

The Coevolution of Network Ties and Perceptions of Team Psychological Safety

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Which comes first—team social networks or emergent team states (e.g., team climate)? We argue that team members' social network ties and team members' climate perceptions coevolve over time as a function of six reciprocal and co-occurring processes. We test our conceptual framework in a 10-month longitudinal study of perceptions of team psychological safety and social network ties in 69 work teams and find considerable support for our hypotheses. Our main results suggest that perceptions of psychological safety predict network ties. The more psychologically safe team members perceive their team to be, the more likely they are to ask their teammates for advice and to see them as friends, and the less likely they are to report difficult relationships with them. At the same time, network ties predict psychological safety. Team members adopt their friends' and advisors' perceptions of the team's psychological safety and reject the perceptions of those with whom they report a difficult relationship. Our framework and findings suggest that conceptual models and tests of unidirectional or team-level effects are likely to substantially misrepresent the mechanisms by which network ties and emergent team states coevolve.

Key words: group processes and performance; psychological processes; network analysis; longitudinal research design; group structure

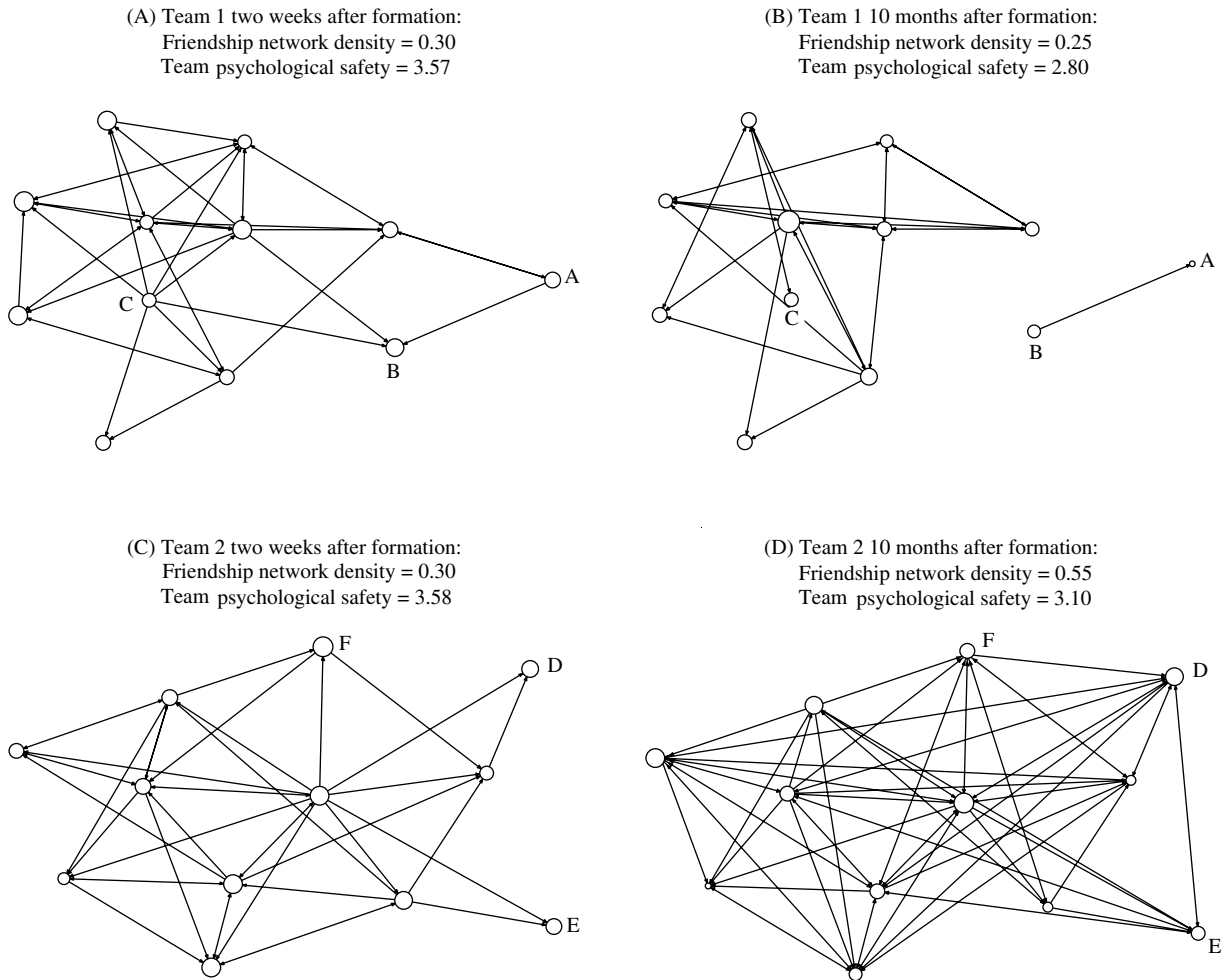
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Over the past decade, as the use of teams in organizations has proliferated, so too has the study of work team effectiveness (for a review, see Kozlowski and Ilgen 2006, Mathieu et al. 2008). Many team researchers have adopted a psychological orientation, emphasizing the role that *emergent team states* (Mathieu et al. 2008, Marks et al. 2001)—team members' shared perceptual, cognitive, emotional, or affective states—play in explaining team processes and outcomes. Research in this stream suggests, for example, that team members' perceptions of their team's cohesiveness (e.g., Gully 2000), climate (e.g., Zohar and Tenne-Gazit 2008), psychological safety (e.g., Edmondson 1999), and distribution of expertise (e.g., Moreland 1999) predict important team processes and outcomes. Other researchers have adopted a sociological orientation, documenting the effects on team outcomes of team social networks—the webs of interpersonal connections among the members of a team (Brass 1984). Research in this stream suggests that dense friendship and advice networks within a team enhance team effectiveness and viability (for a review, see Balkundi and Harrison 2006).

To date, researchers have devoted greater attention to the *consequences* of emergent team states and team social networks than to their *antecedents* (Borgatti and Foster 2003, Kozlowski and Ilgen 2006). Addressing this

gap in the research literature, we draw on prior theory (e.g., Mathieu et al. 2008, Marks et al. 2001) to argue that emergent team states and team social networks are each a key antecedent of the other; the two are mutually influential and coevolve over time. Team members' perceptions of their team thus both reflect *and* shape the extent to which team members turn to one another for advice, help, and support, or avoid one another fearing a conflict-laden or difficult exchange (e.g., Dean and Brass 1985, Ibarra and Andrews 1993, Labianca et al. 1998, Umphress et al. 2003).

That team members' perceptions of their team and team members' social network ties are likely to coevolve is, with a moment's reflection, intuitively obvious. More puzzling is *how*. Consider, for example, the two teams—real teams from our data—shown in Figure 1. Soon after their inception, the two teams were similarly low in friendship network density and team psychological safety, the emergent team state on which we focus. And yet, several months later, the two teams exhibited markedly different levels of psychological safety and friendship network density. To influence a team's trajectory toward greater psychological safety and network density, we must gain greater insight into the ways in which team members' network ties and perceptions coevolve over time.

Figure 1 Examples of Different Coevolution Patterns of Team Members' Perceptions and Network Ties

Notes. The graph displays two teams two weeks after their formation (A and C) and immediately prior to disbanding, 10 months after their formation (B and D). The nodes represent all team members. The size of the nodes represents their individual perceptions of team psychological safety, with larger circles indicating a more positive perception of team psychological safety. Ties are directed friendship ties. Psychological safety is measured on a scale of 1 to 5, with 1 being very low and 5 being very high.

Toward this end, we formulate and test a framework designed to illuminate the processes by which team members' perceptions of their team and team members' social network ties coevolve. At the heart of our framework are six sociopsychological mechanisms—three that describe how individuals' perceptions of the team affect their network ties and three that describe how individuals' network ties affect their perceptions of the team. Using data regarding (a) team members' advice, friendship, and difficulty ties and (b) team members' perceptions of their team's psychological safety collected at three points over the 10-month life of 69 work teams, we test each mechanism we hypothesize. We focus on psychological safety—"a shared belief held by members of a team that the team is safe for interpersonal risk taking" (Edmondson 1999, p. 350)—as both an exemplar of an emergent team state and a phenomenon of interest in its own right given accumulating evidence of its

import for team learning and effectiveness (Edmondson 1999, Tucker et al. 2007).

