to avoid experimenter bias. Naturally, the raters did not have access to the participants' co-rumination scores, so if there is a signal, it should be coming from the participants, not from confounds.

In the more detailed analyses, self-reported co-rumination was predicted only by dwelling identified from silent videos. This suggests that when people are motivated to spot excessive negativity in conversations, they hone in on something that looks like “dwelling,” even when they do not hear the actual words being spoken. A logical consequence of this finding is that co-rumination does not exist in a social vacuum. If third-parties can read “dwelling” from the nonverbal behaviour of others, co-ruminative conversations taken place in view of others could have third-party consequences. If the people witnessing co-rumination interact differently with the perceived co-ruminators, this could have important social consequences. This possibility leaves us with an interesting question: can people spot a co-ruminator “in the wild” and do co-ruminators get treated differently in the everyday social context?

Limitations

Again, the main limitation is that the sample size for the study was small. This means that the absence of correlation with self-rated co-rumination and the components coded from transcripts does not mean that the correlation was not present. If the true effect of observed language and self-reported co-rumination were $r = .34$ or smaller, it is possible that the effect went unnoticed due to underpowered sample. Before these results get replicated with a sufficient sample size, I do not think we should not discard the notion that language is irrelevant in co-rumination, as other studies have identified linguistic correlates to recovery from emotional events (for a succinct review, see Pennebaker, 2004).

The fact that observed co-rumination predicted self-reported co-rumination only for women raises at least two possible scenarios: 1) women could express co-rumination differently and in more visible ways than men, or 2) co-rumination might be a gender-specific phenomenon. However, there are limitations to the present study that prevent us from concluding either way, because all of the raters were women. For example, there may be gender differences in the way co-rumination is perceived and communicated, and the lack of male raters may have made the present scores less sensitive—or even blind—to signs of male rumination. It is possible that the female raters paid attention to different nonverbal cues that the men were expressing. This calls into question the validity of the gender-difference finding about co-rumination on video predicting self-reported co-rumination for women only.

Finally, because the sample consisted of heterosexual romantic partners instead of same-sex friends as in most of the past co-rumination research, the theoretical assumptions behind predictions might have been invalid. Since co-rumination is associated with different outcomes depending on relationship type (Calmes & Roberts, 2008), similar data on co-rumination between close friends might have yielded different results. In short, predictions made on a theory built on data from same-sex friends may not be applicable to the relationship context.

BEYOND RELATIONAL CO-RUMINATION

When we look at the experiments in this part of the thesis as a whole, the overall pattern of findings points to an under-recognised aspect of co-rumination: it is indeed relational. Different combinations of high and low co-ruminating men and women had different outcomes, which suggests that at some rudimentary level, co-rumination is tied to the relational context in which it unfolds. In addition to affirming the fundamentally dyadic nature of co-rumination, the findings of Study 2.3 also highlight a more complex side of co-rumination. Rather than being exclusively dyadic, co-rumination is also visible—albeit in complicated ways—outside the dyad. People can detect co-rumination without being an active participant in the co-ruminative conversation itself. This simple observation has important theoretical implications. The key shift in theoretical viewpoint is to think about co-rumination in terms of a triad instead of a dyad. Just like individual-level data is not optimal to study dyads, exclusively dyadic data are not good to study processes that involve more than two people.

Although co-rumination is typically conceived as a dyadic process, it could be subject to social processes that take place outside the dyad. While relational emotions are grounded in dyadic processes, there are many reasons why they could organically extend beyond exclusive pairs of individuals. For one, people tend to kiss and tell: even emotion that is initially experienced either in isolation or within a dyadic relationship may propagate beyond the initially involved individuals. When people experience a strong emotion, they almost invariably share it later with others (social sharing; Rimé, 2009; Rimé et al., 1991). Emotion that unfolds in one interaction is very likely to be shared later in another, linking individual dyads into a larger, networked structure. Likewise, people are not limited to experiencing emotions only about the person in front of them. Many interpersonal encounters occur in the presence of more than two persons, creating multiple simultaneous dyadic relations and the tension in many social situations is caused by the competing demands of each relation (Fleming, 1994). Relational emotions often operate in a dynamic social context of multiple interacting individuals, and perceptions of others' emotions or appraisals can change and calibrate how people think and feel about the situation and the actors in it (Manstead & Fischer, 2001).

When co-rumination is framed as a triadic phenomenon, some key questions naturally emerge. Do people co-ruminate with multiple people or is co-rumination exclusive to a single dyad? Because the amount of co-rumination with a friend can correlate with the amount of co-rumination in other relationships (Calmes & Roberts, 2008), it is unlikely that co-rumination is contained within just one dyad. If people co-ruminated with various numbers of partners, co-rumination could function differently among people whose sole emotional outlet consists of just one person versus people who can share their concerns with a wider range of people.

Adding a third person also gives a point of comparison. Perhaps because past co-rumination research has focused on already strong relationships of best friends (and long-term couples in the present studies), maybe the researchers took the relationship-enhancing nature of co-rumination for granted. Like best friends, long-term partners are a captive audience. Even if the partner is not as eager to dwell on problems, the costs of ignoring one's partner's feelings are high and it is possible that partners feel obliged (or otherwise more inclined) to engage in co-rumination for relationship-maintenance reasons. But what about other people who do not have strong ties to the co-ruminators, such as colleagues and peers? Would third parties be so accommodating as to indulge in co-rumination without the obligation created by a long-term social bond?

Furthermore, if people can tune in to other's co-ruminative conversations just by observing them, could some aspects of co-rumination be influenced by the behaviour of the extradyadic people? For example, if a person co-ruminates about a problem with a close friend, sibling, romantic partner, and other people, the appropriate data about such behaviour cannot be limited to the dyadic level as the dyads are not independent of each other. Rather, because multiple co-ruminative dyads are linked to each other, the data analysis should be sensitive to such linkages. If co-rumination is to be understood at the level of interconnected individuals, researchers must leverage data that captures the entire social context around the co-ruminators.

To my knowledge, co-rumination has not been studied at a scale beyond the dyadic level of analysis, although Hankin et al. (2010) suggested using multiple informants (e.g., parents, peers) as an important next step for future research in co-rumination. This lack of studies is unfortunate, because supradynamic questions such as whether people with co-ruminative tendencies

choose each other as friends or whether friends become more co-ruminative over time are very interesting and have the possibility to really expand the current theory. Conceptually, thinking about co-rumination in triadic terms also opens a whole new branch of mathematics to draw upon for analyses, which will be explored in the next part of the thesis.

Part III:
Co-rumination in a network context

The final part is the logical culmination of my thesis. It draws together key concepts from before: individual people and their qualities, the way in which they communicate, and their interlocking relationships. This part models co-rumination—both in theory and in empirical practice—as a distributed social process involving multiple individuals who interact with each other over time. When people have many face-to-face conversations, the sum of all those interactions over time creates the web of social relations that serve as the environment in which co-rumination operates. This part of the thesis analyzes how the person-to-person social network is shaped by co-rumination.

I will first review the scant literature on the social dimension of co-rumination at the level of multiple people (i.e, beyond a single dyad). After the literature review, I identify both major gaps and opportunities in the co-rumination literature and connect it with other theories, specifically social sharing of emotion (Rimé, 2009) and its subcomponent, social constraint (Pennebaker & Harber, 1993).

My main theoretical contribution is to frame co-rumination as a networked phenomenon within a single framework by using social network analysis as a unifying perspective. Networks provide a relatively new approach to emotion research. The network-oriented co-rumination, which I present after introduction to network science, incorporates social networks, emotion as relation alignment (Parkinson, 2009), social sharing of emotion (Rimé, 2009), and social constraint (Pennebaker & Harber, 1993). It is my hope that the proposed framework enriches research by expanding the range of applicable theory, methodology, and findings. I also hope that it will encourage cross-pollination between various research programs. Using an integrated theoretical framework, I will point out a plausible mechanism for the formation of co-ruminative dyads and make specific predictions about how co-rumination could reduce social contact with peers.

To test my predictions, I will use computer simulations based on real-world data (after a brief preliminary experiment on the social perceptibility of co-rumination). Specific predictions about the effects of network-level behavior on co-rumination and vice versa will be tested with data from two longitudinal experiments among student cohorts. The findings elucidate the mechanisms behind co-rumination's corrosive effect on social relations.

LITERATURE REVIEW

Because past literature has conceptualised co-rumination as a dyadic phenomena, most of the research has been constrained to examine co-rumination in a single relation between two individuals. As a consequence, co-rumination research involving multiple relations has been rare. This literature review will focus on aggregating the current knowledge on how one co-ruminative relation might influence other social relations in which the co-ruminators are engaged. First, I will discuss findings from co-rumination studies that have included more than one relationship in their analyses, such as relations with peers, parents, teachers, roommates, and romantic partners. Second, I will revisit the social sharing literature, which is conceptually very compatible with networked theories and provides a clear entry point to social networks in social psychology research. Finally, I will review evidence about social constraint, a processes which could be a contributing factor to reduced peer-group relations associated with co-rumination.

Co-rumination

Because co-rumination research has mostly focused on the individual and dyadic level, very few theoretical or empirical points in the literature concern the network level (i.e., the broader social context that surrounds the co-ruminative dyad). Fortunately, such articles are not completely lacking. In 2006, Rose and Rudolph suggested that peer interactions may shape youths' social networks in terms of density, or number of shared friends. However, the observation was not directly linked to co-rumination, but gender differences in general (e.g., boys having denser networks and more well-defined dominance hierarchies).

In a different domain, Marmenout (2012) suggested that “collective rumination” among coworkers could be an intragroup bonding opportunity. During a merger, collectively dwelling on the negatives might be a way to circle the wagons within the company as a way of showing solidarity and affiliation to one's coworkers. However, such pulling together might come at the cost of intergroup conflict. Marmenout suggested that dwelling on the negatives as a group could have detrimental effects on intergroup relations between people in the two companies being merged. Although the group discussions about hypothetical corporate mergers that Marmenout

used to collect her data were not exact equivalently to adolescent co-rumination, the same line of reasoning might apply to both.

Marmenout articulates a potentially important aspect of co-rumination: in certain situations, it may create divisions between people who co-ruminate and those who do not. A similar exclusionary process might take place in interpersonal relationships, too: intense problem-talk within a dyad might have adverse effects on other relationships that the dyad members have. Indeed, Starr and Davila (2009) found that baseline co-rumination predicted a decrease in the number of friends among a sample of adolescent girls one year later. The researchers suggested that co-rumination may have short-term benefits for friendship, but may put strain on friendship networks over time, causing same-sex friendships to be dissolved. However, empirical corroboration for this suggestion was left as a matter for future studies.

In another study, higher levels of co-rumination predicted a lower number of self-reported friends and teacher-reported estimates of popularity among peers, implying that the suggested adverse consequences of co-rumination on social acceptance and peer network size might be real (Tompkins et al., 2011). When discussing these findings, the researchers speculated that co-ruminating with one's closest friend may limit opportunities to engage with the broader peer network. However, neither their data nor their methods were enough to determine the direction of causality, and the mechanism responsible for this finding has not been established. Currently, the main contender is social anxiety. Jose and colleagues (2012) found that adolescents who experience high levels of social anxiety ruminate about their social performance, which, in turn, seem to precipitate co-ruminative discussions with friends. This is worrisome, because Starr and Davila (2009) justified their findings with the opposite reasoning that people with social anxiety are less likely to self-disclose.

In total, these findings suggest that co-rumination in one relationship can indeed influence other relationships. In other words, it is plausible that co-rumination has social causes and consequences beyond the focal pair of co-ruminators.

Co-rumination across relationships

Usually, co-rumination research has focused on a single type of relation: close friendship between same-sex friends, but Calmes and Roberts (2008) looked at co-rumination among different types of relations. In effect, isolated participants were asked to report on multiple co-ruminative relations they had with a range of other close people. The study included questions about relationships between parents and children, same-sex roommates, same-sex friendships, and romantic partners. According to the findings, co-rumination in one dyadic relation was frequently positively correlated with co-rumination in others. The highest correlation was found between co-rumination in a romantic partnership and a close same-sex friend. In fact, co-rumination with a friend was significantly correlated with all other types of co-rumination. However, the magnitude of the effects could be due to assumed similarity or false consensus bias, since data was only collected from the focal individual alone.

Recently, Stone and her colleagues (2012) looked at 1,584 young children in 792 dyads who were friends, either reciprocally (both dyad members nominated each other as friends) or unilaterally (only one dyad member nominated the other as a friend). The researchers hypothesised that similarity in emotional problems would make friendships more likely in reciprocal dyads, based on either selection or influence: the dyad can either end up together based on their behaviour stemming from the problems or adopt each other's maladaptive cognitions and become more similar over time. Although their analyses were not based on social network analysis (SNA) methods, the researchers found evidence of similarity between reciprocated friendships of young children, regardless of gender.

Another study that branched out beyond exclusive co-ruminative dyads was conducted by White and Shih (2012), who did not limit the scope of co-rumination to one's best same-sex friend. Instead, the participants were allowed to nominate the closest confidant with whom they discussed problems. The options for the closest confidant were best friend (sex not specified), mother, father, significant other, roommate (if not best friend), and an unspecified other. For a baseline measure of co-rumination, the respondents were most likely to indicate best friend (58%) as their closest confidant, followed by significant other (21%), mother (15%), other (3%), and finally roommate and father (1%). For day-to-day co-rumination, the participants were most likely to report co-

ruminating with their best friend, followed by significant other, other, mother, roommate, and father (at almost zero-level of probability). Since there was day-to-day variation in the preferred co-rumination partner, it suggests that co-rumination may not be limited to exclusive dyads. Instead, co-rumination appears to involve a number of people.

However, findings at the dyadic level can hint at this interdependency. Calmes and Roberts (2008) found that co-rumination is significantly correlated across some relationships (e.g., co-rumination with one's friend was positively correlated with co-rumination with a roommate, parent, and romantic partner). How a particular co-ruminative relationship might affect other relationships has not been addressed, however. If one co-ruminative relation were to influence other relations, it would suggest that co-rumination must then be conceptualised to include higher-order units, such as triads and networks, instead of only dyads.

Social Sharing Of Emotion

Social sharing research has shown that emotion is rarely limited to the brief moment during which it is experienced, but almost invariably shared with others at a later time (Rimé et al., 1991). In part II of my thesis, I reviewed social sharing literature from the dyadic point of view and focused on the immediate act of primary sharing when a person talks about an emotional experience with a close confidant. The primary sharing—and the rumination that fuels it—ensures that the person affected by negative emotion reaches out to others (Rime et al., 1992). However, the targets of social sharing become active participants in the sharing process and engage others through secondary sharing (Harber & Cohen, 2005; Rimé et al., 1998).

The emotional broadcaster theory (EBT) of emotional disclosure (Harber & Pennebaker, 1993; Harber & Cohen, 2005) provides a model of how psychologically arousing stories spread in social networks as a function of the potency of the shared emotion. As an example, within 10 days, nearly 900 people heard about a visit to a hospital morgue by a class of 33 college students (Harber & Cohen, 2005). As the students told about their morgue experience to their friends (primary sharing), the friends related the story they heard to their friends (secondary sharing), and the friends of friends relayed the story to their friends (tertiary sharing).

Following this logic, Rimé (2009) argues that the primary sharing by the focal person elicits negative emotion within the listeners, and the listeners' negative emotion creates a further need to share that results in secondary sharing. In turn, listeners in the secondary sharing interactions vicariously experience negative emotion and thus develop a corresponding need to share it themselves. Social sharing theory does not specifically postulate anything beyond tertiary sharing, but presumably the chain of sharing continues until the emotional story does not evoke high enough levels of emotion to trigger further sharing.

Social constraint

Rimé and colleagues (1998) observed that at high levels of emotional intensity (i.e., when the precipitating event had been particularly emotional), actual sharing was often limited by a ceiling effect (with the modal number of repetitions being four to five). According to Rimé (2009), social sharing stops for two principal reasons: either the sharer finds relief or the listeners simply stop listening. As a person continues to share negative emotion beyond the tolerance of his or her peers, the peers may start to actively discourage talking about the matter or otherwise indicate their unwillingness to participate in the sharing process. This suggests that each listener can probably only tolerate a certain level of emotional disclosure from the sharer, especially when the topic is repeatedly the same.

Pennebaker and Harber (1993) named this dampening process social constraint. Their findings suggest that over time, people become less and less receptive toward emotional disclosures and start to express this to the perpetual sharer either in direct or indirect manner. Social constraint has similarities to Coyne's (1976) interpersonal model of depression, as both predict that the behaviours by the person sharing negative emotions will result in tension between sharers and their social environment. Like social sharing, Coyne's interactional theory of depression posits the initial response by the social environment towards the depressed person is concern, support, and acceptance, but the continuance of depressive behaviors elicit either outright rejection or inauthentic support motivated by guilt.

Social constraint was documented on a collective level after traumatic events that affected people in the local community (the Loma Prieta earthquake in 1989) and national level (the Gulf

War in 1990–1991). When people have been collectively subjected to a negative event, usually in the form of one of the “Three C’s”: crisis, conflict, or catastrophe (Koenig, 1985), they often find themselves compelled to talk about the events—to engage in social sharing (Rimé, 2009). By using follow-up surveys after such traumatic events, Pennebaker and Harber (1993) found out that people thought about the events and openly discussed them for approximately two weeks. About two to three weeks after the event, people still thought about the event (and wanted to talk about it), but actively discouraged others from discussing it. As a physical manifestation of this collective wish to end trauma-related discussion, a local store started selling T-shirts that read “Thank you for not sharing your earthquake experience” (Pennebaker & Harber, 1993, p. 133). This suggests that at some point, people do not wish to continue rehashing negative emotion and actively start to discourage others from doing so. Although people did scale down their level of sharing, the unfortunate fact was that many still felt the need to talk about their negative emotion, but now had fewer opportunities to do so.

Talking about a major event that influence the entire community may be qualitatively different from talking about personal problems, however. Whereas people who experience a collective trauma might be more understanding towards others who wish to talk about it, the same courtesy may not be extended to people dealing with personal issues. On the other hand, the opposite may be true: perhaps the inevitability of a collective trauma as a topic of conversation may induce a quicker “burnout” among listeners, whereas personal issues might receive more tolerance. That is, perhaps social constraint in such traumatic situations is due to the actors getting tired of the topic as a whole rather than getting tired of a particular person talking about it. Because of this, it is not immediately clear whether a situation in which a large section of the community has experienced similar negative emotions is comparable to a situation in which only a handful of individuals—or perhaps just one—needs to share their emotion. While Rimé framed social constraint in terms of unwillingness to listen to social sharing, this kind of social behaviour inhibition could also be tantamount to cooling down a friendship.

Social constraint could act as a “conspiracy of silence” by the people around the co-ruminators, limiting their sharing opportunities. If people actively withdraw from social contact with people who dwell on negative emotion, social constraint process could explain why co-

ruminators appear to become marginalised in their peer groups. This mechanism appears to be very similar to the deselection process demonstrated by Van Zalk et al. (2010) by which nondepressive adolescents “filter out” depressive peers from their peer relationships. A methodological implication of this is that if one wants to capture network dynamics based on social constraint or depenetration, the network in question must be observed for a period preferably longer than three weeks (i.e., the timeframe in which social constraint was observed in the original study by Pennebaker and Harber, 1993). Because of this transformation in the peer network as documented by Zalk et al. (2010), depressed adolescents mainly remained friends with other depressed adolescents. If the co-ruminators are abandoned by the rest of the social network, the co-ruminative dyad could easily develop an “you and me against the world” attitude and develop an even closer relationship with each other.

GAPS IN THE LITERATURE

The main gap in the literature that is relevant to the present thesis is that ideas and tools from social network analysis have not been applied to either co-rumination or social sharing, despite obvious points of overlap. At the level of multiple interacting individuals, research on co-rumination is very scant to the point where the gaps are larger than existing research. Because the theoretical foundation of co-rumination is rooted at the intrapersonal and dyadic levels, very few hypotheses about co-rumination at the network level have been framed. Even when researchers use terms such as “social networks” or “peer networks,” statistical analyses that model the actual intertwined relations among people are rare. However, researchers have expressed interest in studying co-rumination beyond the dyadic level. Starr and Davila (2009) advocated that future research should examine how co-rumination impacts friendship networks to determine whether it may strain or strengthen relationships and the conditions under which it may do so. Furthermore, Waller and Rose (2009) point out that from the family systems perspective (e.g., Minuchin, 1974), co-rumination between mothers and children should impact other family members as well.

The fact that human relations are determined by multiple people who interact in complex ways poses challenges for data collection and analysis. Adapting traditional statistical tools for use in this domain is difficult, because faithfully modeling the dynamics of how people create,

dissolve, and maintain relations not only needs to take into account the qualities of the people but also to keep track of all the dyadic relations among them. Attempting to model this with conventional tools such as multilevel modeling or structural equation modeling would quickly become too complex to manage. Thus, the accumulation of evidence on individual and dyadic levels—but not on the network level—could simply be a reflection of the methods that researchers are using. Thus, although both co-rumination and social sharing are compatible with social network analysis, researchers may have overlooked networked processes because they lacked an applicable framework of ideas and tools suitable for such analyses.

In this section, I will point out that 1) forcing a social process to dyadic analyses can create systematic biases and unnecessarily lead researchers to discard a lot of usable data, 2) very little is known about the extent to which co-rumination in one relationship affects others relationships, and 3) the observation that co-rumination is linked with reduced peer network size is difficult to explain without implicitly invoking supradyadic structures, such as triads.

Exclusive Focus On Dyads

Perhaps the conventional focus on inherently dyadic relationships like best friendships has inadvertently stopped co-rumination researchers from considering the networked nature of co-rumination. Ironically, data about co-rumination has included information about the co-ruminators' social networks since the beginning, but these data have not been utilised to their full potential. In the original study by Rose (2002) and in at least two studies since (Rose et al., 2007; Smith et al., 2011), the participating students indicated three of their best friends by circling their names on a class roster. Then, the participants drew a star next to the person's name who was their "very, very best friend." (Rose, 2002, p. 1833). These data could immediately be used to construct the participants' friendship networks, but instead, the researchers proceeded to discard large portions of usable data by opting for exclusively dyadic analysis instead.

In order to study co-rumination as a dyadic phenomenon, the researchers must arrange the data into exclusive dyads in which both members report on the same relationship. In terms of friendship quality, for example, the participants in Rose's (2002) study reported their own perception about their relationship with a specific other participant, who in turn provided his or her

perception on the same relationship. The problem is that schoolchildren are not exclusive in their friendships and therefore the data are not naturally dyadic. Rather, the researchers had to take extra steps in order to arrange the data into exclusive dyads. To make the data dyadic, the researchers had to discard some of the collected data. For example, participants who had no reciprocal same-sex friendships still completed all of the questionnaires, but these data were not used (Rose, 2002 reports this as a common practice, citing Parker & Asher, 1993; Rose & Asher, 1999). Likewise, cross-sex friendships were excluded, even if these were reciprocal (Rose, 2002; Rose et al., 2007; Smith et al., 2011). In each study, the decision rules behind data exclusion were justified on the basis that they originated from past research (Parker & Asher, 1993; Rose & Asher, 1999).

The amount of discarded data is considerable. In the original study by Rose (2002), participants had to be assigned to mutually reciprocal same-sex friendships in order to collect symmetrical data from both members of the friendship dyad. Rose started out with 608 consenting and present students. For the next step of the study, questionnaire forms were customised so that all participants reported their relationship satisfaction regarding one of their friends. Out of these data, 284 participants reported on each other as dyads (i.e., 142 friendships with completed relationship measures by both friends reporting on each other). In total, this means that data from 324 participants were not used in the analyses—a data loss of 53 percent. A similar process was followed by Smith and Rose (2011), who started with 434 students and discarded 23% of the total data.

These practices in arranging the data to reciprocal dyads lead researchers to overlook several situations and bias the sample. Consider Albert (labeled A in Figure 16), who is a “fifth wheel” in a group of four friends: Bill, Claude, Dominic, and Emil (i.e., actors B through E in the same figure). If student A nominates B, C, and D as his best friends, but students B, C, D, and E nominate each other as best friends instead, Albert is left out without a single reciprocated friendship and his data would be completely excluded from the study. Even if one of the other boys reciprocate a friendship, Albert might not be assigned into a dyad where both members report on each other, as the other boys might have been assigned to report on higher priority relationships, such as reciprocal “very, very best” friendships. The selective arrangement of data virtually guarantees that each of the reported friendship is of high quality, potentially inflating (or

confounding) the findings on relationship quality and co-rumination. Relatedly, it was noted that participants who were excluded for not having a reciprocated friendship were higher on depression measures in the first longitudinal study on co-rumination (Rose et al., 2007 as reanalysed by Schwartz-Mette & Rose, 2012).

Because past results suggest that co-rumination may come at a cost in terms of social acceptance and peer network size (Starr & Davila, 2009; Tompkins et al., 2011), it would seem necessary to include the structure of the peer network in the analyses, especially as the “need to adopt a careful, nuanced view” has been highlighted (Rose et al. 2007, p. 1030). By forcing the data into a dyadic format, they cannot speak for the impact social network structure on co-rumination and vice versa. For example, our fictional Albert—whose data would have been discarded—might have been ostracised from the group for chronic co-rumination. In order to detect network-wide effects and avoid discarding large portions of the data, my suggestion is to expand the unit of analysis from a dyad to a triad—a fundamental building block of a network. A triad is the smallest group of actors within which more than one relationship is possible. This configuration opens up the theoretical possibility that a relation may depend on another relation. Three individuals are also the lay definition of a smallest possible “group,” making triads a special unit of analysis. Because a network structure also encompasses dyads, dyadic level analyses are still possible at the network level of analysis (as a triad decomposes into two dyads), but network level analyses are impossible when data are forced to be dyadic.

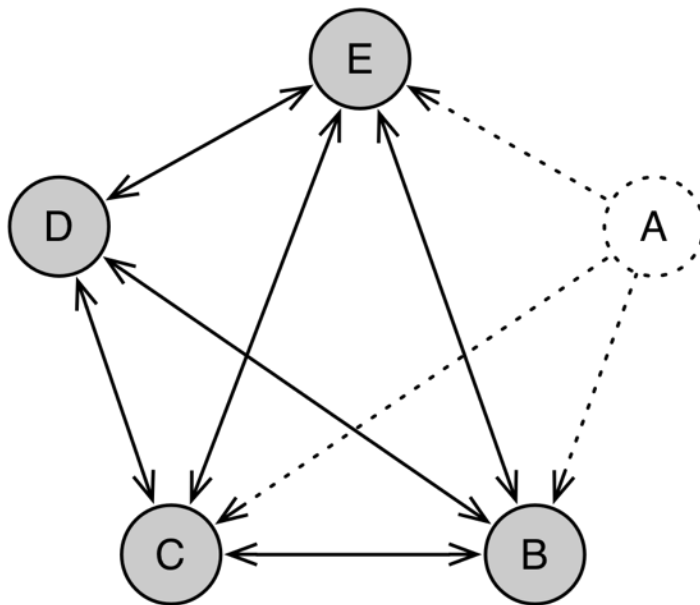


Figure 16. An illustration of “fifth-wheel” problem in exclusively dyadic data.

The Role Of Social Exclusion

One of the main arguments in co-rumination literature is that it strengthens the social bond of the co-ruminative dyad, but makes both dyad-members vulnerable to depression (Rose, 2002; Rose et al., 2007). From a network perspective, people who excessively dwell on negative conversations with just a handful of people could be allowing the rest of the network to fall in disrepair. In the worst case, their social networks could become so disconnected that they have only few connections to rely upon for advice and support when problems arise.

Humans, as a social species, do not fare well in solitary confinement and being in the periphery of a social network can be depressive in its own right (Cacioppo, Fowler, Christakis, 2009; Cacioppo & Hawkley, 2009; Cohen, 2004). Furthermore, socially isolated positions in a network have less access to support and advice (Burt, 1992), which could multiply the influence of other stressors. As shown by Cacioppo, Fowler, and Christakis (2009), loneliness occurs in clusters, extends up to three degrees of separation, is disproportionately represented at the periphery of social networks, and spreads through a contagious process in which contact with lonely individuals appears to induce loneliness (induction), instead of lonely individuals merely finding each other (homophily). However, it is unclear which emotional, cognitive, and behavioral aspect of loneliness contributed to the induction of loneliness in others. In addition to spreading

within a social network, loneliness also reduces the ties lonely individuals have with others. Thus, loneliness is found in clusters within social networks, is more common at the periphery of social networks, and threatens the cohesiveness of entire the network.

Cacioppo and Hawkley (2009) point out that there is no unambiguous term for the exact opposite of loneliness, just like there are no single terms for the polar opposites of pain and thirst. The terms that come the closest are “social connection,” “social contentment,” and “social bondedness” (Dunbar & Shultz, 2007), but all fall short for lack of precision. Cacioppo and Hawkley suggest that the absence of a term for “not lonely” suggests that loneliness is the problematic state that deviates from the norm. If fish had language, being in water might be such an self-evident fact of life that they might not have a word for it—just words for not being in it. Like being in water is to fish, perhaps being embedded in a social network is the homeostatic default state required to maintain a healthy and balanced life for people—and any deviation from this equilibrium would be detrimental to well-being. The very definition of loneliness is framed in precisely these kinds of terms of a relational imbalance: lack of social integration or absence of a reliable attachment figure (Weiss, 1973).

Co-rumination has been shown to have negative effects on one’s peer network (e.g., co-rumination predicted reduced number of friends and social acceptance; Starr & Davila, 2009; Tompkins et al., 2011). Thus, the only redeeming quality of co-rumination—enhanced relationship quality in the primary dyad—might be detrimental, if it comes at the expense of maintaining and creating other relationships. Likewise, if loneliness increases depression, it is possible that the pathway from co-rumination to depression could be through social isolation instead of through rehashing negative mental content.

Lack Of SNA Studies

Haggard and colleagues (2010) suggested that in future studies of co-rumination in the workplace, the adjustment outcomes of the co-workers who are exposed to co-rumination should also be considered. While this direction strongly implies using social network methods, no such studies have been conducted to date. Likewise, although the theory of social sharing (Rimé, 2009) is inherently networked in nature with the concept of secondary and tertiary sharing, it has not

leveraged analyses at the network-level either. This is particularly odd, because key parts of the theory are discussed directly in social network terminology. For example, when discussing secondary and tertiary sharing, Rimé notes that “an emotional event sparks the spread of emotional information across social networks,” (p. 73). Although social sharing has not yet been studied using social network analysis methodology, the compatibility is clear.

As explained above, the individual experience of emotion leads to social sharing that propagates emotions beyond the initial dyad. Rimé (2009) suggests that listening to narratives of negative emotions is likely to elicit negative emotions in the listener, which compels listeners themselves engage in secondary social sharing in order to downregulate the negative emotions elicited by primary sharing. It is also possible that even if listening to negative emotion narratives does not elicit sufficient levels of negative emotion in the listeners to trigger further social sharing for direct emotion regulation purposes, emotional stories may be generally interesting to people and shared similarly to gossip.

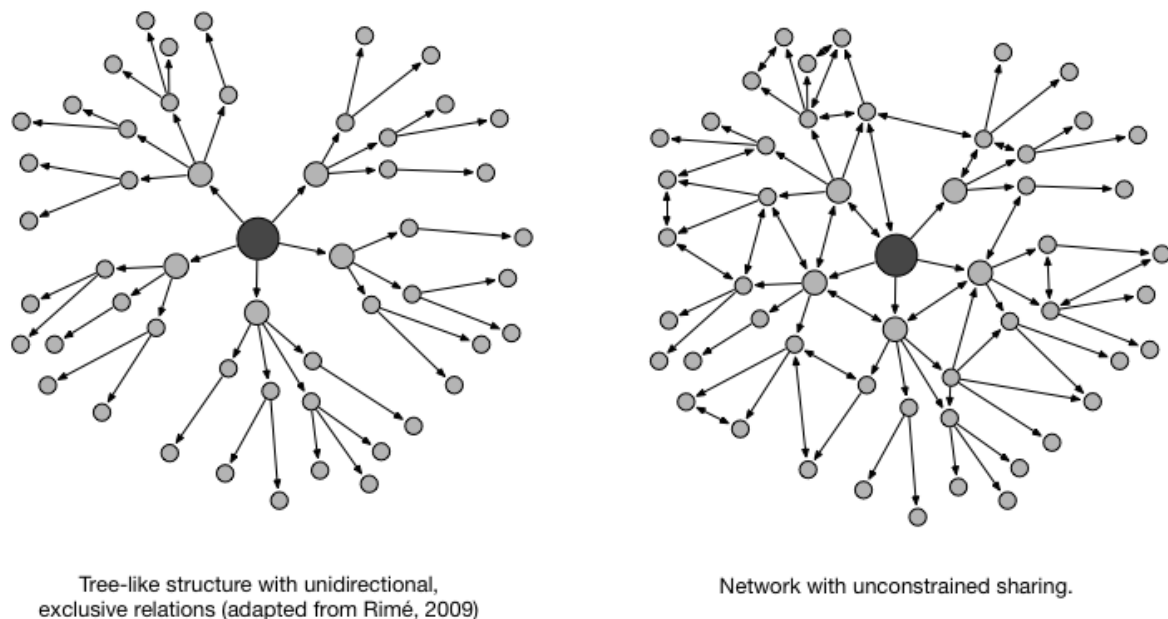


Figure 17. Propagation of social sharing (adapted from a figure in Rimé, 2009).

As the recipients of the primary social sharing share their emotions in turn (secondary sharing), the recipients of their social sharing may engage in tertiary sharing, propagating information about the initial emotion to a wide audience. Rimé’s (2009) visualisation of how social sharing might propagate closely matches this narrative (see left panel of Figure 17). In Rimé’s

original figure, social sharing is depicted as a unidirectional process, because each person only shares forward (i.e., does not re-engage the source of the emotional information). Likewise, each person in Rimé's original figure appears to find a target who has not yet heard the narrative being shared (i.e., people do not "compare notes" with each other). However, these lines were probably omitted to simplify the figure in order to highlight the reach of emotion in a network and their absence should not be interpreted as theoretical statement. By filling in these lines (see right panel of Figure 17), we depict a more realistic milieu of social constraint in which actively people share their experiences back and forth (Pennebaker & Harber, 1993). Given that the figure clearly resembles a graph of a social network, it is obvious that social sharing research would greatly benefit from methodology and theory borrowed from the rich literature on networks.

SUMMARY OF KNOWN AND UNKNOWN

In its simplest form, co-rumination is a dyadic process that involves excessive self-disclosure that dwells on the negative (Rose, 2002). Longitudinally, it has been associated with both depression and increased intimacy between the two co-ruminators (Rose, 2002; Rose et al, 2007). The main short-coming of the co-rumination theory proposed by Rose (2002) is that it does not take into account the relations that surround the co-ruminators. It is framed in dyadic terminology while the extended process is likely to involve multiple people, at least indirectly. I propose that co-rumination (Rose, 2002) is best understood as a specific, dysfunctional outcome of social sharing (Rimé, 2009) and that both social sharing and co-ruminative processes are situated in a wider social network. Some of the processes involved in co-rumination are parts of typical social sharing, while others are maladaptive and possibly unique to co-rumination.

By focusing almost exclusively on isolated data points and exclusively reciprocal relationships, co-rumination studies to date have not addressed network-wide mechanisms of co-rumination in detail. At this level, there are more open questions than there are answers. As it is currently conceptualised, dyadic co-rumination enhances relationship quality within the primary pair of co-ruminators while making them vulnerable to depression, at least among adolescent girls

(Rose, 2002). The problem with this formulation of co-rumination is that is defined only in terms of dyads, although these dyads do not exist in a social vacuum. In fact, both of the co-ruminators are connected with other people through numerous personal relationships, such as parent–child relations, friendships, and romantic partnerships.

Calmes and Roberts (2008) demonstrated that co-rumination in one relationship is correlated with co-rumination in another, which suggests that negative emotion that unfolds in one relationship also seeps into others. When this assumption is combined with findings from the social sharing literature, it appears quite clear that people co-ruminate with many close friends instead of just a single confidant, making co-rumination an inherently networked phenomenon, and not just a dyadic one. Thus, co-rumination must be considered in the context of an interlocked network of social relationships, each with their unique co-ruminative conversations. However, due to the lack of co-rumination research at the social network level, our understanding of the social network processes that act upon co-ruminators are largely based on speculation.

Research on depression and social networks shows that emotionally distressed youth are more likely to be socially excluded, befriend each other based on their shared depressive symptoms, and influence each other's mood (Cheadle & Goosby, 2012). Co-rumination, too, has been demonstrated to erode friendship networks and reduce social acceptance among peers over time (Starr & Davila, 2009; Tompkins et al., 2011). However, researchers have not yet been able to give a conclusive answer to the question of why this happens. Whether it is because being seen as a co-ruminator by others tend to make youth less popular or whether co-rumination isolates people from others is unclear.

Regardless of why co-ruminators' peer relations erode, social network decay can increase vulnerability to depression for both functional and structural reasons. Because social embeddedness and (perceived) availability of instrumental, informational, and emotional support is beneficial for mental and physical well-being (e.g., Barrera, 1986; Cohen, 2004), diminished contact with peers is likely to reduce perceptions of available assistance (and times help was actually enacted) as well as create depressogenic feelings of loneliness (Cacioppo & Hawkley, 2009).

