Team Member's Centrality, Cohesion, Conflict, and Performance in Multi-University Geographically Distributed Project Teams

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Team Collaboration

Team interaction represents a common collaborative activity that occurs within and across organizations, particularly among academics. Collaborative relationships, whether formal or informal in nature, may form for a variety of reasons: (a) synergy - to blend skills or expertise which any one individual may not possess; (b) workload segmentation - to divide the workload process; and/or (c) comfort or convenience - to coordinate mutual efforts among superiors, subordinates, or colleagues. With an increasing use of media in organizations (Haythornthwaite & Wellman, 1998), these collaborative relationships often span geographic and temporal boundaries, creating distributed, dispersed, or virtual teams (Connaughton & Shuffler, 2007).

Given the vast amount of collaboration that occurs in academic settings, academics must understand and manage various elements of teamwork. Unlike groups of loosely connected individuals, teams require individuals to work effectively as an interconnected system in which members have collective responsibility, respect for diversity, cohesiveness, and consensus on shared objectives (Littlejohn & Domenici, 2001). With appropriate organizational support, team members' gain confidence in their ability to succeed in teamwork, a relationship explained by effective team processes (Kennedy, Loughry, Klammer, & Beyerlein, 2009). As team members collaborate in an "interconnected system," members must manage their connections with others, particularly in distributed teams, in which members might engage in less frequent communication within their groups (Cummings, 2008). A well-focused team effort is often associated with more effective outcomes through an interactive enrichment of work and social processes (Campion, Medsker & Higgs, 1993; Campion, Papper & Medsker, 1996; Hackman, 1987) and an understanding of the importance of processes and people in virtual teams (Ebrahim, Ahmed & Taha, 2009).

With its emphasis on “relational dependencies and/or interdependencies” within and across group boundaries over time (Keyton, 2000, p. 388), this study includes a dual focus on individuals’ perceptions of team processes and communication by examining the influence of centrality, cohesion, and conflict, on team member performance in distributed teams over a 14-month period, exploring temporal aspects for research development (Arrow, Poole, Henry, Wheelan, & Moreland, 2004). Working in project teams over time seems to offer a substantial benefit in developing one’s network as Strubler and York (2007) found that team members had significantly more contacts that span interdepartmental boundaries than non-team members. Since naturally occurring work teams can further our understanding of how teams actually function in organizations (Lira, Ripoll, Peiró, & Zornoza, 2008; Strubler & York, 2007), this study uses a field-based sample of intact, interorganizational project teams where the teams exist for a reason other than this investigation. Examining individual performance as an outcome measure in teams is important “so that the abilities, behaviors, and status of these individuals can be recognized and leveraged in distributed contexts to develop a more effective collaboration unit” (Sarker, Ahuja, Sarker, & Kirkeby, 2011, p. 275).

In this article, we begin with a review of relevant literature on network centrality, team cohesion, team conflict, and performance that forms the basis of our hypotheses. Next, we present our research methodology, including background information on the sample, research procedure, measures, analyses, and design considerations. We conclude with a discussion of our results, its significance, and implications for future research.

Network Centrality

The ability to influence others in geographically dispersed networks depends to some extent on individuals’ embeddedness in practice (i.e., knowledge about informal content) and structure (i.e., knowledge about expertise connections), emphasizing individuals’ usefulness in sharing relevant knowledge with others in the network (Kleinnijenhuis, van den Hooff, Utz, Vermeulen, & Huysman, 2011; Su, 2012; Yuan, Fulk, Monge, & Contractor, 2010). A team member’s position in connecting other unconnected individuals can provide access to relevant knowledge and different expertise for performing complex work projects (Cross & Cummings, 2004). By examining interaction networks, researchers can identify structural factors that lead to and influence network members’ perceptions, attitudes, and work-related perceptions, attitudes, and behavior (Burt, Jannotta & Mahoney, 1998; Hartman & Johnson, 1990; Pearce & David, 1983; Susskind, 2007; Susskind, Miller & Johnson, 1998).