Integrating sociological and psychological perspectives on team development, our conceptual framework and findings make four key contributions to the literature. First, our framework and findings challenge prior conceptual models and studies that suggest one-way effects (e.g. Pastor et al. 2002) of team networks on emergent team states (or vice versa) and that gloss over the individual-level mechanisms linking social network ties and perceptions of the team (e.g., Zohar and Tenne-Gazit 2008). Such models and studies may substantially misrepresent the mechanisms by which team networks and emergent team states coevolve. Second, our framework and findings shed new light on the meaning and mechanisms of "emergence"—a term widely used within the team literature to suggest that team-level properties originate in and arise from individual team members' behaviors, perceptions, attitudes, and affect (e.g.,

Poole 1999, Kozlowski and Klein 2000, Edmondson and Mogelof 2005), but is rarely specified or studied with precision. Third, our framework and findings offer new insights regarding the antecedents of both team psychological safety and interpersonal ties¹ within teams. Whereas prior research (e.g., Edmondson 1999, Detert and Burris 2007) has documented team-level antecedents of psychological safety, such as the behavior of the team leader, our findings suggest ways in which *individual* team members' network ties may shape the level and dispersion of psychological safety that ultimately emerges within a team. Furthermore, whereas prior research has documented the influence of team members' enduring demographic and personality traits on their network ties (e.g., Klein et al. 2004, Mehra et al. 2001), our framework and findings highlight the potential influence of team members' perceptions of the team on the network ties that they send and receive. And finally, our framework and findings yield practical suggestions regarding the ways in which team managers, leaders, and members may intervene to influence the level of psychological safety and the density of social networks that emerge within a team.

Theory and Hypotheses

Team Psychological Safety

Team psychological safety is an emergent team state—a “climate-like shared perception” (Kozlowski and Ilgen 2006, p. 86). When a team is psychologically safe, team members expect that their teammates will treat them with respect and acceptance; they will not be embarrassed or punished by their peers if they express their views or display weaknesses. Psychological safety has two beneficial effects. First, it allows self-expression and personal engagement (Kahn 1990, Brown and Leigh 1996, May et al. 2004). Individuals who feel psychologically safe are more likely to bring their personal voice, creativity, feelings, and self-concepts into their work roles (Kahn 1990). Second, psychological safety promotes learning, which in turn enhances team effectiveness (Edmondson 1999, Nembhard and Edmondson 2006, Tucker et al. 2007). Recent research has documented the consequences of team psychological safety (Baer and Frese 2003, Nembhard and Edmondson 2006) and begun to identify key team-level antecedents (Detert and Burris 2007, Nembhard and Edmondson 2006). However, the dynamic mechanisms through which individuals' perceptions of their team's psychological safety develop and influence team members' interactions have received little attention in theory or research.

Team Social Networks

Team social networks describe the patterned and repeated interactions among team members that determine the flow of resources among teammates (Ibarra and

Andrews 1993). Network researchers have commonly focused on two archetypes of network resources or content. *Instrumental* ties are channels of work-related advice and information relevant to task completion (Nebus 2006). *Expressive* ties are affect-laden ties that may be positive or negative (Lincoln and Miller 1979, Krackhardt 1992, Labianca et al. 1998). In this study, we consider instrumental ties (advice) and both positive (friendship) and negative (difficulty) expressive ties. Advice ties provide a means for individuals to leverage their teammates' experiences and expertise, enhancing individual and team performance (Balkundi and Harrison 2006). Advice ties tend to be cognition based, nonreciprocal, and relatively short lived (Umphress et al. 2003, Nebus 2006). Friendship ties are based on liking and affection for another person and serve as conduits for social and emotional support as well as entertainment (Krackhardt 1992, Lincoln and Miller 1979, Fehr 2004). They tend to be affect based, reciprocal, and more enduring than advice ties (Umphress et al. 2003). Finally, difficulty ties reflect reoccurring feelings of discomfort or disapproval of another person. Difficulty ties are not simply the opposite of positive ties; they may exist even in the presence of positive ties. Negative ties are, however, typically less common than are positive ties, although they may well have greater salience and greater impact on individual and organizational outcomes than do positive ties (Labianca et al. 1998, Labianca and Brass 2006).

Toward a Conceptualization of the Coevolution of Team Members' Perceptions and Network Ties

Our conceptual framework describing the coevolution of team members' perceptions and network ties rests on three foundational assumptions within the team and social network literatures. The first is that emergent team states and team social networks originate in and emerge from individual team members' behaviors, perceptions, attitudes, and affect (Kozlowski and Klein 2000, Contractor et al. 2006, Casciaro and Lobo 2008). Individuals' interpersonal ties and perceptions of psychological safety are the building blocks of team networks and team psychological safety; in the absence of the former, the latter cannot exist. Moreover, changes in a team's psychological safety and in the density of its networks occur as a function of the changing perceptions and behaviors of *individual* team members, not the team as a uniform whole. The second foundational assumption is that individuals' network ties are directional (e.g., Brass and Burkhardt 1993, Wasserman and Faust 1994). Individual A may “send” a network tie to Individual B (extending his or her friendship *to* B or directing a request for advice *to* B), and/or Individual A may “receive” a network tie from Individual B (receiving overtures of friendship *from* B or being asked for advice *from* B). We thus distinguish the antecedents and

consequences of ties *sent* from the antecedents and consequences of ties *received*. Finally, the third foundational assumption is that team emergent states and team social networks are not static. Rather, over the life of a team, network ties may develop or fray (Wellman et al. 1997), and positive perceptions of the team may grow or diminish (Edmondson and Mogelof 2005).

Six Mechanisms: Reciprocal Influences Between Perceptions of the Team and Network Ties. Because our conceptual framework may well apply not just to team psychological safety and friendship, advice, and difficulty ties but also to other emergent team states and team networks, we first provide a brief description of the six mechanisms in relatively generic terms. We then elaborate, presenting specific hypotheses regarding the role of the six mechanisms in explaining the coevolution of perceptions of psychological safety and of friendship, advice, and difficulty ties, respectively.

As shown in the left column of Table 1, our framework suggests that individuals' perceptions of their team may influence the social network ties they send or receive in three ways. The mechanism that we call *prospective action* suggests that an individual's perceptions of what the team is like may influence the ties that he or she sends to other team members. The more positive an individual's perceptions and expectations of the team, the more likely he or she is to take constructive action, sending positive ties to his or her teammates in anticipation of their positive response to his or her overtures (Nebus 2006, Vroom 1995). The less positive an individual's perceptions of the team, the more likely he or she is to withdraw from social interaction, limiting the positive ties he or she sends and forming negative ties with teammates instead. The mechanism *attraction* links an individual's perceptions to the ties that others send him or her. Through this mechanism, an individual who holds positive perceptions of the team may attract others' expressions of affection or inquiry. For example, individuals who perceive their team's task to be highly important may attract their teammates' requests for advice, assistance, or leadership. Finally, the mechanism *homophily* describes the familiar argument that individuals form ties with similar others (for a review, see Huston and Levinger 1978, McPherson et al. 2001). Here, an individual reaches out to teammates who hold similar perceptions of the team. The similarity mechanism may also operate inversely, however; that is, individuals may form negative or difficulty ties with teammates who hold *dissimilar* perceptions of the team.

As outlined in the right column of Table 1, social network ties may also shape, in three ways, the perceptions that individuals develop regarding their teams. Through the mechanism that we have labeled *retrospective sensemaking*, the social network ties that individuals

Table 1 A Conceptual Framework of the Sociopsychological Mechanisms That Link Team Perceptions and Network Ties

	Perceptions of the team influence network ties	Network ties influence perceptions of the team
Sender	Prospective action (My perceptions of the team influence the ties I send)	Retrospective sensemaking (The ties that I send influence my perceptions of the team)
Receiver	Attraction (My perceptions of the team influence the ties that others send to me)	Reaction (The ties that others send to me influence my perceptions of the team)
Sender-receiver similarity	Homophily (I send ties to others whose perceptions of the team are similar to mine)	Assimilation (My perceptions of the team become similar to those to whom I send ties)

send may influence their subsequent perceptions of the team. As Weick et al. (2005, p. 419) observed, "action is always just a tiny bit ahead of cognition, meaning that we act our way into belated understanding"; that is, individuals reflect not only on others' behaviors but also on their own behavior to draw inferences, craft rationalizations, and make sense of their social environment (Salancik and Pfeffer 1978, Weick et al. 2005). Accordingly, an individual may infer from his or her own behavior toward teammates—that is, from the ties that he or she has sent—what the team is like, explaining and justifying his or her own prior behavior by the climate he or she subsequently ascribes to the team. Through the mechanism *reaction*, the social network ties that an individual receives may influence the individual's subsequent perceptions of the team. Others' requests for work-related advice, for example, may shape the recipient's perceptions of the team social environment. Thus, an individual may infer from others' behaviors toward him or her what the team is like. Finally, we use the term *assimilation* to describe the informational and normative processes whereby individuals come to adopt the perceptions of trusted others—those to whom they send positive ties—and to reject the perceptions of those whom they find difficult (Cialdini et al. 1991, Monge and Contractor 2003). Here, what changes a focal individual's perceptions is not the *number* of ties he or she has sent to others (retrospective sensemaking) or received from others (reaction) but the *perceptions* of those to whom the individual has sent network ties.