Understanding social network processes could also help explain the two key findings of co-rumination literature: the tendency to find co-rumination associated with stronger relationships and its depressive long-term trajectory. Rose (2002) suggested that increased self-disclosure in co-rumination leads to relationship satisfaction, while rumination leads to depressive symptoms (Rose et al., 2007). In addition, some observations about co-rumination might be enriched with relational and network explanations, such as that co-ruminators might already be close others. Some people may be more willing to continue to engage with co-ruminators due to role expectations (e.g., being a parent, best friend, or romantic partner) or disposition (e.g., tendency to co-ruminate). If co-ruminators refrain from sharing with unwilling peers and channel social sharing toward individuals most open to co-rumination, the entire social network will reconfigure in a way that both isolates co-ruminators from the wider network, but at the same time, increases contact in at least one relation. Thus, the final co-ruminative dyad—the last sympathetic ear willing to listen ego’s woes—is likely to be a close relationship by default.

Because co-rumination partners are usually already at the inner core of the co-ruminators social network—commonly the people closest to the co-ruminator—the association between co-rumination and relationship satisfaction may be especially visible in these relations. Furthermore, the perception of a strong relationship could be made even stronger by the reduction in other relations. Since people make comparisons on a relative instead of an absolute basis, it seem like the close co-ruminative relationship is actually growing stronger, when in reality it is merely treading water while the relations around it are eroding.

The defining characteristic of a network is that includes interconnected relations that exert influence over each other recursively, which is a good theoretical match to the network of social relationships and co-rumination within them. This kind of interdependency is very difficult to model with the statistical tools that are typically used in social psychological research. Because the co-rumination pairs all share one person, their levels of co-rumination are not independent of each other. At least in the basic statistical sense, co-rumination in one dyadic relationship “leaks out” and influences other relations as well. While this kind of behaviour is extremely cumbersome to model using tools available in SPSS, social network analysis researchers have flexible tools designed to handle exactly this kind of situation. Thus, the lack of theoretical and empirical work

on networked process in co-rumination could be an indication that ideas and tools used by network researchers are still foreign to many social psychology researchers. This state of affairs signals a significant opportunity to broaden the scope and detail of co-rumination research by formulating key aspects of the co-rumination literature in terms of social networks.

NETWORK THEORY

Due to compatible methodology and theoretical interests, social psychology and social network analysis (SNA) have a lot to offer to each other. The main benefit of these tools is that they can simultaneously include data from three different levels of analysis (i.e., individual, dyadic, and social context) at the same time. This methodology allows researchers to model human social behaviour at a scale that would be difficult, if not impossible, to achieve using traditional research tools. However, because of differences in vocabulary and relative separation of the fields, social psychology researchers may not yet be familiar with the new empirical and theoretical opportunities at their disposal.

First, I will review the science of networks as it has developed in other fields. Then, I will review the core concepts, terminology, and best practices in social network analysis to establish a framework that can be used to accurately and precisely describe individual persons, their multiple relations, and their interactions as a whole system. After being equipped with the terminology to describe social interactions at all levels, I will highlight the compatibilities between social psychology and SNA. I will use intergroup contact as a specific example of how SNA ideas and tools can enrich social psychology research. This section does not contain empirical findings; the main contribution here is to bridge disciplines to import fresh ideas and advanced tools into social psychology research.

The idea of a network is a powerful explanatory tool, because it can integrate complex phenomena into a single structure. However, to really appreciate the usefulness of network thinking in co-rumination, let us first examine a more concrete example. In nature, spiderwebs are one of the tangible examples of networks. Because they are such a visible structure, NASA researchers used spiders to develop a test to assess the neurotoxic potential of a chemical (Noever, Cronise, & Relwani, 1995). When common house spiders (*Araneus diadematus*) were given various psychoactive substances like marijuana, caffeine, and chloral hydrate, the network structure of their webs changed dramatically. The greater the toxicity of the substance, the more deformed webs looked in comparison to a normal web.

Networks are a matter of life and death to both people and spiders. When a flying insect collides with the net and struggles to get free, it makes the web vibrate. These vibrations ripple through the web's network of silk-thread linkages, and the patterns in which they travel depend on the spot where the insect hit the net. Thus, a spider can quickly sense from the oscillations where to find its struggling victim. However, if some unlucky (or drugged out) spider cannot weave a well-structured network, it would have serious negative implications for survival and reproductive success. A too sparse or misplaced web might fail to catch insects altogether or a misshapen network might confuse the spider about where to find its prey, giving the trapped insects extra time to escape.

People also rely on networks for survival, but our networks are less visible, because the threads that bind individuals into networks are not visible to the naked eye. Instead of spiderwebs, people build and maintain networks of personal relationships to help them deal with daily problems. Social capital is one of the critical success factors in life. It is measured in terms of quality of one's personal and community ties, and is found to support both physical health and subjective well-being (Helliwell & Putnam, 2004). Therefore, people who are unable to maintain a well-structured social network could face difficulties in life and be at risk for depression.

Complex behaviour, such as spiders weaving networks or humans coming together in communities, can emerge from relatively simple rules. For example, in order to explain the vast complexity of life and the dizzyingly rich diversity in the natural kingdom, including our arachnid friends and ourselves, Charles Darwin postulated that only three processes that were acting in parallel. With mathematical certainty, evolution would arise wherever variability, inheritability, and competition came into contact. Later, Watson and Crick showed that the plot turns in the book of life were based on a twisted double helix that arranged the language of life—itsself written in only four letters—into long, knotted sentences that fold onto themselves.

The interaction of simple dynamics can create complex dynamic systems that have homeostatic steady states. In mechanical engineering, this principle has been understood for a very long time. In early steam engines, safety relief valves were simple mechanisms that were triggered by excess steam pressure. The simple dynamic of thresholded opening and closing a valve is an

active counter-process to the excess heat in the system. Although it does nothing to regulate the fuel source, it still keeps the entire engine from exploding. More sophisticated mechanisms, such as thermostats, may operate by directly triggering or terminating other processes. Thus, the action and counter-action of simple, easy-to-describe dynamics can produce self-organising behaviour: order can arise from chaos through simple feedback mechanisms that trigger each other. Guastello and Liebovitch (2004) argue that “50% of the explanation for a phenomenon comes from knowing which dynamics are involved. In situations where model statistics can be compared, the analysis of simple dynamics tends to have a cumulative advantage of 2:1” (p. 4).

While natural sciences have made good headway towards an elegant formulation of the Grand Theory of Everything, behavioural sciences are just getting started. Network theory has a compact set of components to use as interlocking building blocks to build models of social behaviour. In social networks, relationships organise people into complex structures, allowing the network behaviour to manifest itself as intrapersonal, interpersonal, or distributed group processes—any of which can be combined into yet more complex, richly inter-connected structures. Often, dynamic systems can also be summarised using simple graphical representations of the dynamics (e.g., Feynman diagrams are visual representations of the mathematics describing the behaviour of subatomic particles).

Network Science

Network science is a blossoming new discipline that studies how networks of all kinds behave (Strogatz, 2001). A wide range of phenomena can be conceptualised in network terms (e.g., telecommunications, gene co-regulation, neural activity, etc.) and the field as a whole seeks to discover common principles, algorithms, and tools that govern their behavior. In short, network science is about formulating and solving problems that have a network structure. Ideas and tools from network science have broad interdisciplinary appeal, because problems and solutions in many fields can easily be conceptualised as networks of different types. By using networks as explanatory tools, it is possible to understand how processes in one level of the network system affect other levels, from the micro to the macro (Wasserman & Galaskiewicz, 1994). Networks can provide a seamless linkage between different levels of analysis in a way that successive levels are

embedded in one another. For example, a relation between two individuals is a prerequisite of a dyad. Linkages between dyads give rise to triads, which are in turn embedded in higher order groups of individuals. Groups come together in a larger institutional context, may it be social, political, or organisational. Such institutions are embedded in larger arrangements, such as industrial sectors or political coalitions in a national or international context—a global network of networks.

Social network analysis

While network science is the umbrella for the study of any network, social network analysis (SNA) is the application of network science to networks of people: it is the study of social structure (Hawe, Webster, & Shiell, 2004). Instead of analysing individual behavior, cognition, or emotion in isolation, social network analysis focuses on how people interact with each another and how these interactions create a structure that can be studied in its own right.

Social network analysis offers an integrative perspective on studying emotions from a standpoint that respects their relational core. According to Wellman (1988), the network approach can be summarised in five principles. First, people's behaviour is best predicted by the pattern of their relations instead of their intrinsic qualities like attitudes or demographic characteristics. This is because network relations present opportunities and impose constraints on what individuals can feel and do. Second, analysis of isolated people or their individual differences can be misleading if the relations between them is not taken into account. Third, since all network data is relational by default, the conventional assumption of statistical independence must be abandoned and interdependence among people should be assumed. Fourth, understanding a network cannot be done by aggregating the dyadic ties as the overall shape of the network gives context to each dyad. Fifth, social life consists of overlapping networks instead of dichotomous groups, and individuals may have affiliations with many groups.

Because SNA is fundamentally relational, it is capable of describing and analysing interpersonal phenomena better than tools that do not take into account interdependencies between people (Wasserman & Faust, 1994). Explanations based on social network analysis are capable of simultaneously including the interlocking influences of the social environment and individual

people in it. To clarify, social network analysis centers on the relations that connect people rather than on the people alone. Instead of having to study people as independent and isolated individuals, social network analysis allows the researcher to both see the big picture and keep the small details in sharp focus. In social network analysis, the locus of causation is not solely within the individual. In addition to individual differences in people, the overall social structure of the network is in dynamic interaction with the behaviour of the people in it. Furthermore, social network analysis can incorporate longitudinal data to capture network-wide dynamics over time.

Multiple theoretical, mathematical, and computational advances have converged in social network analysis (SNA), making it a sophisticated platform on which social psychology can build theoretical advances and improvements in quantitative analyses. In addition to being a new set of analytical tools for visualisation and analysis of networks, SNA is more than just the methodology, it is a whole new way of looking at questions in social psychology. Overall, SNA is a flexible and powerful set of ideas and tools that social psychology can use to its benefit.

In the language of networks, complex social phenomena can be expressed accurately. SNA makes it is possible to describe and analyse—both in theory and numbers— complicated relationship patterns among people. For example, the complex social logic that goes into the dictum “the enemy of my enemy is my friend” can be operationalised as an increased likelihood of a positive relation between actors who have a negative relation with the same alter. Likewise, “birds of a feather flock together” can be expressed as sameness in a categorical actor attribute (e.g., gender or ethnicity) or similarity on a continuous attribute (e.g., age or drinking behavior) predicting increased likelihood of a relation between actors.

The strength of SNA is that individual-level outcomes and effects can be used in higher-level analyses and vice versa. For example, Selfhout and colleagues (2010) found out that individuals who score high on extraversion (i.e., intrapersonal trait) tend to select more friends than people with low extraversion (individual behavior) and select others with similar levels of extraversion to their own (interpersonal relations).

Basic Concepts

From a mathematical point of view, a network is collection of entities and the connections among them. Thus, the core terms in social network analysis are a network, a network member, and a relation. These three core terms match well the typical three levels of analysis in psychology and fit together like cogs in a machine. The intrapersonal level describes the parts of the system, the interpersonal level describes how the pieces fit together, and the social network level models how the entire system functions. Many topics in social psychology concern questions that involve all of these levels, from the individual to the social network as a whole.

Network terminology is not set in stone and tends to vary across disciplines. Network members are often called—depending on the field of study—actors, nodes, points, agents, or vertices while relations may be called ties, edges, links, lines, degrees, or arcs. The collective systems that are comprised of the actors and their relations are called either graphs or networks. For consistency and an intuitive mapping onto individual people, this thesis refers to network members as actors, the connections between them as relations, and the whole system as a network. An important point of distinction is that the term graph often also refers to a visualisation of a network, often in the form of circles (or other shapes) representing the actors and lines that connect the circles representing their relations. Visualising networks is often helpful, but it is good to keep in mind that the network is the list of relations, not any particular visualisation of it.

Actors

As a fundamental building block of a social network, an individual person is a crucial unit of analysis. In SNA, each actor is conceptualised as a social entity with agency, capable of forming relationships with other actors. An actor can have a range of attributes (i.e., individual differences in social psychological terminology). In social psychology, individual differences refer to various measurable observations about a person that have meaningful variance between people. In social network analysis, the corresponding term is actor attribute that describes data associated with an actor in a social network. These actor attributes can be used as covariates in statistical modeling and can be either constant, such as gender or ethnicity, or subject to change, such as opinions, attitudes, or behaviors (Snijders, Bunt, & Steglich, 2010).

In addition to individual differences, social network analysts have new metrics at their disposal. At the level of an individual actor, these measures can quantify how many people the actor can reach directly (degree), how likely it is that the actor is on the most direct route between two people in the network (betweenness), how fast the actor can reach everyone in the network (closeness), and how well the actor is connected to other well-connected people (eigen-vector centrality). Although these metrics are calculated for individuals, they stem from the individual's position vis-à-vis others.

It is important to note that although many of the words used to describe individuals, their relations, and the network itself have pre-existing meaning in common English vocabulary, many of them have more precise definitions in social network analysis. For example, centrality is not the same thing as role-based importance in an organisational network. A reclusive department head who maintains a closed-door policy can be a prominent figure on an organisation chart, but remain isolated from the social network of the department. On the other hand, a socially active secretary may be the most central person in the department's social network, despite lacking formal gravitas. In SNA, many measures of centrality have been defined to identify network members based on their number of connections to others, structural positions to bridge otherwise unconnected parts of the network, and distance to the furthest member of the network, to name a few.

Relations

Relations link actors together into dyads, and these relationships can have qualities that are not properties of either actor. That is, the attributes of the relationship are unique to the relationship, not to the actors involved in the relationship. For example, the duration of a friendship or frequency of contact between friends is an attribute of the relationship itself. Although relations can be defined in multiple ways, they typically fall into four broad categories: similarities, social relations, interactions, and flows (Borgatti, Mehra, Brass, & Labianca, 2009). A relation based on similarity can be, for example, living in a same dormitory or belonging to a same club. Social relations include kinship or other common role relations (e.g., co-worker, friend) as well as affective (e.g., respect, liking) and cognitive relations (e.g., knowing about someone, perceiving someone as a happy person). Relations based on interaction can include any mutual behavioural engagement (e.g., sex, talking), whereas flow relationships involve a transaction of

sorts (e.g., information, beliefs, resources). In many contexts, social networks tend to be multiplex (i.e., actors share more than one type of relation). For example, co-workers may have a role-based relation through one reporting to the other and an affective relation through being friends.

Relations can also vary in direction and strength, although the operationalisation of strong and weak relations may differ depending on context (Marin & Wellman, 2010). When the direction of the relation is taken into account, a relation goes from one actor to another. For example, in the original study on co-rumination (Rose, 2002), the participants nominated three of their best friends. In SNA parlance, the participant “sent out” an outgoing relation, giving it a direction. If one of the nominated friends also nominated the focal participant as a friend, this “incoming” relation made the friendship reciprocal. In plain English, relations have a direction and a sender, like Cupid’s arrows. For example, when Alice “falls in love” with Bob, it would be noted—in network terms—as a romantic relation originating from Alice and pointing to Bob. As the receiver, Bob has no agency over the relation that Alice “sends out” to him. Bob may not reciprocate the relationship (i.e., Bob may not love Alice back): the nature of unrequited love is such that only Alice—as the source of the relation—has the power to dissolve it. The best case scenario for Alice and Bob is, of course, mutual love that depends on reciprocated relations originating from Alice to Bob and vice versa.

In terms of strength, weak relations tend to be infrequently maintained and not intimate, such as the relations between coworkers in different departments. Strong relations are characterised by intimacy, self-disclosure, reciprocal support, frequent contact and so on (Burt, 1992; Granovetter, 1972). Relations can be represented using binary values that indicate whether two persons are friends, or using higher or lower scores based on how close the friendship is perceived to be, or how often the friends interact. For the purposes of this thesis, all relations are considered to be directional and measured as binary variables.

Networks

Just as intrapersonal mechanisms give rise to interpersonal processes at the dyadic level, interpersonal relations at the dyadic level are an integral component of more inclusive social networks. The broader patterns of relations within the network give individuals and their

relationships a meaningful context (Borgatti et al., 2009). For example, in Shakespeare's *Romeo and Juliet*, the crucial point is not that the lovers have a dyadic relation, but instead that each lover is embedded in a separate cluster of people, and these clusters do not communicate with each other—it is the structure of social relations that creates the dramatic tension in the play. In real life, social psychological terms like peers, ingroup members, classmates, kin, and co-workers refer to specific social networks in which people are embedded. Taking into account the big picture of these relations is a significant improvement over focusing only on the attributes of individual actors or just dyadic relationships.

Ego and whole networks. There are two principal ways of conceptualising a network: ego-centric (or personal) networks and socio-centric whole networks. Garton, Haythornthwaite, and Wellman (1997) compare personal networks to the geocentric model of the solar system in which the focal person (i.e., ego) is located at the centre of their social universe and members of the network (i.e., alters) are defined by their specific relations with him or her. This approach is particularly useful when the boundaries of the relevant population are hard to define. A modern example of this type of a network can be found on Facebook, a popular social media site where users can map and interact with their personal networks, but cannot see the networks of other people. Analysing an ego-centred network can show patterns in the breadth and depth of connections that the individual at its centre has.

The second, socio-centric way to define a network considers a whole network based on some specified criterion to demarcate the population of interest. The boundaries for the population can be defined, for example, by membership in a formal hierarchy, such as a corporation, a cohort, or club. Methodologically, the collection and analysis of such data differs from typical quantitative social science studies: instead of random samples, SNA data collection aims to include all of the actors in the network, not just a probabilistic sample thereof. Since every potential member of the population needs to be surveyed, this places practical limits on the size of the whole networks that can be defined (although modern online data collection is extending the researcher's reach beyond the scope of paper-based methods).

Social Psychology And Networks

A network perspective is very compatible with social psychology: everyday relationships that are the basis of human social behavior are very easy to conceptualise as a network. Because both social psychology and social network analysis are fundamentally interested in the same thing (i.e., interlinked people functioning as a complex system), they have a great amount of synergy.

Past use of social network analysis.

Although social network analysis is not very common in contemporary social psychology, it has deep roots in the history of social psychology. Intellectually, Kurt Lewin's (1936) contribution to take into account the influence of environmental factors—especially other people—has been recognised as an important influence in the genesis of contemporary social network research (Freeman, 2004).

In 1946, Heider defined balance in social relations using considered directed relations with valence and Back (1951) laid out basics of social influence. A little later, Harary (1953) introduced the notion of structural balance, according to which relations are structurally balanced when two actors like each other and they both like and dislike the same alters (or disagree in all relations if the actors do not like each other). On a larger scale, the famous “lost letter” experiment by Travers and Milgram (1969) demonstrated that the average path length between two randomly chosen Americans is six degrees.

Despite a strong start, social network analysis in social psychology has languished for years and other disciplines have picked up the torch. Whereas Milgram was one of the first people to study small-world networks from an empirical point of view, one of the major theoretical advances was provided by a physicist, Duncan Watts, and a mathematician, Steven Strogatz (1998) in their article on the small world phenomenon published in *Nature*. The current academic strongholds for social network analysis are sociology, economics, physics, and mathematics (Freeman, 2004). Even in topics that used to be mainly psychological, research has shifted towards structural explanations (e.g., social influence; Marsden & Friedkin, 1993). Social network analysis has already found a stronghold in sociology that often focuses more on structure of relations instead of individuals. Fortunately, social psychology has many research questions in common

with sociology, and can borrow research methods from sociology with relative ease, as has been the case with agent-based modeling (Smith & Conrey, 2005).

Intergroup psychology

Although the main focus of the thesis is co-rumination, I will use a more general example from intergroup psychology to demonstrate that a network perspective is widely applicable to research beyond co-rumination. By using an example from intergroup psychology, I am hoping to highlight the applicability and utility of social network analysis in the study of groups, and by extension to social phenomena that transcend the level of individuals and their dyadic relationships. The discussion will also permit me to compare and contrast network-based and group-based analyses.

Groups and networks. Intergroup psychology has accumulated an impressive body of knowledge about how people behave in groups and how groups behave in relation to each other. However, the definition of a group differs in the social identity and network approaches. In the common intergroup sense, the word “group” primarily refers to ways to categorise people at a cognitive level (in particular the self-categorisations adopted by potential group members; Turner et al., 1987). In this sense, groups are built around socially relevant attributes, such as ethnicity, religion, or other exogenously determined or imposed factors.

To a social network researcher, on the other hand, “the world is composed of networks, not groups” (Wellman, 1988, p. 37). Rather than focusing on the self-categorisation and social identity of individuals, the network approach finds clusters of people based on their relations with others. Thus, a network indicates a set of specific individuals who are connected to each other with interconnected relations. Within a network, cohesive communities are discovered algorithmically from the overall network as emergent structures (Wasserman & Faust, 1994). A network has a community structure if its actors can be divided into sets in which those actors have many relations with each other, but only sparse connections outside their cluster (Girvan & Newman, 2002).

The strength of the social network approach is that people can be connected to groups with varying levels of embeddedness through their interpersonal relations (Granovetter, 1985) in addition to their perceived group memberships. To contextualise this, consider a fictional situation

in which actors from different backgrounds come into contact with each other (see Figure 18). Suppose that network in the figure represents a network of individuals who self-categorise themselves as either “black” or “grey.” In the graph, the circles represent individuals and lines the friendship relations among them. While the graph colors were chosen mainly for legibility in black-and-white print, the color of the individual circles could be thought of in terms of ethnic background. However, any categorical variable could be mapped as colour in the network visualisation, including religion, sexual orientation, gender, and so on. Regardless of the variable, the social network analyses would still be carried out in an identical fashion. (Even continuous variables could be mapped as shades of colour.)

The large dotted circles indicate network clusters that can be mathematically identified by actors’ dense interrelations, and their sparse relations with actors outside the cluster. (The dashed line from A to C represents a potential relation and will be discussed later in the section about transitive relations.)

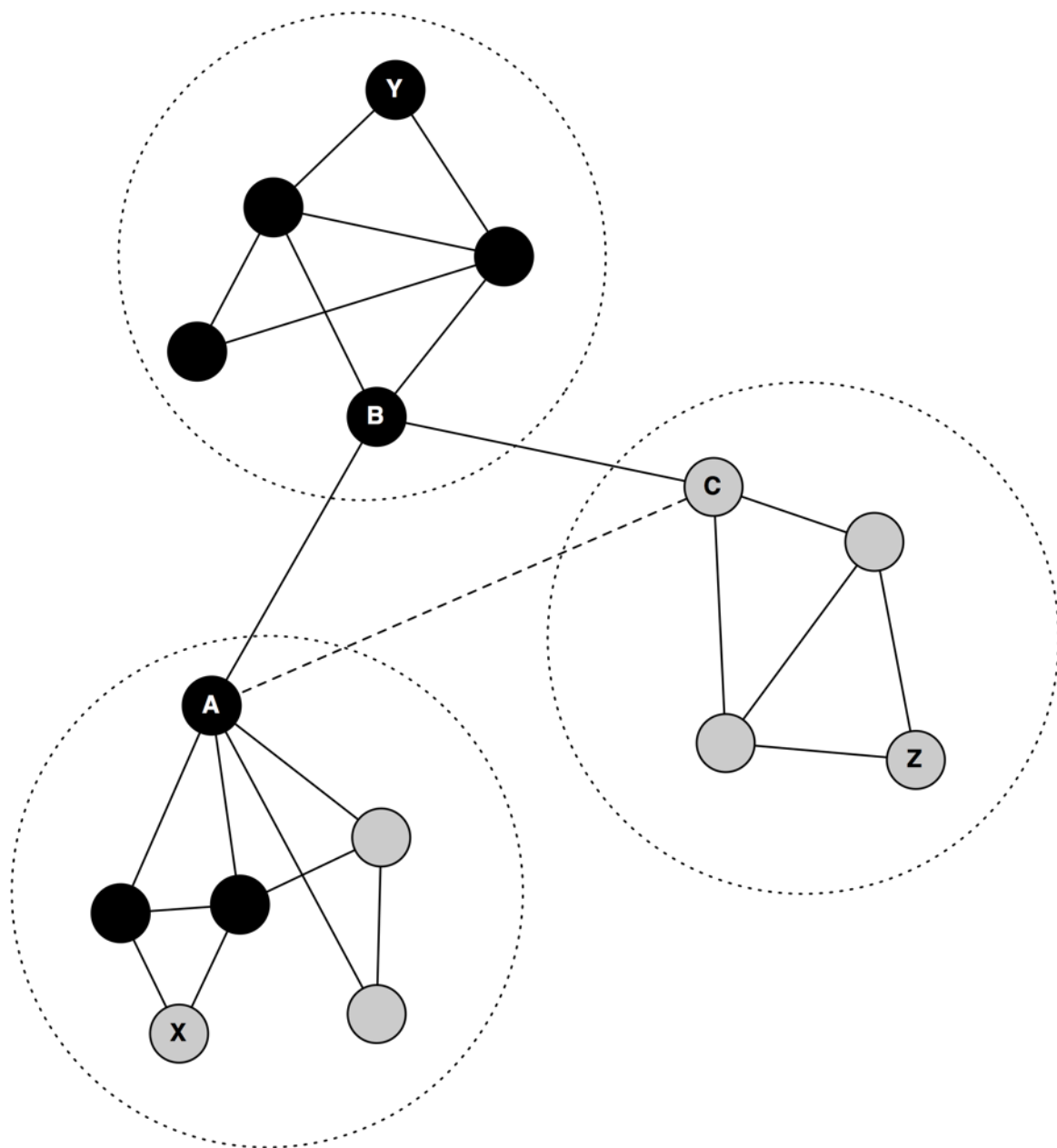


Figure 18. Community structure versus identification with a group.

Even a brief visual examination of the network conveys a lot of information. For example, there is a single cut-off point: removing actor B would separate the network into three disconnected components. Thus, actor B occupies an important role in the network and can broker information and opportunities between the clusters (Burt, 1992). Having such a network position could also influence the attitude of others as well, as the extended contact hypothesis (Wright et al., 1997) suggests that knowing that a member of one's own group has a close relationship with a

member of an outgroup can lead to more positive attitudes towards that outgroup. Social network analysis can fine-tune such theorising, there are measures to quantify how easily networks can be cleaved into separate clusters and how unambiguous the resulting divisions would be. In other words, analysing the number of relations between people in a network can put precise numbers on the level of integration within and between clusters (Porter, Onnela, & Mucha, 2009).

Another feature of the network in Figure 2 is that the clusters are not entirely based on whether actors identify themselves as black or grey: while two of the clusters are homogeneous in terms of their members' group identification, the third cluster contains both black and grey members. Instead of using information about different levels of identification, a network analyst would use the observed structure of relations to predict actor C's emotions toward actor A. For example, since C is friends with B, who in turn is friends with A, it follows that C is likely to become friends with A as well (i.e., transitivity of relations). This prediction can be made from the pattern of relations alone without any reference to the individual characteristics, such as group identification, of actors C or A.

Attitudes and network structure. If each student in the fictional example completed a measure of their attitudes towards black and grey individuals, it would be possible to compare their attitude scores with the path length to nearest person from a different group (i.e., an outgroup member in terms of social identity as indicated by node color in Figure 18). For example, the centrally located actor B has a direct connection to a grey actor and thus can be said to have the path-length of one—the shortest possible one. Visually, to reach from B to C in Figure 18, just one line is enough to connect them—there are no “go-betweens.” In comparison, the right-most grey actor Z has a path length of three to the nearest outgroup member. Put in another way, actor B is a friend with an outgroup member, whereas actor Z has a friend who has a friend who is friends with an outgroup member. These differences in social distance between actual group members are likely to be meaningful in terms of intergroup bias, for example. The same would apply to the black actor Y as well.

Recently, this kind of approach has been used to disentangle racial homophily from other mechanisms that influence relations between individuals with interesting findings. For example,

Wimmer and Lewis (2010) found out that while African-American students tended to prefer same-race friends, Hispanics overprivileged friendships with Asian students. However, they also documented within-race segregation: in American institutions, students from Africa avoided befriending other students from other African countries (especially Nigerians) and chose African-American friends instead. Therefore, the aggregate-level homophily of a race may hide within-race divisions that cannot be teased apart—or even discovered—without social network analysis.

Transitivity of relationships

The network structure is an important determinant of who become friends with each other by creating social opportunities and constraints for actors' behaviour. In social network analysis, there are ways to estimate in precise terms the increased probability of two specific actors becoming friends, given that they have a common friend. For example, it is possible to compare the observed network of students to networks generated by statistical simulations. In these models, the behaviour of the students is simulated in a way that virtual students form friendships according to certain rules, such as “otherwise choose friends at random, but prefer friends of friends with the probability of X.” By running the simulation multiple times with varying values for X, it is possible to estimate the strength of the transitivity effect among the actual students by determining which value produces the most networks that are similar to the observed real-world network. Because this “friend of a friend” effect is in operation everywhere in the network, it is possible to calculate the boost that a mutual friend confers to the befriending process in general, regardless of group membership. By including an interaction of group membership with the transitivity effect, it would be possible to say, for example, whether cross-group “friend of a friend” situations are more or less likely to result in a friendship than among ingroup members only. Therefore, it is possible to estimate the specific contribution of the general tendency for transitive closure, effect of gender, effect of racial homophily, differences in ages, etc. on the likelihood that a friendship forms between the students.

Stochastic Actor-oriented Models For Network Change

Many real-world networks are in constant flux and a single observation of a network is of limited utility: the dynamics of a network and its actors cannot be adequately explained without a time dimension (Burk, Steglich, & Snijders, 2007). Networks truly come alive as entities that evolve over time.

Statistical methods for longitudinal network data have been developed (Snijders, 2001; 2005; Snijders, Steglich, & Schweinberger, 2007) and an important methodological development was the use of stochastic simulation (Wasserman, 1980). With stochastic actor-oriented models (SAOMs), a wide variety of influences that affect relations can be operationalised, parameters expressing such influences can be estimated, and corresponding hypotheses tested. SAOMs allow researchers to differentiate the effects of influence (i.e., actors becoming similar to the company they keep) from those of selection (i.e., actors choosing to keep company with similar others) in an evolving network (for software to do this, see RSiena; Ripley, Snijders, & Preciado, 2012 and R statistical environment; R Development Core Team, 2012).

Simulation

For longitudinal models of networks, the state of the network is observed at two (or preferably more) time points, often by surveying the network members with questionnaires about their relations and behaviour at the time (Ripley et al., 2012). Because the collected data only represents a snapshot of the network at a given moment, the question of interest is what happened among the actors between the times when data was collected. The basic premise of actor-oriented models is that the unobserved behaviour and evolution of the network between these observations is then simulated as a sequence of mini-steps during which one network actor gets an opportunity to change one of its outgoing relations.

In SAOM the change of one relation is seen as the outcome of a decision by one of the actors. As part of the simulation, actors are given opportunities to change one of their outgoing relations (i.e., to create a new relation, dissolve an existing one, or do nothing). The actors are picked to make their decisions one at a time and are selected for the opportunity in a probabilistic manner. These simulations use a continuous-time model and the sequence of each actor's mini-

steps to represent the unobserved network evolution. In other words, the models assume that between the times the data were collected, the network continued to change in small, incremental steps to produce the state of the network observed at the next round of data collection. These network changes are modelled like a multinomial logistic regression that reflects the attractiveness of the outcome to the actor who is making the change. As such, the technique allows researchers to investigate network evolution as a function of structural effects (e.g., reciprocity, transitivity, etc.), explanatory actor variables (e.g., gender, rumination style, etc.), and explanatory dyadic variables (e.g., pre-established friendships) simultaneously.

The simulation of actor-based network evolution consists of at least two stochastic processes: rate and evaluation functions. During the simulation of mini-steps, each actor in the network tries to obtain a favourable pattern of relationships as determined by the effects included in the model. Assessment of the actor's situation is represented by evaluation function, interpreted as that which the actors seem to strive after in the short run (Snijders & Koskinen, . Repeated simulation of actors' choices subsequently allows the estimation of the model parameters. Once estimated, a direct comparison among the parameter estimates is possible.

Rate function. The first function represents the opportunity for the actors to make changes in their relations. It models the frequency of changes in the relations between actors. In other words, it is the speed by which each network actor gets an opportunity to change a relation in the simulation. The parameters for the rate function are defined as the expected frequencies between the network observations with which actors get the opportunity to change a network tie. Incidentally, testing whether this rate is different from zero (i.e., the standard null hypothesis) is meaningless, because zero would mean that nobody in the network ever got an opportunity to change their relations at all. Put in another way, a zero rate of change would imply a completely static network. It is also important to note that the estimated rate of change may differ from the actual observed number of relation changes, because actors can choose not to change their relations, even if given an opportunity. Likewise, the actors may enact a sequence of relation changes that ends up canceling out the earlier changes.

Usually, the rate is modeled as a constant among all actors, but it may be defined to depend on the actors' existing pattern of relations to others or a set of covariates or behaviors. That is, the basic rate function estimates the rate of change that affords everyone equal opportunities to make changes in their relations. However, by incorporating various effects into the rate function, some actors can get opportunities to change their relations more often than others.

Evaluation function. For the purposes of this thesis, the evaluation function is the most important function in the model. To understand its role, it is perhaps best to start from a intuitive point of view. Imagine that you were one of the actors whose social life was being modeled with a stochastic simulation. The rate function just decided that you are allowed to make one change in your outgoing relations. How would you decide which relation to change? In this simulated life, each existing relation and every potential new relation has its benefits and drawbacks. For example, reciprocating an incoming communication from a friend might be more satisfying than sending out a new communication to a complete stranger.

In the same way, the evaluation function represents what actors regard as a favourable pattern of relationships. Any relational change that increases the value of this function (i.e., “satisfaction”) receives a higher probability to get implemented. The exact probability for each change may depend on the network positions, behaviours, and covariates of both you and the other actors in the simulation. As an acknowledgement of the limited predictability of social behavior, a random element is added to the function. This means that the objectively best relationship change is very likely—but not guaranteed—to be implemented in the end.

Covariates and behaviors

The probabilities of relation changes are determined in part by the current network structure and in part by both the characteristics of the actors beyond their own control (actor covariates), volitional actor behavior (actor behaviours), and characteristics of pairs of actors (dyadic covariates). The difference between actor behaviour and covariate is that covariates are considered to be exogenous: they change according to mechanisms that are not included in the model. Behaviours, on the other hand, are endogenous: they depend on their own values and on the changing relations in the network.

Depending on their nature, both actor and dyad covariates may be constant or subject to change over time. If the construct is not expected to meaningfully change during the network data collection period, such actor attributes are called constant actor covariates. Constant actor covariates include, for example, ethnicity and gender. Time-varying actor covariates could include, for example, weight of the actor or bank account balance. Most measures that assess psychological states would be classified as actor behaviours, as they are expected to both influence the pattern of relations and be influenced by them.

Assumptions

There are some assumptions that underlie the actor-oriented stochastic models of network change. In the same way that the assumptions underlying an ordinary least-squares regression model must be met in order for the results to be valid, these assumptions must be satisfied for the results to be properly interpretable.

Relations as states. For one, the relations are thought to represent states that tend to endure over time rather than transient events. For example, when the participants are asked with whom did they communicate over the period of the last seven days, the question aims to index an enduring social relation between the actors that facilitates their communication. Rather than attempting to model communication as the exchange of each individual message as a discrete event, the model would assume that a relation is a state that is subject to gradual change over time and that communication is an observable effect of the latent relation.

Markov-process. Because the relations are taken to represent states, the network dynamics are interpreted as the outcome of a Markov process. This means that for any point in time, the current state of the network determines its own further evolution in a probabilistic manner without additional effects from the past. In other words, all relevant information that has a part in the evolution of the network is assumed to be included in its current state. However, since people often refer to the past in social interaction, this assumption is often made more plausible by including relevant variables in the model specification (for example, by including information about long-standing friendships). Thus, the information about past events is translated to the present, making the Markov-process assumption plausible.

Actor-controlled relations. The models are called actor-oriented, because the actors are in control of their outgoing relations. This does not mean that the actors have arbitrary control over their social world, but instead that the actors are assumed to base their decisions on specific aspects of the network. The actors are assumed to take into account their own current position in the network and attributes of both themselves and others when making decisions about their relations with others. Importantly, each actor controls their outgoing relations only. Thus, the actors in a SAOM cannot make decisions about the relations of others. They can terminate their own relations with undesirable others, but cannot directly influence the evaluation process whether others choose to create, maintain, or terminate relations with them.

Continuous time. To make the simulation of mini-steps possible, the underlying time parameter in network evolution is taken to be continuous: the processes that determine the shape of the network unfolds in arbitrarily small units of time between observations. For example, consider that three actors—Alice, Bob, and Eve—are observed at times T1 and T2. At T1, all three actors are unconnected and at T2, all of them have become friends with each other. A discrete-time model (i.e., only one step from T1 to T2) would have to explain how such a triad can come into existence from nothing. A continuous-time model, on the other hand, would explain the formation of a closed triangle as a sequence of steps. That is, if the time-resolution of network data is one week, the simulation would model the formation of the closed triad in time units shorter than a week (e.g., days, hours, minutes, seconds etc.).