Centrality represents an important communication measure in the network model, reflecting both an individual's activity and embeddedness in the network (Feeley, 2000). Because connections between individuals can vary in the network, research has examined differences using three common measures: degree centrality, betweenness centrality, and closeness centrality (Katz, Lazer, Arrow, and Contractor, 2004; Sarker et al., 2011). Defined by Freeman (1979), degree centrality represents the number of connections for a network member. Closeness centrality is the minimum distance required for a member to connect with other network members. Betweenness centrality indicates the network position that controls or mediates the flow of information for other network members. While degree, closeness, and betweenness centrality are normally correlated to one another, these measures offer a slightly different look into how network members are connected. For example, degree centrality—compared to betweenness and closeness centrality— was shown to be the strongest network measure for predicting an individual outcome, such as employee retention (Feeley, 2000) and was connected to structural prestige in assessing members' expertise (Su, 2012). In an examination of turnover in organizations, Feeley found that individuals who had more direct contact (i.e., high degree centrality) with peers that provided information and social support were less likely to leave the organization over time. Likewise, network centrality, specifically betweenness centrality, is consistent with social exchange or dependency theories that emphasize "individuals' motivation to create ties is based on their ability to minimize their dependence on others from whom they need resources and maximize the dependence of others who need resources they can offer" (Katz et al., 2004, p. 314). Therefore, centrality represents an important structural property of the social network and the individuals that compose that network.

A key element of degree centrality is that this measure captures the breadth of connections in the network. Team members who have a high degree centrality—being connected to a larger percentage of network members—might develop a network that consists mainly of weak ties as defined by Granovetter's (1973) four elements: interaction frequency, emotional intensity, mutual intimacy, and reciprocal relations. These elements are interrelated; for example, interaction frequency relates positively to closeness and relational multiplexity, as Contractor and Monge (2002) reported that individuals gather information from those who they view as knowledgeable and can share expertise with, and those who are in close proximity. Haythornthwaite and Wellman (1998) also found that individuals with closer work ties and friendship ties engaged in multiple relationships than those with less close ties. While weak ties require less time and effort to create in one's network, such ties can provide valuable bridges or paths between unconnected network members, reflecting the "strength of weak ties"

(Granovetter, 1973, p. 1361). However, with less interaction, emotional intensity and shared intimacy, weak ties can reduce team cohesion since external (nongroup) ties provide access to new (nonredundant) information that may decrease members' attachment, creating less stable groups (McPherson, Popielarz, & Drobnic, 1992). For this reason, we expect that individual network members' formal and informal degree centrality will be related to decreases in team cohesion but increases in team conflict as members must balance their network centrality and strength of ties (Feeley, Moon, Kozey, & Slowe, 2010).

The present study considers the relationship between team members' project-related and nonproject-related network connections (represented as degree centrality) and team members' perceptions toward their work on project teams.[1] Specifically, we examine the connection between formal and informal degree centrality and team members' individual perceptions toward their team and teamwork over time measured as cohesion and conflict, which we discuss below. The following four hypotheses detail our predictions about degree centrality, cohesion, and conflict at the individual level.

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[1] We refer to team project-related interaction as "formal" and nonproject-related interaction as "informal."

Hypothesis 1a: Informal degree centrality will relate to decreases in team cohesion, showing a negative network centrality-cohesion relationship among individuals in distributed project teams.

Hypothesis 1b: Informal degree centrality will relate to increases in team conflict, showing a positive network centrality-conflict relationship among individuals in distributed project teams.

Hypothesis 2a: Formal degree centrality will relate to decreases in team cohesion, showing a negative network centrality-cohesion relationship among individuals in distributed project teams.

Hypothesis 2b: Formal degree centrality will relate to increases in team conflict, showing a positive network centrality-conflict relationship among individuals in distributed project teams.

Team Cohesion

At the individual level, team cohesion is often defined as positive feelings toward team members or the sharing of similar attitudes among team members (Danowski, 1980; Shah, 1998), emphasizing social inclusion and internalization associated with normative control (Stewart, Courtright & Barrick, 2012). In this manner, team cohesion emphasizes an affective component in group processes (Mason & Griffin, 2002). Viewed as a perception of "we-ness" (Pavitt, 1998), cohesion is typically a result of perceived closeness among team members and relates positively with members' socialization in small groups (Riddle, Anderson,

& Martin 2000) and team process and outcomes for team members (Hoegl, Ernst & Proserpio, 2007; Stokes, 1983).

Experimental and correlational research often conceptualizes cohesion in terms of task-related (i.e., formal) and interpersonal (i.e., informal) interaction (Bettenhausen, 1991; González, Burke, Santuzzi, & Bradley, 2003; Hirunyawipada, Beyerlein & Blankson, 2010; Mullen & Cooper, 1994) or maintenance-based cohesiveness (Pavitt, 1998), with high-quality task-procedural interaction occurring in mediated rather than traditional groups (Li, 2007). Task-based cohesion allows team members to transform tacit knowledge into collective knowledge (Hirunyawipada et al., 2010) and is more likely to occur in formal settings. Group pride, the extent to which members like their group's status or ideologies, represents a third but often ignored component of cohesion (Mullen & Cooper, 1994) and correlates strongly with performance as task commitment and interpersonal attraction (Beal, Cohen, Burke & McLendon, 2003).