In the section that follows, we use this framework to develop hypotheses regarding the dynamic coevolution of individuals' perceptions of team psychological safety and their friendship, advice, and difficulty network ties. We hypothesize that the key mechanisms at play differ as a function of network type; all six mechanisms are

not equally relevant or likely for each of the three network types. Accordingly, we discuss each network in turn, first describing the coevolution of perceptions of psychological safety and of friendship ties.

Friendship Ties and Perceptions of Psychological Safety

Prospective Action. Individuals who perceive that their team is psychologically safe expect that they will not be rejected by others and that they are valued for their talents and skills (Edmondson 1999). These expectations create conditions in which people can disclose what they think and feel and engage cognitively and emotionally in building positive interpersonal relationships (Kahn 1990). Self-disclosure to others engenders positive emotions that become associated with the recipient and lead to an increased liking of the recipient (for a meta-analysis, see Collins and Miller 1994). We thus hypothesize the following.

HYPOTHESIS 1A (H1A). *The more psychologically safe a person perceives his or her team to be, the more friendship ties the person will subsequently send to other team members (friendship prospective action).*

Retrospective Sensemaking. If a person has extended ties of friendship to many of his or her teammates, he or she is likely to infer from his or her own behavior that the team is psychologically safe. Consistent with this line of reasoning, Edmondson (1996) found that hospital employees' perceptions of the quality of interpersonal relationships in their units were negatively related to employees' shared belief that mistakes would be held against them. Similarly, May et al. (2004) showed a positive relationship between employees' perceptions of how rewarding their coworker relations were and their perceptions of psychological safety. We thus hypothesize the following.

HYPOTHESIS 1B (H1B). *The more friendship ties a person sends, the more psychologically safe he or she will subsequently perceive the team to be (friendship retrospective sensemaking).*

Reaction. Perceptions of psychological safety are likely to be a function of friendship ties not only sent but also received. Research on affectionate communication has shown that not only expressing but also receiving positive affection has positive effects on a person's physical and psychological well-being (for a review, see Floyd 2006). A person who receives expressions of friendship from many teammates will feel accepted and appreciated by his or her teammates and thus will have a more positive perception of the team's psychological safety than a person who receives expressions of friendship from fewer teammates.

HYPOTHESIS 1C (H1C). *The more friendship ties a person receives, the more psychologically safe he or she will subsequently perceive the team to be (friendship reaction).*

Homophily. Sociological research on homophily, like psychological research on similarity attraction, demonstrates that people like and are attracted to those who hold similar attitudes, opinions and beliefs. An individual who perceives that his or her teammates view the team in the same way that he or she does experiences reduced feelings of aloneness and cognitive dissonance (Festinger 1957) and enhanced positive affect (Bryne 1971). These feelings encourage the individual to reach out in friendship to his or her similar teammates. Thus,

HYPOTHESIS 1D (H1D). *Over time, a person will send more friendship ties to team members who hold similar perceptions of the team's psychological safety than to those who hold dissimilar perceptions of the team's psychological safety (friendship homophily).*

Assimilation. Theories of social information processing and social comparison suggest that people rely on salient others to reduce ambiguity in interpreting social situations (Festinger 1954, Salancik and Pfeffer 1978). Friends are particularly credible sources of norm-related information because of the mutual trust and positive affect that characterizes most friendship relationships (Shah 1998, Gibbons 2004). Furthermore, people want to be similar to their friends and may adjust their perceptions, attitudes, and behaviors accordingly (Krackhardt 1992). Thus, an individual's perceptions of the team's psychological safety are likely to grow increasingly similar to the perceptions of those to whom the individual sends friendship ties. Note that we focus here on the influence of ties sent, not received. Our logic is that if an individual *thinks* that a teammate is a friend (sending a friendship tie), then the individual will find the teammate's perceptions and attitudes of interest and influence whether or not the teammate considers the focal individual a friend (receiving a tie). Thus,

HYPOTHESIS 1E (H1E). *Over time, a person's perception of the team's psychological safety will grow more similar to the perceptions of those to whom he or she sends friendship ties than to the perceptions of those to whom he or she does not send friendship ties (friendship assimilation).*

We do not hypothesize that individuals who find the team psychologically safe attract more friendship ties than those who find the team less psychologically safe (friendship attraction). Although similar perceptions of the team's psychological safety may inspire friendship ties, an individual's positive perception of the team's psychological safety seems unlikely, in and of itself, to be so appealing as to foster others' attraction.

Advice Ties and Perceptions of Psychological Safety

Prospective Action. People who rely on others' help may feel vulnerable, fearing that they have revealed their own ignorance or uncertainty, and may feel rejected or ridiculed as a result (Dewhirst 1971). Perceptions of psychological safety can assuage these concerns, strengthening trust and the perception that it is safe and acceptable to ask others for advice (Nebus 2006). We thus hypothesize the following.

HYPOTHESIS 2A (H2A). *The more psychologically safe a person perceives the team to be, the more advice ties the person will subsequently send to other team members (advice prospective action).*

Retrospective Sensemaking. Reflecting on his or her many requests for advice from teammates, an individual may conclude that the costs of advice seeking are bearable, that is, that the team as a whole is trustworthy and psychologically safe. Conversely, an individual who seeks advice from few teammates may attribute his or her hesitancy to seek others' advice to the team's low psychological safety. We thus hypothesize the following.

HYPOTHESIS 2B (H2B). *The more advice ties a person sends, the more psychologically safe he or she will subsequently perceive the team to be (advice retrospective sensemaking).*

Reaction. Team members may change their perceptions of the team's psychological safety not only as a function of the advice ties they send but also as a function of the advice ties they receive. The number of people who ask a person for advice is indicative of that person's position, status, and acceptance within the group (Krackhardt 1990, Brass 1984, Neubert and Taggar 2004). People in favorable network positions attribute more positive characteristics to their work environment than do people in less favorable positions. For example, Ibarra and Andrews (1993) found that professionals in an advertising company had higher perceptions of organizational conditions (including encouragement of risk taking) when they were high rather than low in advice centrality. Thus,

HYPOTHESIS 2C (H2C). *The more advice ties a person receives, the more psychologically safe he or she will subsequently perceive the team to be (advice reaction).*

Assimilation. Because of their perceived expertise, power, and status, advice givers are credible sources of information regarding work matters and the team's climate (Nebus 2006). Advice givers' behaviors and comments provide normative cues regarding what is and is not appropriate behavior in the team. Thus,

HYPOTHESIS 2D (H2D). *Over time, a person's perceptions of the team's psychological safety will grow more similar to the perceptions of those to whom he or she sends advice ties than to those to whom he or she does not send advice ties (advice assimilation).*

We do not expect that team members are particularly likely to seek advice from teammates who hold similar perceptions of the team's psychological safety (homophily), nor do we expect that individuals who feel psychologically safe are particularly likely to receive advice ties (attraction). Individuals are more likely to turn for advice to expert and experienced others (e.g., Lin 1982, Ibarra and Andrews 1993, Klein et al. 2004) than to those whose perceptions of the team's psychological safety are similar to their own or simply generally high.