Sequential change. At any given moment in the simulation, only one relation can change at a time. This assumption breaks the change process down into its smallest components. The implication of this assumption is that the changes in relations are not co-ordinated and influence each other only via the sequential changes in the structure of the network. In terms of the closed triad mentioned above, perhaps Alice first becomes friendly with Bob, who then reciprocates the friendship with her. At the next step, Bob can become friendly toward Eve, who then reciprocates the relation with him. Because friends of friends are likely to become friends with each other, in the next two steps Alice and Eve can reciprocally send out friendship ties to

each other, thus completing the triad. During multiple simulation rounds, the most likely sequences of mini-steps that bring about the triad are identified.

Model selection

The actual steps in specifying the model amount to the determination of the effects included in the simulation. Parameter estimation amounts to estimation of the weights of these components through repeated iterations of the simulation and comparing the results to randomly generated networks. Ideally, model selection should be guided by theory, common sense, and topic-specific hypotheses. In practice, the newness of the method in social psychology may mean that the process of model selection is still largely a matter of induction and intuition. In order to illustrate best practices, will first review model selection advice as outlined by the principal developers of RSiena (Ripley et al., 2011). The exact model representing the relevant effects included in each study and the rationale for choosing them is discussed in the respective Method sections.

Currently, tools for modeling stochastic actor-oriented network dynamics are novel and undergoing rapid development. Because the statistical methods for such models have not yet been fully established, the analysis of social network dynamics are still lacking certain statistics and criteria that are commonly accepted or even required when reporting typical social psychology research. Overall, however, the model selection steps resemble the practical steps required to build a good multiple regression model. Due to technical limitations, choosing which effects to include in the model is still largely an ad hoc procedure that combines forward steps (effects are added to the model) and backward steps (effects are removed from the model) that are guided by the significance level of various effects. The goal is to create a parsimonious model that is sophisticated enough to be realistic, but not more complicated than what is empirically necessary.

Like in multiple regression, including one effect may mask other, perhaps more important effects. Because pure forward selection of effects (i.e., adding effects one at a time) would be likely to overlook some effects, the current best practice is to start with a model that includes all effects that are theoretically considered to be important. However, models with many effects are computationally expensive and time-consuming (e.g., the very basic models presented in Study

3.1, below, took about 120 seconds to compute and the more complex models over an hour each). This makes backward selection cumbersome, leaving forward selection as the only alternative despite its shortcomings (Lospinoso et al., 2010). Fortunately, forward selection steps are beneficial from the algorithmic point of view, because parameter values from good model fits can be used as initial values in the next round of iteration. Passing parameter values from one generation of models to the next helps the algorithm to converge better.

Some of the network statistics can be highly correlated by definition. Therefore, their parameter estimates may also be strongly correlated. In multiple regression model selection, typically only one of the highly correlated variables would be retained. However, due to their importance in any networked behavior, a basic set of network effects is recommended be retained in all models (Ripley et al., 2011). There are also other effects that should be included from the start in the course of good model building practice. These effects include covariate effects predicted by theory and obvious control effects, such as gender homophily. Likewise, individual differences can have important corresponding structural effects. For example, popularity and activity are important degree-level effects that are commonly addressed at some stage of the model selection process.

In traditional social psychology research, participants who score extremely high or low in some measures create a problem of how to best handle these outliers in statistical analyses. In social network analysis, similar outliers are commonly observed: some actors can have very high or very low number of incoming relations (indegrees) or outgoing relations (outdegrees). Ideally, these network outliers would be explained by the model alone by including an appropriate actor covariate based on collected data. If sufficient data were not collected to include the relevant measures, dummy variables may be created based on theoretical expectations. Anyhow, if theoretical interpretations are not enough to explain the variation, non-theoretical model adaptation (e.g., ad hoc dummy variables) may be preferable over large unmodeled heterogeneity.

Overall, the model selection process should lead to a model that parsimoniously explains the observed data. Each effect included in the model should have either a strong theoretical reason

to be included, account for a common network characteristic, or control for a known source of variance (whether expected or not).

Benefits Of SNA

In summary, social network analysis has deep roots in social psychology and is currently experiencing tremendous success in other social science disciplines, especially in sociology. Furthermore, SNA is extremely compatible with social psychology research questions and offers unprecedented levels of analytical sophistication for researchers in the field. SNA is not a competitor to existing theories about human behaviour in groups, but an opportunity to better describe and operationalise existing theories within a common framework and analyse deeply interrelated data. In the next section, I will develop a networked model of processes involved in co-rumination.

COLLECTIVE EMOTION REGULATION NETWORK (CERN)

I think a great amount of empirical and theoretical traction can be gained by conceptualising co-rumination as a network-wide process that reconfigures relations among network members in a predictable pattern, ultimately leading to social isolation of co-ruminators. The main improvement to co-rumination theory is to make the analytical framework accommodate more people than just the co-ruminative dyad. Instead of being an exclusively dyadic process, I propose a more social formulation of co-rumination that is distributed across many actors and can be best understood at the network level of analysis. By using theory and methodology from social network analysis, I will look at how sharing of emotion changes relations, which is one of the fundamental premises in the theory of emotions as relational adjustment (Parkinson, 1996, 2009).

For the purposes of my integrated co-rumination theory, I will call the entire social network that takes part in the process a *collaborative emotion regulation network* (CERN). A CERN is as a distributed social system that involves multiple individuals who interact with each other and whose interactions are guided by the emotions of self and others. A CERN is constructed from only two main building blocks: people (or actors, to use RSiena terminology) and their relations—the rest of the system emerges from the interactions of the two. At the personal level of the explanatory framework, each actor can have intrapersonal processes, such as ruminative responses to stressors that keep the actor focused on negative emotions for prolonged durations. Each actor's stable intrapersonal characteristics, such as gender, age, and personality influence how he or she interacts with others and how others treat him or her in return. Thus, the intrapersonal is naturally linked with the interpersonal in a CERN. At the interpersonal level, actors' behaviour is dependent on the behaviour of others. At the network level, social processes are distributed over many actors and their interpersonal relations.

Holistically viewed, a CERN is an emergent, auto-regulating, and self-organising entity that plays a role in interpersonal emotion regulation. Perhaps the best metaphor for a CERN is a psychological immune system that operates at a collective level, a self-organising system in which network-wide responses emerge from individual interactions to achieve relational balance. At the

intrapersonal level, belonging to a well-functioning CERN makes people more resilient against mental and physical stress. At a relational level, a CERN promotes collaborative relations that help people share advice and (im)material support, enabling them to successfully overcome greater challenges together than what they could handle as individuals alone. Finally, a CERN can improve entire communities (i.e., networks of individuals) by effectively disseminating emotionally relevant information and auto-regulating collective responses to emotional events by reconfiguring relationship patterns to a more optimal state. In a CERN, the reconfiguration of relations is a self-organising process that emerges from the joint effects of individual states and traits, relational emotions, and a changing network structure.

The idea of a CERN should not be a huge departure from existing theories, as it shares many features with social support as interpersonal emotion regulation (Marroquín, 2011) and social sharing of emotion (Rimé, 2009). Instead of reinventing the wheel, CERN combines processes identified by other theories into a social network analysis framework.

A Successful CERN

Before analysing what goes wrong in co-rumination, let us first examine an example of a healthy emotional regulation response at a network level. This idealised scenario is the point of reference to which we can compare the case of co-rumination. Imagine that Egor is a bereaved man who recently lost his beloved spouse, Alterna, in a tragic car crash. When Egor's friends and family learn the news about his loss, they immediately approach him with condolences and offers of emotional and tangible support. The depth of Egor's grief could be so overwhelming that he experiences flashbacks and has Alterna's death on top of his mind all the time. During Egor's mourning period, friends can support his grieving by being sympathetic listeners. However, being exposed to Egor's pain is an intense emotional experience in its own right. When Egor's friends talk to their friends to share their responses to Alterna's passing (as brought to the foreground by conversations with Egor), they propagate the news even further. As the message propagates towards casual acquaintances and distant friends who have weaker ties to Egor, the increased reach of the information can trigger an additional show of sympathy from friends of friends. In effect, people who know Egor come to his side when he is in need, buttressing his coping resources. With

this supportive safety net ready to catch him, Egor can begin to come to terms with his situation. If people around him continue to be supportive listeners, Egor can piece together a coherent narrative of his experience through the conversations he has with others and incorporate the events into his meaning structures. When negative emotions are constructively discussed with others, the process leads to emotional resolution through cognitive work enabled by those conversations. The conversations themselves were indicative of increased social contact between Egor and his support network.

Co-rumination In A CERN

Unfortunately, social sharing does not always have a happy ending. Some people are not able to resolve the impact of negative emotion, the ruminative processes do not run out of steam, and their sharing turns chronic. While social sharing is a typical reaction to intense experiences of emotion, co-rumination appears to be a maladaptive deviation from this normal functioning. As an emotion regulation attempt, co-rumination leads to a dead end: whereas successful social sharing should yield emotional resolution and closer social bonds, co-rumination is associated with loneliness and depression.

Let's revisit Egor and see what might happen if he became a co-ruminator. If Egor were to constantly dwell on the negative and spoke about Alterna's passing excessively, his interminable negativity could prompt an adverse reaction from others. At some point, people around Egor might start to suggest to him that he should just "let go" and move on with his life. However, if Egor fails to follow this advice and keeps on dwelling on death and misery, his friends—who initially rushed to his side in support—might begin to reduce social contact with him. While some friends might recognise that they wish to steer clear of Egor to avoid being affected by his negative mood, others might see more benevolent reasons for reducing contact with him. Some of Egor's friends could justify their actions by saying things like "maybe we should give Egor some space to do his mourning" or "inviting Egor to our engagement party might not be the best thing for him right now." Some well-intending individuals might even try to be considerate for the happiness of others: "I don't think we should bring Egor to the party—he would just bring everyone's mood down." As Egor's social network begins to withdraw from contact with him, Egor's opportunities

to share his emotion would dwindle. As a consequence, Egor would end up with only a limited number of close confidants—or even just one. The people willing to humor Egor’s repeated negative emotion would either be similarly inclined to co-ruminate (and thus have higher tolerance for it) or be obligated to listen due to a pre-existing strong relationship (e.g., kinship).

Constituent Processes

Intrapersonal rumination

Andrews and Thomson’s (2009) analytical rumination hypothesis argues that depression is an evolved response to complex problems, especially of social origin. In their view, the function of rumination is to sustain analysis of problems by giving the triggering problem prioritised access to processing resources and promoting an analytical reasoning style. As a consequence, rumination ensures that the afflicted individual pays greater attention to detail and that information is processed more slowly, methodically, thoroughly, and in smaller chunks. From this evolutionary perspective, rumination is not the cause of mood disorders rather than a symptom of stress. It facilitates a search for solutions by drawing attention to problems and promoting their analysis.

However, rumination can turn unproductive if people develop avoidant strategies. By a biological analogy, fever—a thermal stress response to an infection—causes significant functional impairments in multiple domains, but unlike rumination, fever is recognised as a symptom of illness rather than the cause of such. This does not mean that fevers are harmless, of course. A too violent of a defensive mechanism from the body can end up causing more harm than good. A fever that runs too high may end up killing—rather than healing—a sick person. The important thing to notice is that any stress response mechanism, including rumination, can produce short- and long-term impairments by trading off optimal functioning in many domains in order to produce an effective response to an immediate problem. From the social sharing point of view, intraindividual mental rumination keeps the individual engaged in social sharing that promotes social contact, cognitive work, and socio-affective benefits.

Brooding and reflective rumination. In terms of theory, co-rumination and social sharing both focus on mental rumination as an important causal factor and agree that focus on negative emotion and problems instead of solutions is a risk factor for depressive mood (Rose,

2002; Rimé, 2009). Although mental rumination is a shared component of both social sharing of emotion and co-rumination theories, Rimé (2009) stresses its information processing aspects, while Rose (2002) emphasises its emotional aspects. The social sharing literature considers rumination as a normal response to negative emotion and places the co-ruminative dyad in the context of multiple instances of social sharing. In the co-rumination literature, on the other hand, rumination is seen as a key depressogenic ingredient that perpetuates negative content co-ruminative conversations and intensifies maladaptive responses (Rose, 2002). Thus, the prime candidate for the misbehaving part in co-rumination is that co-ruminators think about and share their negative emotions in a maladaptive way.

This division between cognitive and emotional aspects is also present in the rumination literature. A psychometric analysis of the Ruminative Responses Scale (Nolen-Hoeksema, 1991) revealed a three-factor solution that differentiated between the reflective and brooding components of rumination, in addition to items associated with depressive symptoms (Treynor, Gonzalez, & Nolen-Hoeksema, 2003). Of the two ruminative components, reflection items are neutrally valenced and capture the contemplative aspects of rumination. The brooding items, on the other hand, involve thinking anxiously, gloomily, or self-critically about one's problems. Thus, the damaging features of "co-rumination" may hinge upon whether its "rumination" aspect involves predominantly brooding or reflection. It is possible that only brooding leads to worse mental outcomes, as it has been identified as an important risk-factor for depression. Brooding is associated with higher current levels of depression, having a history of depression, attentional biases toward negative stimuli, and social phobia (Joorman, Dkane, & Gotlib, 2006; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Given that brooding has been associated with social phobia, it might also impact social sharing (e.g., reduce number of sharing partners). However, brooding appears to be a transdiagnostic condition (Watkins, 2009), which suggests that while people with social phobia maybe more brooding than the general population, not everyone who broods on their problems has social phobia.

Reflection, on the other hand, has generally been unrelated to depression, suggesting that neutrally contemplating one's problems is not a risk-factor to depression. Instead, reflection has

been thought of as the adaptive component in rumination (Joorman, Dkane, & Gotlib, 2006; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008).

Social sharing

In a CERN, the need to share is an adaptive, auto-regulative behaviour: as negative emotion is expressed, it elicits social responses that uniquely suited to help resolve it. A lynchpin of my reasoning is social sharing theory (Rimé, 2009), which already describes how people turn to others to help them to recover from intensely emotional, negative events. As empirical data shows, a specific pattern of interpersonal behaviour often follow traumatic events: people respond to emotional upheavals by talking about them (Pennebaker & Harber, 1993; Rimé et al., 1992). The principal benefit of sharing one's emotion with others is that heart-to-heart conversations offer the primary sharer opportunities to satisfy his needs for affiliation and cognitive processing. Repeated iterations of social sharing give the talker an opportunity to organise the negative emotion experience to a cohesive, personally acceptable narrative. The sharing will continue until the damage to personal meaning structures has been repaired and the emotional debris brushed away, which may be a long process. The private experience of emotion is shared often for days, weeks, even years (Rimé et al., 1992).

Social constraint

The analogy of a spider allowing its network to fall into disrepair by only focusing on a single thread segment suggests a way in which co-rumination might undermine someone's network by channeling too much effort into a single relationship at the expense of keeping in touch with the rest of one's friends. The problem with this narrative is that it places too much agency on a lone individual and overlooks the actions of others. In comparison with solitary spiders, humans are an ultrasocial, collaborative species. Whereas the construction of a spiderweb is the handiwork of a lone spider, knitting a human social network is a dynamically co-ordinated group effort. Whereas a spiderweb falls passively into disrepair and only the spider's lack of maintenance is to blame for its sorry state, the fates of relations in a human social network are multiply determined by the actions (and non-actions) of many people.

As suggested by transactional theories of depression (e.g., Coyne, 1976), once someone is caught in the downward spiral of co-rumination, the increasing depression of the co-ruminators

could elicit rejection from others. However, even pre-depressive co-rumination could be aversive to others in itself, even in the absence of direct interaction with the primary co-ruminator (i.e., others do not necessarily need to become a part of the co-ruminative process itself). If co-rumination occurs publicly within a social context, it can be witnessed by others. Totterdell and colleagues (2012) demonstrated that witnessing unpleasant interactions between co-workers can be emotionally draining. Possibly, seeing someone endlessly rehash a problem with someone else could also be emotionally draining and something people would rather avoid seeing. When people in the social context encounter situations in which co-rumination of others impinges on their emotional well-being, they might regulate their own emotions by limiting social exposure to the co-ruminators. Over time, this kind of social avoidance could end up diminishing the peer networks of co-ruminators.

Social penetration theory (Altman & Taylor, 1983) already links excess self-disclosure to deterioration of close relationships. According to this theory, communication moves from relatively shallow, non-intimate levels to deeper, more personal ones as relationships develop. Social penetration is conceptualised in terms of sharing a wide variety of topics (breadth) and personally revealing central things about one's self-concept (depth). Social penetration theory also includes the notion of costs and rewards from social exchange theory (Thibaut & Kelley, 1959), meaning that if the costs (e.g., time, effort, etc.) exceed the rewards (e.g., friendship, acceptance, etc.) of the relationship, people start a depenetration process. During depenetration, disclosure is withdrawn and the relationship is terminated. Whether these kinds of impaired peer relations are a cause or effect of co-rumination is less clear. Tompkins et al. (2011) speculated that co-rumination may cause social avoidance from others, but also suggested that a limited social network and poor acceptance increases co-rumination. Therefore, the chicken-and-egg problem is whether co-rumination precedes social isolation or the other way around.

This line of theorising also has important empirical consequences. In order to detect social ostracism, a self-report from the person being ostracised may not be the most reliable source of information. Likewise, getting accurate data from the people doing the avoiding might be difficult due to social desirability bias: it might be hard for people to admit withdrawing social support from others. Instead of asking them to go on the record with a "sin of commission," it may be

easier to map the results of their “sins of omission.” Although the second kind of data are still based on self-reported information, the research hypothesis is better hidden from participants. As *de facto* social ostracism is inferred from the dissolution of relationships over time, participants only respond to questions about their active social behaviour (i.e., listing their friends) and are not exposed to any direct questions about hypothetical or actual ostracism that might prime the participants.

Research Questions And Predictions

The entire concept of a CERN is too complex to test at once (or even within one thesis), so I am narrowing the present hypotheses and predictions to a set of key assumptions behind social sharing, co-rumination, and CERN. Specifically, by framing some basic aspects of co-rumination in network terms, I can address some of the hypothesised CERN mechanisms as testable effects in stochastic actor-oriented models. There are two mechanisms of interest in particular: social sharing of normative negative emotion and social constraint of excessive negative emotion. The first is expected to be part of the typical, successful operation of a CERN, whereas the latter is expected to play a role in how co-rumination might damage someone’s peer relations and isolate the co-ruminators.

Does emotion drive social contact?

The most basic assumption behind a CERN is that emotion is a factor that shapes the pattern of how people send and receive social contact. If emotion had no measurable impact on how relationships grow and wither, the entire concept of a CERN would be irrelevant. Thus, a key test is to demonstrate that intrapersonal emotion has interpersonal consequences. This kind of reasoning has already been established in the past (e.g., Parkinson, 1996), but never with network-wide measurement. Thus, Study 3.1 will focus on mood perception and communication patterns and pilot the social network analysis methodology used in this part of the thesis.

Negative emotion. A basic premise of social sharing is that intrapersonal experience of negative emotion is a powerful motivator for seeking social contact (Rimé, 2009). Does emotion really drive affiliative behaviors in a way that could shape social networks? If this were the case, we would expect to see a positive ego-effect for negative emotion, meaning that people in a

negative mood would initiate communications with others more than individuals in a neutral or cheerful mood. This will be one of the questions that Study 3.2 aims to answer.

Study 3.2 also provides an opportunity to test whether negative emotion itself begets more negative emotion. If this hypothesis were true, we should observe a significant quadratic effect in how gloomy people feel over time, meaning that already gloomy people are especially likely to become gloomier in the future. Social sharing literature, on the other hand, suggests that negative emotion almost invariably triggers a distributed process that aims to resolve it. Thus, we could expect to see a self-regulatory pattern in negative emotion: an increase in negative emotion should be associated with increased resistance towards even higher levels of negative emotion.

To reconcile these opposite predictions made by co-rumination and social sharing theories, Study 3.2 will examine the longitudinal dynamics of gloom. The CERN approach is more compatible with the prediction by social sharing theory, and the expectation is that gloom will be self-regulating.

Rumination. Another theoretical point of contention is whether rumination is associated with more or less social contact. Traditionally, rumination has been seen as a trigger for an inward focus that manifests in social withdrawal and solitary activity (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). This is in direct opposition to the predictions made by the social sharing literature, which suggests that any experience of negative emotion is accompanied by affiliative behavior and shared activity (Rimé, 2009). To test which theory is closer to the truth, we can measure rumination at the intrapersonal level and use it to predict the number of people with which ego interacts at the relational level (i.e., outbound communication).

Likewise, social sharing literature suggests that the way in which people discuss their negative emotion influences their recovery from it. Specifically, people whose emotional sharing stimulates cognitive work should recover faster while those who only focus on the emotion itself should get stuck in a self-perpetuating process of endless sharing. From the point of view of the model presented above, this crucial distinction should be the difference between salubrious social sharing and depressive co-rumination. This, too, can be tested by correlating brooding and reflective rumination with both gloom and co-rumination.

Does emotion drive social isolation?

Co-ruminators' peer relations have been observed to degrade over time (e.g., Starr & Davila, 2009; Tompkins et al., 2011), but co-rumination theory as a dyadic construction has a hard time explaining why. From a CERN point of view, the creation and termination of relations among people can be understood as the result of competitive processes: on one hand, there are factors that promote social contact and social embeddedness; on the other hand, there are processes that corrode relations and isolate people. Thus, a big question is to understand how co-ruminators' peer-relations degrade over time.

The erosion of peer relations could occur in two principal ways. First, co-ruminators might become reclusive and withdraw from contact with others, possibly due to the inward focus that is thought to be involved with rumination. It is also possible that the co-ruminative relationship is so all-consuming that co-ruminators reduce the amount of social contact they have with others, thus privileging their co-rumination partners over others. If co-rumination as an activity draws two people closer together while distancing themselves from others, this could easily explain why co-ruminators would experience increasing intimacy in their relationship, as more and more of their social interaction would get channeled into the primary co-ruminative relationship. This is a distinct possibility, as the second item in the CRQ-27 states that "If one of us has a problem, we will talk about the problem rather than talking about something else or doing something else." In practical terms, co-ruminative people prefer to engage in a dyadic conversation ("talk about the problem") at the expense of other social activity ("doing something else"). In the long term, such dyad-centric behavior would direct resources away from maintenance of peer relations, eating away at one's social network. The reduced social network could then be a risk-factor for depression, as a dysfunctional network is likely to reduce the amount of social support available, or the mere absence of social relations (i.e., loneliness) could be depressive in its own right (Cacioppo et al., 2009).

However, the key aspect in a CERN is that network-wide effects (such as reduced peer acceptance) can be driven by the actions of others, not by people themselves alone. For example, it is possible that people respond to co-rumination in specific ways, and these responses by others are not directly in the co-ruminators' sphere of influence. This kind of effect caused by the actions

of others is called an alter-effect and making it apparent and measurable is one of the key methodological advantages of social network analysis.

Social constraint. The prime candidate for such an isolationary mechanism is social constraint (Pennebaker & Harber, 1993), which could push co-ruminators away from others, putting people with negative emotion at increased risk of depression through social isolation. The first possibility is that even everyday levels of negative emotion is enough to make others pull away. If this were the case, co-rumination itself would not need to be a causal factor, as the negative emotion itself would be the culprit. However, since the social sharing of negative emotion appears to be a nearly universal occurrence, this does not seem likely. On the other hand, if only excessive sharing triggered social constraint, we would expect to see co-rumination having a unique effect above and beyond mere negative emotion. Based on the social constraint literature, I suggest that the co-ruminative mechanism that corrodes social relations is the orientation of others toward the co-ruminator instead. In short, as a consequence of unwelcome social sharing, people avoid social contact with co-ruminators. As others can identify co-ruminators without even engaging directly with them (see findings of Study 2.3, above), this social withdrawal can become widespread and effectively isolate co-ruminators.

Personality. Although there is no existing literature on the topic, based on the findings of Study 1.2 in Part I, neuroticism and agreeableness should be included at least as control variables in the model. It is possible that neuroticism could make someone more likely to co-ruminate or that agreeableness would make someone more receptive to listening to co-rumination. However, since the exact relationships among co-rumination, neuroticism, and agreeableness are not well understood, I am not framing any specific predictions in this regard.

STUDY 3.1: SOCIAL INTERACTION AND MOOD PERCEPTION

People may avoid interacting with persons who are depressed or in low mood. Based on transactional theories of depression (e.g., Coyne, 1976; Hammen, 2006) and social constraint (Pennebaker & Harber, 1993), people should disengage from interactions with people who are seen to be in a negative mood or excessively share negative emotion. If this were true, participants' perception of a negative mood in a target person should predict reduced communication with him or her. However, it is uncertain whether such processes operate at typical, everyday levels of mood. In the present study, I will use SNA methodology to examine whether the perception of positive or negative mood influences communication patterns by following a cohort of psychology undergraduate students over several weeks and asking them to report on how they perceive others in the cohort and communicate with them.

In order to understand how one's mood might influence the behaviour of others, it is not enough to survey individuals at random, because answering the question requires data from at least two individuals. Because the hypotheses for the present study involve processes that unfolds as much between individuals as within them, social network data were needed. This is due to the fact that how an individual behaves depends in large part on how that individual is embedded in a larger web of social connections with other individuals. Thus, a better approach is to survey a bounded group (such as a class) and map the patterns of communication and mood perception that take place within it. Social network analysis an excellent tool to uncover patterns in people's interaction.

Instead of assuming that mood is a unipolar construct, mood was differentiated from positive mood as the two have been shown to be distinctive dimensions (Watson, Clark, & Tellegen, 1988). Furthermore, participant mood was not operationalised as a typical individual difference measure completed by the participants about themselves (e.g., PANAS). Instead, the participants reported on their perceptions of mood in other participants. As each participant reported only on participants whose mood had been salient to them during each data collection period (instead of rating everyone), the resulting data were a social network.

Whereas in the dyadic studies in Part II, co-rumination was expected to have an instant effect on emotional valence both during and after negative discussions, networked processes are expected to exert their effects at a slower pace over weeks and months as friendships wax and wane. Thus, the data collection was longitudinal.

Hypotheses

Studies in Part II suggested that co-rumination might be—at least in some situations—observable by third parties. If the negative emotion that co-ruminators express influences others' social approach and withdrawal tendencies, it might explain why co-ruminators' peer-relations appear to erode over time.

The main hypothesis was that if perception of mood has an influence on communicational approach or withdrawal, individuals who are perceived to be in a negative mood should be less likely communication targets. This effect can be thought of as the direct effect of negative mood perception on communication (see Figure 19). The effect quantifies the direct influence that a negative mood perception relation from actor A to actor B exerts on the probability of a similarly directed communication relation between the same actors. Thus, if an alter is perceived to be in a negative mood, ego would be less likely to communicate with the said alter.

As a corollary to the first hypothesis, positive emotion was hypothesised to have an opposite effect on communication: perceived positive mood was predicted to increase communication (i.e., participants were expected to seek interactions with people whom they perceived to be in a positive mood). Because past research has highlighted the role of positive emotion in overall sociability and building of social resources (Fredrickson, 1998; Lyubomirsky, King & Diener, 2005), positive mood perception relations were predicted to be significantly and positively related to communication relations.

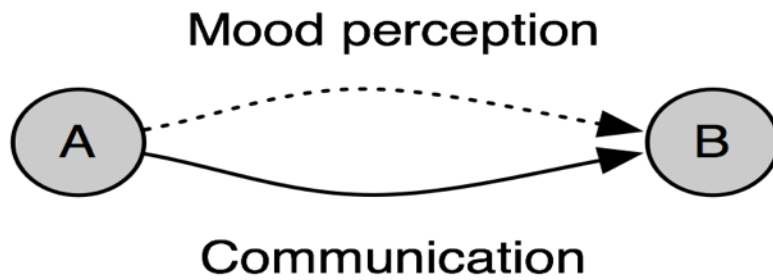


Figure 19. Illustration of the cross-network effect between mood perception and communication.

Other social processes. The social stage on which mood has a role to play is not a static, pristine environment. Instead, human social networks are vibrant and lively places. In order to study the influence of mood, it must be contrasted against the ever-shifting tapestry of the social context in which it occurs. Once basic social processes are defined and held constant, the action of processes involved in co-rumination becomes easier to detect.

In the same way as a researcher using multiple regression models would collect additional data on related constructs to use as control variables, a network analyst should specify other processes that can be expected to shape how relations between participants will be patterned in addition to the effects of the primary hypotheses. For example, homophily (i.e., birds of a feather flock together) is a well-documented force that shapes many human networks (McPherson, Smith-Lovin, & Cook, 2001) and should be accounted for. Therefore, factors such as gender, physical proximity, and pre-existing relationships should be captured by the model to ensure accurate predictions. Thus, testing whether perception of negative emotions reduces the likelihood of in-person communication is not just a matter of framing a single hypothesis and testing a single effect. The resulting models must be elaborate enough to reflect the true intricacies of real social network dynamics, yet as concise and parsimonious as possible.

The song *"High School Never Ends"* by Bowling for Soup (Reddick & Schlesinger, 2006) suggests that social behavior typical to adolescents continues well into adulthood. In a way, the need to specify the other social processes that are expected to influence the observed data offers an indirect opportunity to compare how social behaviour changes from adolescence (the population most sampled for co-rumination studies) to young adulthood (the present sample). Instead of song

lyrics, a review paper on gender differences in peer-relationship processes from the same year will be used as the source document (Rose & Rudolph, 2006). If adolescent gender differences persist to undergraduate years, then predictions based on findings regarding children and adolescents should replicate with the older sample of the present study. To save time, these secondary hypotheses are discussed in the next section about model specification.

Model Specification

Where possible, the effects are discussed with intuitive examples rather than with mathematical equations. For a more formal definition of the effects, please see the RSiena manual (Ripley et al., 2011). All effects and the associated predictions are summarised in Table 8.

Actor-level effects

Ego-effect of gender. An ego-effect is based on the number of relations ego sends out to others and quantifies activity in sending out relations to others. It operationalises the breadth of ego's relations, but does not consider how strong or weak the relations are.

In the context of the communication network, a significant ego-effect would indicate that one gender nominates more conversation partners. A positive parameter value for this effect would mean that women (coded as 2) nominated more people as communication partners (i.e., outdegree activity) than men (coded as 1) did. For both the mood perception networks, a significant ego-effect would mean that one gender was more active in perceiving moods—either negative or positive, regardless of accuracy—in others.

In Rose and Rudolph's (2006) review of gender differences in peer relationship processes, they observed that boys tend to have larger playgroups and prefer group interaction. If this were to persist into (young) adulthood, we could expect to find that men communicated with more people as communications with a group require more communication relations by default. This, in turn, should be reflected as a significantly different ego-effect for gender in the communication network formation. This means that the ego-effect should indicate that male participants communicated with a larger group of individuals than women.

Rose and Rudolph (2006) also point out that girls are generally more socially oriented and attuned to the distress of others, which can be translated to positive and negative mood perception

networks as a significant ego-effect as well: female participants are predicted to be more active in perceiving moods of others.

Alter-effect of gender. An alter-effect measures popularity by quantifying whether actors with higher covariate values will tend to be the recipient of relations sent out by others. Since women were coded as 2 and men as 1, a “higher covariate value” would indicate a woman. In terms of the communication network, a positive alter-effect for gender would mean that women would receive more incoming communication relations than men (i.e., would be preferred conversation companions). Conversely, in the context of a positive mood perception network, a positive alter-effect for gender would mean that women were perceived more often than men to be in a positive mood.

The adolescent literature (Rose & Rudolph, 2006) suggests that popular youth may prefer communication with boys, although the evidence for this is mixed. However, the previous logic of boys having larger group sizes would imply that boys are also more on the receiving end of communication. In terms of mood perception, Rose and Rudolph (2006) point out that boys’ activity-focused styles promote a positive mood, which should make the alter-effect significant for the positive mood perception network—men should appear to be in a positive mood more often than women. Women, on the other hand, could be expected to be seen in a negative mood more often, if the trend of girls’ higher vulnerability to depression were to influence older undergraduate women as well.

Sameness effect of gender. Another basic effect is homophily (McPherson, Smith-Lovin, & Cook, 2001), which quantifies the actors’ preference for others like them. A positive parameter estimate in the communications networks would mean that actors prefer to communicate with same-sex alters. A negative value would indicate heterophily, a preference for the opposite sex. In a mood perception network, homophily would indicate that the genders prefer to observe the moods of their own gender.

From adolescent literature, gender homophily is an obvious prediction for the communication network, because girls and boys prefer same-sex company in childhood and adolescence (Rose & Rudolph, 2006). However, the adolescent and child literature does not

provide clear guidance whether the participants would limit their mood perceptions to their own gender alone. Thus, no gender homophily effects were predicted for mood perception networks.

Sameness effect of team. Unlike gender, participants switched teams during the duration of the study. Thus, team membership was added to the model as a time-variable actor covariate. Because all teams were working on similar tasks, it is unlikely that any particular team was a source or origin of more communications or mood perceptions more than others (beyond what could be expected based on the team members' individual characteristics, such as gender). Therefore, the activity (ego) and popularity (alter) effects of team membership were not included in the model. However, the close physical proximity to other members of the project teams may influence communication and mood perception patterns (MacPherson et al., 2001). Therefore, the effect of being in the same team was included for all three networks.

Dyad-level effects.

Just as there are differences at the level of individual actors, there are differences between relationships. For example, one pair of actors may be better friends with each other than another pair, or in absence of shared history, some pairs may just have better chemistry than others. Such dyadic effects are important for modeling network evolution as well, because dyadic covariates can model why a certain pair of actors would be more inclined to form a relation between them than a random dyad. In the present model, pre-existing friendships were included as a constant dyadic covariate.

Baseline friendships. Because the participants were students in the same department with previously established friendship networks, it was expected that friendship history would have an effect on their social behavior beyond the current communication network. Since the Markov-property assumption expects the evolution of the network to depend only on the current state, it is often necessary to control for "past history" by including appropriate variables. Therefore, baseline friendships among the participants were included as a constant dyadic covariate.

Friendships entail interpersonal intimacy and increased communication (Sullivan, 1953). In addition to being an obvious impact on the pattern of communications, the sheer increase in

personal contact with friends may contribute to mood perception as well. It is possible that the participants would report having perceived more positive and negative emotion in their friends simply because they have more contact with friends than with other people. People who are in contact with one another also tend to converge emotionally over time (Andersen, Keltner, & John, 2003), and this increased similarity may impact on the perception of emotion among long-term friends. For example, if friends have a better understanding of each others' emotions, they might be more sensitive to the other's expressions and perceive more emotion as a consequence. Regardless of the possible mechanisms, the direct effect of existing friendship relation was added to each of the measured networks. Each effect was predicted to be positive (i.e., friends communicate and perceive each others' mood more frequently than non-friends).

Network-level effects

In Study 3.1, there are three networks of interest. These social networks consist of the participants and three different types of relations among them. In the communication network, talking to each other during the last seven days constitutes a relation. Likewise, making a perception of others' positive and negative mood constitute a relation each in their respective networks. Although these three networks are different by definition (i.e., communications with others, perception of positive mood in others, and perception of negative mood in others), it is very likely that there are effects that causally entangle them. These effects are the operationalisation of the main hypotheses and needed to quantify mood's influence on communication.

Within-network structural effects. The RSiena manual recommends that a number of basic structural effects should be included in the model by default. These effects include the outdegree (network density) and reciprocity effects, which are so basic to so many social networks that they simply cannot be left out. Similarly as most typical social psychology research controls for age and gender, SNA analysis almost invariably controls for these effects. Furthermore, including such variables in the model should offer some protection against unintended ego- and alter-effects of unobserved actor-level variables.

Density. Most human networks exhibit certain characteristics that probably stem from basic social cognition processes. First of all, the negative parameter estimate for the outdegree

effect (i.e., the density of the network) indicates that participants were frugal with initiating social relations within the cohort: all things being equal, participants preferred not to initiate communication with others. According to anthropology research, the human brain can only track a social network of somewhere between 100 and 200 individuals and their interrelations (Dunbar, 1992). This “social brain” hypothesis puts a cognitive upper limit to the number of relationships a person can maintain, making it costly to initiate new relations. Therefore, people tend to maintain social relations with a selected few alters, typically resulting in a negative parameter estimate for network density. This means that the more existing relationships participants had, the less likely they became to establish new ones. According to the RSiena manual (Ripley et al., 2011), the density effect is difficult to interpret by itself. However, since most other effects depend on it, it has to be included in the model. Therefore, density is not interpreted in the results or discussed further.

Reciprocity. The reciprocity effect is defined by the number of reciprocated relations. These effects are commonly observed in many types of social networks (Borgatti et al., 2009). The common social norm for conversational reciprocity (i.e., if someone speaks to you, it is polite to respond) is quite enough to make the effect significant in the communication network. However, since such expectations of reciprocity would be absent from merely observing others (i.e., the participants had no way of knowing that someone had formed a perception of their mood), it is uncertain how (or why) reciprocity would play a role in the mood perception networks. Therefore, no predictions were made for reciprocity in mood perception.