Team cohesion can vary based on team size and development. Smaller teams tend to be more cohesive (van Woerkom & Sanders, 2010) and achieve higher stages in its group development (Wheelan, 2009). Consistent with temporal patterns related to systematic change in group development (Arrow et al., 2004), team cohesion fluctuates across different phases interaction, particularly in advice networks and social networks, indicating higher cohesion in later stages (Yang & Tang, 2004).

Team Cohesion and Performance

Recognizing that team members' perceptions can differ from individual perceptions about work characteristics, Strubler and York (2007) developed a "Team Characteristics Model" to extend Hackman and Oldham's (1976) "*Job Characteristics Model* (Hackman, 1987)." In examining this model for real organizational teams, Strubler and York found that team members reported significantly higher levels of critical psychological states in experienced meaningfulness and experienced participation than nonteam members both before and after working as a team. The idea that team members' self-efficacy perceptions can influence their performance is a central theme in Staples and Webster's (2007) teamwork model based on social cognitive theory. Their theory suggests that multiple external practices (i.e., modeling of best practices, coaching, and organizational) influence teamwork self-efficacy beliefs (i.e., modeling for capability, coaching for social persuasion, and organizational practices for team ability) and relate positively to perceived effectiveness. Consistent with this model, team members' self-efficacy perceptions related positively to perceived effectiveness for individual and team performance, with a stronger relationship between self-efficacy for teamwork and perceived team performance for virtual rather than traditional teams (Staples & Webster, 2007) and team performance in competitive racing teams (Edmonds, Tenenbaum, Kamata, & Johnson, 2009).

Previous research suggests that team cohesion relates positively with performance. Mullen and Copper's (1994) meta-analysis research integrated 49 experimental and correlational studies to confirm a small but significant relationship between group cohesiveness and performance, showing a stronger effect in correlational studies. Although research has defined group cohesiveness based on three components (i.e., interpersonal attraction, task commitment, and group pride), Mullen and Copper found that groups' task commitment predicted the "cohesiveness-performance effect" independently for both types of studies. Group nature, as reflected by the reality and group size, also influenced this relationship, indicating a stronger effect for real groups and smaller groups than artificial groups and larger groups, respectively. Garrison, Wakefield, Xu and Kim (2010) also found that perceived trust and team cohesion relate positively to individual performance in globally distributed teams. Team cohesiveness might relate to individual performance indirectly as van Woerkom and Sanders' (2010) research suggests that knowledge sharing (e.g., asking and giving advance) mediates this relationship. Other research by Stewart et al. (2012) showed that normative team cohesion relates positively to individual performance for members in self-managed teams and moderates the relationship between rational control (e.g., reward-linked peer evaluations) and individual performance, indicating a stronger association for low team cohesion.

The strength of the cohesion-performance relationship, however, might depend upon how performance is conceptualized and measured. For example, Beal et al.'s (2003) meta-analytic research showed a stronger relationship when performance is measured as a behavior versus an outcome using measures of performance efficiency (i.e., ratio of inputs relative to outputs that considers the cost of achieving effectiveness) rather than performance effectiveness (i.e., evaluation of performance results without considering the costs of achieving the results).

To examine the team cohesion-performance relationship at the individual level, we propose the following research hypothesis:

> Hypothesis 3: As team members' perceptions of cohesion increase over time, team members will show a higher level of individual performance, confirming a positive team cohesion-team member performance relationship in geographically distributed project teams.

Team Conflict

Conflict occurs when teams cannot manage its individual differences constructively, requiring members to build relationships and engage in an "ongoing conversation" to resolve conflict (Littlejohn & Domenici, 2001, p.11). Applying social network theory to group conflict focuses attention on an individual's connections or centrality in "conflict networks," that is, group members' perceptions about interpersonal conflict with other members in the network (Jen, 2013, p. 128). Teams that are mismatched, maladjusted, or unfocused may experience abnormally high levels of conflict that are negatively associated with positive team member interaction and exchange (Jehn, 1997). While a certain level of conflict is desirable in team interaction (Labianca, Brass and Gray, 1998), failure to resolve task conflict effectively can impede knowledge sharing among team members since teams with more disagreements are less open to sharing ideas (van Woerkom & Sanders, 2010).