Difficulty Ties and Perceptions of Psychological Safety

Prospective Action. Team members who find their team psychologically unsafe anticipate the occurrence of unpleasant or rejecting interactions with other teammates. They are thus likely to watch for and focus on negative behaviors by their teammates (Fiske and Taylor 1991); that is, people who perceive their team as low in psychological safety are particularly sensitive to negative interactions with others. Accordingly,

HYPOTHESIS 3A (H3A). *The less psychologically safe a person perceives the team to be, the more difficulty ties the person will subsequently send to other team members (difficulty prospective action).*

Retrospective Sensemaking. At the same time, individuals who find their relationships with other teammates difficult are likely to infer that their team is unsafe for interpersonal risk taking. Indeed, according to attribution theory (Kelley 1973), individuals who find many of their teammates difficult may be eager to blame the team, not themselves, for their discomfort with or disdain for other teammates. Thus,

HYPOTHESIS 3B (H3B). *The more difficulty ties a person sends, the less psychologically safe he or she will subsequently perceive the team to be (difficulty retrospective sensemaking).*

Because the overt display of negative affect toward another person is typically inappropriate in a work team, a person may be unaware that he or she is the recipient of difficulty ties. Accordingly, we offer no *reaction* hypothesis in the case of difficulty ties. Furthermore, because difficulty ties are rarer than other types of relationships (Labiancia and Brass 2006), we suspect that individuals who perceive the team to be low in psychological safety are unlikely to *attract* difficulty ties; individuals are unlikely to send difficulty ties to a teammate if he or she is simply reserved or cautious within the team.

Table 2 summarizes our hypotheses and previews our findings.

Table 2 Summary of Study Hypotheses and Results

	Perceptions of the team influence network ties	Network ties influence perceptions of the team
Sender	Prospective action Friendship (H1A) ⁺ Advice (H2A) ⁺ Difficulty (H3A) [−]	Retrospective sensemaking Friendship (H1B) ^{ns} Advice (H2B) ^{ns} Difficulty (H3B) [−]
Receiver	Attraction	Reaction Friendship (H1C) ^{ns} Advice (H2C) ⁺
Sender–receiver similarity	Homophily Friendship (H1D) ⁺	Assimilation Friendship (H1E) ⁺ Advice (H2D) ⁺ Difficulty (not hypothesized) [−]

+, a significant positive relationship; −, a significant negative relationship; ns, a hypothesized but nonsignificant relationship.

Methods

Sample and Procedures

We collected survey data from a full-time, team-based, residential, federally funded and managed national service program in the United States. (By “national service,” we mean nonmilitary service designed to improve communities.) Members of the program were randomly assigned to teams of 9 to 12 people. All teams were of roughly comparable gender and racial diversity, and each team was headed by a formal team leader. Team members worked together over a 10-month period, performing community improvement projects in cooperation with state and local agencies, nonprofit organizations, and other community organizations such as schools, churches, and national parks. Service projects included tutoring school children, constructing or renovating low-income housing, responding to natural disasters, and working to clean up, enhance, or preserve community, state, and national parks.

We gathered survey data from 80 teams on five regional campuses at three points in time. Time 1 (T1) was within the first 2 weeks after team formation; time 2 (T2), after 5 months; and time 3 (T3), after 10 months, shortly before the 10-month program ended and the teams disbanded. At all three points in time, we measured team psychology safety and friendship, advice, and difficulty network ties within the teams. Although 10–20 teams were colocated on each regional campus, team members had very few interactions with others outside their own team. Accordingly, we measured intrateam social networks exclusively. For the analyses reported here, we included teams from which we had at least eight matched time 1, 2, and 3 responses. The final sample consisted of 834 participants, nested in 69 teams and five regional campuses. In our sample, 69% of the team members were female. The average age was 20, ranging from 17 to 27. Most team members (82%) were Caucasian; 5% were African American, 5% were

Hispanic, 3% were Asian, 1% was Native American, and 4% were “other.”

Measures

Perceptions of Team Psychological Safety. Participants used a five-point Likert scale (1 = strongly disagree, 5 = strongly agree) to indicate their agreement with Edmondson’s (1999) measure of team psychological safety. Sample items include “It is safe to take a risk on this team” and “Working with members of this team, my unique skills and talents are valued and utilized.” Internal consistency reliability, based on the five items that yielded the highest scale reliability, ranged from 0.77 to 0.79 across times 1, 2, and 3 (see Table 3).

Network Ties. To assess advice, friendship, and difficulty ties, respectively, respondents answered yes or no to three questions (adapted from Baldwin et al. 1997) regarding each member of their team: (1) “Do you go to this person for work-related advice?” (2) “Is this person a good friend of yours, someone you socialize with during your free time?” and (3) “Do you have a difficult relationship with this person?”

Control Variables. Previous studies have shown that individual demographic variables such as gender, race, and age may influence the creation of social network ties (McPherson and Smith-Lovin 1987), as may some personality traits (e.g., Mehra et al. 2001, Klein et al. 2004). Team members’ demographic characteristics and personality traits may also influence their perceptions of team psychological safety (e.g., Edmondson and Mogelof 2005, Nembhard and Edmondson 2006, Detert and Burris 2007). Thus, we controlled for age, gender, race, and personality (measured in the T1 survey) in all analyses.

Respondents reported their age in years, their gender (0 for male and 1 for female), and their race/ethnicity (coded 0 for white and 1 for nonwhite). We measured respondents’ personality with the International Personality Item Pool (IPIP) (Goldberg 1992). The IPIP measures the Big Five model of personality (extraversion, neuroticism, agreeableness, conscientiousness, and openness to experience) with 10 items for each dimension. The internal consistency of the personality scales ranged from 0.76 to 0.88 (see Table 3). Furthermore, we included a dummy variable in the analyses that identified the designated team leader of each team (0, team member; 1, team leader) as well as one that identified the time period (0, time 1–time 2; 1, time 2–time 3).

Analyses

We were faced with multiple challenges in testing our hypotheses. First, testing the effects of psychological safety on network ties and of network ties on psychological safety requires a longitudinal approach that allows

for separating these effects. Second, people were nested in teams, which, in turn, were nested in regional campuses. Finally, the creation of a network tie depends not only on the characteristics of the people linked by the tie (i.e., their perceptions of team psychological safety) but also on these individuals' other ties within the team. Two prominent types of such *network dependence* are reciprocity (Sahlins 2003) (i.e., "if you extend your friendship to me, I will in turn extend my friendship to you") and transitivity (Davis 1970) (i.e., "friends of my friends are my friends"). As a result, estimations of the mutual effects of psychological safety and network ties that do not take into account these network mechanisms (e.g., that collapse network ties into individual-level variables such as the number of outgoing ties that a person has) may yield inaccurate or misleading results.

To address these challenges, we used SIENA (Simulation Investigation for Empirical Network Analysis), a software program developed by Snijders and his colleagues (Snijders 2005, Ripley and Snijders 2009) to investigate "network structure together with relevant actor attributes as joint dependent variables in a longitudinal framework, assuming that data have been collected according to a panel design" (Snijders et al. 2007, p. 3). "Actor attributes" are any changeable personal characteristics such as perceptions, attitudes, or behaviors. For example, Steglich et al. (2006) used SIENA to study the coevolution of friendships between adolescents and their changing taste for music.

SIENA's specifications and assumptions offered several benefits in testing our hypotheses. First, SIENA considers the changes in team members' perceptions of psychological safety and the changes of the *complete* team network (i.e., the whole network configuration of a team at a given point in time). This way, network mechanisms such as reciprocity and transitivity can be estimated and controlled for in the analyses. The model further assumes that change does not only occur at the observed points in time but also in between at multiple points in time. This assumption is realistic as changes in the pattern of team relationships and perceptions of psychological safety are likely to occur continuously throughout the team life and not only at the three points of measurement. Statistically, continuous change between discrete time points is modeled as a probabilistic (stochastic) process utilizing a continuous-time Markov chain. In other words, the overall observed changes in team networks and perceptions of psychological safety are broken down into sequences of many small changes. SIENA simulates these unobserved small changes and determines the most likely sequence of changes given the observed data at the three points of measurement. Finally, the model conceptualizes these small changes as "actor driven." The underlying assumption is that, at any stochastically determined moment, a team member makes a decision to create or dissolve

a tie to another team member or to adjust his or her perception of team psychological safety. These "micro steps" are modeled by a multinomial logit distribution based on a random utility function. The estimated model parameters predict team members' individual decisions to change—or to not change—their ties and perceptions. The actor-driven model of SIENA corresponds to our premise that team networks and psychological safety are emergent team properties and that their reciprocal relationship and coevolution are rooted in individual-level processes.