Transitive triplets effect. The transitive triplets effect is a representation of network closure and is proportional to the total number of transitive triplets that a relation forms. By way of an example—and in the context of a communications network—if Bob communicates a lot with people who also communicate a lot with Alice (with whom Bob does not yet communicate), transitive triplets effect means that the more communication partners Bob and Alice have in common, the more likely a communicative relation between Bob and Alice will become. The mechanisms behind this increased likelihood could be as simple as social affordances: friends of friends are more likely to be encountered in situations that permit social interaction. For example,

people are more likely to communicate and perceive of friends of friends differently based on the propinquity effect alone (Festinger, Schachter, & Back, 1950). Furthermore, since preference to establish friendships with friends of friends is commonly observed in many types of social networks, the parameter value for transitive triplets was expected to be positive and significant in all three observed networks.

Cross-network structural effects. Structural effects that occur in one network can have effects on the relations in another. All the network effects described in the previous section were within-network effects, whereas this section concerns effects that involve multiple networks. Cross-network effects are defined in such a way that one network always has the role of the dependent variable, while the other network, or networks, have the role of explanatory variable(s). Therefore, these effects are always expressed as influence on the likelihood that a relation in one network is explained by the structures of other networks. Since the model is co-evolutionary, addition of any network effect will automatically also add another in which the network roles are reversed. Unlike in a traditional correlation, however, it is often possible to causally differentiate between these two effects in simulation-based results.

Because the main hypothesis for the present study is that communication patterns are influenced by social perception of negative mood, these structural cross-network effects are the main effects of interest. If this basic hypothesis were true, then we should find structural effects in one network significantly related to the relations in the other(s). In other words, if patterns of mood perception were to influence the people with whom participants communicated, the parameters estimated for cross-network effects would be significantly different from zero.

The main cross-network effect is the influence that an outgoing relation in one network has on the corresponding outgoing relation in another network. The main hypotheses concern the impact that positive and negative mood perception relations might have on communication. Social constraint theory (Pennebaker & Harber, 1993) would suggest that the parameter estimate for the effect of negative mood perception relations on the communication relations network would be negative. Put another way: people would shy away from talking with people who are perceived to be in a negative mood. Conversely, perceptions of positive mood might attract communication,

and the expected parameter estimate for the effect of positive mood perception on communications would be positive. In sum, I expect positive mood perception to be linked with increased communication and negative mood perception with decreased communication.

Likewise, the same effect can be at play in the reverse direction: when an actor communicates with others, the communication relation may be the impetus for a subsequent mood perception about them. With SAOMs, it is possible to separate these effects from the cross-network effects listed above. For instance, a communicative relation with someone may increase the likelihood that the communicator perceives a positive (or negative) emotion in that someone. Based on the fact that one is more likely to pay attention to the emotions of one's conversation partners, a communication relation would also increase the likelihood of mood perception for both positive and negative moods.

Method

Participants

Third-year Oxford psychology undergraduates ($N = 34$; 27 women and 7 men) participated in Study 3.1 as a part of their undergraduate requirements to take research methods classes with a practical research experience component. The mean age of all participants was 20.6 years, $SD = 0.66$. As already mentioned in the section about network theory, social network data samples are not sampled probabilistically from a larger population. Instead, the participants form a unique social group and data is collected from the entire group.

During the course of the experiment, one participant dropped out of class due to health problems and did not participate in the third wave of data collection. To avoid changing the questionnaire mid-experiment, the dropped-out participant's name was retained on the roster as one of the response options until the end of data collection. Therefore, the remaining participants could report communication with the participant throughout the full length of the experiment, even if the particular participant was not able to reciprocate in person. However, to preserve the integrity of the model, these data were not used in the calculations for the last wave. In addition, two participants failed to provide responses to the last wave of data collection and were also excluded from the simulations after the penultimate wave.

Measures

In-person communication network. The social network consisting of dyadic in-person communication among the students in the class was constructed from the students' self-reports. Each weekly survey included a roster of all the students in the class, and participants were asked to indicate with whom they had communicated face-to-face in the past week by checking a box next to the corresponding classmate's name. These data were combined to a directional communications network based on the participants' self-reported binary (i.e., yes–no) relations.

Data about relations among actors can be analysed and visualised in multiple ways. As with any statistically analysable set of data, a visual representation of social networks data can provide important insights about the network and its actors. One basic visualisation is a sociomatrix. The figure [ref:S3.1SocMatrix] has nine sociomatrices, one for each of the collected social network data in three networks over three waves of data collection. In a sociomatrix, a black square indicates a relation between the numbered network members.

Outliers. Sociomatrices are useful to quickly identify participants with anomalous numbers of incoming or outgoing relations. The overall density of the black squares is an indication of the network density: in a uniformly black sociomatrix, every actor would have a relation with every other actor (including themselves; otherwise, the diagonal would be blank), whereas an empty sociomatrix would indicate that the actors do not share a single relation with each other. From looking at the sociomatrices in Figure [ref:S3.1SocMatrix], it is evident that some participants reported far more communications or emotion perceptions than the other participants. If you inspect the top row of the first sociomatrix, you can see that it is almost a continuous black line. This means that participant 1 reported having communicated with all but three of his or her classmates: there are four gaps in the line, three of which are classmates and one being the diagonal (i.e., communication with oneself, which is meaningless for the present purposes). However, inspection of the sociomatrices for the same network at T2 and T3 shows that this anomalous burst of communications with his or her classmates was limited to the first wave only.

In traditional statistical analyses, outliers can be problematic and exert an undue influence on the results. Social network data, on the other hand, is more robust against outliers. Because

each relation is reported on by two parties, this provides a level of protection against skewed results: a single person cannot form a network patterns unless others corroborate them. In fact, the pattern of findings reported in the results remain the same whether data from participant 1 in wave 1 is included or excluded, which speaks to the tolerance of SNA methods for outliers.

Mood perception networks. Each week, the participants had an option to nominate people from the class roster whom they perceived in the past week to have had positive and/or negative emotional experiences (i.e., estimated weekly mood). Perceptions of positive and negative mood were collected separately, allowing the participants to nominate classmates simultaneously in both categories. Weekly negative and positive mood nominations were combined into two directed social networks (see Figure 21).

Outliers. It is evident from the sociomatrices that some participants' self-reports followed a radically different pattern from the rest (see the nearly solid black horizontal lines in the sociomatrices in Figure 20). In the first wave of data collection, participant 27 did not report having perceived any emotion in the other participants and participants 24 and 28 reported having perceived positive mood in almost all of them. This pattern was limited to only the first wave and to positive mood perception. Because the outlier pattern regarding participants 24 and 28 is identical to the communication patterns of participant 1, no further actions are needed.

Participant 27, however, had abnormal data across all collection waves. During the first wave, participant 27 did not report having perceived any kind of mood in any of the other participants, but in the last two data collection waves reported having perceived positive and negative mood in everyone. However, the pattern of findings remained stable whether data from participant 27 were used in the analysis or not. In order to be as conservative with the analyses as possible, data from participant 27 were marked as missing.

Sociomatrices.

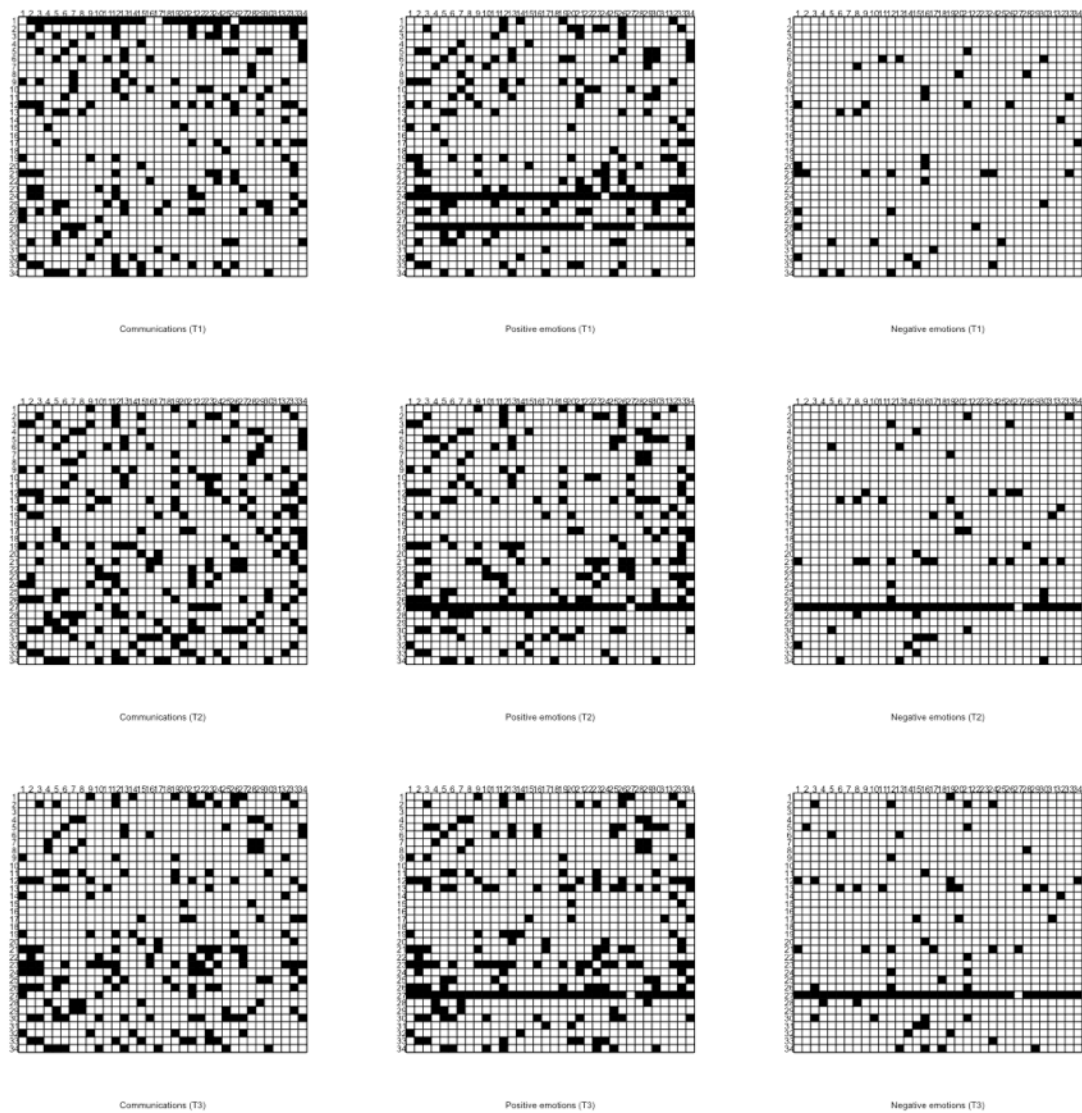


Figure 20. Sociomatrices of communications and emotion perception data.

Existing friendships. Because the students participating in the study were final-year undergraduates and had had prior opportunities to socialise, they were asked to indicate which of their classmates were their friends. The students were presented with a roster of all the students in the class, and they indicated on a scale from 1 to 5 how well they knew each of them. Any response higher than three was coded as a friendship relation and included in the model as a constant dyadic covariate.

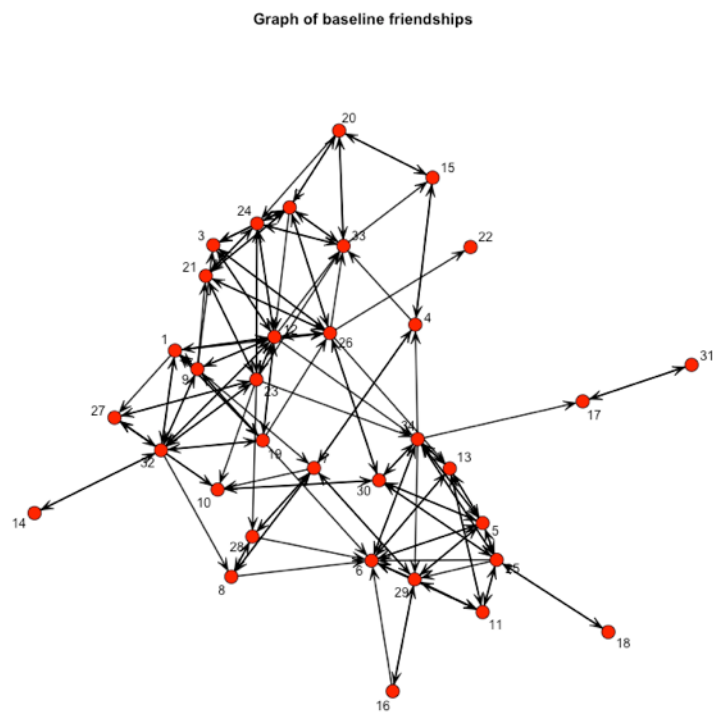
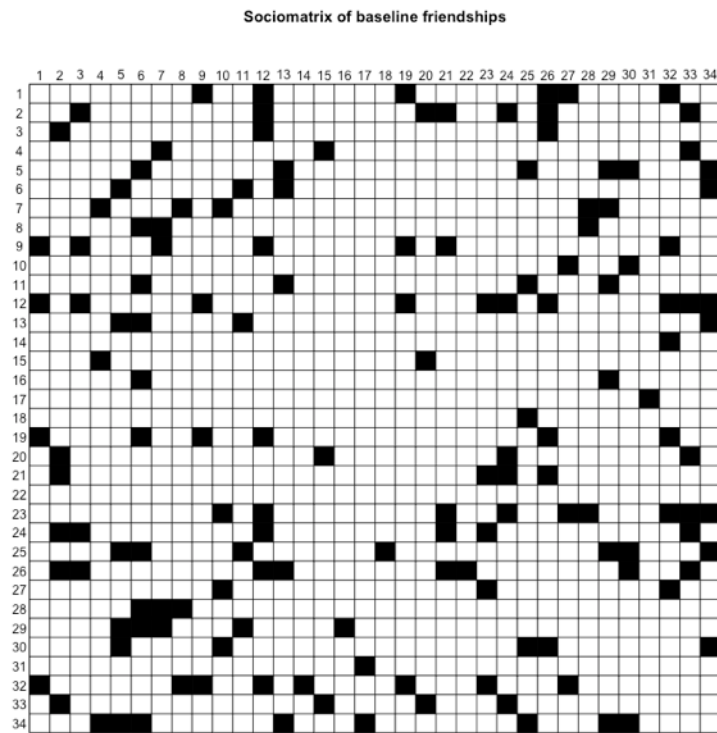


Figure 21. A sociomatrix and a network diagram of self-reported friendships among Study 3.1 participants.

Team memberships. During the study, the students were collaborating with each other in teams which had the potential to influence their communication patterns. During the course, the students were assigned to different groups at two separate points. At the first point, the students were randomly assigned to groups for the purpose of collaborating on an oral presentation to the rest of the class. This first group assignment was done during the first class meeting and influenced the first wave of data collection. The second point at which students divided into groups was after the second class meeting, when the students left their original teams and self-organised into new project groups for the rest of the course (i.e., data collection waves 2 and 3). Team membership at both points was included in the model as a time-varying actor covariate.

Procedure

During the first class meeting, the participants were introduced to the purpose of the experiment. After reading the participant information sheet, the participants gave their written informed consent. Within the 24 hours after the class, the participants completed the first online survey about their existing friendships with their classmates. After that, on three successive Sundays, the students filled in an online questionnaire about their interactions with the other students in the class during the week. These longitudinal network data were analysed with RSiena (Ripley, Snijders, & Preciado, 2011).

Results

This section includes the simulation results, statistical tests, and the estimated parameters for the network evolution between observed time points. As a reminder, the analysis of dynamic changes in a network consists of modeling the actors' decisions to establish new ties or dissolve existing ties in order to optimise their position in that network (as defined by the effects included in the evaluation function).

When interpreting RSiena results, it is important to keep in mind that the parameter estimates are expressed in terms of probability of actor choice. This choice can either be in terms of relations (i.e., changing a relation) or behaviour (i.e., changing up or down by one point on a behaviour variable). In Study 3.1, only changes in relations are modeled. Therefore, each effect is reported in terms of whether it makes a change in a relation more or less likely. Each parameter

estimate is given as a log odds ratio for choosing between two alternatives (with all other aspects of the situation kept constant). An odds ratio is commonly used to compare the odds for two groups, and it is calculated by dividing the odds in one group by the odds in the other group (Bland & Altman, 2000). In RSiena, rather than comparing groups, the odds ratio indicates the probability of choosing one relation over another. Thus, when an actor is given the opportunity to enact a mini-step (i.e., to change one outgoing relation), the parameter estimate for each effect is the log odds ratio of the probability that one relation is chosen compared to the probability that another is chosen. These parameters can be thought of as reflecting a “preference” of the average network member for forming and maintaining relations based on the effect, with higher parameter values implying that relations that produce the given effect are more likely to be formed.

Convergence

The quality of the simulation results can be quantified by how well they match the observed network. Convergence considers the deviations between simulated values and observed values. Ideally, these deviations should be zero, but the stochastic nature of the simulations inevitably introduces small deviations to the estimated values. RSiena calculates the averages and standard deviations of these deviations. The t-ratio is average divided by standard deviation. Values less than $|0.1|$ indicate an excellent convergence. Overall, the simulation algorithm found a good convergence between the simulated results and the observed networks, as all convergence t-ratios were less than 0.1 in absolute value (see Appendix 3 for full output). It is important to note that these values are not t-statistics for testing significance, just the quality of the estimations.

Time heterogeneity

Different mechanisms that influence the way a network evolves over time may have different influence at different times (i.e., time heterogeneity). For example, consider a situation in which no actor yet knows each other. In this situation, reciprocity has no effect, since nonexistent ties cannot be reciprocated. However, in the next stages of the network evolution, reciprocity can be an important factor in forming dyads. Likewise, in a network where only dyads are observed, transitivity is irrelevant until some actors form more than one reciprocated tie.

It is plausible that various effects operated differently during the experiment, because there were changes to the composition of the teams as well as the type of work in which the

participating students were engaged. These changes may have caused changes in the social dynamics among the participants. For example, gender could have played a role in how the participants chose their teams during the second period between data collections.

In order to control for changes in the influence of mechanisms over time, the model was tested for time heterogeneity (see Lospinoso et al., 2011 for a full explanation of the technical details). The time test indicated that some effects did not remain constant between the periods. Dummy variables were entered into the model to allow specific effects to vary in strength between the simulated periods. The time dummies were entered for effects where parameter-wise joint significance tests (i.e., each parameter across all dummies) were outside 95% confidence intervals. The time test also suggested which effects were the likeliest to have changed over time. For all networks, time dummies were inserted for reciprocity. Time dummies for transitive triplets were added to the communications and positive mood perception networks. Furthermore, an actor covariate time dummy was also entered to the communication network for gender ego-effect. After the inclusion of these time dummies, the joint significant time test did not suggest the presence of further time heterogeneity, $p = 0.785$.

Main findings

The main hypotheses of the experiment stated that negative mood perception would decrease communication and positive increase it. To test the hypothesis that a negative mood relation makes a subsequent communication less likely, the communications network was used as a dependent variable and the negative mood perception network as an explanatory one. The prediction that negative mood perception would decrease communication was not supported by the data. The results are summarised in Table 8 (please refer to Appendix 3 for the full estimates, standard errors, and p-values of the model). Contrary to what was expected, the probability of a communication relation was statistically independent of a negative mood perception in the sample, suggesting that the participants did not base their communication relations on perceptions of negative mood—thus, negative mood neither repelled nor attracted communication. In addition to the list of usual suspects (e.g., small sample size,) the null effect could signal that everyday levels of negative emotion are not strong enough to trigger social constraint.

Conversely, the data supported the corollary hypothesis that positive mood perception would increase communication. The existence of a positive mood perception relation with someone made subsequent communication relations with that person 2.9 times more likely, $p < 0.001$. In short, the data suggest that participants preferred to communicate with individuals whom they perceived to be in a positive mood. Interestingly, the outcome of this positivity-bias can be identical to the outcome predicted by transactional theories of depression (Coyne, 1976) and social constraint (Harber & Pennebaker, 1993). These theories posit that negative emotion and mood has a repelling effect: it actively pushes people away and the social isolation experienced by people in low mood are due to the low mood itself. The locus of this explanation is still mostly within the low-mood individual, although the social exclusion is enacted by other people.

The findings of this study suggest that a different social mechanism operates to create the same outcome. For these findings, the locus of explanation is not within the low-mood individual, but high-mood others. Instead of becoming an active repulsive force centred on the low-mood individual, negative mood is neutral to a fault: it could be powerless to either attract or repel communications. People in a positive mood, on the other hand, are actively sought as conversation partners. This can mean that in the ebb-and-flow of face-to-face conversations, people in a negative mood are not eliciting rejection or being actively discriminated against—others just naturally gravitate towards people in a positive mood. Therefore, the observation that low-mood individuals tend to be socially isolated may be the result of others' social preferences instead of withdrawal by the low-mood individual.

Table 8
Summary of Study 3.1 predictions and results

Predictions of effects and effect parameter values in each network				
Effect		Communication	Positive mood	Negative mood
Gender	ego	Men would communicate with more people, because boys prefer group interaction. (-0.2093)	Women would be more active in perceiving negative mood, because girls are more socially oriented. (-0.1809)	Women would be more active in perceiving negative mood, because girls are more attuned to distress of others. (0.7984)
	alter	Men would receive more communications from others people, because boys prefer group interaction. (-0.2216)	Men would be perceived more often in a positive mood, because boys' activity-focused styles promote positive mood. (-0.1099)	Women would be perceived more often in a negative mood, because mood disorders are more common in girls. (0.9756)†
	same	Participants would prefer same-sex communication partners, because girls and boys prefer same-sex company. (0.0818)	No prediction. (-0.0076)	No prediction. (-0.2451)
Team	same	Participants would communicate more with team mates due to proximity. (0.9540)***	Participants would perceive more positive mood in team mates due to proximity. (0.2832)	Participants would perceive more negative mood in team mates due to close proximity. (-0.0030)
Friendship	direct effect	Participants would communicate more with friends due to intimacy. (0.6406)**	Participants would perceive more positive mood in friends due to proximity and emotional convergence. (0.6470)***	Participants would perceive more negative mood in friends due to proximity and emotional convergence. (0.6844)*
Within-network	reciprocity	Participants would reciprocate communications due to common social norms. (1.0144)***	None. (0.4219)*	None. (0.2009)
	transitive triplets	Participants would converse more with friends of friends due to common social affordances. (0.1415)***	Participants would perceive more positive mood in friends of friends due to common social affordances. (0.1524)***	Participants would perceive more negative mood in friends of friends due to common social affordances. (0.4232)*
Cross-network	communication	-	Positive mood perception would increase communication. (1.0492)	Negative mood perception would decrease communication. (-0.0944)
	positive mood	Communication would increase positive mood perception. (1.6185)***	-	No prediction. (0.0323)
	negative mood	Communication would increase negative mood perception. (1.5253)	No prediction. (-0.1387)	-

Note. [†] $p < .1$ * $p < .05$, ** $p < .01$ *** $p < .001$. Significant effects indicated **with bold typeface**.

Other social processes.

Since the main processes of interest do not take place in a vacuum, the model incorporated a number of effects to capture other relevant social dynamics that operated within and among the participants.

Gender differences. Of the nine gender effects included in the model, only one came close to significance: women were marginally more likely to be seen in a negative mood, $p = .057$. None of the other gender effects were statistically significant. Overall, the lack of gender difference findings suggest that unlike in adolescent peer-relations, the social forces that shaped the networks of communication and mood perception among the young adult participants were largely gender-neutral. This suggests that findings from adolescents might not be possible to generalise to older populations without modifications.

However, this result may be an artifact of the heavily skewed gender distribution of the participants, which may have masked gender effects that could have emerged in a classroom with more equal gender balance. In a typical random survey design, the experimenters can always recruit more of one gender to balance out the gender distribution of their sample. However, the present study observed an existing group of people in naturalistic interaction, it was impossible to integrate 20 new male participants into the social network of the class out of nowhere—the composition of the class was predetermined by the gender, and due to ever-increasing popularity of psychology among female students (Cynkar, 2007), close to 80% of them were women.

It is also possible that the lack of findings is an indicator for a true lack of gender differences among adult social behaviour. This explanation is in line with the *gender similarities hypothesis*, which posits that men and women are similar on most psychological variables (Hyde, 2005).

Friends and teammates. Whether the participants knew each other before the class (i.e., pre-existing friendship) was highly predictive of communication and mood perception patterns. Not surprisingly, friends were about twice as likely to talk to a friend than a stranger. Friends were also almost twice as likely to perceive a negative or positive mood in their friends over strangers. The same was true with communication with team members (2.6 times more

likely). However, being on the same team did not make participants more likely to perceive each other in a more positive or negative mood.

Networks. Both reciprocity and transitive triplets effects were positive and significant for the communication network. This indicates that participants tended to reciprocate communications and preferred friends of friends as communication partners as predicted. The pattern of findings in the participants' communications with each other suggested that—in absence of other explanatory variables—the main driving force behind communicative activity was reciprocity as well as talking to friends and members of the same team, regardless of gender. Corresponding effects were also significant in the positive mood perception network. Like in communication, positive mood perceptions were influenced by reciprocity as well as talking to friends and members of the same team, regardless of gender. The increased perceptivity toward friends and team mates is congruent with social affordances, as it is more likely that the participants spent more time with these individuals and had better opportunities to witness their mood. Unlike communication and positive mood perception, negative mood perceptions were not significantly reciprocated, although participants were still more likely to perceive negative emotions in their friends and friends of friends.

Discussion

The purpose of Study 3.1 was to test the basic premises of whether communication patterns could be swayed by perceptions of mood at a network level of analysis. The findings suggest that mood perception does influence patterns in communication, but in a different way than expected: positive emotion that ended being a stronger force shaping the networks. As such, these results do not support social constraint hypothesis: participants did not appear to actively withhold communications from people perceived to experience negative emotions. However, it is possible that the negative mood sampled were simply not strong enough to be socially repelling.

Although the hypothesised mechanism responsible for social constraint was not supported, a situation functionally equivalent to social constraint can still emerge through alternative mechanisms. These findings suggest that preference for positive mood can lead to isolated low-mood individuals (i.e., the outcome of social constraint). For example, if communication is

dependent on finite resources (e.g., investment of time and effort) and participants prefer to communicate with people in a positive mood, low(er)-mood individuals could receive a smaller share of communicational relations without being actively discriminated against. In other words, preference for positive mood could allocate less communication to people in a negative mood. The important thing to notice is that the main effect is a preference for something else than trying to avoid something else, similarly as moths are drawn to the light instead of trying to get out of the dark.

Although the effect of positive—not negative—mood turned out to be significant, these findings suggest that mood does play a role in how people communicate. For example, the finding that children and adolescents who co-ruminate have the smaller peer networks could be explained as a ripple-effect of peers preferring to talk about more fun topics: co-ruminators might be entertained as interaction partners for only until someone more fun comes around.

The null findings of gender are also worth noting. The fact that none of the basic predictions about gender and social interaction were supported casts a shadow of doubt over the generalisability of findings from research on adolescent relations to even young adults. In the worst case, adults' social dynamics operate so differently from teenagers' peer relations that the two just are not the same. All and all, Study 3.1 demonstrated that mood and communication are related (although in possibly complicated ways). Likewise, it showed that ideas and tools from SNA can be applied to the social context in which co-rumination is supposed to take place.

Limitations

The finding that negative mood played no role in communicational preferences could have been spurious or confounded. The design of the study included at least one possible culprit, as the study did not differentiate between communication for personal and work reasons. Because of this, data from this study is not enough to differentiate between, for example, intense communication about an academic project and dwelling on romantic problems from casual banter or chit-chat about the weather. Because the communication relations were operationalised as communication between participants—emotionally relevant or not—these data only captured the target of the information, but not the nature of the exchange. Thus, if social constraint is more prevalent in

communication about personal matters, these results may have muddled the effect by not differentiating academic communication from personal communication. This aspect of the study will be improved upon in Study 3.2.

Another limitation of the study is that it did not assess whether participants' perceptions of other participants' moods were accurate. Therefore, the effect on communication could be completely disconnected from the actual emotional experience of the communication targets. By collecting self-reported emotion reports from each network members, it would possible to calculate the accuracy of each perception to see if it moderated or mediated the effects. However, a more direct way to study the social permeability of emotion would be to bypass the perception ratings altogether and instead observe the patterns between self-reported emotion and social behaviour of others. This methodology will be implemented in Study 3.2.

STUDY 3.2: CO-RUMINATION IN SOCIAL NETWORKS

The final study in my thesis draws together lines of reasoning from earlier parts of this thesis. In terms of theory, the present study extends the logic of Study 3.1, but proceeds to test a wider array of hypotheses. The main aim of this study is to observe co-rumination in its natural habitat, extend co-rumination literature to include networked processes, and clarify some of the mechanisms by which co-rumination leads to deterioration of social relations and undermines mental well-being in a malfunctioning CERN. The fundamental premise of the study—social constraint can lead to social isolation of co-ruminators—was framed as groups of hypotheses to capture the processes by which mood (both positive and negative), individual rumination, co-rumination, and personality could contribute to erosion in peer-relations. Like in Study 3.1 above, the effects that are of interest are examined in reference to processes that are expected to be almost universal in human social networks. Against this backdrop of typical social processes, I will then build a model of co-rumination in a CERN, adding one hypothesised process at a time.

Statistically, this kind of iterated model building is similar to comparing consecutive regression models to see which best matches the observed data. However, one limitation is that goodness-of-fit measures for SAOMs are still largely experimental, which makes it difficult to quantify the model differences in absolute terms. Furthermore, the addition of effects should be parsimonious as not to waste precious degrees of freedom. Fortunately, we can interpret model differences by evaluating whether the proposed effects for inclusion would make a significant difference to the model's fit (although this does not capture the effect size). Score-type tests are used to test whether new effects are suitable for inclusion without estimating them beforehand (Ripley et al., 2011). For score-type tests, one or more candidate effect parameters are restricted to zero, which basically defines the null hypothesis being tested (i.e., that the effect is not different from zero). When this restricted model is estimated, the networks produced by the restricted model simulations (which assume that the candidate effects have a null impact) should deviate from the observed network data. Thus, a large mismatch between the data simulated with restrictions in place and the actual, observed data can suggest when a model ought to be amended.

This two-stage testing process affords us an opportunity to compare predictions based on different theories. If two or more theories make different predictions about which effects should be included in the model, we can use score-type tests to find out which theory's effect can reject the null hypothesis based on the observed data. Although in strict terms this process provides a crucial test between the theories only in the special case that the theoretical predictions are mutually exclusive, it should still provide instructive information about the relative merits of the theories even when the predicted effects differ, but are not mutually exclusive. That is, if the effects predicted by one theory consistently fail to gather enough evidence to reject the null hypothesis while the effects of the other prove to make a significant difference, this should at least hint at the relative value of the theories.

For ten weeks, I followed a cohort of incoming graduate students ("Freshers") at the Department of Experimental Psychology during their first term in Oxford. The students were invited to participate on the morning of their first day on the course and followed until the end of their first term, spanning a nine-week period which is typically an emotional rollercoaster ride. Experimentally, this unique period in academic life offers an attractive opportunity to control some of the confounding factors that commonly cloud naturalistic social behaviour data. The first confounding factor (which plagued the studies in Part II and Study 3.1) is that emotionally intense events are not the norm. For researchers interested in going beyond humdrum experiences must attempt to tap into deeper emotional experiences. One strategy is to wait until a traumatic event impacts a community. For example, both ruminative response style (Nolen-Hoeksema & Morrow, 1991) and social constraint (Pennebaker & Harber, 1993) literatures originated from observing the aftermath of a collective trauma. (Interestingly, both classic papers stemmed from the same event, the 1989 San Francisco Bay Area earthquake known as the Loma Prieta Quake.)

Although the start of a graduate course is—hopefully!—not as unsettling as a devastating earthquake, it still has potential to perturb established patterns, cause stress, and trigger various intense emotions due to the increased workload and academic demands (Toews, Lockyer, Dobson, & Brownwell, 1993). As a transformational period, the start of graduate school should provide ample topics for co-ruminators to dwell upon. As all the students were in the same boat, the entire network experienced a similar, emotionally significant period. Therefore, by recruiting Oxford

Freshers at the beginning of their course, the present study collected data from a sample 1) that would have plentiful opportunities to experience emotional events and 2) wherein every participant would go through roughly the same basic experiences.

Another important feature of the study is that most of the participants started out as strangers to each other (which was not the case in Study 3.1). Observing an emerging network with more dynamic relationship negotiations could be more instructive than studying an existing network with more rigid connections. While the participating students in Study 3.1 were final-year undergraduates who had known each other for years and probably already had fairly well-established and stable configuration of social relations with at least some of the others, the participants in Study 3.2 were all new graduate students and the majority did not know each other in advance. Because most (but not all) of the participants were previously unacquainted at the onset of the study, the social network in the present study started essentially as a clean slate. It is also possible that the possible (de)selection processes that lead into the formation of co-ruminative dyads are more likely to occur during these kinds of transformation periods when social relations are more actively formed and dissolved.

The students in the study were also embedded in a network of academic relations. This comes close to randomly assigning social contact, as the nature of academic work virtually guarantees differences in contact frequency within the doctoral and masters students. For example, all of the masters students shared a large workspace, putting the entire cohort in frequent contact, whereas most of the doctoral students had offices limiting the contact to office-mates. Thus, the students' course is an important additional factor that is likely to strongly influence friendship selection (and virtually guarantees colleague selection). Modeling these factors will help to distinguish between co-rumination in private and professional contexts. Co-rumination has already been studied in workplace context and it has been suggested to be a coping strategy for individual employees and collectively for teams. Co-rumination at the level of individuals, Haggard and colleagues (2010) found in their survey of business school alumni that female subordinates of abusive supervisors might be particularly at risk. Co-rumination has also been suggested to occur collectively within organisations when colleagues process bad rumours or news with each other

(Marmenout, 2012). However, the present study focuses only on co-rumination in personal relationships, to keep in line of the majority of past co-rumination literature.

One the main improvements in the present study is the direct measurement of co-rumination and individual rumination, a core component in theories of both co-rumination (Rose, 2002) and social sharing (Rimé, 2009). Individual rumination is a mode of responding to distress that involves repetitively and passively focusing on symptoms of distress and on the possible causes and consequences of these symptoms (Nolen-Hoeksema, 1991). However, rumination does not necessarily lead to active problem solving. Instead, it tends to keep people passively fixated on the problems and associated negative feelings (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Although rumination most clearly manifests itself as a *response* distressed state, rumination is generally considered a trait-like *response style* that increases vulnerability to depression (Joormann, Dkane, & Gotlib, 2006; Roberts et al., 1998). For example, students in the San Francisco Bay area who endorsed more ruminative responses to distress were most likely to show elevated depressive symptoms shortly after an earthquake hit the area (Nolen-Hoeksema & Morrow, 1991). The present study conceptualises individual rumination as a stable trait that predisposes people to respond to stressors in a problem-focused manner. In other words, rumination was assumed to be similar to personality: relatively stable and unaffected by short- and medium-term fluctuations in one's circumstances. Such traits can then be assumed to exert an exogenous influence on the network, but remain unaffected by it. Making this assumption simplifies the model evaluation a little bit and reduced the need for participants to complete a long scale repeatedly. Thus, for the purposes of the present study, ruminative response style and personality were considered as stable traits and measured only once (instead of at each wave of data collection).

Although both co-rumination and social sharing literature treat mental rumination as a unidimensional construct, factor analyses of rumination have revealed that the scores vary on two principal dimensions: reflection, and brooding (Treynor, Gonzalez, & Nolan-Hoeksema, 2003). The same analyses also revealed that many of the items are synonymous with depressive symptoms (see Appendix 4). When these items are subtracted from the measure, the remaining items for reflection and brooding are unconfounded with depression content. This distinction will

help us to hone in on the differential effects of emotional and cognitive focus on one's mood. Theory on both co-rumination and social sharing predict that excessive emotional focus is maladaptive, but social sharing literature includes an additional line of logic that implies that affect-laden brooding should be more harmful than cognitively focused reflection.

In comparison to trait-like individual rumination, co-rumination is a more flexible construct, because it involves two interacting individuals. Although the ruminative response styles the co-ruminators may shape how the process unfolds, it is not feasible to assume that co-rumination is a trait. For one, co-rumination takes place in a relational context, which suggests that it responds to social input. Thus, co-rumination is assumed to be more like a state instead of a trait, and was measured at each data collection wave. Furthermore, the present study collected information about the participants' co-rumination partners. As previous research has shown, co-rumination can take place in many relationships (e.g., between parents and children, roommates, romantic partners, same-sex friends; Calmes & Roberts, 2008). By asking the participants to also indicate with whom they co-ruminate, the present study approximates the original data collection method used by Rose (2002) that asked schoolchildren to report on a specific friendship. However, the participants in the present study were free to report on any type of relationship within which they co-ruminated, not just their "very, very best friend."

An additional improvement to the study was made by changing the way in which participants' social networks were operationalised. Study 3.1 did not differentiate between intimate and impersonal communication. Because the participants only indicated the frequency—but not the type—of their peer communication, heartfelt emails between lovers were given the same weight and importance as emailing a manuscript draft to a colleague. This was improved upon in the present study as relations were separated into friendships and work relations that were defined by specific types of behaviors for each.