Work groups experience three different types of conflict, including *relationship* or interpersonal issues that involve intense feelings and other affective components; *task* or competing ideas and perspectives about a group task, which reflect the cognitive component; and *process* conflict or disagreements about the process that the group will use to complete its task (Jehn & Mannix, 2001). With its focus on differences, conflict is associated with work stress: team task conflict relates positively to challenge-related stress that contributes to feelings of achievement, compared to team personal (relationship) conflict that relates positively with hindrance-related stress, creating negative feelings about work demands or threats (Hon & Chan, 2013). While task and relationship conflict can occur independently of one another, task conflict often leads to relationship conflict when team members are unable to agree on task-related issues (Jehn, 1997). For example, Simons and Peterson (2000) found that task conflict relates positively to relationship conflict for top management groups in hospitality companies, producing a stronger effect for groups with low intragroup trust that are more likely to attribute task conflict incorrectly to personal motives that result in relationship conflict. However, as social interaction increases among team members, the association between task conflict and relationship conflict becomes weaker (Gamero, González-Romá, & Peiró, 2008).

Examining conflict over time, Jehn and Mannix (2001) found that conflict–process, relationship, and task conflict– influenced high and low-performing business school student teams differently, even for similar organizational tasks. While high-performing teams did well in managing process and relationship conflict during the early and middle stages, these teams encountered significantly higher levels of task conflict during the middle stage. In contrast, low-performing teams did not manage process conflict well in both the early and late stages, and experienced significantly higher relationship and task conflict levels in the late stage, requiring these teams to manage all three types of conflicts concurrently in the late stage. Taken together, these differences indicate the importance of examining the conflict-performance relationship using longitudinal rather than cross-sectional research.

<u>Team Conflict and Performance</u>

Although certain research (Hon & Chan, 2013; Jen, 2013) suggests that task conflict relates positively to individual performance, this research examines the relationship indirectly, uses only cross-sectional research, and/or includes a more limited sample. For example, Hon and Chan (2013) examined team members in the hospitality industry and found that team task conflict creates positive challenge-related stress that, in turn, relates positively to individual job performance, reflecting an indirect relationship between team task conflict and job performance. Because Hon and Chan utilized a cross-sectional research design that included team members from multiple hospitality companies in only the Chinese culture, their findings might differ from other research that examines the task conflict-individual performance relationship over time and in different cultures. In a study that investigated conflict centrality and individual performance for engineers in a large research and development institution, Jen (2013) found that central individuals in the task conflict network had higher job performance (actual and perceived) than less central individuals, a relationship that was not moderated by task interdependency. Similar to Hon and Chan, Jen examined this relationship using cross-sectional research for individuals employed in an organization based outside the United States. Therefore, these studies offer limited direction about the expected relationship between task conflict and individual performance over time and geographic boundaries in interorganizational project teams.

An analysis of other research (De Dreu & Weingart, 2003) indicates that team conflict relates negatively to team performance. For example, De Dreu and

Weingart's meta-analysis of correlational studies showed that both task conflict and relationship conflict relate negatively to team performance for complex decision making and/or project tasks, suggesting that task type moderates the task conflict-team performance relationship, although this finding was not confirmed in a later meta-analysis by de Wit, Greer, & Jehn (2012). However, consistent with De Dreu and Weingart (2003), de Wit et al. (2012) found that task conflict had a negative relationship with team performance when task and relationship conflict correlated strongly with each other. Further, de Wit et al. found that organizational level (more negative for lower-level teams) and research context (more negative in field studies than classroom or laboratory studies) influenced the task conflict-team performance relationship.

Considering high-performing teams tend to manage task conflict in the middle rather than late development stage (Jenh & Mannix, 2001) and the relationship between task conflict and performance is more negative for lower-level organizational teams and in field studies (De Dreu and Weingart, 2003; de Wit et al., 2012), we propose the following research hypothesis to examine the relationship between team members' *changes in conflict and performance*:

Hypothesis 4: As team member's perceptions of task conflict decrease over time, team members will demonstrate higher individual performance on the team, confirming a negative team conflict-team member performance relationship in geographically distributed project teams.

In sum, the research hypotheses for this study propose that degree centrality is negatively related to changes in team cohesion but positively related to team conflict over time. Further, we expect that increases in cohesion and decreases in conflict are related to higher team member performance. The next section discusses the research methodology, including background information about the team tasks, the sample and structure of the teams, research procedure, measures, analyses, and design considerations.