To account for the fact that individuals were nested within teams which were nested in regions, we followed the multilevel approach suggested by Snijders and Baerveldt (2003). We first analyzed separate SIENA models for each of the five campuses. We controlled for team membership with a series of dummy variables and *structural zeros* in the analyses. Structural zeros in this case are constraints added to the network data that indicate that a tie between two people who belong to different teams is not possible. Then, we combined parameter estimates and standard error estimates using Snijders and Baerfelder's (2003) meta-analysis procedure for aggregating the results of multiple networks. Because it is not possible to analyze more than one network type at the same time in SIENA, we created separate models for the coevolution of perceptions of psychological safety and friendship ties, advice ties, and difficulty ties.

Following the recommendation of Snijders et al. (2010), we included the network control variables reciprocity and transitivity in all models by default. We also included dummy variables for identifying the team leader and the two time periods in all models. To determine which demographic and personality variables to include as control variables in our hypothesis-testing models, we tested each variable by itself. That means, in addition to the default parameters described above, we included the four effects for each control variable: the sender, receiver, similarity effects on network ties, as well as the effect of the control variable on psychological safety. This way, we tested eight separate models (one for each demographic or personality variable) for each of the friendship, advice, and difficulty networks. In the final models, we kept only those personality and demographic effects that were significant in the separate control models. We adopted this strategy to prevent convergence problems and inflated standard errors that could result from the inclusion of too many weak or nonsignificant parameter estimates in the models (Snijders et al. 2007, Ripley and Snijders, 2009), as was the case with these demographic and personality variables.

Results

Descriptives

Table 3 presents means, standard deviations, Cronbach's alpha coefficients, and correlations between individ-

ual perceptions of psychological safety; the number of friendship, advice, and difficulty ties a person sends to others; and the control variables. On average, psychological safety decreased over time (from a grand mean of 3.81 at time 1 to a grand mean of 3.37 over the 10-month period). The low to moderate autocorrelations of psychological safety across points in time ranging from 0.15 to 0.47 suggest that team members tended to shift their perceptions of psychological safety over the course of the team's life. On average, team members had the most sent friendship and advice ties at time 2 (6.21 and 5.40) and the most sent difficulty ties before the teams disbanded at time 3 (1.69). Similar to psychological safety, the moderate autocorrelations among the number of ties across the three points in time suggest that team members changed their network ties, particularly between times 1 and 2. Autocorrelations of friendship, advice, and difficulty ties between times 1 and 2 were consistently lower (0.31, 0.30, and 0.29, respectively) than those between times 2 and 3 (0.54, 0.51, and 0.39, respectively).

Friendship Ties and Perceptions of Psychological Safety. We predicted that friendship ties and perceptions of psychological safety coevolve as a function of five mechanisms: prospective action (H1A), retrospective sensemaking (H1B), reaction (H1C), homophily (H1D), and assimilation (H1E). Friendship ties are the dependent variable in the submodel shown in panel A of Table 4. Perceptions of psychological safety are the dependent variable in the submodel shown in panel B of the table. Accordingly, the top submodel includes the parameter estimates for prospective action and homophily (perceptions shape friendship ties), and the bottom submodel includes those for retrospective sensemaking, reaction, and assimilation (friendship ties shape perceptions).² As predicted in Hypothesis 1A, team members with more positive perceptions of team psychological safety subsequently sent more friendship ties to their teammates than did team members who perceived less team psychological safety (prospective action estimate, 0.15; $p = 0.033$). Hypothesis 1B was not supported; individuals who sent more friendship ties were not more likely than individuals who sent fewer friendship ties to subsequently develop more positive perceptions of their team's psychological safety (retrospective sensemaking). Hypothesis 1C was not supported either; individuals who received more friendship ties were not more likely than individuals who received few friendship ties to develop more positive perceptions of their team's psychological safety (reaction). As predicted in Hypothesis 1D, team members sent more friendship ties to those whose perceptions of psychological safety were similar to, rather than different from, their own (homophily estimate, 0.74; $p = 0.006$). Finally, as predicted in Hypothesis 1E, team members' perceptions of psychological

Table 3 Means, Standard Deviations, Cronbach's Alpha Coefficients, and Correlations of Study Variables

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Psychological safety																							
1. Time 1	3.81	0.65	(0.78)																				
2. Time 2	3.59	0.78	0.25	(0.79)																			
3. Time 3	3.37	0.77	0.15	0.47	(0.77)																		
No. of sent ties/person																							
4. Friendship T1	4.80	3.48	0.31	0.01	0.05																		
5. Friendship T2	6.21	2.68	0.14	0.22	0.19	0.31																	
6. Friendship T3	5.94	2.60	0.13	0.20	0.35	0.24	0.54																
7. Advice T1	5.08	3.83	0.27	0.05	0.34	0.18	0.15	0.18															
8. Advice T2	5.40	2.72	0.16	0.22	0.19	0.11	0.42	0.32	0.30														
9. Advice T3	5.09	2.64	0.10	0.12	0.24	0.13	0.33	0.48	0.29	0.51													
10. Difficulty T1	0.57	1.14	-0.26	-0.10	-0.10	-0.10	-0.15	-0.06	-0.08	-0.10	-0.12												
11. Difficulty T2	1.34	1.48	-0.14	-0.37	-0.18	-0.01	-0.17	-0.05	-0.05	-0.09	-0.07	0.29											
12. Difficulty T3	1.69	1.73	-0.09	-0.22	-0.32	-0.04	-0.14	-0.16	-0.06	-0.09	-0.11	0.22	0.39										
Control variables																							
13. Leader	0.08	0.28	-0.04	0.00	-0.07	-0.21	-0.14	-0.10	-0.12	-0.05	-0.13	-0.04	-0.02	0.07									
14. Gender	0.67	0.47	0.00	0.10	0.07	-0.05	0.07	0.04	0.08	0.14	0.14	0.12	-0.04	0.00	-0.05								
15. Age	20.89	2.06	-0.08	-0.11	-0.05	-0.10	-0.05	-0.07	-0.10	-0.16	-0.09	0.02	0.04	-0.02	0.36	-0.03							
16. Race	0.19	0.39	0.03	0.00	0.03	-0.05	0.04	0.02	-0.01	-0.01	0.04	-0.06	-0.03	-0.06	-0.02	-0.05	-0.04						
17. Agreeableness	4.16	0.44	0.30	0.10	0.12	0.14	0.14	0.07	0.13	0.14	0.12	-0.02	-0.08	0.02	-0.01	0.25	0.04	-0.09	(0.78)				
18. Conscientiousness	3.55	0.57	0.10	0.07	0.06	0.11	0.04	0.11	0.05	0.01	0.03	0.03	-0.04	-0.02	0.04	0.17	0.14	0.00	0.21	(0.82)			
19. Extraversion	3.41	0.66	0.17	0.01	-0.03	0.20	0.07	0.01	0.08	0.01	0.06	0.02	0.03	0.05	0.04	0.01	-0.02	0.01	0.28	-0.02	(0.88)		
20. Neuroticism	2.64	0.66	-0.24	-0.16	-0.08	-0.10	-0.07	-0.03	-0.06	-0.03	-0.02	0.15	0.19	0.11	0.04	0.10	0.01	-0.01	-0.18	-0.20	-0.22	(0.86)	
21. Openness	3.75	0.47	0.09	-0.05	-0.06	0.03	-0.03	-0.03	-0.01	-0.04	0.01	-0.04	0.09	0.05	-0.03	-0.12	0.09	-0.07	0.27	0.06	0.28	-0.12	(0.76)

Notes. $N = 834$. Correlations equal to $|0.06|$ are significant at $p < 0.05$; correlations equal to $|0.08|$ are significant at $p < 0.01$.