Hypotheses

For convenience, all predictions that go beyond typically expected social behaviour are listed in Table 9.

Negative mood. Based on the reasoning that mere experience of negative emotion triggers social sharing with many people (e.g., Rimé, 2009; Rimé et al., 1991), negative mood should make participants seek social interaction (i.e., positive ego-effect of negative mood). Co-rumination, on the other hand, implies that negative emotion is shared within an exclusively dyadic relationship (Rose, 2002), and should thus limit one's social outreach. The CERN approach takes cue from social sharing and predicts an increase in outbound social activity as ego engages the network.

In terms of others' response to negative emotion, co-rumination theory does not offer much guidance beyond incoming communication from one's co-rumination partner. In the interpersonal dynamic of emotion sharing proposed by Rimé (2009), an initial expression of emotion should spark interest in others and elicit—at least initially—empathic responses. However, these interactions are initiated by ego, and social sharing theory does not suggest that mere experience of negative mood by ego influences others' proactive social behavior (i.e., social sharing does not predict any alter-effect of negative mood). As emotional information propagates in a CERN, however, it should encourage people to actively offer support to ego, suggesting a positive alter-effect for negative emotion.

Positive mood. While co-rumination theory is completely silent on the role of positive emotions, social sharing literature suggests that *all* emotion gets shared, predicting a positive ego-effect for positive mood. Social sharing does not suggest any direct alter-effect for positive mood, so presumably it has the same null effect on others' social behavior as negative mood was hypothesised to have. As demonstrated by Study 3.1, positive mood might be a powerful factor in shaping friendships among people by attracting communications from others (a positive alter-effect). From a CERN point of view, this could reflect people's desire to upregulate their mood by seeking the company of cheerful others (i.e., a positive alter-effect for positive mood).

Rumination. The main difference between intrapersonal rumination and co-rumination is that only co-rumination involves self-disclosure (Rose, 2002). The basic premise of co-rumination is that individual ruminative tendencies find an exclusively dyadic outlet, but this is problematic, because it conflates individual rumination (a silent intrapersonal process) with dyadic

co-rumination (a verbalised process). Thus, it is difficult to determine whether the the predictions of Rose's theory (2002) would be separate for rumination and co-rumination. For clarity, I will not attempt to make predictions for individual rumination based on co-rumination theory, but save these for the section on co-rumination proper.

At face value, individual rumination appears to promote social withdrawal and inward focus. The intrapersonal nature of the rumination scale (Nolen-Hoeksema & Morrow, 1991) is reflected in the fact that all of the behavioural responses are either direct withdrawals from others (cf. "Go away by yourself") or activities that are often done in silence (cf., "think," "write," and "analyze"). Thus, we could expect the effects of rumination to be self-directed: people who respond to negative emotion by ruminating could withdraw from others (i.e., a negative ego effect). However, rumination appears to intensify negative emotion, which could negate social withdrawal though the need to share the emotion. In social sharing, the role of rumination is to keep the negative emotion salient to ego. Thus, according to social sharing theory, rumination should not have an effect of its own on ego's social outreach, but it would maintain negative emotion, and thus promote social outreach indirectly.

In terms of alter-effects, neither co-rumination nor social sharing literature offer any guidance. However, we could expect intrapersonal rumination to mainly be a private process that is socially invisible to others (unless verbalised, of course, but that makes it a matter of co-rumination). Thus, I predict that rumination should have no significant alter-effect.

Neither co-rumination nor social sharing literature explicitly differentiate between brooding and reflective forms of rumination, but the two theories imply different outcomes for each. Of the two components of rumination, affect-focused brooding has been linked to depression whereas cognition-focused reflection has not (e.g., Joormann, Dkane, & Gotlib, 2006). This differential impact on depression mirrors the logic of social sharing theory that suggests that the only way to recover from negative emotion is to put in cognitive effort and rearrange one's meaning structures. Thus, social sharing theory suggests that brooding—but not reflection—could be expected to increase negative mood, whereas co-rumination theory appears to make no such distinction.

Co-rumination. Unlike silent intrapersonal rumination, co-rumination is characterised by verbalising one's negative feelings. However, as defined by Rose (2002), co-rumination is a dyadic process, which implies that ego's social outreach is focused on a single individual, reducing the total amount of social outreach (i.e., a negative ego-effect). Social sharing theory (Rimé, 2009), on the other hand, suggests that the social outreach is a function of negative emotion itself. However, since co-rumination is characterised with an excess of sharing, it could be associated with sharing above and beyond of what ego's level of negative emotion would warrant. If this were the case, social sharing literature would predict that this sharing takes place with many individuals, thus predicting a positive ego effect.

Likewise, the excessive nature of co-rumination should be the component that pushes typical social sharing of emotion beyond the level that the social environment tolerates. As such, it is the prime candidate for triggering social constraint and rejection from others (a negative alter effect). Furthermore, as shown by Study 2.3, co-rumination is a socially visible process, which might elicit a negative alter effect even if the ego does engage more people than predicted by their level of negative emotion alone.

In terms of mood, Rose (2002) suggests that the pervasive focus on negative content has a detrimental impact on the co-ruminators' mood. However, the CERN model suggests that the depressive effect is due to either individual rumination (i.e., negative focus regardless of verbalisation) or loneliness caused by social constraint. Thus, CERN predicts that co-rumination itself has no effect on mood above and beyond of the effect of brooding rumination.

Personality. Given that co-rumination was associated with agreeableness and neuroticism in Study 1.2, the model should be tested for personality as well. If the inclusion of ego- and alter-effects of these two personality dimensions changes any of the effects of co-rumination, the social processes might be driven by personality factors, not co-rumination.

Table 9
Summary of Study 3.2 main predictions by theory

Effect	Theory		
	Co-rumination	Social sharing	CERN
Negative mood			
ego	Misery loves the exclusive company of one person, which reduces ego's overall social contact.	Misery loves the company of many people, which increases ego's overall social contact.	Same as social sharing.
alter	A guaranteed indegree of one (i.e., the co-rumination partner), but no predictions thereafter.	Negative emotion itself does not change alters' social behaviour toward ego.	Negative emotion elicits affiliation from alters who come to support ego.
Positive mood			
ego	-	Positive emotion gets shared with many people, increasing overall social outreach by ego.	Same as social sharing.
alter	-	Positive emotion itself does not change alters' social behaviour toward ego (i.e., null).	Positive emotion elicits affiliation as people wish to upregulate their own mood by association.
Brooding			
ego	-	Rumination maintains negative emotion, but has no additional effect on social outreach.	Same as social sharing.
alter	-	-	Brooding is socially invisible.
direct effect	Rumination depresses mood.	Affect-focused rumination depresses mood.	Same as social sharing.
Reflection			
ego	-	Rumination maintains emotion, but has no effect of its own on social outreach.	Same as social sharing.
alter	-	-	Reflection is socially invisible.
direct effect	Rumination depresses mood.	Cognition-focused rumination improves mood.	Same as social sharing.
Co-rumination			
ego	Excessive sharing occurs within a dyadic relation, reducing overall social outreach.	Excessive sharing occurs with many people, increasing overall social outreach.	Same as social sharing.
alter	-	Excessive sharing elicits social rejection.	Same as social sharing.
direct effect	Co-rumination depresses mood.	-	No effect.

Note. Predictions that were supported by data indicated in **bold typeface**.

Other social processes

In the same way that Study 3.1 included a set of effects that were presumed to shape the relations among participants, the present study contains a baseline model of common social behaviour. The baseline model included factors that are thought to operate independently of co-rumination and that can be considered as part of normal functioning of a human social network. It includes effects that represent typical ways by which people form relations based on gender, group affiliation, features of the physical environment, and so on. All of the models will include these control variables, allowing us to contrast effects related to collective emotion regulation with an established baseline of behaviour. The predictions for the baseline model are summarised in Table 10.

Table 10
Summary of Study 3.2 baseline model predictions.

Effect	Prediction of effects in each network	
	Friendships	Work relations
Gender		
<i>same</i>	<i>Preference for same-sex friends.</i>	<i>Preference for same-sex colleagues.</i>
Course		
<i>same</i>	<i>Coursemates would befriend each other due to close proximity at the department.</i>	<i>Coursemates would work together due to close proximity at the department.</i>
Existing friends		
<i>direct effect</i>	<i>Participants would communicate more with existing acquaintances in extracurricular context.</i>	<i>Participants would communicate more with existing acquaintances in professional context.</i>
Within-network		
<i>reciprocity</i>	<i>Participants would reciprocate communications with friends due to common social norms.</i>	<i>Participants would reciprocate communications with colleagues due to common social norms.</i>
<i>transitive triplets</i>	<i>Participants would have more contact with friends of friends due to common social affordances.</i>	<i>Participants would have more contact with colleagues of colleagues due to common social affordances.</i>
<i>3-cycles</i>	<i>Tendency towards social hierarchy among friends.</i>	<i>Tendency towards social hierarchy among colleagues.</i>
Cross-network		
<i>work</i>	<i>Academic contact promotes friendship formation.</i>	-

Gender. Because Study 3.1 found no relevant gender differences and evidence from meta-reviews suggests that men and women are similar on many psychological variables (Hyde, 2005), no ego or alter effects for gender were included. However, since homophily based on gender is common in many networks (McPherson, Smith-Lovin, & Cook, 2001), the similarity effect was retained with the prediction that men and women would seek same-sex company for both friendships and work relations.

Course. As the participants were enrolled in courses at both masters and doctoral levels, their interactions were expected to be shaped by their course membership. Therefore, the same course effect was added to the baseline model with the expectation that same course membership would be grounds for homophily.

Pre-existing friendships. Friendships that existed before the start of the term were expected to strongly influence the formation of subsequent relationships. Therefore, the direct effect from existing friendships was included in both the friendship and work relation networks with the expectation that those friendships would continue during the term.

Within-network effects. As in Study 3.1, reciprocity and transitivity were expected to shape relations. The reciprocity effect simply captures the tendency for people to return incoming communications. The transitive triplets effect is easiest to conceptualise as the increased likelihood of someone befriending a “friend of a friend.” Transitive triplets are a commonly observed network phenomena, and in the present study it means that the participants had a preference to initiate social relations with people with whom they already had mutual friends and colleagues. Because the sample consisted of students in two different groups of unequal status, a measure for hierarchy was included. The three-cycles effect is a type of generalised reciprocity or the opposite of hierarchy. For example, think of a research intern, who reports to a graduate student, who in turn reports to a postdoctoral researcher. If the postdoctoral researcher then reports to the research intern, the resulting pattern would be a three-cycle (and highly unusual in terms of academic hierarchy). Human social networks tend to organise around some form of dominance or status hierarchy (Davis, 1970), so a three-cycle effect was expected to be negative, especially for the work relations network.

Cross-network effects. For the psychology graduate students in the experiment, academic relations (e.g., with supervisor or fellow graduate students and postdocs at the lab group) are extremely likely to reflect on the formation of social relations as well. After all, simply sharing a supervisor or being interested in similar topics makes it more likely for certain students to come into more frequent social contact than chance would predict. To control for such influence, the baseline model includes the network of university-related communication among the students in addition to the network of social relations. The main effect of a work relation influencing the creation of a social relation was modeled as the cross-product effect of the networks. However, it is beyond the scope of this thesis to fully predict the formation of academic collaborations. Therefore the baseline model only controls for the mere existence of work relations and only minimal endogenous processes that shape work relations were modelled (i.e., reciprocity, transitivity, etc.). This way, the influence of work relations is taken into account with the least empirical distraction.

Method

The data for the study were collected in the same context as Study 3.1 (i.e., same educational institute, same department, same longitudinal design, same online survey methodology etc.).

Participants

In total, 19 women and 12 men out of a cohort of 33 psychology graduate students (94%) chose to participate in the experiment. Of the students, 17 were enrolled in a doctoral program (9 women and 8 men) by research and 14 were in a taught masters program (10 women and 4 men). On average, the doctoral students were 27.2 years of age, which made them 2.9 years older than the masters students, $t(27) = 3.3751, p = .002$. There were no gender differences in age.

Measures

In RSiena, actor attributes that are considered to be endogenous to the network are called *behaviours*. A behaviour (in RSiena sense) can influence—and be influenced by—the pattern of relations around the actor. Thus, mood is referred to as a *behaviour*, although in a strictly psychological sense, it would not be classified as such. Mood was measured at each wave of data

collection and the participants were asked to rate how they felt over the past three weeks by indicating the extent they felt eight different emotions (i.e., *happy, gloomy, anxious, calm, energetic, sluggish, angry, and guilty*) on a scale from 1 (“*Not at all*”) to 7 (“*A great extent*”).

Negative mood. The scores for the negative emotions (i.e., *gloomy, anxious, sluggish, angry, guilty*) were averaged to a single composite variable. Across all measurement waves, the composite showed acceptable levels of internal reliability, Cronbach’s $\alpha = .76$.

Positive mood. The three variables that were intended to measure positive mood did not form a coherent composite measure, Cronbach’s $\alpha = .48$. The *happy* variable was weakly correlated with *calm*, $r = .36$, $p = .035$, and *energetic*, $r = .19$, $p < .001$. Given that a one-item assessment of happiness has been shown to provide appropriate diagnostic information in other contexts (Goodwin, 1992), only responses to the question “*To what extent have you felt happy over the past three weeks*” were used as an overall indicator of positive mood.

Co-rumination. The core measure of the experiment, co-rumination, was assessed at each wave with the brief CRQ-9 measure developed from the 27-item measure by Rose (2002; see Part I of this thesis for detailed description of the new measure). The participants responded to statements about their problem-talk behaviour during the last three weeks (i.e., the time between data collection waves) on a five-point Likert-type scale (1 = *Not at all true*, 5 = *Really true*). The internal reliability of the measure was good, Cronbach’s $\alpha = .90$.

Instead of restricting the target of co-rumination a priori, the participants were instructed to think about a “*close person with whom you have talked about problems the most over the past three weeks*,” with response options for *parent, sibling, other relative, romantic partner, friend*, or *other* (i.e., free text entry). The participants were also asked to indicate whether the close other was a classmate, in which case they were asked to name the person as well. Based on past co-rumination research that asked schoolchildren to nominate their friends and then report the typical levels of co-rumination within that friendship (e.g., Rose, 2002; Smith & Rose, 2011), the expectation was to find co-ruminative relations among the participants and gain two datapoints for each co-ruminative relation (i.e., data from two classmates who reported having co-ruminated with

each other). However, when the responses from participants were reviewed, no reciprocal dyads among the cohort reported co-rumination. Only one participant indicated having co-ruminated with a classmate during one wave, but the target person did not reciprocate the report. The most common recipient of the participants' co-rumination was a romantic partner (63 mentions), followed by a friend (34), and a parent (9). All of the remaining categories received a total of 11 mentions.

Because the participants co-ruminated largely with people outside the cohort, co-rumination was treated as an actor-level behaviour. In effect, CRQ-9 only measures the spillover effect of co-rumination for the present purposes. Because primary co-rumination occurred outside the cohort, the co-ruminators brought their co-ruminative tendencies with them into the cohort, but not the co-ruminative relationship itself. Thus, co-rumination was operationalised as an individual—not dyadic—behaviour.

Brooding. The first component of rumination, brooding, reflects a passive comparison of one's current situation with some unachieved standard (Treynor, Gonzalez, & Nolan-Hoeksema, 2003). For my analyses, the brooding subscale is taken as a proxy of unconstructive, ruminative dwelling on the negative aspects of the situation—a behavior that has been pointed out as an important causal agent in both co-rumination (Rose, 2002) and social sharing (Rimé, 2009). In the sample, the measure had a good reliability statistic, Cronbach's alpha = .82.

Reflection. Whereas brooding represented the depressive, affective aspect of rumination, reflection captures the adaptive, intrapersonal problem-solving aspect of it. The items in the reflection component focus on purposeful turning inward to engage in cognitive problem solving to alleviate one's depressive symptoms (Treynor, Gonzalez, & Nolan-Hoeksema, 2003). The measure had good internal reliability in the sample, Cronbach's alpha = .82.

Personality. During the first wave of data collection, the participants completed the Ten-Item Personality Inventory (TIPI; Gosling, Rentfrow, & Swann, 2003), which is a very brief, five-factor measure of personality. As suggested by the name of the measure already, it has only two items that address each of the five personality dimension. As noted by Gosling et al. (2003), their

goal was to create a very short, but optimally valid instrument. Because estimates of internal reliability are usually misleading for scales with very low numbers of items (Kline, 2000; Wood & Hampson, 2005), low coefficient alphas should not be taken as indicators of a poor factor structure. However, when expressed in terms of direct correlation, the two items measuring agreeableness were not significantly correlated with each other, $r = .09$, $p = .637$. This strongly suggests that the agreeableness measure may not be sufficiently reliable and findings based on it may be entirely due to chance.

Pre-existing contacts. Participants were asked to indicate the extent to which they knew each other before meeting on the department Induction Day. The students were largely unfamiliar with each other: only one dyad reported a mutual, pre-existing acquaintance. However, since the data were collected a week after the cohort first met—and although the instructions specifically asked participants to report relationships that existed before the Induction Day—some participants may have erroneously reported relations that were formed during the cohort's first day together. (Although it is also possible that for some genuine pre-existing dyads, only one dyad member reported the relation.) In total, 14 people reported already knowing someone in the cohort, but the targets did not reciprocate. Of the one-sided reports, a handful of participants ($n = 4$) accounted for 57% of the total reported acquaintances ($N = 30$). Because it is possible that these existing (and possibly nascent) relations served as the nucleus around which social relations begin to coalesce, their influence was controlled for in the simulations of network dynamics.

Friendship network. From a theoretical perspective, most of the interesting social activity was expected to unfold in the close personal relations among the cohort members. In order to capture this network, participants were instructed to think about the amount of extracurricular social contact they had with each coursemate. Specifically, we named a list of voluntary affiliative behaviours and non-work related leisure activities (e.g., going out for the night, going to the cinema, spending time in each others' houses) to indicate the context for social contact outside the University that the participants were expected to report on.

For each data collection wave, the participants were presented a roster of names (provided by the department administration) that included everyone in the cohort. The participants then

indicated how much they engaged in these social behaviour with each peer, with anchors at 1 (“*Not at all*”) and 5 (“*A great deal*”). However, to make the simulations computationally tractable, the data were recorded as binary relationships (0 = no contact, 1 = contact). Because co-rumination is thought to occur mostly in close relations, only two of the highest responses, “*Quite a lot*” and “*A great deal*,” were counted as a friendship. Figure 22 illustrates the number of mutual friendship dyads over time.

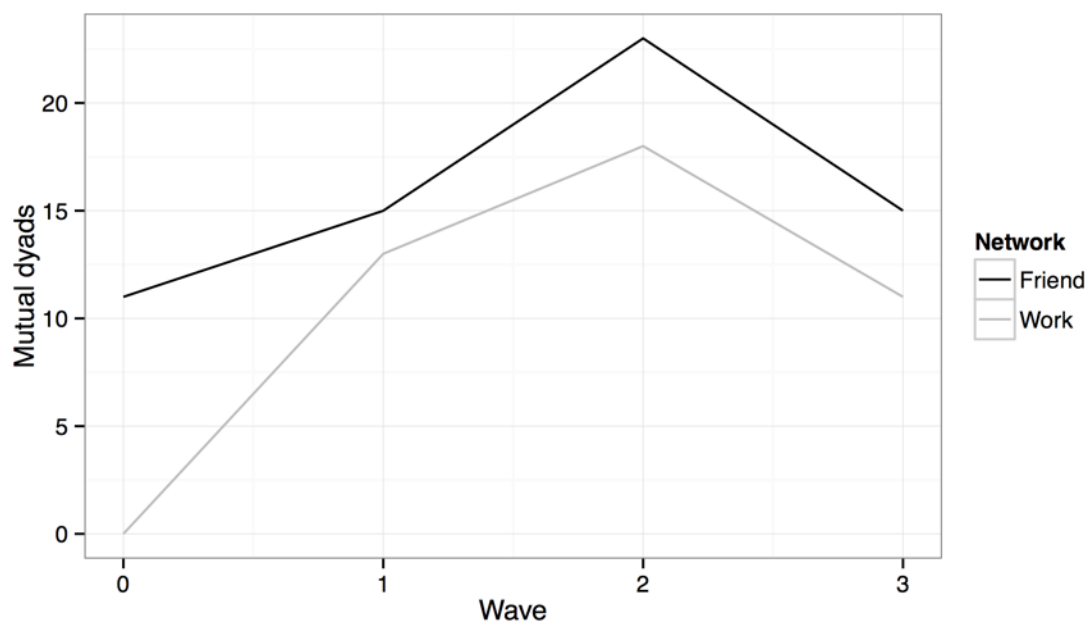


Figure 22. Number of mutual friendship and work colleague dyads over time.

Work relationships. In order to capture the participants’ academic relationships, a similar measure to the one above were presented to them. It focused on behaviours such as studying together, working on projects together, or asking each other for academic advice—basically, any university-related work activity. Similarly to the cut-off for friendship relations, only two of the highest responses, “*Quite a lot*” and “*A great deal*,” were counted as a relation. Figure 22 also illustrates the number of mutual work dyads over time.

Some of the network data were missing (4.6% of the friendships and 7.0% of the work relation). By default, RSiena assumes relations to carry over unchanged from the previous observation where data is missing. According to simulations conducted by Huisman (2009), low proportions of missing data generally do not introduce a large bias for network analyses.

Procedure

During the first day of the students' scheduled events at the department (i.e., Induction Day), they were given a presentation about the goals of the study and invited to participate. Participants either handed in a signed consent form after the presentation or completed an electronic consent form online as part of the first questionnaire. All subsequent data was collected via an online questionnaire.

The participants were sent a link to an online questionnaire every three weeks during the term (baseline measure during induction week, T1 at 3rd week, T2 at 6th week, and T3 at 9th week of term). Each questionnaire contained a mix of questions about actor attributes (e.g., personality) and social network relations (i.e., social with others in extracurricular and work contexts).

Results

This section reviews the results of the simulations performed with RSiena and compares the models that resulted from the study hypotheses. The model comparisons are summarised in Table 11 (see Appendix 5 for the exact parameter estimates for all of the included effects for all the models). Because the present study's model is more complex than in Study 3.1, the model testing proceeded in stages. First, a baseline model was specified, and groups of potential effects were tested for inclusion in the model to find out the extent to which the creation and dissolution of relations between participants was driven by negative mood, rumination, or co-rumination.

Network evolution overview

The general dynamics for friendships and work relations at the network level were clear: both networks branched out from a small core of relations and spread sparsely among the cohort (see Figure 23 for friendships and Figure 24 for work relations). Since the last point of data collection was after the term had ended, there was a small reduction in both networks (See Figure 22). In many ways, this was good for the present analyses, as it encouraged the dissolution of some of the relations, which was a necessary condition for social constraint to take place.

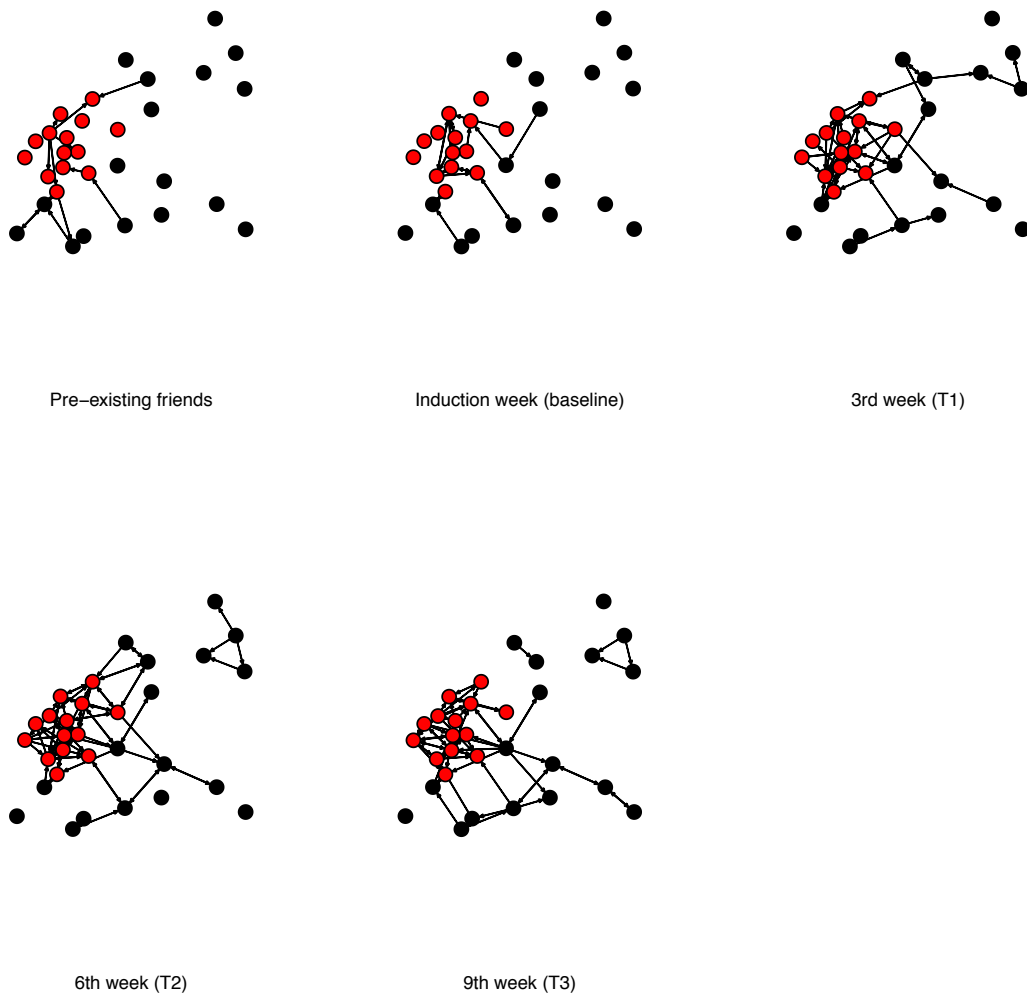


Figure 23. Friendship network evolution.

Note. Black dots represent doctoral students, red (gray in print) indicates masters students.

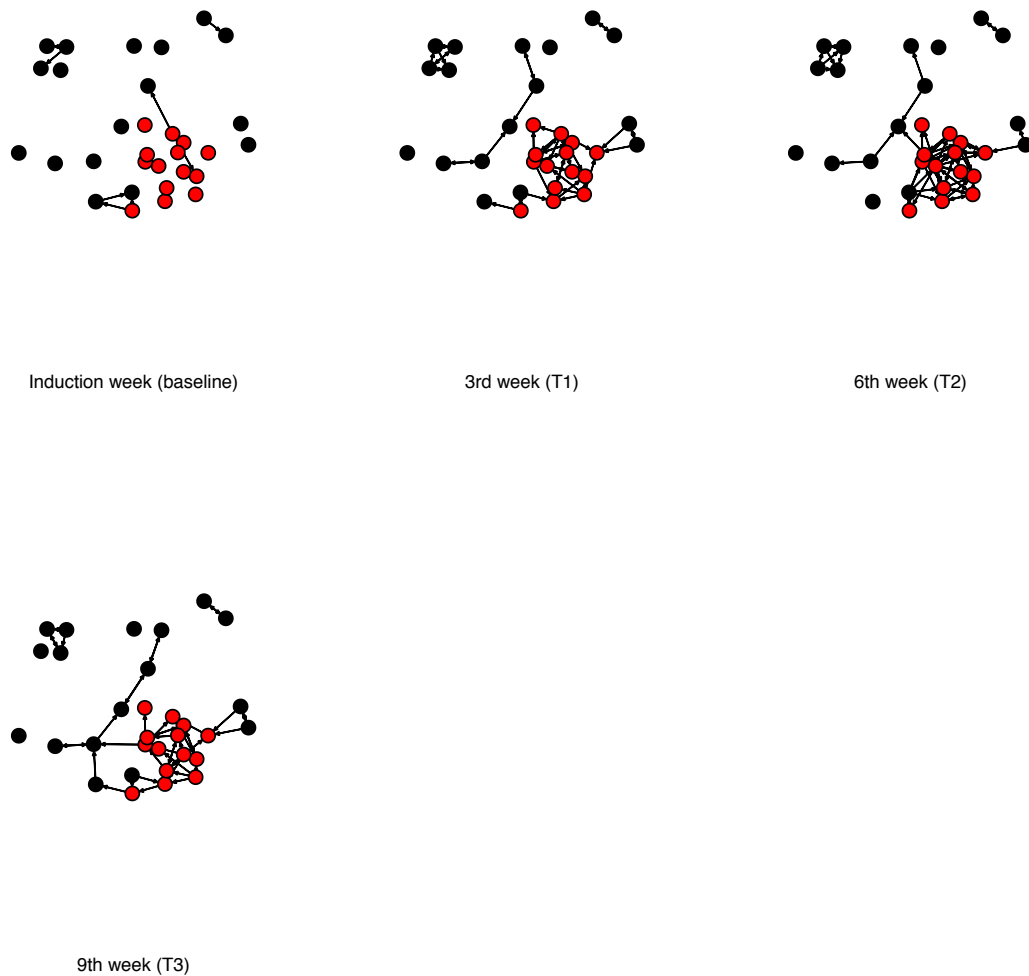


Figure 24. Work relation network evolution.

Note. Black dots represent doctoral students, red (gray in print) indicates masters students.

Baseline model

To explain the pattern of relations (i.e., who became friends with whom and which relations were cooled down over time), various general processes were hypothesised to exert an influence in addition to the hypothesised social sharing and social constraint processes. The parameter estimates for these effects are listed under *Baseline* column header in Table 11. Since people are extremely eager to return a favour (Regan, 1971), it would be likely that communication attempts by others would be reciprocated. Indeed, the reciprocity effect was positive and significant, which is not at all surprising, given that reciprocity is normative in many

social relations. Among the participants, people were very likely to reciprocate both friendship and work relations: if an alter indicated ego as a close friend or a colleague, then ego was inclined to return the favour over time. A reciprocated friendship relation was about five times more likely to happen than a non-reciprocated one. The relation was even stronger in academic relations, where reciprocal ties were eight times more likely.

The transitive triplets effect was positive and significant as expected. However, this effect was not uniform over time. In general, people were more likely to make friends with the friends of their own friends early on. This was somewhat expected, as meeting friends of friends as a way to meet new people is more effective when interconnected relations are still rather sparse. Later on, when the social network begins to stabilise, opportunities to meet friends-of-friends becomes less common over time. However, to account for this variation, a time dummy variable was added for the final timepoint. The three-cycle effects were negative, but did not reach significance, suggesting that the participants did not have a hierarchy or dominance structure guiding the formation of their personal or academic relations.

The participants were students enrolled either in a taught Masters of Science or a research-based doctoral course. As expected, friendships were more likely to form within students enrolled in the same course. In terms of classical social psychology, participants showed evidence of a significant “in-course bias” in their social relations by being close to twice as likely to befriend their own coursemates over students enrolled in the other degree course. Unsurprisingly, this effect was even stronger for academic relations, which were over three times more likely between coursemates. This “in-course bias” was an expected side-effect of the course structure itself. Because the style of work required for each course is very different, being a student on each course creates different social affordances. The masters students attend lectures together and participate in group work together whereas doctoral students have fewer opportunities for contact with each other through joint activity, but when they do, it is mostly with other doctoral students rather than masters students. In addition, whereas masters students share one large study room and computer facilities in one central location, doctoral students generally have separate desks in offices scattered throughout the department. Because of these realities of the physical environment, a

masters student was simply more likely to come in contact with a fellow masters student than a doctoral student and vice versa.

In terms of the predicted same-gender bias, the effect of gender did not reach significance for friendships or work relations. The pre-existing network of relations within the cohort, however, did serve as a foundation for continued relations in both friendship and work contexts. All in all, the baseline model suggests that the social network among the cohort evolved according to commonly observed dynamics, except for gender homophily. The entire baseline model was included in all of the other models to control for the above social behaviour, the these results will not be reviewed again in the below discussions of results from other models. However, the results from those models can be interpreted with the assumption that the baseline effects were held constant. In other words, the subsequent effects were operating in parallel with the effects listed above.

Table 11
Summary of Study 3.2 models and parameter estimates for included effects

	<i>Baseline</i>		<i>Neg. mood</i>		<i>Brooding rumination</i>			<i>Co-rumination</i>		
	Friends	Work	Friends	Work	Friends	Work	Neg.mood	Friends	Work	Neg.mood
Gender										
<i>same</i>	0.3154	0.3662	0.3403†	0.3704†	0.3407†	0.3713†		0.3837†	0.3630†	
Course										
<i>same</i>	0.5712**	1.1507**	0.5931**	1.1501**	0.5874*	1.1493**		0.5859**	1.1511**	
Existing friends										
<i>direct effect</i>	1.1999**	1.4413**	1.3030**	1.4333**	1.3072*			1.4101**	1.4251**	
Within-network										
<i>reciprocity</i>	1.6257**	2.0856**	1.7300**	2.0797**	1.7415**	2.0831**		1.8094***	2.0860**	
<i>transitive triplets</i>	0.5620*	0.8944**	0.5714**	0.8919**	0.5744**	0.8895**		0.5408**	0.8911**	
<i>3-cycles</i>	-0.7742	-1.0253	-0.8051**	-1.0262†	-0.8023*	-1.0234†		-0.7115*	-1.0305†	
Cross-network										
<i>work</i>	2.3984**		2.4684**		2.5134**			2.5831**		
Negative mood										
<i>ego</i>			0.3270*		0.3427†			0.3202		
Brooding										
<i>direct effect</i>							0.3982*			0.3943*
Co-rumination										
<i>alter</i>								-0.3897**		

Note. † $p < .1$ * $p < .05$, ** $p < .01$ *** $p < .001$.

Negative mood model

When behavioural variables are added into an RSiena model, two effects—a linear and quadratic effect—are included by default. These behaviour dynamics concern the effect of the behaviour over time and on itself. The linear effect of negative mood was non-significant, suggesting that there were no overall linear pattern over time. However, it is important to keep in mind that the simulations are done at the actor-level, so there is a difference between aggregate-level analyses (i.e., the overall level of negative mood in the cohort) and actor-level analyses (i.e., the dynamics of negative mood within actors). Starting at the aggregate level, negative mood appeared relatively flat within the cohort (see Figure 25). Although the genders appear to diverge in their level of negative mood at the end, this difference was not significant. At the actor-level, the linear shape effect of negative mood was non-significant too, but this indicates that for actors who were in a negative mood, there was no change in their level of negative mood that was purely dependent on time. That is, just being in a negative mood and “sitting with it” had no effect on future levels of negative mood.

The quadratic effect of behaviour captures the effect of behavior on itself. The effect can indicate how “addictive” the behaviour is. For example, if the quadratic effect is positive, a small increase is reinforced via positive feedback, multiplying the behavior in the future. On the other hand, negative coefficient can be regarded as negative feedback, or a self-correcting mechanism: when negative mood increases, even higher levels of negative mood become less likely. In the present data, negative mood demonstrated such a self-regulatory pattern: rather than spiralling out of control, negative mood has a tendency to return to equilibrium, -0.1173 , $p = .028$. However, because the linear effect of negative mood was insignificant, the mere passage of time cannot explain this self-regulatory process. Instead, other processes are likely to play a role.

There are two main ways in which negative mood could influence the pattern of relations within the cohort: negative mood could change how much ego communicates with alters (ego-effect) and how much alters communicate with ego (alter-effect). However, when the score-type tests were carried out, only the ego-effect for negative mood was fit for inclusion, $p < .019$. The ego-effect of negative mood quantifies the impact of negative mood on ego’s likelihood to approach others. A positive ego-effect means the emotion increases approach tendencies and

makes ego more likely to reach out and communicate with others. When the negative mood model was estimated (see columns under *Neg. mood* in Table 11), the ego-effect of negative mood turned out to be positive and significant: people in a negative mood were 1.4 times more likely to reach out to others for social contact. In other words, misery indeed loved company for the present study. This could represent the basic mechanism that propagates emotion quickly across a social network: there appears to be an intrapersonal motivation to share it.

The null alter-effect suggests that merely experiencing negative mood is not enough to actively drive others away. This finding is in line with the findings from Study 3.1, where mere negative perception of negative emotion was not enough to deter others from communicating with low-mood individuals. However, despite lacking an active repelling effect, experiencing negative emotion may still end up isolating people, if positive emotion attracts others. If negative emotion neutralises or—even weakens—the attraction others feel toward ego, it is just a matter of time until some friends of ego gravitate towards alters who are in a more cheerful mood. Also, the null similarity effect suggests that merely experiencing a negative emotion is not enough to make low-mood people actively seek each other. Thus, other processes than homophily should explain why low-mood individuals might end up together.