Table 4 SIENA Estimation Results: Coevolution of Friendship Ties and Perceptions of Psychological Safety

Submodel	Parameter	Estimate	Standard error	<i>p</i>
(A) DV: <i>Friendship ties</i>	Psychological safety			
	Prospective action (sender)	0.15	0.07	0.033
	Attraction (receiver)	−0.04	0.05	0.352
	Homophily (similarity)	0.74	0.27	0.006
	Intercept			
	Friendship outdegree	−0.94	0.05	<0.001
	Control variables: Network			
	Friendship reciprocity	0.74	0.05	<0.001
	Friendship transitivity	0.08	0.01	<0.001
	Control variables:			
	Person characteristics			
	Leader (sender)	0.04	0.16	0.822
	Gender (similarity)	0.28	0.03	<0.001
	Age (similarity)	0.30	0.10	0.004
	Openness (receiver)	−0.06	0.04	0.181
	Extraversion (receiver)	−0.11	0.05	0.017
	Time period	0.21	0.07	0.004
	Rate function			
	Rate period 1 (T1–T2)	9.40	1.02	<0.001
	Rate period 2 (T2–T3)	4.63	0.78	<0.001
(B) DV: <i>Psychological safety</i>	Friendship ties			
	Retrospective sensemaking (sender)	−0.02	0.04	0.655
	Reaction (receiver)	0.10	0.06	0.066
	Assimilation (similarity)	3.13	0.66	<0.001
	Intercept			
	Psych. safety tendency	−0.62	0.21	0.004
	Psych. safety tendency sq.	−0.27	0.07	<0.001
	Control variables:			
	Person characteristics			
	Leader	0.08	0.18	0.652
	Neuroticism	−0.12	0.08	0.160
	Time period	0.32	0.21	0.118
	Rate function			
	Rate period 1 (T1–T2)	1.95	0.20	<0.001
	Rate period 2 (T2–T3)	1.39	0.14	<0.001

Note. DV, dependent variable.

safety grew increasingly similar to those to whom they sent friendship ties (assimilation estimate, 3.13; $p < 0.001$). We wondered, however, whether a reciprocated friendship tie was more influential than a sent friendship tie: Are individuals particularly likely to adopt the perceptions of the individuals with whom they share a reciprocated friendship tie? To find out, we tested the interaction between the assimilation effect and friendship reciprocity in a post hoc analysis. The interaction was not significant, suggesting that individuals are not more likely to adopt the perceptions of the individuals with whom they share a reciprocated friendship tie than with those to whom they just send a tie. In sum, the results suggest that friendship ties and perceptions of psychological safety coevolve as a function of prospective action, homophily, and assimilation.

Advice Ties and Perceptions of Psychological Safety. We predicted that four mechanisms link advice ties

and perceptions of psychological safety: prospective action (H2A), retrospective sensemaking (H2B), reaction (H2C), and assimilation (H2D). We first focus on the results of the submodel shown in panel A of Table 5 (from perceptions to advice ties), where advice ties are the dependent variable. Consistent with Hypothesis 2A, team members who perceived that their team was high in psychological safety subsequently sent more advice ties (that is, they reported that they requested advice from more of their teammates) than did team members who perceived less team psychological safety (prospective action estimate, 0.14; $p = 0.020$). Contrary to Hypothesis 2B, individuals who asked many of their teammates for advice were not more likely than individuals who asked fewer of their teammates for advice to grow more positive in their perceptions of the team's psychological safety (retrospective sensemaking estimate, 0.03; $p = 0.650$). The submodel shown in panel B of Table 5

Table 5 SIENA Estimation Results: Coevolution of Advice Ties and Perceptions of Psychological Safety

Submodel	Parameter	Estimate	Standard error	<i>p</i>
(A) DV: <i>Advice ties</i>	Psychological safety			
	Prospective action (sender)	0.14	0.06	0.020
	Attraction (receiver)	0.11	0.08	0.196
	Homophily (similarity)	0.13	0.46	0.774
	Intercept			
	Advice outdegree	−1.20	0.07	<0.001
	Control variables: Network			
	Advice reciprocity	0.48	0.13	<0.001
	Advice transitivity	0.11	0.02	<0.001
	Control variables:			
	Person characteristics			
	Leader (sender)	−0.05	0.18	0.758
	Extraversion (receiver)	0.18	0.07	0.012
	Time period	−0.03	0.06	0.606
	Rate function			
	Rate period 1 (T1–T2)	7.65	1.05	<0.001
	Rate period 2 (T2–T3)	4.32	0.39	<0.001
(B) DV: <i>Psychological safety</i>	Advice ties			
	Retrospective sensemaking (sender)	0.03	0.06	0.650
	Reaction (receiver)	0.19	0.05	<0.001
	Assimilation (similarity)	3.32	1.43	0.020
	Intercept			
	Psych. safety tendency	0.07	0.17	0.684
	Psych. safety tendency sq.	−0.26	0.10	0.008
	Control variables:			
	Person characteristics			
	Leader	0.10	0.25	0.674
	Neuroticism	−0.15	0.11	0.160
	Time period	0.18	0.24	0.455
	Rate function			
	Rate period 1 (T1–T2)	1.59	0.18	<0.001
	Rate period 2 (T2–T3)	1.23	0.12	<0.001

Note. DV, dependent variable.

presents the results of the relationships from advice ties to perceptions with perceptions of psychological safety as the dependent variable. Consistent with Hypothesis 2C, the more requests for advice an individual received, the more positive the individual's assessment of the team's psychological safety became (reaction estimate, 0.19; $p < 0.001$). Finally, consistent with Hypothesis 2D, we found a significant assimilation effect (3.32; $p = 0.020$); team members tended to adopt their advice givers' perceptions of the team's psychological safety. In sum, the results suggest that advice ties and perceptions of psychological safety coevolve as a function of prospective action, reaction, and assimilation.

Difficulty Ties and Perceptions of Psychological Safety. We predicted that two mechanisms link difficulty ties and perceptions of psychological safety: prospective action (H3A) and retrospective sensemaking (H3B). As shown in submodel of Table 6, panel A, the results support Hypothesis 3A: individuals who found their team low in psychological safety subsequently reported that

they had difficult relationships with more of their teammates than did individuals who found their team high in psychological safety (difficulty prospective action estimate, -0.26 ; $p = 0.030$). The results support Hypothesis 3B as well: the more difficulty ties a person sent, the lower his or her perception of the team's psychological safety subsequently became (difficulty retrospective sensemaking estimate, -0.16 ; $p = 0.010$). Interestingly, we also found, but did not predict, a significant negative assimilation effect (-1.02 ; $p = 0.003$), indicating that team members' perceptions of their team's psychological safety grew increasingly dissimilar from the perceptions of those with whom they reported an earlier difficult relationship (that is, of those to whom they sent difficulty ties). In sum, the analyses suggest that difficulty ties and perceptions of psychological safety coevolve as a function of prospective action, retrospective sensemaking, and assimilation.

See the appendix for an explanation of the SIENA-specific parameters (the intercept parameter and rate

Table 6 SIENA Estimation Results: Coevolution of Difficulty Ties and Perceptions of Psychological Safety

Submodel	Parameter	Estimate	Standard error	<i>p</i>
(A) DV: <i>Difficulty ties</i>	Psychological safety			
	<i>Prospective action</i> (sender)	−0.26	0.12	0.030
	<i>Attraction</i> (receiver)	−0.34	0.25	0.187
	<i>Homophily</i> (similarity)	−1.44	0.94	0.126
	Intercept			
	<i>Difficulty outdegree</i>	−0.33	0.13	0.014
	Control variables: Network			
	<i>Difficulty reciprocity</i>	0.77	0.09	<0.001
	<i>Difficulty transitivity</i>	0.01	0.04	0.688
	Control variables:			
	Person characteristics			
	<i>Leader</i> (sender)	0.47	0.35	0.176
	<i>Gender</i> (receiver)	0.39	0.19	0.039
	<i>Gender</i> (similarity)	−0.35	0.13	0.007
	<i>Age</i> (receiver)	0.04	0.02	0.004
	<i>Agreeableness</i> (receiver)	−0.30	0.17	0.071
	<i>Extraversion</i> (receiver)	0.35	0.09	<0.001
	<i>Neuroticism</i> (receiver)	0.11	0.08	0.160
	<i>Time period</i>	0.64	0.18	<0.001
	Rate function			
	<i>Rate period 1</i> (T1–T2)	1.57	0.12	<0.001
	<i>Rate period 2</i> (T2–T3)	2.06	0.24	<0.001
(B) DV: <i>Psychological safety</i>	Difficulty ties			
	<i>Retrospective sensemaking</i> (sender)	−0.16	0.06	0.010
	<i>Reaction</i> (receiver)	−0.13	0.13	0.313
	<i>Assimilation</i> (similarity)	−1.02	0.35	0.003
	Intercept			
	<i>Psych. safety tendency</i>	0.05	0.17	0.754
	<i>Psych. safety tendency sq.</i>	−0.50	0.07	<0.001
	Control variables:			
	Person characteristics			
	<i>Leader</i>	0.26	0.36	0.470
	<i>Neuroticism</i>	−0.09	0.12	0.454
	<i>Time period</i>	0.11	0.22	0.630
	Rate function			
	<i>Rate period 1</i> (T1–T2)	1.57	0.10	<0.001
	<i>Rate period 2</i> (T2–T3)	1.32	0.11	<0.001

Note. DV, dependent variable.

function), as well as the parameters representing control variables shown in Tables 4, 5, and 6.