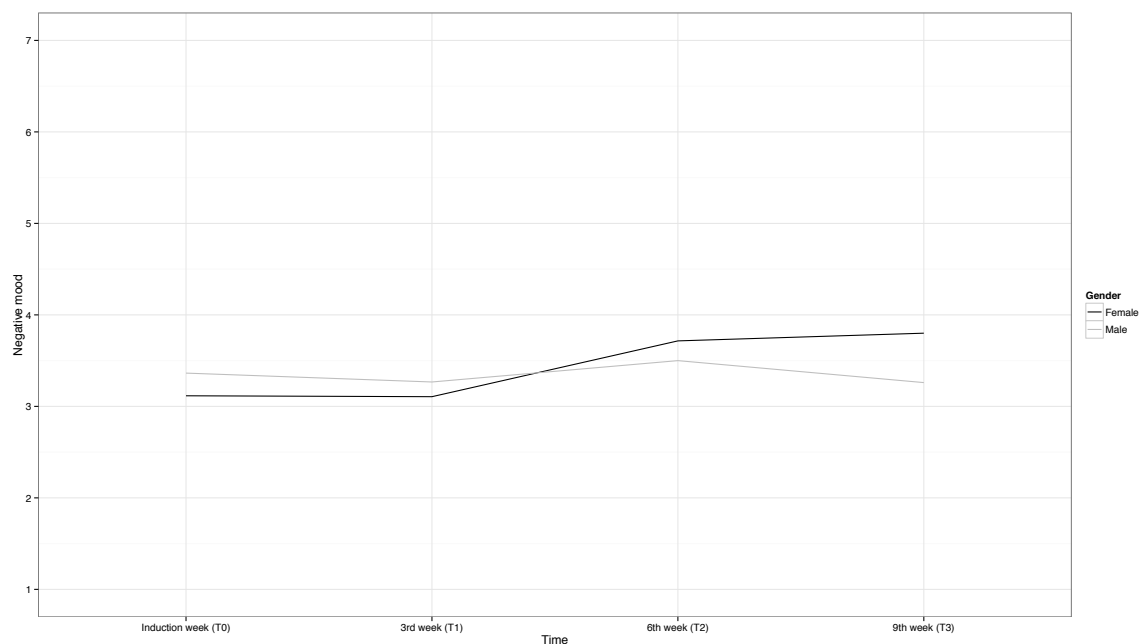


Figure 25. Negative mood over time.

Positive mood model

Study 3.1 suggested that being perceived to experience positive mood attracts communication from others. At the aggregate level, levels of positive mood were somewhat higher among the cohort (see Figure 26). The difference between genders at the end of data collection was slightly wider than it was for negative mood. However, the difference in positive mood was not large enough to reach significance, although it came close, $R^2 = .116$, $F(1, 25) = 3.28$, $p = .082$. When the ego, alter, and similarity effects of positive mood were tested for inclusion in the model, none of the effects was strong enough to reject the null. Thus, contrary to the findings of Study 3.1, positive mood did *not* appear to influence the patterns of friendships relations among the cohort. However, there may be at least two methodological reasons for the null finding. First of all, due to lack of coherence in the intended measures of positive emotion, the construct of positive mood was operationalised as scores to a single item. However, using single-item measures is controversial (e.g., Loo, 2002) and it is thus difficult to tell whether the null finding is due to measurement issues. Another point is that in Study 3.1 both the communication ties and the perception of mood were reported by the same actor, which could have created a level of non-independence between the variables. In the present study, the positive mood reported by ego was compared to relations reported by alters, making the data points inherently more independent of each other.

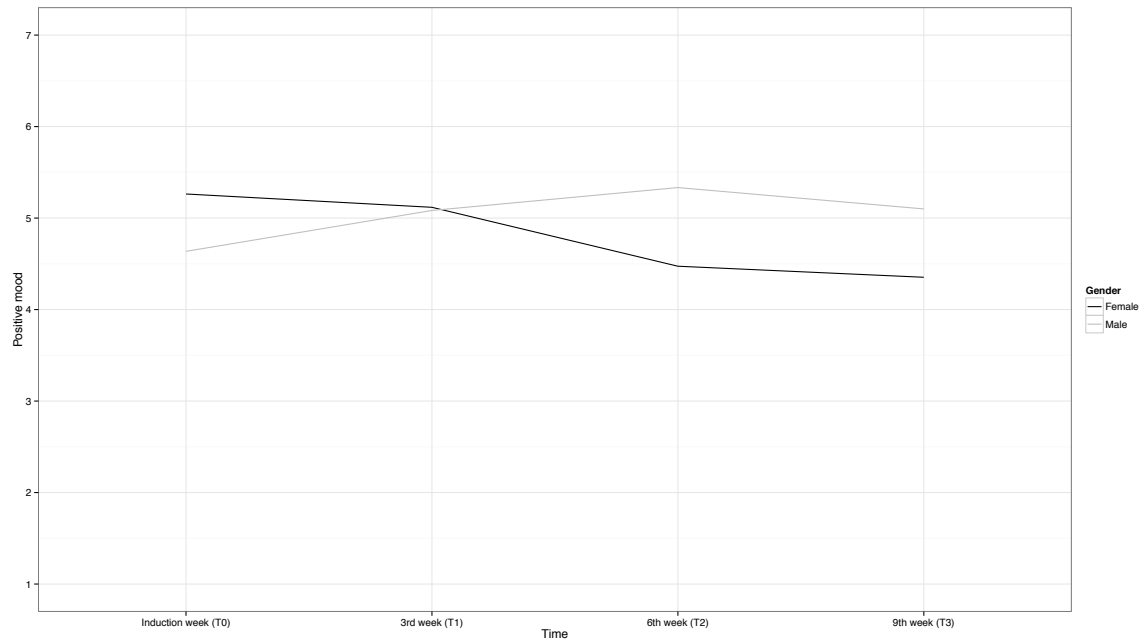


Figure 26. Positive mood over time.

Brooding and rumination models

Unlike mood, which was measured at each wave, intrapersonal rumination (i.e., brooding and reflection) was only measured once during the experiment, because it was conceptualised as a stable trait. Thus, brooding and reflection were treated as exogenous covariates in the model, and cannot have neither linear nor quadratic effects associated with them as the scores did not vary over time. At the aggregate, between-participants level ($N = 31$), brooding was related to negative mood as higher scores in brooding were—as predicted—positively correlated with average levels of negative mood across the waves, $r = .67$, $p < .001$. Reflective rumination style, on the other hand, was not correlated with negative mood, although it was trending toward significance, $r = .35$, $p = .096$. Neither brooding nor reflection was related to positive mood at the aggregate level. In terms of the actor-level effects of rumination in the RSiena simulations, the direct effect of brooding on negative mood was deemed fit for inclusion to the model ($p = .046$), but the corresponding effect from reflective rumination was not. See Table 11 for the parameter estimates for the brooding model.

Curiously, the inclusion of the direct effect of brooding on negative mood dropped the ego-effect of negative mood on friendship relations below significant level, 0.3427 , $p = .090$.

Whether this is due to the inherently stochastic nature of the simulations (i.e., some variation in p -values should be expected by chance) or shared variance with brooding is difficult to determine. The fact that the simulations were based on data from a relatively small number of participants exaggerates the problem. Given that the parameter estimate for the ego-effect of negative mood remains relatively stable between models and that brooding itself did not have an ego-effect of its own suggests that the culprit is small sample size.

Based on the assumption that intrapersonal rumination is a socially invisible process, neither brooding nor reflection were predicted to influence how others form friendships or work relations with ruminators (i.e., the effects would be explained either via negative mood or co-rumination, but not rumination itself). However, as both styles of rumination are conducive for solitary activity and social withdrawal, they were predicted to reduce the amount of social contact ego seeks with others. In total, four effects were tested for inclusion: ego- and alter-effects for both brooding and reflective rumination styles. However, none of these effects were indicated for inclusion in the model.

Co-rumination model

At the aggregate level, the level of co-rumination in the cohort remained rather stable throughout the experiment (see Figure 27). This means that the cohort as *a whole group*, did not experience dramatic shifts in their co-ruminative behaviour or engage in collective rumination. However, this does not mean that *everyone* in the cohort had stable levels of co-rumination. For example, although the mean level of co-rumination followed a rather narrow channel, there were many individuals at every time point who scored very high in co-rumination. Likewise, there were participants who were not at all co-ruminative. One of the benefits of using SAOMs is that it models actors as individuals, not aggregates, which allows the model to estimate how *individual actors* respond to co-rumination. Overall, actor-level co-rumination showed time-dependent dynamics, as the linear shape of co-rumination was negative and significant, $-0.7053, p = .013$. This means that individual participants' co-rumination scores tended to come down over time. Unlike negative mood, co-rumination did not demonstrate self-regulatory behaviour, as the quadratic effect of co-rumination was insignificant. On the other hand, this means that co-rumination did not appear to be a self-reinforcing cycle either.

In terms of the effect of co-rumination on mood, there could be a bidirectional link: either co-rumination worsens one's mood or decreasing mood increases co-rumination. The prediction based on CERN was that co-rumination itself would not have an effect beyond individual rumination or social constraint, whereas Rose's theory on co-rumination (2002) suggests that co-rumination leads to depressed mood. When the direct effects of co-rumination on negative mood and negative mood on co-rumination were tested, neither was indicated for inclusion. This is consistent with the CERN predictions that suggest the main effect is between brooding and depression (as well as isolation caused by social rejection).

Unlike individual rumination, co-rumination was hypothesised to be socially visible. To investigate whether co-rumination played a significant role in the formation of social relationships among the participants, ego, alter, and similarity effects of co-rumination were tested for inclusion in the model. Since co-rumination is characterised by excessive talking about problems, the ego-effect was predicted to be significant. More importantly, co-rumination was predicted to be the trigger that initiates social constraint from others. That is, the excessive nature of co-rumination—not just the negative emotion in it—was predicted to make others withdraw socially from co-ruminators. Furthermore, people with similar levels of co-rumination could be expected to seek each others' company. When these effects were tested for inclusion, only the inclusion of the alter-effect of co-rumination turned out to be statistically warranted, $p = .004$. When the model was estimated, the negative parameter for the alter-effect suggests that co-rumination did indeed lead to fewer social relations initiated by others, -0.3897 , $p = .007$. This means that others were less likely to form friendships with co-ruminators. The entire co-rumination model is listed in Table 11. To complicate the overall picture, the previously marginally significant ego-effect of negative mood became insignificant, $p = .162$. However, this is probably due to the shared variance that brooding, co-rumination, and negative emotion variables have in common.

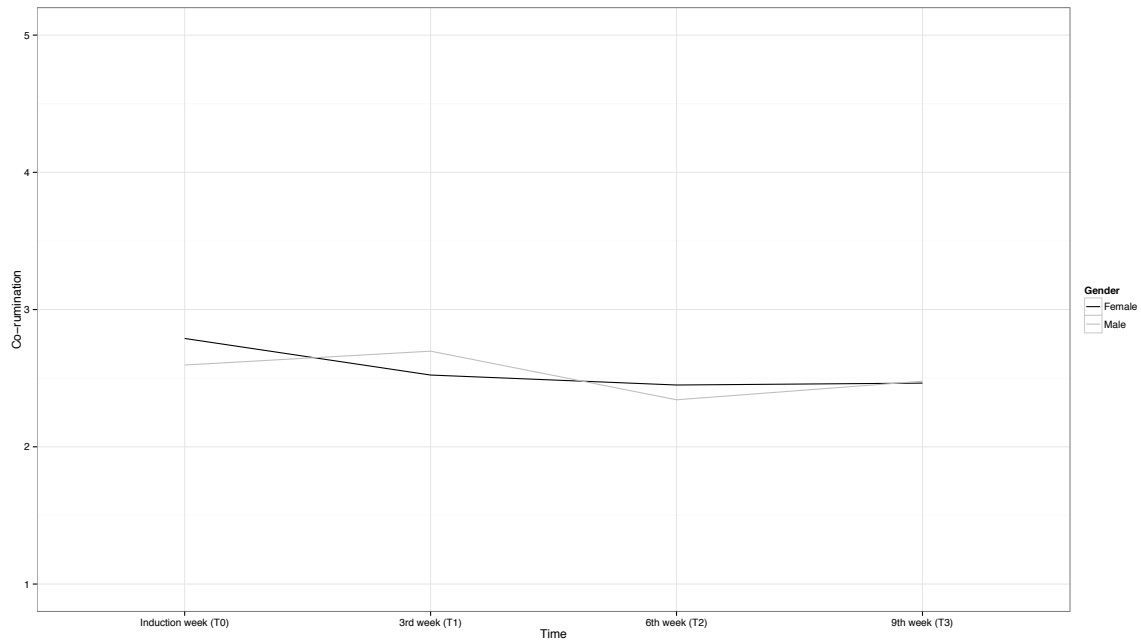


Figure 27. Aggregate co-rumination over time.

Personality model

As reported in Part I of this thesis, co-rumination appeared to have associations with two personality dimensions: neuroticism and agreeableness. At the aggregate level, personality trended toward significant correlation with co-rumination: neuroticism was almost significantly correlated with co-rumination, $r = .35$, $p = .086$, but agreeableness fell further from the mark, $r = .29$, $p = .153$. This is not surprising, given the dubious levels of internal reliability of the agreeableness scale.

It is also possible that the positive ego- and alter-effects in the other models are confounded with personality. To account for this possibility, ego- and alter-effects for both neuroticism and agreeableness were tested for inclusion. The only effect that was indicated for inclusion in the model was the alter-effect for agreeableness. When the model was estimated, the agreeableness alter-effect was negative and nearly significant, -0.2869 , $p = .058$. This suggests that people actively avoided social contact with agreeable individuals, which sounds odd, because agreeableness is typically associated with social harmony and would appear to be conducive for friendships at face value. However, there are a number of caveats that must be considered. For one,

the p-value suggests that mere chance cannot be ruled out as an explanation. Second, the internal consistency of the agreeableness measure fell far below typical thresholds of acceptability (on the other hand, it is another question whether these conventional psychometric standards are applicable to ultra-brief measures; Wood & Hampson, 2005). Given these grave concerns of measurement validity, these findings are not discussed further.

Discussion

The present study examined co-rumination “in the wild” as a cohort of graduate students came together for their first term at Oxford. This scenario allowed me to track many of processes that I had hypothesised to underpin collective emotion regulation networks and differentiate maladaptive co-rumination from adaptive social sharing. Based on the observed data, I ran computer simulations of how various factors influenced the formation, maintenance, and dissolution of relations within the cohort, based on a theoretical framework of co-rumination as a dysfunction of a collective emotion-regulation network.

Against a backdrop of commonly observed social behavior, such as reciprocity and becoming friends with one’s friend’s friends, some clear patterns emerged as predicted. For one, negative mood was observed to increase social approach. This was predicted based on social sharing theory that suggests that negative emotion leads to social sharing. The dynamics of negative mood additionally suggested that negative mood does not linearly dissipate by itself over time, but instead appears to be subject to a self-regulatory process: as participants’ negative mood increased, a subsequent increase became less and less likely. Overall, these findings hint at the possibility that negative emotion triggers social sharing, which in turn creates the conditions for social regulation of the said emotion.

In terms of co-rumination, the principal goal was to explain why co-rumination would reduce the number of one’s friends and standing in the peer group. Whereas negative emotion was not a sufficient cause for others to shun low-mood people, co-rumination did seem to push others away. The negative alter-effect of co-rumination indicates that the reduction in social contact was due to the actions of the alters, not the co-ruminative ego. This result is consistent with findings in

social constraint literature: excessive sharing may discourage others from initiating social relations with co-ruminators.

Furthermore, only a certain type of mental rumination—brooding, or dwelling on the emotional aspect of one's problems—was linked with increased negative mood. This finding was also predicted based on rumination and social sharing literature, as the key aspect that differentiates adaptive social sharing from maladaptive co-rumination is the emphasis placed on the emotional aspects of the situation (e.g., Joormann, Dkane, & Gotlib, 2006; Rimé, 2009). However, as an intrapersonal process, individual rumination was assumed to be socially invisible unless verbalised as co-rumination. The results suggest rumination itself does not change patterns of social contact itself—even though the construct strongly suggests social withdrawal. However, there appears to be an *indirect* link between brooding and increased social contact, as brooding had a direct impact on negative mood, which made low-mood people seek social contact. Thus, it is possible that brooding could indirectly increase social contact by intensifying negative emotion, but brooding on its own had no effect beyond the effect of increased negative mood alone. Unfortunately, the small sample size of the study makes it impossible to resolve this question.

Positive mood, on the other hand, showed no effects, although Study 3.1 strongly suggested that cheerful people attract more social contact from others. Although there were strong methodological reasons (i.e., positive mood was measured by a single item) to doubt the veracity of the findings, an alternative explanation is that the subjective experience of happiness is not immediately obvious to outsiders and would have to be communicated to others in some way. This is comparable to the findings regarding rumination and co-rumination: unless verbalised as co-rumination, private rumination was largely invisible to others. Likewise, the mere subjective experience of negative mood did not appear to influence the behaviour of others, mirroring the null finding regarding positive mood. However, for future studies, it would be instructive to combine measures of self-reported emotion and other-reported perceptions of emotion to resolve this ambiguity.

In summary, Study 3.2 demonstrated that social sharing, co-rumination, and social constraint processes could operate in parallel: normative levels of negative emotion can trigger

social sharing, but do not appear to trigger social constraint from others. On the other hand, co-rumination seems to lead to social ostracism by one's peers, which is likely to lead to reduced standing in one's peer group. The main strength of this study was the sophisticated simulation technique that allows the specification of multiple, precise intrapersonal, dyadic, and network effects.

Limitations

The main weakness is that the model was probably overspecified for the sample size, despite only allowing in effects that were tested for inclusion. However, for the present study, the sample size was dependent on departmental decisions about the number of students to admit and beyond experimental control.

In addition, these data only captured the social relations that occurred within the psychology department. This might not be an issue in any other university, where friendships generally tend to follow departmental boundaries. However, due to the college system at the University of Oxford, it is very likely that the participants had many friendships outside the department that were not captured by the present study. Given that colleges are the central hubs of social life in Oxford, it is possible that these friendships were more important and intimate than the friendships at the department. In short, social relations at the department that were measured and the unmeasured relations outside of it might be governed by different dynamics. However, this fact may have had only a limited influence, because the exclusion of one source of social contact from the network does not necessarily undermine the dynamics that were observed within the network.

The present study improved upon Study 3.1 by operationalising a friendship relation in terms of specific social behaviors instead of any type of interpersonal communication, creating a more fine-grained measure. However, the new scope of friendship could have been too restrictive. Because the wording of the friendship measure focused on social contact outside the university context, it excluded things such as lunchtime and coffee break conversations at the department. Thus, it is possible that people had "department-only" classmates whose influence is not adequately captured by the present study, as the evolution of the network of work relations was not modeled in the same detail as the friendship network. It is also possible that some of these

“department-only” classmates were not direct colleagues or labmates. If participants engaged in friendly affiliative behavior with peers at the department, but did not have contact outside of it, and did not engage in joint academic activity, such data would go unreported by the present measures.

Another shortcoming was that the direct effect of co-ruminative relations on other relations were neither observed nor modeled, because only one participant reported having co-ruminated with a classmate. Thus, the majority of actual co-rumination occurred in social relations defined either by kinship or sexual relations—and neither network was directly sampled by the study.

Finally, the three-week period between data collection waves could have been too long for a number of reasons. For example, it is unlikely that the participants were able to accurately recall their mood for the entire period, their mood might have shifted over the period in a way that was not reflected in the scores they gave, and the scores could be affected by recent events more strongly than earlier events.

SUMMARY

The main motivation of the final part of my thesis was to demonstrate the utility and applicability of social network analysis theory and methodology to social psychology research questions. A growing body of literature has argued that emotion is not an exclusively private experience, but a shared one (Oatley, 2010; Parkinson, 1996; Rimé, 2009). Social network analysis is an especially good match for emotion research, because it can model both intrapersonal and interpersonal aspects of emotion simultaneously in the same model. For example, while intrapersonal emotion predisposes individuals to behave in a certain way, people can also observe emotional states of others and modify their behavior accordingly. Given the recursive and non-independent nature of emotion, typical statistical tools start to fall short of empirical tractability, whereas tools from social network analysis are a near-perfect match for emotion research. Thus, one of the key contributions of this part of the thesis was to show that co-rumination and social sharing could be explained within one theoretical framework as the combined effect of few, relatively simple effects that operate in a social network.

As an explanatory vehicle, I outlined how a collective emotion regulation network might respond to emotion expressed by a single individual and construed co-rumination as a process that begins as a part of a normative social sharing of emotion, but gets derailed from adaptive to maladaptive functioning. From this point of view, co-rumination is a combination of social sharing (Rimé, 2009) and social constraint (Pennebaker & Harber, 1993) processes. The advantage of framing co-rumination in network terms is that these effects could explain why co-rumination has been observed to have deleterious effects on peer acceptance (Starr & Davila, 2009; Tompkins et al., 2011), something which is difficult to explain within the dyadic formulation of co-rumination.

The networked formulation of co-rumination was tested in two longitudinal studies that tracked psychology students and their communication with each other. The main findings of the studies were that intrapersonal experience of emotion triggers social contact and that co-rumination repels others from having social contact with co-ruminators. These findings were in line with predictions from social sharing and social constraint literatures, suggesting that while

sharing of negative emotion is a normative, self-regulating process, co-rumination might elicit social shunning that erodes social relations.

Study 3.1 demonstrated that mood perceptions do shift communication patterns in a social network. Among a stable group of undergraduates who knew each other relatively well, those who were seen to be in a positive mood attracted more communication from others. Although the motivation for the study was to examine whether negative mood repels others, the effect of negative mood on incoming communication from others was non-significant. While people who were perceived to be in a negative mood were not actively discriminated against, the differential social allure of individuals could lead to permanent changes in peer-group structure. If people gravitate towards cheery others (although the evidence for this was mixed), gloomy people might still end up alone, even if they did not actively push others away or if others did not actively shun them.

Overall, the results showed that negative emotion alone is not enough to push others away, which is in line with the general premise of social sharing: when people reach out to share their negative emotion, others are generally willing to listen. Study 3.2 showed that the social exclusion process enacted by others is a function of co-rumination, not negative emotion alone. Whereas people were willing to interact with low-mood people in general, they actively withdraw from co-ruminators, suggesting that there is something particular about co-rumination that drives people away.

In terms of comparing co-rumination, social sharing, and CERN theories, the verdict was clearly in favour of social sharing (Rimé, 2009). This is not surprising, because it is the most mature of the compared theories with significant body of evidence supporting it. As co-rumination has a more limited explanatory scope, there were numerous situations in which no predictions could have been made based on it, while social sharing had a direct prediction based on its fundamental theory. In total, 13 separate predictions were posed and in seven cases, the evidence voted in favour of social sharing theory. In terms of CERN, most of the predictions were the same as those made by social sharing theory, which is not enough to differentiate it from social sharing. In the cases where CERN had a differing prediction (e.g., the network would proactively approach

people in negative mood to provide support), the evidence still favoured social sharing predictions. There were some cases in which CERN made unique predictions above and beyond the other theories, but unfortunately all of these predictions suggested that some variable would *not* have an effect on relations (i.e., predicting a null). However, this is the least powerful argument a theory can make, and the sample size of the study is not large enough to show that the results were due to genuine lack of association instead of a case of undetected signal. Based on the above, the most beneficial approach for future studies on co-rumination would be, in my opinion, to integrate them into a framework that combines the mature theory of social sharing literature and new empirical opportunities provided by social networking methodology.

CONCLUSION

What makes both co-rumination and social sharing interesting research topics is that both of the constructs straddle the divide between intrapersonal and social. The entire thesis was organised to address three levels of analysis to investigate within-person correlates of co-rumination, between-people dyadic interaction, and network-level processes that could be involved. At the individual level of analysis, this thesis extended the scope of co-rumination research from adolescent samples to a more inclusive range of ages in an attempt to sketch a picture of co-rumination over the lifespan. This life course pattern of co-rumination suggested that women co-ruminate more than men at any age, but that the levels of co-rumination appeared to plateau shortly before the 30th birthday for both sexes. Perhaps the most useful contribution of this thesis at the individual level is a validation of a short measure of co-rumination, which I put to use for longitudinal data collection in the last part of the thesis. However, if co-rumination were to be treated as an inherently relational quality, instead of a combination of two individual differences, it would make sense to collect more relationally oriented co-rumination data, such as transactional roles associated with co-rumination and co-rumination among members of an extended social network. Also, collecting more precise data about the frequency, duration, and topics of co-rumination might help us to understand the process better.

Although co-rumination has been defined to be a dyadic phenomenon, truly dyadic research on it has still been rare. To get a better sense of how co-rumination exerts its depressive influence during dyadic interaction, I studied how people talk about negative events and collected real-time information about people's emotional valence during these conversations. While the pattern of results was too complex to provide a simple explanation, at least a linear decline due to co-rumination could be ruled out. Perhaps the most valuable lesson at the dyadic level studies was that when studying an inherently relational process, one must include data from both participants, as male and female co-rumination appears to interact in intricate ways. While clear linguistic markers of co-rumination proved to be too elusive for me to capture, the take-home message of the dyadic studies was that co-rumination is not the exclusive domain of the primary co-ruminators. Observational coding of co-rumination from silent videos demonstrated that sufficiently motivated

bystanders could detect aspects of co-rumination without having a direct involvement in the co-ruminative conversations. Thus, co-rumination could have social consequences beyond the two co-ruminators.

While this thesis identified gaps in co-rumination theory and tested hypotheses about potential processes that operate in these gaps, it also suggested new tools and directions for future research that are applicable to a wide range of topics. As a contribution to the meta-discussion of social psychology as a science, this thesis provided an overview of the intellectual and technological developments that have placed social psychology in a position of great opportunity to use networks as an organising paradigm for broad areas of research. A major theme of this thesis, social network analysis, should be a welcome addition to social psychology's research toolbox. Network theory can easily bridge the gaps within a level of analysis (e.g., traits that promote co-rumination) and between them (e.g., integration of social sharing dynamics into co-rumination). A large part of the third and final part of my thesis was dedicated to advancing this methodology by drawing attention to how it could be used to integrate research from three levels of analysis, from the individual traits to the functioning of whole networks. By using networks as an integrative framework, I proposed that co-rumination could be understood in terms of a collective emotion regulation network, an idea built on social sharing (Rimé, 2009). In terms of advancing theory, the findings in this thesis suggest that co-rumination plays part of a larger social process by which multiple interacting individuals negotiate the arrangement of their relations in a social network based on the way in which they share emotion. When controlling for various social processes and biases, participants in Study 3.2 were less likely to initiate social relations with co-ruminators.

I hope that this integrative exercise inspires future researchers to integrate co-rumination theory with more mature lines of related research, with or without the help of social networks. The most obvious candidate for integration is—as demonstrated by this thesis—social sharing (Rimé, 2009). By incorporating a more nuanced view of socio-affective and cognitive modes, social sharing can, for example, lead to a fruitful re-evaluation of the role of rumination in co-rumination. As the brooding and reflection subcomponents of rumination map quite well on the idea that exclusive focus on emotion is maladaptive due to its short-lived soothing of symptoms and

cognitive effort is required for resolving negative emotion, importing this two-factor view of rumination into future co-rumination research might prove to be instructive. For example, the capstone Study 3.2 showed that 1) brooding decreased mood, 2) negative mood increased social outreach, and 3) co-rumination elicited social rejection from others. These findings match the assumption that co-rumination is a special case of social sharing gone wrong, an adaptive process that has turned maladaptive.

Understanding how co-rumination unfolds within the context of individuals' social networks has clinical implications that will hopefully help mental health professionals better identify individuals at risk for depression and recognise potentially maladaptive processes in how individuals share problems with each other. The most often studied effect of co-rumination is depression, which—at least for teenage girls—appears to be the price of a more intimate, emotional connection with one's closest friend. However, even this benefit of co-rumination appears to be of dubious value, as the final study of the thesis suggested that co-rumination alienates co-ruminators from others. If co-rumination indeed elicits social rejection from others (and the findings from Study 3.2 done on an older sample generalise to adolescents), it could mean that adolescent co-rumination could permanently alter youths' nascent social networks. If a child's social network becomes misshapen for one reason or another, it could have a profound impact on the long-term well-being of the child. Damage done to a social network early on could have a lasting influence, including future employment options. Granovetter (1973) showed that professional opportunities commonly arise through contact with weak ties, acquaintances not in the core of one's social network. If the reduction in co-ruminators' friendship network size is permanent, co-rumination could prune away connections that might have been useful later on in life. The long-term implication of early co-rumination is that the reduced peer-relations of co-ruminators could lead to fewer employment opportunities later on as co-ruminators might have to draw upon resources of a malformed social networks. It would be interesting to compare adolescent social networks to see if there is any evidence of structural differences between co-ruminators and non-co-ruminators.

Looking Forward

In many ways the strengths and weaknesses of this thesis reflect the ultimatum that traditional methodology in social psychology poses for researchers. While inviting participants to visit a laboratory allows researcher to collect rich data about participants interactions (cf. Studies 2.1, 2.2, and 2.3), lab-based methodology does not scale well to large sample sizes due to cost and effort required to process each participant. In addition, lab-based methods suffer from limited external validity since they occur in artificial circumstances. On the other hand, it is becoming easier and easier to recruit large sample sizes online, but single-shot self-report measures have their own problems due to retrospective memory biases and shared method variance. Thus, researchers have been forced to choose between rich data from small samples or limited data from large samples.

To avoid problems stemming from the artificial nature of the recorded situation, it would be preferable to collect the conversation data by eavesdropping on private conversations and ask for informed consent afterwards. However, only national espionage organisations have the technological wherewithal and ethical latitude to collect such data at will. If informed consent can be secured, one technical workaround to the ethical problem has been invented at MIT. Sandy Pentland's lab has built sociometric badges that are able to record conversations without violating the participants' right to privacy (Olguín-Olguín & Pentland, 2010). Rather than recording audio word-by-word like a tape recorder would, the badges extract in realtime non-linguistic signals. For example, the badge can record vocal characteristics like volume and cadence while ignoring the words themselves. From such data, it is possible to infer psychological states such as interest and excitement (Pentland, 2005). Likewise, the badges are very non-intrusive while being visible. It is very likely that the equipment can "hide in plain sight" as participants are likely to stop paying attention to the devices over time. Although such badges would have been ideal for the research presented in this thesis, the cost of the equipment is still prohibitively high at \$500 USD per device (with a minimum order of ten). However, as the price of technology comes down significantly over time, these devices might become inexpensive enough for even limited research budgets to accommodate.

Consumer technology, however, is making another alternative available. Computerised event-sampling methods offer a way to collect rich, ecologically valid data (Barrett & Barrett, 2001). When participants are equipped with electronic devices, researchers can ask participants to questions about their immediate feelings, thoughts, and behaviours to minimise memory biases. Furthermore, event-sampling studies can last for weeks, providing researchers with repeated-measures data that can model both within- and between-person effects. Despite the advantages of event-sampling methodology, it used to require researchers to supply participants with expensive devices, which limited the number of concurrent participants. However, smartphone technology has greatly progressed in the past ten years and the current generation of mobiles regularly include touch screens, motion sensors, cameras, global positioning system (GPS), and numerous wireless communication standards (e.g., WiFi, Bluetooth etc.). By leveraging participants' own mobile phones as a research platform, researchers can recruit much larger samples to participate in event-sampling studies as the number of devices owned by the researcher no longer constitutes a bottleneck.

Another benefit of smart mobile phones is that they can supplement self-reported data with a wide spectrum of sensor data. For example, in Study 3.1 and 3.2, I had to rely on participants manual reports about their social contact. With the help of Bluetooth-enabled mobiles, it is possible to keep a continuous log of which other phones were within a 10-meter range to supplement self-reported information about social contact. Furthermore, EmotionSense app (Rachuri et al., 2010) for Android mobiles can be trained to recognise the users voice and to detect basic emotional states from conversations within the phone's microphone range. The increasing technical ability of mobile phones also allows researchers to target their data collection based on various factors instead of randomly triggered queries. For example, using EmotionSense, it would be possible to trigger different questionnaires based on whether the participant is at the department, at home, or elsewhere (as determined by GPS location). These kind of data would be invaluable for understanding ecologically valid social behaviour.

Overall, social psychology seems to be undergoing a transformation. As an illustration of the broad intellectual developments in the discipline, Figure 28 shows shows how frequently the words “social psychology” have been mentioned in print during the 100-year period from 1908 to

2008. This range of years is very fitting, as I started graduate school in 2008, exactly 100 years after the publication of *Social Psychology* (Ross, 1908). One way to interpret the figure is to think of it as an indicator of how many times English literature has “cited” social psychology as a branch of science. It is quite evident from the chart that social psychology has been on a prolonged downward path since the mid-1980s. In comparison, neuroscience and social networks have steadily increased in popularity since the late 1960s. My interpretation of the chart is that the rise of social networks and neuroscience has been powered by—at least in part—by a powerful central paradigm to organise research in these disciplines and technological advances to bring in vast amounts of data to fuel research and theoretical developments.

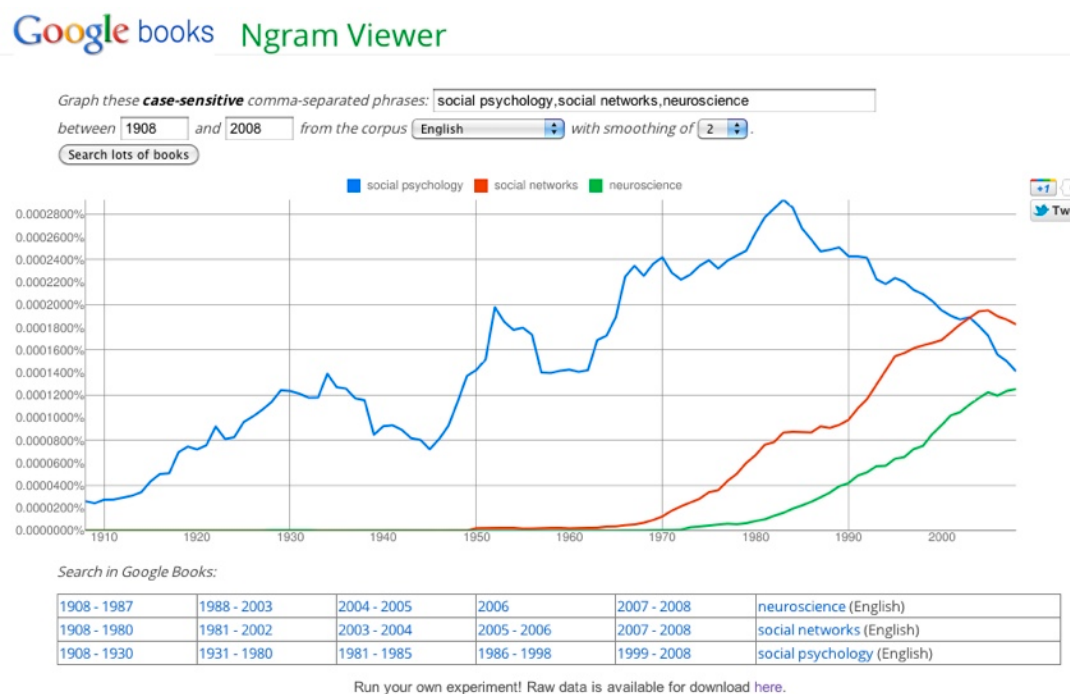


Figure 28. The occurrence of “social psychology” in English literature (1908–2008).

In both neuroscience and social networks, the central paradigm is a network. Neuroscience is the scientific study of the nervous system, one of the most complicated networks known to humanity. Social networks, on the other hand, model structures of social groups, how these structures influence other variables, or how structures change over time. Because the subject matter of social psychology includes both kinds of networks (i.e., the nervous system of an individual person and the study of high-level social structures such as culture), it has a great opportunity to straddle the divide between the two disciplines by integrating the within-person

biological networks and the social networks of people interacting together. Social psychology as a scientific discipline covers networks at vastly different scales, from the neuronal to national. For example, the intracranial activity of a world leader's nucleus accumbens or amygdala during high-stakes trade negotiations can have far-reaching consequences: a small network of neurons can send ripples to larger, global networks of trade. However, the apparent decline of social psychology seems to indicate that discipline has not been very successful at articulating its importance in the contemporary world. In my opinion, social psychology has lacked an effective methodology to tackle its central questions, which has held back the field. I hope a wider adoption of social networks will correct this, because the vast amounts of data enabled by sophisticated consumer technology like mobile phones and social media combined with the explanatory power of social networks can put social psychology at the dawn of a new golden era.