Discussion

Positing that emergent team states are both product and predictor of team members' social interactions, we developed and tested a conceptual framework to document six reciprocal mechanisms through which individual team members' perceptions of their teams and team members' social network ties may coevolve. Our findings lend considerable support to our hypotheses and illustrate the varied, complex, and intertwining mechanisms by which team members' perceptions of their team's psychological safety and team members' ties of advice, friendship, and difficulty may coevolve. Our framework and findings thus call into question simpler

models of the relationship of network ties and emergent team states. Conceptual models and tests of unidirectional or team-level effects are likely to substantially misrepresent the mechanisms by which network ties and emergent team states coevolve.

Consistent Effects Across the Three Networks: Prospective Action and Assimilation

Across the three networks we studied, we find consistent evidence in support of two of the six mechanisms we proposed: prospective action and assimilation. Individuals high in psychological safety send more friendship and advice ties and fewer difficulty ties than do individuals low in psychological safety (prospective action). Individuals thus show agency, sending network ties that reflect their individual perceptions of the team. Yet individuals are also susceptible to the social influence

of those to whom they send ties; their perceptions grow increasingly similar to the perceptions of their friends and advisors and increasingly dissimilar from the perceptions of those they find difficult (assimilation). We did not predict but found the latter effect. Perhaps such divergence reduces the cognitive dissonance one might otherwise experience as a result of finding similar others difficult. Indeed, research has shown that people perceive the views of their adversaries as more biased and more motivated by self-interest than their own views and the views of their friends (Pronin 2007, Reeder et al. 2005).

Across the three networks, we neither hypothesized nor found evidence of “attraction” effects; individuals who perceived their team to be high in psychological safety did not receive significantly more, or fewer, advice, friendship, or difficulty ties than those who perceived their team to be low in psychological safety. Finally, we found network-specific evidence in support of the three remaining mechanisms by which network ties and perceptions of psychological safety may coevolve: homophily, retrospective sensemaking, and reaction. We explore our network-specific findings in more detail below.

Although we focused in our initial theorizing on *each* mechanism in isolation, our findings may stimulate further theorizing regarding the *combined* effects of the mechanisms on the emergence of team-level states and network structures. Consider the likely interplay of prospective action and assimilation over time. Together, prospective action and assimilation may set up a reinforcing cycle leading either to the creation of dense ties of friendship and advice and a shared positive assessment of the team’s psychological safety *or* to the creation of sparse positive networks and more dense difficulty networks coupled with polarized assessments of the team’s psychological safety. If, early in the life of the team, team members perceive their team to be high in psychological safety, they are likely to create many friendship and advice ties (prospective action). Such ties may, in turn, foster the convergence of team members’ positive perceptions of the team’s psychological safety (assimilation). If, however, team members’ early perceptions of their team’s psychological safety are less positive, team members are likely to create few advice and friendship ties and many difficulty ties (prospective action). These ties may lead to subgroups converging on differing perceptions of the team’s psychological safety (assimilation). In sum, the interplay of prospective action and assimilation offers intriguing though still untested insights regarding the emergence of team-level psychological safety and network structure.

Network-Specific Effects: Reaction, Homophily, and Retrospective Sensemaking

Advice Ties: Reaction. As hypothesized, individuals whose advice team members seek are likely to grow

increasingly confident of their team’s psychological safety. The fact that we found a reaction effect for advice ties but not for friendship ties (as we also hypothesized), nor for difficulty ties, suggests that team members are more responsive to the receipt of instrumental ties than to the receipt of affective ties (friendship and difficulty). Asking for advice is an overt behavior clearly visible to the would-be advice giver. In contrast, extensions of friendship and of difficulty ties may be more subtle and ambiguous (Kilduff et al. 2008); a target may not know he or she is the object of others’ affection or animosity.

Reaction, we speculate, may accelerate the prospective action–assimilation cycle proposed above. When individuals high in psychological safety send advice ties (prospective action), recipients grow in psychological safety (reaction). The advice they offer then serves as a conduit for the spread of psychological safety (assimilation). In this way, the presence, early in the life of a team, of individuals who perceive the team to be high in psychological safety may have a catalytic effect, boosting both the creation of a dense advice network within the team and the development of a strong, shared sense of the team’s psychological safety.

Friendship Ties: Homophily. We found that individuals are more likely to send friendship ties to those whose perceptions of the team’s psychological safety are similar rather than dissimilar to their own. This finding adds credence to the growing evidence that similarity not only of demographic characteristics but also of psychological attributes such as perceptions and attitudes may engender positive network ties (McPherson et al. 2001).

Homophily, we speculate, may subtly alter the prospective action–assimilation cycle described above, increasing the likelihood that teams develop subgroups characterized by differing levels of psychological safety. Initially high in psychological safety, the members of one subgroup may build dense friendship ties (prospective action and homophily) and increasingly positive assessments of the team’s psychological safety (assimilation). The members of a second subgroup, lower in psychological safety, may—reflecting the counterbalancing effects of both prospective action (decreasing the likelihood of sent friendship ties) and homophily (increasing the likelihood of sent friendship ties)—send occasional if not abundant friendship ties to one another, engendering further declines in the team’s psychological safety (assimilation).

Difficulty Ties: Retrospective Sensemaking. As predicted, individuals who find many of their teammates difficult experience subsequent declines in their perceptions of the team’s psychological safety. The presence of a retrospective sensemaking effect for difficulty ties, but not for friendship and advice ties, may reflect the particular salience and infrequency of negative ties (Labianca and Brass 2006).

In conjunction with the mechanisms of prospective action and assimilation, the retrospective sensemaking effect may set up a dynamic that is at once damaging and largely self-imposed and self-fulfilling. Team members who perceive the team to be low in psychological safety send more difficulty ties than do team members who perceive that the team is high in psychological safety (prospective action). Team members who send many difficulty ties tend, in turn, to develop low perceptions of the team's psychological safety (retrospective sensemaking). This cycle of prospective action and retrospective sensemaking has the potential to result in a destructive downward spiral in which a person's perception of the team and his or her perceptions of negative relationships with teammates are mutually reinforcing. Because the downward spiral is based solely on sender effects (prospective action and retrospective sensemaking), it may exist in the sender's head largely independent of the views of other team members and thus may be difficult to interrupt. Assimilation may compound this negative spiral we have described. Assimilation causes those who send difficulty ties to others with more positive perceptions of the team's psychological safety to experience subsequent *declines* in their own perceptions of the team's psychological safety. Alternatively, assimilation may lead those who send ties to others with low perceptions to *gain* in their perceptions of the team's psychological safety. And yet, retrospective sensemaking may well weaken this effect, attenuating any boost in psychological safety that might result from the assimilation effects of sending a difficulty tie to a teammate low in psychological safety.

Together, our framework and findings highlight the reciprocating and complex ways in which team members' interpersonal ties and team members' perceptions of their team coevolve, shaping over time the team's network structure and psychological safety climate. The emergence of a team's network structure and psychological safety climate occurs, our framework and findings suggest, through a bottom-up process driven by the individual-level mechanisms of prospective action and assimilation, and the network-specific effects of homophily, reaction, and retrospective sensemaking. Emergence, of course, does not ensure convergence. Through the processes we have described, teams may develop strong, weak, or divided climates for psychological safety and dense, sparse, or fragmented network structures.

To highlight this point, we return to the two teams referenced in Figure 1. The two teams depicted begin with similar mean levels of team psychological safety and similar levels of friendship network density.³ Yet, over time, they diverge to yield quite different team network structures. Why? One possible if clearly speculative explanation is that the initial pattern of network

ties and the distribution of psychological safety perceptions within each team trigger different coevolutionary dynamics. As both teams start with below-average psychological safety, we would expect, under prospective action, that members would send few, or even withdraw, friendship ties over time. Indeed, this is what we observe in team 1. For example, team member C, who is relatively low in psychological safety, appears to jettison all but one of his or her friendships over the 10-month life of the team. Because team 1's friendship network was relatively sparse to begin with, the removal of just a few ties results in fragmentation, with members A and B disconnected from the rest of the team. In team 2, in contrast, homophily may counteract the effects of prospective action. Members D, E, and F are very similar in psychological safety to many other members of this team. Homophily may lead them to both send and receive new friendship ties, increasing the density of the team's friendship network. Perhaps as a result of the increasing density of the team's friendship network, and the benefits of assimilation among those high in psychological safety, the mean level of psychological safety does not decline as much in team 2 as in team 1.

Strengths and Limitations of the Research

Our research sample—69 real teams studied at three points in time over a 10-month period—is an important strength of this study, capturing the full life cycles of teams and allowing us to test the direction of perception–tie relationships. At the same time, in the absence of an experimental design, we cannot establish with certainty the causal direction of our findings. Furthermore, although we included multiple control variables (gender, race, age, and the Big Five personality factors) in our analyses, we cannot rule out the possibility that our findings reflect the influence of other, unobserved variables. And although our findings yielded robust linkages between network ties and psychological safety, had we measured network ties with valued and continuous rather than dichotomous scales, we might have gained still greater insights into the evolving nature of interpersonal ties within the teams we studied.

The unique nature of our sample and setting suggests that we should be cautious about the generalizability of our results to other, more conventional organizations. Working closely together on highly interdependent tasks and living together in the same dormitories for a limited time period creates an intense team experience that is not typical of most organizations and that might have heightened the importance of team perceptions in shaping interpersonal relationships. In addition, participants were younger than those found in most organizations and, therefore, may have been particularly susceptible to assimilation effects (Sears 1986). Finally, the fixed life span of the teams might have affected the results we found, because team members knew that they were

likely to have little or no contact with one another after the 10-month program ended. Research is thus needed to replicate our findings in other types of teams and organizational settings.

New Directions for Research

We hope that our framework and findings will spur new research. Although we focused on team psychological safety, we anticipate that other emergent team states such as team cohesion, team potency, team justice climate, and team transactive memory are also both the product and predictor of network ties. The mechanisms by which differing team states and network ties coevolve may, however, vary, suggesting the possibility of precise and differing conceptual models of coevolutionary processes in organizations. Future theory and research are needed to extend our findings and clarify the mechanisms of coevolution across team constructs.

Additional research is also needed to explore the coevolution of emergent team states and multiple team networks over time. Our analyses, constrained by the current limits of SIENA, examined the separate coevolution of each network. But, friendship, advice, and difficulty ties may coevolve as well and may interact in their relationships to psychological safety. How, for example, does the presence of both a friendship tie *and* a difficulty tie between individuals influence the assimilation of psychological safety perceptions between the two individuals? More conceptual, methodological, and empirical work is needed to address these important questions.

Further research is also needed to examine more closely the role of team stages and cycles in the coevolution patterns. Our analyses have examined the process of change over time, without distinguishing between early team stage and later team stage coevolutionary dynamics—an analysis requiring data collection at least four times over the life of a team. But the influence of particular perception–tie mechanisms may change depending on a team’s life stage. Furthermore, we suspect that as teams mature over a longer period of time than in our sample, maintaining the same team members and team tasks, team members’ perceptions of psychological safety and team members’ network ties may stabilize, making evolution—and coevolution—less likely. Research is needed to test this possibility.

Finally, we see an exciting opportunity for simulation research to illuminate the team-level coevolutionary patterns that may result, we have suggested, from the co-occurrence of specific mechanisms. Simulations may provide organizational scholars and managers alike with an enhanced understanding of likely team-level patterns of coevolving team perceptions and team social networks.

Managerial Implications

Our study suggests an expanded set of tools at the disposal of both leaders and team members to manage

team effectiveness. First, although prior research suggests actions that leaders may take to enhance team psychological safety (e.g., Nembhard and Edmondson 2006), these actions focus on the team as a whole. Our conceptual framework and findings suggest that managers may also target their efforts at specific individuals. For example, the consistent effect of the *prospective action* mechanism suggests that leaders may enhance team psychological safety and the creation of dense, positive team networks by stocking teams with individuals who are likely to perceive the team as psychologically safe; these individuals, our findings suggest, are likely to foster the creation of dense advice and friendship networks. Leaders may also seek—or ask key team members to seek—advice from others, perhaps even if the advice is not essential. According to the mechanism of *reaction*, the targets of advice requests are likely to experience an increase in perceived psychological safety, which, in turn, can boost the overall level of psychological safety of the team. The mechanism of *assimilation* provides a cautionary note, however. Individuals who send ties of friendship and advice are susceptible to the views of those whom they target. If individuals send friendship and advice ties to teammates who are low in psychological safety, the senders’ own psychological safety may decline. Leaders may thus wish to step in, intervening directly to enhance the perceived psychological safety of those who find the team least safe. Conversely, given the potentially corrosive impact of those low in psychological safety (as a result of the dynamics of difficulty ties), leaders may wish to isolate these individuals within the team or even to remove them from the team.

Conclusion

Organizational scholars have posited that team emergent states and team social networks coevolve in a dynamic, reciprocating fashion (Mathieu et al. 2008, Marks et al. 2001). Yet this notion has remained broadly descriptive in the literature—more metaphorical than analytical. Moving beyond metaphor, our framework and findings offer a rich picture of multiple ways in which individual team members’ perceptions of their team shape and are shaped by their network ties. Mathieu et al. (2008, p. 461) advised team researchers to “embrace the complexity” of teams. We have done so here and hope that our findings are a stepping stone that will allow team and network researchers to evolve still further in our understanding of teams and social networks.

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Appendix

Each of the submodels shown in Tables 4, 5, and 6 has a separate intercept parameter. The negative intercepts for the submodels predicting network ties (*outdegree*) (panel A in Tables 4, 5, and 6) indicate that team members are more likely to report that they do not send friendship, advice, or difficulty ties to each of their teammates than that they do. The intercepts for the submodels predicting psychological safety (*tendency* and *squared tendency* (*tendency sq.*)) (panel B in Tables 4, 5, and 6) indicate that team members have a general tendency toward midpoint values of the psychological safety scale.

Each SIENA model also includes two rate functions that indicate how frequently team members change their network ties and their perceptions of psychological safety. The rate functions in panel A of Tables 4, 5, and 6 suggest that team members tend to change their friendship ties more frequently than either their advice or difficulty ties. The rate functions in panel B of Tables 4, 5, and 6 reveal that team members' perceptions change at a slower rate than their network ties. Note that the dummy variable *time period* is not part of the rate function but was added to all models to account for the nonstationary data structure. We tested three groups of control variables: network effects (i.e., reciprocity and transitivity), demographic variables, and personality variables. The significant reciprocity estimates in all three models (panel A in Tables 4, 5, and 6) indicate that team member A is most likely to describe team member B as a friend, an advice giver, or a difficult tie if team member B has, in turn, described team member A as a friend, an advice giver, or a difficult tie, respectively. The significant transitivity estimates in panel A of Tables 4 and 5 suggest that team members tend to become friends of their friends and seek advice from those whom their advice givers ask for advice. In terms of demographic control variables, our tests reveal that team members tend to become friends with teammates of the same sex (homophily estimate, 0.28; $p < 0.001$; see Table 4, panel A) and of similar age (homophily estimate, 0.30; $p = 0.004$; see Table 4, panel A) and tend to have more difficult relationships with women than with men (gender receiver estimate, 0.39; $p = 0.039$; see Table 5, panel A), with teammates of the other sex (gender homophily estimate, -0.35 ; $p = 0.007$; see Table 5, panel A), and with older teammates (age receiver estimate, 0.04; $p = 0.004$; see Table 5, panel A). Neither race nor status as a team leader (versus team member) has significant effects on network ties. Demographic variables are not significantly related to team members' perceptions of psychological safety. Finally, in terms of personality variables, extroverted team members are less popular as friends (extroversion receiver effect, -0.11 ; $p = 0.017$; see Table 4, panel A) and are often the target of difficulty ties (extroversion receiver effect, 0.35; $p < 0.001$; Table 6A) and yet are popular as sources of advice (extroversion receiver effect, 0.18; $p = 0.012$; see Table 5, panel A).

Endnotes

¹Throughout this article, we use the terms "social network ties," "network ties," and "interpersonal ties" interchangeably.

²In many applications of social network analysis, including SIENA, *sender* and *receiver* effects are also referred to as *ego* and *alter* effects, respectively. To use consistent terminology throughout this study, we continue to refer to *sender* and *receiver* effects in the Results section and the tables therein.

³We note that both of these teams experience a substantial decrease in psychological safety from time 1 to time 3. This is consistent with the overall pattern within this data set (see Table 3).

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