REFERENCES

- Alden, L. E., & Bieling, P. (1998). Interpersonal consequences of the pursuit of safety. *Behaviour Research and Therapy*, 36(1), 53–64.
- Altman, I., & Taylor, D. A. (1983). *Social penetration: The development of interpersonal relationships*. New York: Irvington Publishers.
- American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: Author.
- Andrews, P. W., & Thomson Jr, J. A. (2009). The bright side of being blue: depression as an adaptation for analyzing complex problems. *Psychological Review*, 116(3), 620–654.
- Arnett, J. J. (2000). Emerging adulthood: A theory of development from the late teens through the twenties. *American Psychologist*, 55, 469–480.
- Back, K. W. (1951). Influence through social communication. *Journal of Abnormal and Social Psychology* 46, 9–23.
- Bahrami, B., Olsen, K., Bang, D., Roepstorff, A., Rees, G., & Frith, C. (2012). Together, slowly but surely: The role of social interaction and feedback on the build-up of benefit in collective decision-making. *Journal of Experimental Psychology: Human Perception and Performance*, 38(1), 3–8.
- Barabási, A. L., & Albert, R. (1999). Emergence of scaling in random networks. *Science*, 286(5439), 509–512.
- Baron, J. N., & Pfeffer, J. (1994). The social psychology of organizations and inequality. *Social Psychology Quarterly*, 57, 190–209.
- Barrera, M. (1986). Distinctions between social support concepts, measures, and models. *American Journal of Community Psychology*, 14(4), 413–445.
- Barrett, L. F. & Barrett, D. J. (2001). An introduction to computerized experience sampling in psychology. *Social Science Computer Review*, 19(2), 175.
- Beck, A. T. (1976). *Cognitive therapy and emotional disorders*. New York: International Universities Press.
- Belle, D. (1989). Gender differences in children's social networks and supports. In D. Belle (Ed.), *Children's social networks and social supports* (pp. 173–188). New York: Wiley.
- Benenson, J. F., Apostoleris, N. H., & Parnass, J. (1997). Age and sex differences in dyadic and group interaction. *Developmental Psychology*, 33(3), 538–543.
- Bentler, P., & Chou, C. (1987). Practical issues in structural modeling. *Sociological Methods & Research*, 16(1), 78–117.
- Bland J.M. & Altman D.G. (2000) The odds ratio. *British Medical Journal*, 320(7247), 1468.
- Bliese, P. (2012). multilevel: Multilevel Functions. R package version 2.4 available at <http://CRAN.R-project.org/package=multilevel>
- Bloom, B. S. (1964). *Stability and change in human characteristics*. New York: Wiley.
- Borgatti, S., Mehra, A., Brass, D., & Labianca, G. (2009). Network analysis in the social sciences, *Science*, 323(5916), 892–895.

- Brown, B. B. (1999). "You're going out with who?": Peer group influences on adolescent romantic relationships. In W. Furman, B. B. Brown, & C. Feiring (Eds.), *The development of romantic relationships in adolescence* (pp. 291–329). Cambridge, UK: Cambridge University Press.
- Brown, R. D., & Hauenstein, N. M. (2005). Interrater agreement reconsidered: An alternative to the rwg indices. *Organizational Research Methods*, 8(2), 165–184.
- Buhrmester, D., & Furman, W. (1987). The development of companionship and intimacy. *Child Development*, 58(4), 1101–1113.
- Buhrmester, M., Kwang, T., & Gosling, S. D. (2011). Amazon's Mechanical Turk: A new source of inexpensive, yet high-quality, data? *Perspectives on Psychological Science*, 6(1), 3–5.
- Buhrmester, D., & Prager, K. (1995). Patterns of functions of self-disclosure during childhood and adolescence. In K. J. Rotenberg (Ed.), *Disclosure processes in children and adolescents* (pp. 10–56). New York: Cambridge University Press.
- Bukowski, W. M., Adams, R. E., & Santo, J. B. (2006). Recent advances in the study of development, social and personal experience, and psychopathology. *International Journal of Behavioral Development*, 30(1), 26–30.
- Bukowski, W. M., Newcomb, A. F., & Hartup, W. W. (1998). *The company they keep: Friendships in childhood and adolescence*. Cambridge University Press.
- Burk, W. J., Steglich, C. E. G., & Snijders, T. A. B. (2007). Beyond dyadic interdependence: Actor-oriented models for co-evolving social networks and individual behaviors. *International Journal of Behavioral Development*, 31(4), 397–404.
- Burt, R.S. (2004). Structural holes and good ideas. *American Journal of Sociology*, 110(2), 349–399.
- Butler, E. A. (2011). Temporal interpersonal emotion systems: The "TIES" That Form Relationships. *Personality and Social Psychology Review*, 15(4), 367–393.
- British Psychological Society. (2007). *Report of the working party on conducting research on the internet: Guidelines for ethical practice in psychological research online* (Report No. 62/06.2007). Leicester, UK: Author.
- Burgoon, J.K., Buller, D.B., Hale, J.L., & deTurck, M.A. (1984). Relational messages associated with nonverbal behaviors. *Human Communication Research*, 10(3), 351–78.
- Byrd-Craven, J., Geary, D. C., Rose, A. J., & Ponzi, D. (2008). Co-ruminating increases stress hormone levels in women. *Hormones and Behavior*, 53(3), 489–92.
- Byrd-Craven, J., Granger, D. A., & Auer, B. J. (2011). Stress reactivity to co-rumination in young women's friendships: Cortisol, alpha-amylase, and negative affect focus. *Journal of Social and Personal Relationships*, 28(4), 469–487.
- Byrne, B. M. (2006). *Structural equation modeling with Amos: Basic concepts, applications, and programming* (2nd ed.). New York: Routledge.
- Cacioppo, J. T., Fowler, J. H., & Christakis, N. A. (2009). Alone in the crowd: The structure and spread of loneliness in a large social network. *Journal of Personality and Social Psychology*, 97(6), 977–991.
- Cacioppo, J. T., & Hawkley, L. C. (2009). Perceived social isolation and cognition. *Trends in Cognitive Science*, 13(10), 447–454.
- 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.

- Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin*, 56(2), 81–105.
- Cegala, D. J. (1981). Interaction involvement: A cognitive dimension of communicative competence. *Communication Education*, 30, 109–21.
- Cheng, C., Chen, Z., & LuoKogan, A. (2008). Social support and money as double-edged swords: Primary soothers and precipitants of pain. *Psychological Inquiry*, 19(3–4), 153–160.
- Christophe, V., & Rimé, B. (1997). Exposure to the social sharing of emotion: Emotional impact, listener responses and secondary social sharing. *European Journal of Social Psychology*, 27(1), 37–54.
- Ciesla, J. A., Dickson, K. S., Anderson, N. L., & Neal, D. J. (2011). Negative repetitive thought and college drinking: Angry rumination, depressive rumination, co-rumination, and worry. *Cognitive Therapy and Research*, 35(2), 142–150.
- Clark, L. A., & Watson, D. (1995). Constructing validity: Basic issues in objective scale development. *Psychological Assessment*, 7(3), 309–319.
- Clark L. A., Watson, D., Mineka, S. (1994). Temperament, personality and the mood and anxiety disorders. *Journal of Abnormal Psychology*, 103(1), 103–16.
- Cohen, S. (2004). Social relationships and health. *American Psychologist*, 59(8), 676–684.
- Connolly, J. A., & Goldberg, A. (1999). Romantic relationships in adolescence: The role of friends and peers in their emergence and development. In W. Furman, B. B. Brown, & C. Feiring (Eds.), *The development of romantic relationships in adolescence* (pp. 266–290). Cambridge, UK: Cambridge University Press.
- Cortina, J. M. (1993). What is coefficient alpha? An examination of theory and applications. *Journal of Applied Psychology*, 78, 98–98.
- Costa, P. T., Jr., & McCrae, R. R. (1994). “Set like plaster”? Evidence for the stability of adult personality. In T. Heatherton & J. Weinberger (Eds.), *Can personality change?* (pp. 21–40). Washington, DC: American Psychological Association.
- Coyne, J. C. (1976). Depression and the response of others. *Journal of Abnormal Psychology*, 85(2), 186–193.
- Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16(3), 297–334.
- Cynkar, A. (2007). The changing gender composition of psychology. *Monitor on Psychology*, 38(6), 46–47.
- Davila, J., Steinberg, S. J., Kachadourian, L., Cobb, R., & Fincham, F. (2004). Romantic involvement and depressive symptoms in early and late adolescence: The role of a preoccupied relational style. *Personal Relationships*, 11(2), 161–178.
- Davis, J.A. (1970). Clustering and hierarchy in interpersonal relations: Testing two graph theoretical models on 742 sociomatrices. *American Sociological Review*, 35, 843–851.
- de Rivera, J. H. (1977). *A Structural Theory of the Emotions*. New York: International Universities Press.
- de Rivera, J. H. & Grinkis, C. (1986). Emotions as social relationships. *Motivation and Emotion*, 10(4), 351–369.
- Donnellan, M. B., Oswald, F. L., Baird, B. M., & Lucas, R. E. (2006). The mini-IPIP scales: tiny-yet-effective measures of the Big Five factors of personality. *Psychological Assessment*, 18(2), 192–203.
- Dunbar, R.I.M. (1992). Neocortex size as a constraint on group size in primates. *Journal of Human Evolution*, 20, 469–493.

- Dunbar, R. I. M., & Shultz, S. (2007). Evolution in the social brain. *Science*, 317(5843), 1344–1347.
- Eisenberg, N., & Lennon, R. (1983). Sex differences in empathy and related capacities. *Psychological Bulletin*, 94(1), 100–131.
- Ekman P. (1977). Biological and cultural contributions to body and facial movement. In J. Blacking (Ed.), *Anthropology of the body* (pp. 34–84). San Diego, CA: Academic Press.
- Enns, M. W. & Cox, B. J. (1997). Personality Dimensions and Depression: Review and Commentary. *Canadian Journal of Psychiatry*, 42, 274–284
- Erdős, P. & Rényi, A. (1960). On the evolution of random graphs. *Publications of the Mathematical Institute of the Hungarian Academy of Sciences*, 5, 17–61.
- Fenlason, K. J., & Beehr, T. A. (1994). Social support and occupational stress: Effects of talking to others. *Journal of Organizational Behavior*, 15(2), 157–175.
- Ferrer, E., & Helm, J. L. (in press). Dynamical systems modeling of physiological coregulation in dyadic interactions. *International Journal of Psychophysiology*.
- Festinger, L., Schachter, S., Back, K., (1950). The spatial ecology of group formation, in L. Festinger, S. Schachter, & K. Back (eds.), *Social Pressure in Informal Groups* (pp. 141–161). Palo Alto, CA: Stanford University Press.
- Field, T., Healy, B. T., Goldstein, S., & Guthertz, M. (1990). Behavior-state matching and synchrony in mother-infant interactions of nondepressed versus depressed dyads. *Developmental Psychology*, 26(1), 7.
- Flanagan, D., & Matsumoto, Y. (2008). *The ruby programming language*. Sebastopol, CA: O'Reilly Media.
- Fox, J. (2000). *Nonparametric simple regression smoothing scatterplots*. Thousand Oaks, Calif: Sage Publications.
- Francis, M. E. & Pennebaker, J. W. (1992). Putting stress into words: the impact of writing on physiological, absentee, and self-reported emotional well-being measures. *American Journal of Health Promotion*, 6, 280.–287.
- Frank, O. & Strauss, D. (1986). Markov Graphs. *Journal of the American Statistical Association*, 81, 832–842.
- Fredrickson, B. L. (1998). What good are positive emotions? *Review of General Psychology*, 2, 300–319.
- Freeman, L. (2004). *The development of social network analysis: A study in the sociology of science*. Vancouver, BC: Empirical Press BookSurge.
- Freud, S. (1975). *Psychopathology of Everyday Life*. In J. Strachey (Ed. and Trans.), *The standard edition of the complete psychological works of Sigmund Freud* (Vol. 6). London: Hogarth Press. (Original work published 1901)
- Freud, S. (1963). *Introductory lectures on psychoanalysis*. In In J. Strachey (Ed. and Trans.) *The standard edition of the complete psychological works of Sigmund Freud* (Vols. 15–16, pp. 9–496). London: Hogarth. (Original work published 1916–1917)
- Gabriel, S., Kawakami, K., Bartak, C., Kang, S.-J., & Mann, N. (2010). Negative self-synchronization: will I change to be like you when it is bad for me? *Journal of Personality and Social psychology*, 98(6), 857–71.
- Garton, L., Haythornthwaite, C., & Wellman, B. (2006). Studying online social networks. *Journal of Computer-Mediated Communication*, 3(1).

- Galesic, M. & Bosnjak, M. (2009). Effects of Questionnaire Length on Participation and Indicators of Response Quality in a Web Survey. *Public Opinion Quarterly*, 73(2), 349–360.
- Gibson, J. J. (1977). The Theory of Affordances. In R. Shaw and J. Bransford (Eds.), *Perceiving, acting, and knowing: Toward an ecological psychology*. (pp. 67-82). Hillsdale, NJ: Erlbaum.
- Girvan, M., & Newman, M. E. (2002). Community structure in social and biological networks. *Proceedings of the National Academy of Sciences*, 99(12), 7821–7826.
- Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Chicago: Aldine de Gruyter.
- Gonzalez, R., & Griffin, D. (2000). On the statistics of interdependence: Treating dyadic data with respect. In W. Ickes & S. Duck (Eds.), *The social psychology of personal relationships* (pp. 181–213). Chichester, UK: Wiley.
- Goodwin, R. (1992). Overall, just how happy are you? The magical Question 31 of the Spanier Dyadic Adjustment Scale. *Family Therapy*, 19(3), 273–275.
- Gore, S., Aseltine Jr, R. H., & Colten, M. E. (1993). Gender, social-relationship involvement, and depression. *Journal of Research on Adolescence*, 3(2), 101–125.
- Gosling, S. D., Rentfrow, P. J., & Swann, W. B., Jr. (2003). A very brief Measure of the Big Five personality domains. *Journal of Research in Personality*, 37(6), 504–528.
- Gottman, J. M., & Levenson, R. W. (1985). A valid procedure for obtaining self-report of affect in marital interaction. *Journal of Consulting and Clinical Psychology*, 53(2), 151–160.
- Grabill, C., & Kerns, K. A. (2000). Attachment style and intimacy in friendship. *Personal Relationships*, 7(4), 363–378.
- Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology*, 78(6), 1360–1380.
- Granovetter, M. (1985). Economic action and social structure: the problem of embeddedness. *American Journal of Sociology*, 91(3), 481–510.
- Gruber, J., Mauss, I. B., & Tamir, M. (2011). A dark side of happiness? How, when, and why happiness is not always good. *Perspectives on Psychological Science*, 6(3), 222–233.
- Guastello, S. J. & Liebovitch, L. S. (2009). Introduction to nonlinear dynamics and complexity. In S. J. Guastello, M. Koopmans, & D. Pincus (Eds.), *Chaos and complexity in Psychology: Theory of nonlinear dynamics* (pp. 1–40). New York: Cambridge University Press.
- Haggard, D. L., Robert, C., & Rose, A. J. (2010). Co-rumination in the workplace: Adjustment trade-offs for men and women who engage in excessive discussions of workplace problems. *Journal of Business and Psychology*, 26(1), 27–40.
- Hammen, C. (2006). Stress generation in depression: Reflections on origins, research, and future directions. *Journal of Clinical Psychology*, 62, 1065–1082.
- Hankin, B.L., Abramson, L.Y., Moffitt, T.E., Silva, P.A., McGee, R., Angell, K.E., (1998). Development of depression from preadolescence to young adulthood: emerging gender differences in a 10-year longitudinal study. *Journal of Abnormal Psychology*, 107(1), 128–140.
- Hankin, B. L., Stone, L., & Wright, P. A. (2010). Corumination, interpersonal stress generation, and internalizing symptoms: accumulating effects and transactional influences in a multiwave study of adolescents. *Development and Psychopathology*, 22(1), 217–35.
- Harary, F. (1953). On the notion of balance of a signed graph. *The Michigan Mathematical Journal*, 2(2), 143–146.

- Harber, K. D., & Cohen, D. J. (2005). The emotional broadcaster theory of social sharing. *Journal of Language and Social Psychology, 24*(4), 382–400.
- Hareli, S., & Hess, U. (2010). What emotional reactions can tell us about the nature of others: An appraisal perspective on person perception. *Cognition and Emotion, 24*(1), 128–140.
- 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), 971–5.
- Heider, F. (1946). Attitudes and cognitive organization. *The Journal of Psychology, 21*(1), 107–112.
- Helliwell, J. F. & Putnam, R. D. (2004). The social context of well-being. *Philosophical Transactions of The Royal Society Biology, 359*(1449), 1435–1446.
- Hill, R. A., & Dunbar, R. I. (2003). Social network size in humans. *Human Nature, 14*(1), 53–72.
- Howes, M. J., Hokanson, J. E., & Loewenstein, D. A. (1985). Induction of depressive affect after prolonged exposure to a mildly depressed individual. *Journal of Personality and Social Psychology, 49*, 1110–1113.
- Hu, L., & Bentler, P. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1–55.
- Hyde, J. S. (2005). The gender similarities hypothesis. *American Psychologist, 60*(6), 581–592.
- John, O., & Srivastava, S. (2001). The Big Five trait taxonomy: History, measurement, and theoretical perspectives. In L. Pervin & O. P. John (Eds.), *Handbook of Personality: Theory and Research* (2nd ed., pp. 102–138). New York: The Guilford Press.
- Jones, D. C. (1991). Friendship satisfaction and gender: An examination of sex differences in contributors to friendship satisfaction. *Journal of Social and Personal Relationships, 8*, 167–185.
- Joormann, J., Dkane, M., & Gotlib, I. H. (2006). Adaptive and Maladaptive Components of Rumination? Diagnostic Specificity and Relation to Depressive Biases. *Behavior Therapy, 37*(3), 269–280.
- Jose, P. E., Wilkins, H., & Spendelow, J. S. (2012). Does social anxiety predict rumination and co-rumination among adolescents? *Journal of Clinical Child & Adolescent Psychology, 41*(1), 86–91.
- Kaufmann, G. M., & Beehr, T. A. (1989). Occupational stressors, individual strains, and social supports among police officers. *Human Relations, 42*(2), 185–197.
- Keltner, D., & Gross, J. J. (1999). Functional accounts of emotions. *Cognition & Emotion, 13*(5), 467–480.
- Keltner, D., & Kring, A. M. (1998). Emotion, social function, and psychopathology. *Review of General Psychology, 2*(3), 320–342.
- Kenny, D. A., Kashy, D. A., & Cook, W. L. (2006). *Dyadic data analysis*. New York: Guilford.
- Kenny, D. A., & Zautra, A. (1995). The trait-state-error model for multiwave data. *Journal of Consulting and Clinical Psychology, 63*(1), 52–59.
- Kessler, R. C., & McLeod, J. D. (1984). Sex differences in vulnerability to undesirable life events. *American Sociological Review, 49*, 620–631.
- Kline, P. (2000). *The handbook of psychological testing* (2nd ed.). London, UK: Routledge.
- Koenig, F. (1985). *Rumor in the marketplace: The social psychology of commercial hearsay*. Dover, MA: Auburn House.

- Koenigsberg, H. W., Teicher, M. H., Mitropoulou, V., Navalta, C., New, A. S., Trestman, R., & Siever, L. J. (2004). 24-h Monitoring of plasma norepinephrine, MHPG, cortisol, growth hormone and prolactin in depression. *Journal of Psychiatric Research*, 38(5), 503–511.
- Kuhn, T. S. (1962/2012). *The Structure of Scientific Revolutions: 50th Anniversary Edition*,. Chicago, IL: Chicago University Press.
- Lakoff, G., & Johnson, M. (1980). The metaphorical structure of the human conceptual system. *Cognitive Science*, 4(2), 195–208.
- Landoll, R. R., Schwartz-Mette, R. A., Rose, A. J., & Prinstein, M. J. (2011). Girls' and Boys' Disclosure about Problems as a Predictor of Changes in Depressive Symptoms Over Time. *Sex Roles*, 65(5–6), 410–420.
- Larsen, R. J. & Fredrickson, B. L. (1999). Measurement issues in emotion research. In D. Kahneman, E. Diener, & N. Schwarz (Eds.) *Well-being: Foundations of hedonic psychology*, pp. 40–60. New York: Russel Sage.
- LaRocco, J. M., House, J. S., & French Jr, J. R. (1980). Social support, occupational stress, and health. *Journal of health and Social Behavior*, 21, 202–218.
- Laurenceau, J. P., & Bolger, N. (2005). Using diary methods to study marital and family processes. *Journal of Family Psychology*, 19(1), 86–97.
- Lemay, E. P., & Clark, M. S. (2008). “Walking on Eggshells”: How Expressing Relationship Insecurities Perpetuates Them. *Journal of Personality and Social Psychology*, 95(2), 420–441.
- Lewin, Kurt. (1936). *Principles of Topological Psychology*. New York: McGraw-Hill.
- Lewinsohn, P. M., Steinmetz, J. L., Larson, D. W., & Franklin, J. (1981). Depression-related cognitions: Antecedent or consequence? *Journal of Abnormal Psychology*, 90(3), 213–219.
- Lewis, M. D., Lamey, A. V. and Douglas, L. (1999), A new dynamic systems method for the analysis of early socioemotional development. *Developmental Science*, 2, 457–475.
- Li, L., Alderson, D., Doyle, J. C., & Willinger, W. (2006). Towards a Theory of Scale-Free Graphs: Definitions, Properties, and Implications. *Internet Mathematics*, 2(4), 431–523.
- Loo, R. (2002). A caveat on using single-item versus multiple-item scales. *Journal of Managerial Psychology*, 17(1), 68–75.
- Lospinoso, J. A., Schweinberger, M., Snijders, T. A. B., and Ripley, R. (2011). Assessing and accounting for time heterogeneity in stochastic actor oriented models. *Advances in Data Analysis and Computation*, 5, 147–176.
- Lyubomirsky, S., King, L., & Diener, E. (2005). The benefits of frequent positive affect: does happiness lead to success? *Psychological bulletin*, 131(6), 803.
- Manstead, A. S. R. & Fischer, A. H. (2001). Social appraisal: The social world as object of and influence on appraisal processes. In K. R. Scherer, A. Schorr, & T. Johnstone, (Eds.), *Appraisal processes in emotion: Theory, methods, research* (pp. 221–232). New York: Oxford University Press.
- Marin, A. & Wellman, B. (2010). Social Network Analysis: An Introduction. In P. Carrington and J. Scott, (eds.), *Handbook of Social Network Analysis*. Sage: London.
- Marmenout, K. (2011). Peer interaction in mergers: evidence of collective rumination. *Human Resource Management*, 50(6), 783–808.
- Marroquín, B. (2011). Interpersonal emotion regulation as a mechanism of social support in depression. *Clinical psychology review*, 31(8), 1276–1290.

- Marsden, P. V., & Friedkin, N. E. (1993). Network studies of social influence. *Sociological Methods & Research*, 22(1), 127–151.
- Martin, M., Ward, J. C., & Clark, D. M. (1983). Neuroticism and the recall of positive and negative personality information. *Behaviour Research and Therapy*, 21(5), 495–503.
- McNulty, J. K. (2010). When positive processes hurt relationships. *Current Directions in Psychological Science*, 19(3), 167–171.
- McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual Review of Sociology*, 27(1), 415–444.
- Meleshko, K. G., & Alden, L. E. (1993). Anxiety and self-disclosure: toward a motivational model. *Journal of Personality and Social Psychology*, 64(6), 1000–1009.
- Mellings, T., & Alden, L. E. (2000). Cognitive processes in social anxiety: The effects of self-focus, rumination and anticipatory processing. *Behaviour Research and Therapy*, 38(3), 243–257.
- Minuchin, S. (1974). *Families and family therapy*. Cambridge, MA: Harvard University Press.
- Muthén, L., & Muthén, B. (2006). *Mplus User's Guide* (6th ed.). Los Angeles, CA: Muthén & Muthén.
- Myers, D. G. (2003). Close relationships and quality of life. In D. Kahneman, E. Diener, and N. Schwarz (Eds.) *Well-being: The foundations of hedonic psychology*. New York: Russell Sage Foundation.
- Nichols, A. L. & Maner, J. K. (2008). The Good-Subject Effect: Investigating Participant Demand Characteristics. *The Journal of General Psychology*, 135(2), 151–165.
- Nils, F., & Rimé, B. (2012). Beyond the myth of venting: social sharing modes determine the benefits of emotional disclosure. *European Journal of Social Psychology*, 42(6), 672–681.
- Noever, D. A., Cronise, R. J., & Relwani, R. A. (1995). Using spider-web patterns to determine toxicity. *NASA Tech Briefs*, 19(4), 82.
- Nolen-Hoeksema, S. (1991). Responses to depression and their effects on the duration of depressive episodes. *Journal of Abnormal Psychology*, 100(4), 569–82.
- Nolen-Hoeksema, S., & Girgus, J. S. (1994). The emergence of gender differences in depression during adolescence. *Psychological Bulletin*, 115(3), 424–443.
- Nolen-Hoeksema, S., & Harrell, Z. A. (2002). Rumination, depression, and alcohol use: Tests of gender differences. *Journal of Cognitive Psychotherapy*, 16(4), 391–403.
- Nolen-Hoeksema, S., & Jackson, B. (2001). Mediators of the gender difference in rumination. *Psychology of Women Quarterly*, 25(1), 37–47.
- Nolen-Hoeksema, S., & Morrow, J. (1991). A prospective study of depression and posttraumatic stress symptoms after a natural disaster: The 1989 Loma Prieta earthquake. *Journal of Personality and Social Psychology*, 61(1), 115–121.
- Nolen-Hoeksema, S., Parker, L. E., & Larson, J. (1994). Ruminative coping with depressed mood following loss. *Journal of Personality and Social Psychology*, 67(1), 92–104.
- Nolen-Hoeksema, S., Wisco, B. E., & Lyubomirsky, S. (2008). Rethinking rumination. *Perspectives on Psychological Science*, 3(5), 400–424.
- Nunnally, J. C. (1978). *Psychometric theory*. New York: McGraw-Hill.
- Oatley, K. (2010). Two movements in emotions: Communication and reflection. *Emotion Review*, 2(1), 29–35.

- Olguín-Olguín, D., & Pentland, A. (2010). Sensor-based organisational design and engineering. *International Journal of Organisational Design and Engineering*, 1(1), 69–97.
- Parker, J. G., & Asher, S. R. (1993). Friendship and friendship quality in middle childhood: Links with peer group acceptance and feelings of loneliness and social dissatisfaction. *Developmental Psychology*, 29, 611–621.
- Parker, J., & Gottman, J. M. (1989). Social and emotional development in a relational context: Friendship interaction from early childhood to adolescence. In T. J. Berndt, & G. W. Ladd (Eds.), *Peer relationships in child development* (pp. 95–131). New York: Wiley.
- Parkinson, B. (1996). Emotions are social. *British Journal of Psychology*, 87(4), 663–683.
- Parkinson, B. (2001). Anger on and off the road. *British Journal of Psychology*, 92(3), 507–526.
- Parkinson, B. (2009). What holds emotions together? Meaning and response coordination. *Cognitive Systems Research*, 10(1), 31–47.
- Parkinson, B., Fischer, A. H., & Manstead, A. S. R. (2005). *Emotion in social relations: Cultural, group, and interpersonal processes*. New York: Psychology Press.
- Parkinson, B., & Simons, G. (2012). Worry spreads: Interpersonal transfer of problem-related anxiety. *Cognition & Emotion*, 26(3), 462–479.
- Pennebaker, J. W. (1993). Mechanisms of social constraint. In D. Wegner & J. W. Pennebaker (Eds.), *Handbook of mental control* (pp. 200–212). Englewood Cliffs, NJ: Prentice-Hall.
- Pennebaker, J. W. (1997). *Opening Up: The Healing Power of Expressing Emotion*. NY: Guilford Press.
- Pennebaker, J. W. (2004). *Writing to Heal: A Guided Journal for Recovering from Trauma and Emotional Upheaval*. Oakland, CA: New Harbinger Press.
- Pennebaker, J. W., & Beall, S. K. (1986). Confronting a traumatic event: Toward an understanding of inhibition and disease. *Journal of Abnormal Psychology*, 95(3), 274–281.
- Pennebaker, J. W., Chung, C. K., Ireland, M., Gonzales, A., & Booth, R. J. (2007). *The development and psychometric properties of LIWC2007*. Austin, TX: LIWC.Net. Available at http://homepage.psy.utexas.edu/homepage/faculty/pennebaker/Reprints/LIWC2007_LanguageManual.pdf
- Pennebaker, J. W., Francis M. E., & Booth R. J. (2001). *Linguistic Inquiry and Word Count (LIWC): LIWC2001*. Mahwah: Lawrence Erlbaum Associates.
- Pennebaker, J. W., & Harber, K. D. (1993). A social stage model of collective coping: The Loma Prieta earthquake and the Persian Gulf War. *Journal of Social Issues*, 49(4), 125–145.
- Pennebaker, J. W., & King, L. A. (1999). Linguistic styles: Language use as an individual difference. *Journal of Personality and Social Psychology*, 77(6), 1296–1312.
- Pennebaker, J. W., & Harber, K., (1993). A social stage model of collective coping: The Loma Prieta earthquake and the Persian Gulf War. *Journal of Social Issues*, 49(4), 125–145.
- Pentland, A. (2005). Socially aware, computation and communication. *Computer*, 38(3), 33–40.
- Petersen, A. C., Compas, B. E., Brooks-Gunn, J., Stemmler, M., Ey, S., & Grant, K. E. (1993). Depression in adolescence. *American Psychologist*, 48(2), 155–168.
- Pinheiro, J. C., & Bates, D. M. (2000). *Mixed effects models in S and S-PLUS*. New York: Springer Verlag.
- Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *The Journal of Applied Psychology*, 88(5), 879–903.

- Porter, M. A., Onnela, J. P., & Mucha, P. J. (2009). Communities in networks. *Notices of the AMS*, 56(9), 1082–1097.
- R Development Core Team (2009). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL <http://www.R-project.org>.
- Rachuri, K., Musolesi, M., Mascolo, C., Rentfrow, P. J., Longworth, C., & Aucinas, A. (2010). EmotionSense: A Mobile Phones Based Adaptive Platform for Experimental Social Psychology Research. In *Proceedings of the 12th ACM International Conference on Ubiquitous Computing*. Copenhagen, Denmark.
- Raudenbush, S. W., Brennan, R. T., & Barnett, R. C. (1995). A multivariate hierarchical model for studying psychological change within married couples. *Journal of Family Psychology*, 9(2), 161–174.
- Reddick, J. & Schlesinger, A. (2006). Highschool never ends. On *The Great Burrito Extortion Case*. New York: Zomba (May 15 – June 14, 2006).
- Regan, R. T. (1971). Effects of a favor and liking on compliance.. *Journal of Experimental Social Psychology*, 7, 627–639
- Rimé, B. (2009). Emotion elicits the social sharing of emotion: Theory and empirical review. *Emotion Review*, 1(1), 60–85.
- Rimé, B., Finkenauer, C., Luminet, O., Zech, E., & Philippot, P. (1998). Social sharing of emotion: New evidence and new questions. *European Review of Social Psychology*, 9, 145–189.
- Rimé, B., Mesquita, B., Boca, S., & Philippot, P. (1991). Beyond the emotional event: Six studies on the social sharing of emotion. *Cognition & Emotion*, 5(5), 435–465.
- Rimé, B., Philippot, P., Boca, S., & Mesquita, B. (1992). Long-lasting cognitive and social consequences of emotion: Social sharing and rumination. *European Review of Social Psychology*, 3(1), 225–258.
- Ripley, R. M., Snijders, T. A. B., and Preciado, P. (2011). *Manual for SIENA version 4.0* (version December 1, 2011). Oxford: University of Oxford, Department of Statistics; Nuffield College. Available at <http://www.stats.ox.ac.uk/siena/>
- Roberts, J. E., Gilboa, E., & Gotlib, I. H. (1998). Ruminative response style and vulnerability to episodes of dysphoria: Gender, neuroticism, and episode duration. *Cognitive Therapy and Research*, 22(4), 401–423.
- Robinson, M. D., Ode, S., Moeller, S. K., & Goetz, P. W. (2007). *Personality and Individual Differences*, 42(7), 1221–1231.
- Rogers, Carl. (1942). *Counseling and Psychotherapy: Newer Concepts in Practice*. Boston: Houghton Mifflin.
- Rohde, P., Lewinsohn, P. M., & Seeley, J. R. (1990). Are people changed by the experience of having an episode of depression? A further test of the scar hypothesis. *Journal of Abnormal Psychology*, 99(3), 264–271.
- Rose, A. J. (2002). Co-rumination in the friendships of girls and boys. *Child Development*, 73(6), 1830–1843.
- Rose, A. J., & Asher, S. R. (1999). Children's goals and strategies in response to conflicts within a friendship. *Developmental Psychology*, 35(1), 69–79.
- 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), 1019–31.

- Rose, A. J., & Rudolph, K. D. (2006). A review of sex differences in peer relationship processes: potential trade-offs for the emotional and behavioral development of girls and boys. *Psychological bulletin*, 132(1), 98.
- Rose, A.J., Schwartz, R.A., & Carlson, W. (2005). *An observational assessment of co-rumination in the friendships of girls and boys*. Paper presented at the Society for Research in Child Development, Atlanta, Georgia, USA.
- Rosenberg, E. L., & Ekman, P. (1994). Coherence between expressive and experiential systems in emotion. *Cognition & Emotion*, 8(3), 201–229.
- Ross, E. A. (1908). *Social psychology: An outline and source book*. Toronto: Macmillan Company.
- Rothbart, M. K., Ahadi, S. A., & Evans, D. E. (2000). Temperament and personality: Origins and outcomes. *Journal of Personality and Social Psychology*, 78(1), 122–135.
- Rude, S. S., Gortner, E.-M., & Pennebaker, J. W. (2004). Language use of depressed and depression-vulnerable college students. *Cognition and Emotion*, 18(8), 1121–1133.
- Rudolph, K. D. (2002). Gender differences in emotional responses to interpersonal stress during adolescence. *Journal of Adolescent Health*, 30(4), 3–13.
- Sandelands, L. E., & Boudens, C. J. (2000). Feeling at work. In S. Fineman (Ed.), *Emotion in organizations* (pp. 46–63). London: Sage.
- Satorra, A., & Bentler, P. (2001). A scaled difference chi-square test statistic for moment structure analysis. *Psychometrika*, 66(4), 507–514.
- Schmitt, N. (1996). Uses and abuses of coefficient alpha. *Psychological Assessment*, 8(4), 350–353.
- Schulenberg, J. E., Sameroff, A. J., & Cicchetti, D. (2004). The transition to adulthood as a critical juncture in the course of psychopathology and mental health. *Development and Psychopathology*, 16(4), 799–806.
- Schwartz-Mette, R. A., & Rose, A. J. (2012). Co-rumination mediates contagion of internalizing symptoms within youths' friendships. *Developmental Psychology*, 48(5), 1355–1365.
- Seligman, M. E. P. S., Nolen-Hoeksema, S. (1987). "Explanatory style and depression". In D. Magnusson and A. Ohman. *Psychopathology: An Interactional Perspective*. New York: Academic Press, pp. 125–139.
- Selfhout, M., Burk, W., Branje, S., Denissen, J. J. A., Van Aken, M. A. G., & Meeus, W. (2010). Emerging late adolescent friendship networks and Big Five personality traits: A dynamic social network perspective. *Journal of Personality*, 78(2), 509–538.
- Shrout, P.E., & Fleiss, J.L. (1979), Intraclass correlation: Uses in assessing rater reliability. *Psychological Bulletin*, 86(2), 420–428.
- Sijtsma, K. (2009). On the use, the misuse, and the very limited usefulness of Cronbach's alpha. *Psychometrika*, 74(1), 107–120.
- Slatcher, R. B., Chung, C. K., Pennebaker, J. W., & Stone, L. D. (2007). Winning words: Individual differences in linguistic style among US presidential and vice presidential candidates. *Journal of Research in Personality*, 41(1), 63–75.
- Smith, E. R., & Conrey, F. R. (2007). Agent-based modeling: A new approach for theory building in social psychology. *Personality and social psychology review*, 11(1), 87–104.
- Smith, R. L., & Rose, A. J. (2011). The "Cost of Caring" in Youths' Friendships: Considering Associations Among Social Perspective Taking, Co-Rumination, and Empathetic Distress. *Developmental psychology*, 47(6), 1792–1803.

- Snijders, T. A. B. (2001). The statistical evaluation of social network dynamics. In M. Sobel and M. Becker (Eds.), *Sociological methodology* (pp. 361–395). Boston and London: Basil Blackwell.
- Snijders T. A. B. (2005) ‘Models for Longitudinal Network Data’, in Carrington P. J., Scott J., Wasserman S. (Eds.) *Models and methods in social network analysis* (pp. 215–47). New York: Cambridge University Press.
- Snijders, T.A.B., Steglich, C.E.G., & Schweinberger, M. (2007). Modeling the co-evolution of networks and behavior. In K. van Montfort, H. Oud, A. Satorra. (Eds.), *Longitudinal models in the behavioral and related sciences* (pp. 41–71). Mahwah, NJ: Lawrence Erlbaum.
- Snijders, T. A. B., van de Bunt, G. G., & Steglich, C. E. G. (2010). Introduction to stochastic actor-based models for network dynamics. *Social Networks*, 32(1), 44–60.
- Snow, R., O'Connor, B., Jurafsky, D., & Ng, A. Y. (2008). Cheap and fast—but is it good?: evaluating non-expert annotations for natural language tasks. In *Proceedings of the conference on empirical methods in natural language processing* (pp. 254–263). Association for Computational Linguistics.
- Springer, D. W., Kamata, A., & Abell, N. (2009). *Developing and validating rapid assessment instruments*. New York: Oxford University Press.
- 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.
- Stiff, W. T. L. (2009). *Shoes*. Retrieved July 16, 2009, from <http://shoesrb.com>
- Stirman, S. W., & Pennebaker, J. W. (2001). Word use in the poetry of suicidal and non-suicidal poets. *Psychosomatic Medicine*, 63(4), 517–522.
- Stone, L. L., Giletta, M., Brendgen, M., Otten, R., Engels, R. C. M. E., & Janssens, J. M. A. M. (2012). Friendship similarities in internalizing problems in early childhood. *Early Childhood Research Quarterly*, 28(2), 210–217.
- Stone, L. B., Hankin, B. L., Gibb, B. E., & Abela, J. R. (2011). Co-rumination predicts the onset of depressive disorders during adolescence. *Journal of Abnormal Psychology*, 120(3), 752–757.
- Stone, L. B., Uhrlas, D. J., & Gibb, B. E. (2010). Co-rumination and lifetime history of depressive disorders in children. *Journal of Clinical Child & Adolescent Psychology*, 39(4), 597–602.
- Strogatz, S. H. (2001). Exploring complex networks. *Nature*, 410(6825), 268–276.
- Switzer, G. E., Wisniewski, S. R., Belle, S. H., Dew, M. A., & Schultz, R. (1999). Selecting, developing, and evaluating research instruments. *Social Psychiatry and Psychiatric Epidemiology*, 34(8), 399–409.
- Tausczik, Y. R., & Pennebaker, J. W. (2010). The psychological meaning of words: LIWC and computerized text analysis methods. *Journal of Language and Social Psychology*, 29(1), 24–54.
- Taylor, S.E. (2006). Tend and befriend: Biobehavioral bases of affiliation under stress. *Current Directions in Psychological Science*, 15(6), 273–277.
- Teasdale, J. D., & Green, H. A. (2004). Ruminative self-focus and autobiographical memory. *Personality and Individual Differences*, 36(8), 1933–1943.
- Thelwall, M., Buckley, K., Paltoglou, G. Cai, D., & Kappas, A. (2010). Sentiment strength detection in short informal text. *Journal of the American Society for Information Science and Technology*, 61(12), 2544–2558.
- Thibaut, J. & Kelley, H. H. (1959). *The Social Psychology of Groups*. New York: Wiley.
- Toews, J., Lockyer, J., & Brownwell, A. (1993). Stress among residents, medical students, and graduate science (MSc/PhD) students. *Academic Medicine*, 68(10), S46–S48.

- 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.
- Totterdell, P., Hershcovis, M. S., Niven, K., Reich, T. C., & Stride, C. (2012). Can employees be emotionally drained by witnessing unpleasant interactions between coworkers? A diary study of induced emotion regulation. *Work & Stress*, 26(2), 112–129.
- Trapnell, P. D., & Campbell, J. D. (1999). Private self-consciousness and the five-factor model of personality: distinguishing rumination from reflection. *Journal of Personality and Social Psychology*, 76(2), 284–304.
- Travers, J. & Milgram, S. (1969). An Experimental study of the small world problem. *Sociometry*, 32(4), 425–443.
- Treynor, W., Gonzalez, R., & Nolan-Hoeksema, S. (2003). *Cognitive Therapy and Research*, 27(3), 247–259.
- Turner, J. C., Hogg, M. A., Oakes, P. J., Reicher, S. D., & Wetherell, M. S. (1987). *Rediscovering the Social Group: A self-categorization theory*. New York: Blackwell.
- Van Kleef, G. A., De Dreu, C. K., & Manstead, A. S. (2004). The interpersonal effects of anger and happiness in negotiations. *Journal of Personality and Social Psychology*, 86(1), 57–76.
- Waller, E. M., & Rose, A. J. (2010). Adjustment trade-offs of co-rumination in mother-adolescent relationships. *Journal of Adolescence*, 33(3), 487–97.
- Wasserman, S. (1980). Analyzing social networks as stochastic processes. *Journal of the American Statistical Association*, 75, 280 – 294.
- Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications*. New York: Cambridge University Press.
- Wasserman, S., & Galaskiewicz, J. (1994). *Advances in social network analysis: Research in the social and behavioral sciences*. Thousand Oaks, CA: SAGE Publications.
- Watkins, E. R. (2009). Depressive rumination and co-morbidity: evidence for brooding as a transdiagnostic process. *Journal of Rational-Emotive & Cognitive-Behavior Therapy*, 27(3), 160–175.
- Watson, D., L.A. Clark, & A. Tellegen (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, 54(6), 1063–1070.
- Watts, D. J., & Strogatz, S. H. (1998). Collective dynamics of ‘small-world’ networks. *Nature*, 393(6684), 440–442.
- Weiss, R. S. (1973). *Loneliness: The experience of emotional and social isolation*. Cambridge, MA: MIT Press.
- Wellman, B. (1988). Structural analysis: From method and metaphor to theory and substance. In B. Wellman and S.D. Berkowitz (Eds.), *Social structures: A network approach* (pp. 19– 61). Cambridge, UK: Cambridge University Press.
- 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.
- Wickham, H. (2009). *ggplot2: Elegant graphics for data analysis*. New York: Springer.
- Wimmer, A., & Lewis, K. (2010). Beyond and Below Racial Homophily: ERG Models of a Friendship Network Documented on Facebook. *American Journal of Sociology*, 116(2), 583–642.

- Wood, S. A., & Hampson, S. E. (2005). Measuring the Big Five with single items using a bipolar response scale. *European Journal of Personality*, 19, 373–390.
- Wright, S. C., Aron, A., McLaughlin-Volpe, T., & Ropp, S. A. (1997). The extended contact effect: Knowledge of cross-group friendships and prejudice. *Journal of Personality and Social Psychology*, 73(1), 73–90.
- Zahn-Waxler, C. (2000). The development of empathy, guilt, and internalization of distress: Implications for gender differences in internalizing and externalizing problems. In R. J. Davidson (Ed.), *Anxiety, depression, and emotion* (pp. 222–265). New York: Oxford University Press.
- Zahn-Waxler, C., & Radke-Yarrow, M. (1990). The origins of empathic concern. *Motivation and emotion*, 14(2), 107–130.

Appendices

APPENDIX 1: MULTILEVEL MODEL OUTPUT

Linear mixed-effects model fit by REML

Data: ratings145.self.sad

AIC	BIC	logLik
72273.13	72430.08	-36114.57

Random effects:

Formula: ~0 + isMale + isFemale | couple_ID

Structure: General positive-definite, Log-Cholesky parametrization

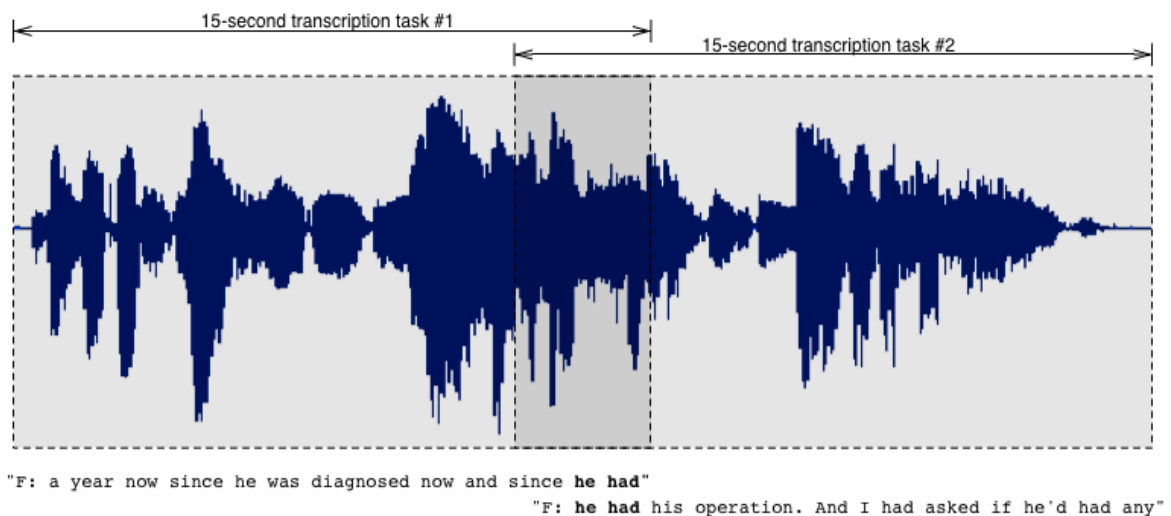
	StdDev	Corr
isMale	9.728567	isMale
isFemale	11.184542	0.134
Residual	11.598960	

Fixed effects: emotion ~ 0 + isMale + m.c.CoRumination * (m.c.time + m.c.time.squared) + m.p.c.CoRumination * (m.c.time + m.c.time.squared) + isFemale + f.c.CoRumination * (f.c.time + f.c.time.squared) + f.p.c.CoRumination * (f.c.time + f.c.time.squared)

	Value	Std.Error	DF	t-value	p-value
isMale	-16.467271	1.738661	9231	-9.471235	0.0000
m.c.CoRumination	0.708302	3.715313	9231	0.190644	0.8488
m.c.time	-0.091325	0.004068	9231	-22.448729	0.0000
m.c.time.squared	0.001810	0.000109	9231	16.657832	0.0000
m.p.c.CoRumination	-5.236598	3.552998	9231	-1.473853	0.1406
isFemale	-17.932778	1.993611	9231	-8.995122	0.0000
f.c.CoRumination	3.779497	4.073995	9231	0.927713	0.3536
f.c.time	-0.092005	0.004068	9231	-22.615868	0.0000
f.c.time.squared	0.001964	0.000109	9231	18.074826	0.0000
f.p.c.CoRumination	-3.051930	4.260111	9231	-0.716397	0.4738
m.c.CoRumination:m.c.time	-0.051728	0.008693	9231	-5.950393	0.0000
m.c.CoRumination:m.c.time.squared	-0.001163	0.000232	9231	-5.010197	0.0000
m.c.time:m.p.c.CoRumination	-0.019551	0.008313	9231	-2.351756	0.0187
m.c.time.squared:m.p.c.CoRumination	0.001562	0.000222	9231	7.035193	0.0000
f.c.CoRumination:f.c.time	0.038179	0.008313	9231	4.592467	0.0000
f.c.CoRumination:f.c.time.squared	0.001482	0.000222	9231	6.675281	0.0000
f.c.time:f.p.c.CoRumination	-0.037326	0.008693	9231	-4.293696	0.0000
f.c.time.squared:f.p.c.CoRumination	-0.000314	0.000232	9231	-1.351112	0.1767

APPENDIX 2: SPEECH-TO-TEXT TRANSCRIPTION

Because transcribing a full conversation is simply a repeated process of listening to a short segment of a conversation and writing it down, an entire transcription project can be broken down into a number of isolated tasks. In short, it does not matter who transcribes each part of the conversation as long as the entire conversation gets accurately transcribed. Thus, each individual transcription task can be worked on in parallel. With the aid of a simple computer script, audio from the recorded conversations were split into 15-second sound clips, yielding a total of 640 mp3-files. Because simple silence detection is not enough to guarantee that the end of the file does not abruptly cut off part of a word, the audio files were made to overlap each other by a few seconds. This way, it would be likely that every word from the conversation was contained in full in one or the other audio file, allowing the resulting transcripts to be pieced together accurately. A visual illustration of this overlap and the resulting transcript fragments is shown below.



In total, 600 HITs were uploaded onto MTurk (as I had already manually translated some of the conversations). Each HIT requested workers to transcribe 15 seconds of conversation (an example of the task view is provided below). Figure 30 shows how each HIT appeared to Mturk workers. In essence, if the worker chose to complete one of the HITs, the webpage for the task provided simple instructions on the transcript notation, an embedded MP3 player for listening the 15-second audio clip, and a text field for text input. The workers were also asked to estimate how confident they felt about their transcription accuracy. This was done to identify difficult-to-transcribe conversations for expert translation, but no conversation proved to be especially problematic. During the transcription project, 146 MTurk workers in total completed the HITs. The total work time was 47.92 hours with each HIT taking a little under four minutes.

Speech-to-text transcription

I recorded conversations between romantic couples as a part of a psychology experiment. Now the audio needs to be transcribed to text for analyses. Your help will be greatly appreciated!

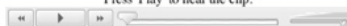
Instructions

1. Listen the conversation (with headphones, if possible).
2. Type in the conversation **exactly** as it unfolds.
3. Mark the speaker's gender by either "M:" or "F:" before his or her lines.
4. Please use **special codes** (see below) to indicate:
 - non-words (e.g., hmm, oh, uh)
 - filler words (e.g., rlike, rryouknow)
 - other sounds (e.g., [laugh], [sigh], [sneeze])
 - inaudible words (****)

Example transcript with explanation

M: [laugh]	<i>The male, who is first to speak, laughs.</i>
F: You were totally rlike drunk.	<i>Female speaks. She says a filler word "like."</i>
M: **** no... uh... I wasn't.	<i>Start of male's response is inaudible.</i>
F: That's not rryouknow cool [sigh]	<i>The female responds. "You know" is marked as filler word. She sighs in the end.</i>

Press 'Play' to hear the clip.



Type transcription below:

Special Codes

Non-words	If the expression has a common written form (e.g., "oh", "uh", "hmm"), use it. Example: <i>He is err, old uh I guess.</i>
Filler words	When words such as "like" and "you know" are used as fillers rather than parts of a sentence, write them as one word starting with "rr". Example: <i>I had, rryouknow, lunch. She was, rlike, 30 minutes late.</i>
Other sounds	Indicate sound-producing actions with brackets. Example: <i>[sob] oh no [sigh] you bastard</i>
Inaudible words	If you cannot hear/understand the words, mark these with ****. Example: <i>And then **** to me.</i>

The resulting transcript fragments consisted of the exact words spoken during the 15 seconds, as well as notation for the speaker's gender, nonwords (e.g., laughs), filler words, other sounds (e.g., ambient noises), and inaudible words. The resulting fragments were stitched together based on their order in the conversation and the overlapped words. Each transcript was then verified against the full video recording for accuracy.

APPENDIX 3: RSIENA OUTPUT FOR STUDY 3.1

Estimates, standard errors, convergence t-ratios, and effect p-values

	Estimate	Standard Error	Convergence t-ratio	p-value	
1. rate constant comms rate (period 1)	12.0040	(2.6714)	-0.0149	0.0000	***
2. rate constant comms rate (period 2)	8.5294	(1.3928)	-0.0317	0.0000	***
3. eval comms: outdegree (density)	-2.1334	(0.1625)	-0.0007	0.0000	***
4. eval comms: reciprocity	1.0144	(0.1704)	-0.0050	0.0000	***
5. eval comms: transitive triplets	0.1415	(0.0279)	-0.0285	0.0000	***
6. eval comms: friends	0.6406	(0.1988)	-0.0196	0.0013	**
7. eval comms: gender alter	-0.2216	(0.1726)	0.0179	0.1990	
8. eval comms: gender ego	-0.2093	(0.1707)	0.0126	0.2201	
9. eval comms: same gender	0.0818	(0.1589)	0.0273	0.6066	
10. eval comms: same team	0.9540	(0.1706)	-0.0255	0.0000	***
11. eval comms: negemo	-0.0944	(0.4887)	0.0108	0.8468	
12. eval comms: posemo	1.0492	(0.2697)	-0.0087	0.0001	***
13. eval Dummy2:comms ego	-0.7273	(0.2219)	0.0227	0.0010	**
14. eval int. Dummy2:comms ego x reciprocity	-0.9423	(0.3359)	-0.0031	0.0050	**
15. eval Dummy2:comms ego x transitive triplets	0.1689	(0.0531)	-0.0052	0.0015	**
16. eval int. comms: gender ego x Dummy2:comms ego	-0.6945	(0.2991)	0.0035	0.0202	*
17. rate constant negemo rate (period 1)	4.2195	(0.9888)	-0.0382	0.0000	***
18. rate constant negemo rate (period 2)	5.3326	(1.3845)	-0.0185	0.0001	***
19. eval negemo: outdegree (density)	-2.5352	(0.4640)	-0.0405	0.0000	***
20. eval negemo: reciprocity	0.2009	(0.3062)	-0.0872	0.5119	
21. eval negemo: transitive triplets	0.4232	(0.2040)	-0.0896	0.0380	*
22. eval negemo: friends	0.6844	(0.3035)	-0.0583	0.0241	*
23. eval negemo: gender alter	0.9756	(0.5126)	-0.0075	0.0570	+
24. eval negemo: gender ego	0.7984	(0.5642)	-0.0372	0.1571	
25. eval negemo: same gender	-0.2451	(0.5277)	-0.0617	0.6423	
26. eval negemo: same team	-0.0030	(0.2894)	-0.1111	0.9919	
27. eval negemo: comms	1.5253	(0.9986)	-0.0761	0.1266	
28. eval negemo: posemo	-0.1387	(0.9480)	-0.0858	0.8837	
29. eval Dummy2:negemo ego	0.1748	(0.2519)	-0.0251	0.4877	
30. eval int. Dummy2:negemo ego x reciprocity	-1.0889	(0.5990)	-0.0207	0.0691	+
31. rate constant posemo rate (period 1)	18.8818	(4.1326)	-0.0312	0.0000	***
32. rate constant posemo rate (period 2)	7.4420	(1.3024)	0.0696	0.0000	***
33. eval posemo: outdegree (density)	-2.2176	(0.2110)	0.0245	0.0000	***
34. eval posemo: reciprocity	0.4219	(0.1840)	0.0055	0.0218	*
35. eval posemo: transitive triplets	0.1524	(0.0286)	0.0343	0.0000	***
36. eval posemo: friends	0.6470	(0.1729)	-0.0394	0.0002	***
37. eval posemo: gender alter	-0.1099	(0.1697)	-0.0440	0.5172	
38. eval posemo: gender ego	-0.1809	(0.1758)	-0.0503	0.3034	
39. eval posemo: same gender	-0.0076	(0.1754)	0.0118	0.9653	
40. eval posemo: same team	0.2832	(0.1859)	-0.0045	0.1277	
41. eval posemo: comms	1.6185	(0.3504)	-0.0077	0.0000	***
42. eval posemo: negemo	0.0323	(0.4776)	-0.0624	0.9460	
43. eval Dummy2:posemo ego	-0.1519	(0.2287)	-0.0269	0.5066	
44. eval int. Dummy2:posemo ego x reciprocity	-0.6276	(0.3123)	-0.0228	0.0444	*
45. eval Dummy2:posemo ego x transitive triplets	0.1307	(0.0546)	-0.0169	0.0166	*

Total of 5331 iteration steps.

p-Val
Joint Significant Test 0.7022665

APPENDIX 4: RUMINATION SUBCOMPONENTS

<i>Item</i>	<i>“What do you generally do when you feel down, sad, or depressed?”</i>	<i>Factor</i>
1	...think about how alone you feel	Depression
2	...think “I won’t be able to do my job if I don’t snap out of this”	Depression
3	...think about your feelings of fatigue and achiness	Depression
4	...think about how hard it is to concentrate	Depression
5	...think “What am I doing to deserve this?”	Brooding
6	...think about how passive and unmotivated you feel.	Depression
7	...analyze recent events to try to understand why you are depressed	Reflection
8	...think about how you don’t seem to feel anything anymore	Depression
9	...think “Why can’t I get going?”	Depression
10	...think “Why do I always react this way?”	Brooding
11	...go away by yourself and think about why you feel this way	Reflection
12	...write down what you are thinking about and analyze it	Reflection
13	...think about a recent situation, wishing it had gone better	Brooding
14	...think “I won’t be able to concentrate if I keep feeling this way.”	Depression
15	...think “Why do I have problems other people don’t have?”	Brooding
16	...think “Why can’t I handle things better?”	Brooding
17	...think about how sad you feel.	Depression
18	...think about all your shortcomings, failings, faults, mistakes	Depression
19	...think about how you don’t feel up to doing anything	Depression
20	...analyze your personality to try to understand why you are depressed	Reflection
21	...go someplace alone to think about your feelings	Reflection
22	...think about how angry you are with yourself	Depression

Note. Items are from from Treynor, Gonzalez, & Nolen-Hoeksema, 2003.

APPENDIX 5: RSIENA OUTPUTS FOR STUDY 3.2

Baseline model

Estimates, standard errors, convergence t-ratios, and effect p-values

	Estimate	Standard Error	Convergence t-ratio	p-value	
Network Dynamics					
1. rate constant friends rate (period 1)	5.9629	(2.0852)	0.0442	0.0042	**
2. rate constant friends rate (period 2)	3.0332	(0.6322)	0.0338	0.0000	***
3. rate constant friends rate (period 3)	4.4004	(0.9669)	-0.0078	0.0000	***
4. eval friends: outdegree (density)	-2.7983	(0.2772)	-0.0012	0.0000	***
5. eval friends: reciprocity	1.6257	(0.3840)	0.0070	0.0000	***
6. eval friends: transitive triplets	0.5620	(0.2585)	0.0369	0.0297	*
7. eval friends: 3-cycles	-0.7742	(0.6293)	0.0226	0.2186	
8. eval friends: baseline	1.1999	(0.4529)	0.0144	0.0081	**
9. eval friends: same gender	0.3154	(0.1980)	-0.0262	0.1113	
10. eval friends: same course	0.5712	(0.1899)	-0.0098	0.0026	**
11. eval friends: work	2.3984	(0.7002)	0.0007	0.0006	***
12. eval Dummy3:friends ego	0.0000	(NA)	-0.0834	NA	
13. eval Dummy3:friends ego x transitive triplets	-0.3691	(0.2214)	-0.0469	0.0955	+
14. rate constant work rate (period 1)	6.8780	(3.5390)	-0.0359	0.0520	+
15. rate constant work rate (period 2)	2.0001	(0.4851)	-0.0440	0.0000	***
16. rate constant work rate (period 3)	3.3052	(0.9044)	-0.0066	0.0003	***
17. eval work: outdegree (density)	-3.2555	(0.3002)	0.0040	0.0000	***
18. eval work: reciprocity	2.0856	(0.4100)	-0.0150	0.0000	***
19. eval work: transitive triplets	0.8944	(0.2241)	-0.0085	0.0001	***
20. eval work: 3-cycles	-1.0253	(0.6519)	-0.0065	0.1158	
21. eval work: baseline	1.4413	(0.3975)	0.0122	0.0003	***
22. eval work: same gender	0.3662	(0.2355)	-0.0293	0.1200	
23. eval work: same course	1.1507	(0.2766)	0.0084	0.0000	***
24. eval Dummy3:work ego	0.0000	(NA)	0.2817	NA	
25. eval int. Dummy3:work ego x transitive triplets	-0.6174	(0.2597)	0.0101	0.0174	*
Behavior Dynamics					
26. rate <1> rate crq9 (period 1)	0.8626	(0.3125)	-0.0206	0.0058	**
27. rate <1> rate crq9 (period 2)	0.9936	(0.4331)	0.0408	0.0218	*
28. rate <1> rate crq9 (period 3)	0.3634	(0.1848)	-0.0282	0.0492	*
29. eval <1> behavior crq9 linear shape	-0.6913	(0.2910)	0.0342	0.0175	*
30. eval <1> behavior crq9 quadratic shape	-0.0417	(0.1612)	0.0966	0.7958	
31. rate <2> rate pos.mood (period 1)	4.2356	(1.5569)	0.0238	0.0065	**
32. rate <2> rate pos.mood (period 2)	6.9555	(15.2828)	-0.0158	0.6490	
33. rate <2> rate pos.mood (period 3)	2.9563	(1.1690)	-0.0043	0.0114	*
34. eval <2> behavior pos.mood linear shape	-0.0505	(0.0926)	0.0151	0.5853	
35. eval <2> behavior pos.mood quadratic shape	-0.2846	(0.0813)	-0.0246	0.0005	***
36. rate <3> rate neg.mood (period 1)	1.8556	(0.6820)	-0.0231	0.0065	**
37. rate <3> rate neg.mood (period 2)	4.2519	(1.6741)	-0.0162	0.0111	*
38. rate <3> rate neg.mood (period 3)	2.7822	(1.1068)	-0.0247	0.0119	*
39. eval <3> behavior neg.mood linear shape	0.0088	(0.1155)	-0.0068	0.9390	
40. eval <3> behavior neg.mood quadratic shape	-0.1198	(0.0541)	-0.0322	0.0267	*

Total of 4974 iteration steps.

p-Val

Joint Significant Test 0.5769265

Negative mood model

Estimates, standard errors, convergence t-ratios, and effect p-values

	Estimate	Standard Error	Convergence t-ratio	p-value	
Network Dynamics					
1. rate constant friends rate (period 1)	5.7047	(1.9279)	0.0222	0.0031	**
2. rate constant friends rate (period 2)	2.9641	(0.5280)	-0.0873	0.0000	***
3. rate constant friends rate (period 3)	4.3696	(0.8981)	-0.0162	0.0000	***
4. eval friends: outdegree (density)	-2.9004	(0.3009)	-0.0663	0.0000	***
5. eval friends: reciprocity	1.7300	(0.3468)	-0.0662	0.0000	***
6. eval friends: transitive triplets	0.5714	(0.1348)	-0.0857	0.0000	***
7. eval friends: 3-cycles	-0.8051	(0.3120)	-0.0665	0.0099	**
8. eval friends: baseline	1.3030	(0.4847)	-0.0344	0.0072	**
9. eval friends: same gender	0.3403	(0.1886)	-0.0518	0.0712	+
10. eval friends: same course	0.5931	(0.2153)	-0.0624	0.0059	**
11. eval friends: neg.mood ego	0.3270	(0.1543)	0.0001	0.0341	*
12. eval friends: work	2.4684	(0.5944)	-0.0965	0.0000	***
13. eval Dummy3:friends ego	0.0000	(NA)	0.3410	NA	***
14. eval Dummy3:friends ego x transitive triplets	-0.4784	(0.1802)	0.0172	0.0080	**
15. rate constant work rate (period 1)	6.9339	(3.0332)	0.0320	0.0223	*
16. rate constant work rate (period 2)	2.0292	(0.5812)	-0.0243	0.0005	***
17. rate constant work rate (period 3)	3.3083	(0.8349)	0.0169	0.0001	***
18. eval work: outdegree (density)	-3.2554	(0.3179)	0.0271	0.0000	***
19. eval work: reciprocity	2.0797	(0.3932)	0.0070	0.0000	***
20. eval work: transitive triplets	0.8919	(0.2137)	-0.0049	0.0000	***
21. eval work: 3-cycles	-1.0262	(0.5437)	-0.0006	0.0591	+
22. eval work: baseline	1.4333	(0.4096)	0.0286	0.0005	***
23. eval work: same gender	0.3704	(0.1918)	0.0594	0.0535	+
24. eval work: same course	1.1501	(0.2614)	0.0287	0.0000	***
25. eval Dummy3:work ego	0.0000	(NA)	0.2290	NA	***
26. eval int. Dummy3:work ego x transitive triplets	-0.6217	(0.2572)	-0.0229	0.0156	*
Behavior Dynamics					
27. rate <1> rate crq9 (period 1)	0.8475	(0.3162)	-0.0020	0.0074	**
28. rate <1> rate crq9 (period 2)	0.9695	(0.3402)	-0.1090	0.0044	**
29. rate <1> rate crq9 (period 3)	0.3559	(0.1684)	-0.0713	0.0345	*
30. eval <1> behavior crq9 linear shape	-0.7033	(0.3002)	-0.0223	0.0191	*
31. eval <1> behavior crq9 quadratic shape	-0.0478	(0.1712)	0.0034	0.7803	
32. rate <2> rate pos.mood (period 1)	4.2331	(2.3537)	0.0564	0.0721	+
33. rate <2> rate pos.mood (period 2)	6.8961	(7.8713)	-0.0582	0.3810	
34. rate <2> rate pos.mood (period 3)	2.9561	(1.3831)	0.0087	0.0326	*
35. eval <2> behavior pos.mood linear shape	-0.0527	(0.1051)	0.0332	0.6162	
36. eval <2> behavior pos.mood quadratic shape	-0.2853	(0.0726)	-0.0648	0.0001	***
37. rate <3> rate neg.mood (period 1)	1.8800	(0.6345)	0.0552	0.0030	**
38. rate <3> rate neg.mood (period 2)	4.2356	(2.7151)	0.0152	0.1188	
39. rate <3> rate neg.mood (period 3)	2.7935	(1.1907)	-0.0077	0.0190	*
40. eval <3> behavior neg.mood linear shape	0.0117	(0.1087)	0.0661	0.9140	
41. eval <3> behavior neg.mood quadratic shape	-0.1173	(0.0534)	0.0113	0.0279	*

Total of 5030 iteration steps.

p-Val
Joint Significant Test 0.164811

Brooding model

Estimates, standard errors, convergence t-ratios, and effect p-values

	Estimate	Standard Error	Convergence t-ratio	p-value	
Network Dynamics					
1. rate constant friends rate (period 1)	5.6705	(1.8676)	-0.0298	0.0024	**
2. rate constant friends rate (period 2)	2.9489	(1.0394)	0.0178	0.0046	**
3. rate constant friends rate (period 3)	4.3844	(0.9795)	0.0943	0.0000	***
4. eval friends: outdegree (density)	-2.9070	(0.3480)	-0.0196	0.0000	***
5. eval friends: reciprocity	1.7415	(0.4269)	-0.0100	0.0000	***
6. eval friends: transitive triplets	0.5744	(0.1743)	0.0030	0.0010	**
7. eval friends: 3-cycles	-0.8023	(0.3521)	-0.0083	0.0227	*
8. eval friends: baseline	1.3072	(0.5578)	-0.0432	0.0191	*
9. eval friends: same gender	0.3407	(0.1971)	-0.0142	0.0839	+
10. eval friends: same course	0.5874	(0.2566)	-0.0174	0.0221	*
11. eval friends: neg.mood ego	0.3427	(0.2023)	0.0955	0.0902	+
12. eval friends: work	2.5134	(0.8221)	-0.0646	0.0022	**
13. eval Dummy3:friends ego	0.0000	(NA)	0.3303	NA	
14. eval Dummy3:friends ego x transitive triplets	-0.4827	(0.2377)	-0.0039	0.0423	*
15. rate constant work rate (period 1)	6.9447	(4.1985)	-0.0086	0.0981	+
16. rate constant work rate (period 2)	2.0225	(0.6595)	0.0426	0.0022	**
17. rate constant work rate (period 3)	3.3168	(0.7306)	0.0461	0.0000	***
18. eval work: outdegree (density)	-3.2576	(0.3115)	-0.0124	0.0000	***
19. eval work: reciprocity	2.0831	(0.5440)	-0.0469	0.0001	***
20. eval work: transitive triplets	0.8895	(0.2306)	0.0227	0.0001	***
21. eval work: 3-cycles	-1.0234	(0.5227)	-0.0096	0.0502	+
22. eval work: baseline	1.4330	(0.4340)	-0.0461	0.0010	**
23. eval work: same gender	0.3713	(0.1916)	0.0141	0.0526	+
24. eval work: same course	1.1493	(0.2826)	0.0170	0.0000	***
25. eval Dummy3:work ego	0.0000	(NA)	0.2720	NA	
26. eval int. Dummy3:work ego x transitive triplets	-0.6074	(0.3055)	0.0206	0.0468	*
Behavior Dynamics					
27. rate <1> rate crq9 (period 1)	0.8668	(0.3289)	-0.0062	0.0084	**
28. rate <1> rate crq9 (period 2)	0.9918	(0.4059)	0.0223	0.0145	*
29. rate <1> rate crq9 (period 3)	0.3586	(0.1703)	0.0147	0.0352	*
30. eval <1> behavior crq9 linear shape	-0.6967	(0.3210)	-0.0615	0.0300	*
31. eval <1> behavior crq9 quadratic shape	-0.0402	(0.2118)	0.0144	0.8494	
32. rate <2> rate pos.mood (period 1)	4.2022	(2.1051)	0.0060	0.0459	*
33. rate <2> rate pos.mood (period 2)	7.0193	(11.9570)	0.0562	0.5572	
34. rate <2> rate pos.mood (period 3)	3.0071	(1.2987)	0.0345	0.0206	*
35. eval <2> behavior pos.mood linear shape	-0.0500	(0.1102)	0.0376	0.6498	
36. eval <2> behavior pos.mood quadratic shape	-0.2821	(0.0666)	-0.0305	0.0000	***
37. rate <3> rate neg.mood (period 1)	2.0246	(0.7601)	-0.0288	0.0077	**
38. rate <3> rate neg.mood (period 2)	6.0210	(4.0099)	0.0228	0.1332	
39. rate <3> rate neg.mood (period 3)	2.8930	(1.4966)	0.0116	0.0532	+
40. eval <3> behavior neg.mood linear shape	-0.0213	(0.0986)	-0.0425	0.8292	
41. eval <3> behavior neg.mood quadratic shape	-0.1681	(0.0556)	-0.0177	0.0025	**
42. eval <3> behavior neg.mood: effect from brooding	0.3982	(0.1838)	0.0088	0.0303	*

Total of 5207 iteration steps.

p-Val
Joint Significant Test 0.1094838

Co-rumination model

Estimates, standard errors, convergence t-ratios, and effect p-values

	Estimate	Standard Error	Convergence t-ratio	p-value	
Network Dynamics					
1. rate constant friends rate (period 1)	6.0634	(1.8522)	0.0195	0.0011	**
2. rate constant friends rate (period 2)	2.9791	(0.8337)	-0.0244	0.0004	***
3. rate constant friends rate (period 3)	4.2708	(0.8592)	0.0515	0.0000	***
4. eval friends: outdegree (density)	-3.0723	(0.3468)	-0.0378	0.0000	***
5. eval friends: reciprocity	1.8094	(0.3601)	-0.0600	0.0000	***
6. eval friends: transitive triplets	0.5408	(0.1654)	-0.0327	0.0011	**
7. eval friends: 3-cycles	-0.7115	(0.3286)	-0.0674	0.0304	*
8. eval friends: baseline	1.4101	(0.4930)	-0.0372	0.0042	**
9. eval friends: same gender	0.3837	(0.1988)	-0.0240	0.0536	+
10. eval friends: same course	0.5859	(0.2178)	-0.0208	0.0071	**
11. eval friends: crq9 alter	-0.3897	(0.1455)	0.0720	0.0074	**
12. eval friends: neg.mood ego	0.3202	(0.2292)	-0.0234	0.1624	
13. eval friends: work	2.5831	(0.7841)	0.0135	0.0010	**
14. eval Dummy3:friends ego	0.0000	(NA)	0.3655	NA	
15. eval Dummy3:friends ego x transitive triplets	-0.5016	(0.2337)	0.0037	0.0319	*
16. rate constant work rate (period 1)	6.8577	(3.1969)	-0.0400	0.0319	*
17. rate constant work rate (period 2)	2.0215	(0.4378)	0.0186	0.0000	***
18. rate constant work rate (period 3)	3.3094	(0.8048)	0.0385	0.0000	***
19. eval work: outdegree (density)	-3.2490	(0.3556)	0.0072	0.0000	***
20. eval work: reciprocity	2.0860	(0.4675)	0.0120	0.0000	***
21. eval work: transitive triplets	0.8911	(0.2227)	-0.0249	0.0001	***
22. eval work: 3-cycles	-1.0305	(0.6050)	-0.0039	0.0885	+
23. eval work: baseline	1.4251	(0.4221)	-0.0690	0.0007	***
24. eval work: same gender	0.3630	(0.1897)	-0.0030	0.0557	+
25. eval work: same course	1.1511	(0.2833)	0.0043	0.0000	***
26. eval Dummy3:work ego	0.0000	(NA)	0.2564	NA	
27. eval int. Dummy3:work ego x transitive triplets	-0.6118	(0.2262)	0.0006	0.0068	**
Behavior Dynamics					
28. rate <1> rate crq9 (period 1)	0.8549	(0.3005)	-0.0359	0.0044	**
29. rate <1> rate crq9 (period 2)	0.9652	(0.4046)	-0.0569	0.0170	*
30. rate <1> rate crq9 (period 3)	0.3613	(0.1677)	-0.0059	0.0312	*
31. eval <1> behavior crq9 linear shape	-0.7053	(0.2844)	0.0223	0.0132	*
32. eval <1> behavior crq9 quadratic shape	-0.0458	(0.1708)	-0.0311	0.7885	
33. rate <2> rate pos.mood (period 1)	4.2574	(2.1583)	0.0623	0.0485	*
34. rate <2> rate pos.mood (period 2)	7.1156	(11.5843)	0.0864	0.5391	
35. rate <2> rate pos.mood (period 3)	3.0457	(1.0709)	0.0114	0.0045	**
36. eval <2> behavior pos.mood linear shape	-0.0537	(0.1192)	-0.0439	0.6523	
37. eval <2> behavior pos.mood quadratic shape	-0.2817	(0.0725)	0.0064	0.0001	***
38. rate <3> rate neg.mood (period 1)	2.0039	(0.7522)	-0.0191	0.0077	**
39. rate <3> rate neg.mood (period 2)	6.0146	(5.2071)	-0.0057	0.2481	
40. rate <3> rate neg.mood (period 3)	2.9501	(1.1574)	0.0556	0.0108	*
41. eval <3> behavior neg.mood linear shape	-0.0176	(0.1141)	-0.0021	0.8775	
42. eval <3> behavior neg.mood quadratic shape	-0.1674	(0.0597)	0.0585	0.0050	**
43. eval <3> behavior neg.mood: effect from brooding	0.3943	(0.1911)	-0.0020	0.0391	*

Total of 5187 iteration steps.

p-Val
Joint Significant Test 0.1648481