Method

Background

The Educational Institute of the American Hotel Lodging Association (AHLA) initiated a nationwide research project in collaboration with six national hotel chains and 11 leading hospitality management programs in the United States. This *Research Alliance* was formed to foster and disseminate innovative research on topics of interest to the members of The Educational Institute of the AHLA and the participating hotel chains, using a set of university-based scholars. The Educational Institute of the AHLA financially sponsored each of the 11 universities to conduct the research and asked each participating university to select a team leader to assemble a team of researchers, such that each research team is comprised of professors from a mix of the these universities. Each team leader had the autonomy to select members that he/she believed would best serve the team. Faculty members from the participating universities were added to teams in three ways: (1) a team leader invited them, (2) one or more of the team members asked them to join the team, and/or (3) faculty members asked a team leader if they could join the team. Each faculty member who joined *the Research Alliance* was paid for his/her participation through the grant provided by the Educational Institute; an additional budget was provided to cover nonsalary project-related expenses for each team.

Ultimately, 49 professors at various ranks joined the alliance from the 11 participating hospitality management programs, along with a team of two administrators and one professor, representing the project sponsors (Educational Institute of the AHLA) who, as a team, worked with the 11 project teams, yielding a total group of 52 researchers among the 12 total teams (11 research teams and one administrative team). These small research teams ranged in size from three to six members.

Using a list of topics identified by the membership of The Educational Institute of the AHMA, the research teams conducted 11 integrated research projects that examined "hot button" management issues relevant to the hotel industry, focusing on three main themes: government regulation/legislation, human resource practices/service processes, and technology. While the teams functioned as self-managed project teams, each team had to meet project component deadlines and develop the elements of its project based on parameters set by the project sponsor. Specifically, each team was tasked with completing a comprehensive study around its hot-button issue, including a complete literature review with a sound theoretical foundation and the proper methods to execute the project. The entire Research Alliance membership met once as a group, the team leaders met twice as a group, and each research team met among itself, as needed or directed by the team leaders. The majority of the intra-team communication was done via conference calls and email, as face-to-face communication was limited for the geographically dispersed teams.

After completing the pilot studies for their proposed projects, teams were given an option to complete the final studies, on their own, once the *alliance* disbanded. The present study focuses on the team members' interaction and individual performance that occurred while *the Research Alliance* was in operation.

Procedure

The data used to conduct this study were collected from the participants over the 14-month period that *the Research Alliance* operated. Researchers collected the *alliance* members' attitudes and perceptions of teamwork and individual performance once during the first three months of the project (T1 – early development stage). While team project performance data were also collected nine months into the project at T2, we did not collect individual performance data, network data, or attitudinal data at this midpoint. During the last four months of the project, the attitudes and perceptions of teamwork and individual performance were measured a second time (T3 – late development stage). At this third measurement period, the *alliance* members also reported their formal and informal communication relationships using a communication relationship directory we provided to them. Hence, our analyses focus on the early development stage (T1) and the late development stage (T3).

Eighty-five percent of the *alliance* participants (N = 52) completed the requisite surveys for this study at T1 and T3 (N = 44)[2]; the participants were 61 percent male, ranging in age from 28 to 61 (M = 44.92). To ensure that no additional factors regarding team composition and the participants' individual characteristics were significant influences upon the study variables, we examined the basic team composition characteristics. We first ran a *t*-test with sex as the factor and included all of the study variables from T1, T3, and Δ T3-T1 variables. Results indicated that sex of the participants was not significantly related to any of study variables over time at the $p < .05$ level. Likewise, we looked at the correlation between age and the study variables and found no significant relationships at the $p < .05$ level. Finally, we looked at team size and found a

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[2] The final N used in the analyses was 44 using listwise deletion. Because the project sponsors functioned as a team and interacted with all teams regularly to help manage the project, we treated the administrative support team as a team in the data set. The administrative support team completed the same measurement instruments and received individual performance scores similar to the 11 project teams.

significant negative correlation between team size and conflict at T1 (r = -.37, p = .01) and team size and formal degree centrality (r = -.44, p = .003), showing that smaller teams reported a higher level of conflict and formal degree centrality. Team size was not significantly related to our outcome measure—individual performance—at T1, T3, or Δ T3-T1 (r = .12, p = .44, r = .24, p = .13, and r = .09, p = .55, respectively); as a result, we did not include the team size variable in the path model.

Communication Network Measurement

Network Relationships. At T3, we measured the distribution of each participant's communication relationships within the *Research Alliance* in two ways: formal connections were defined as communication among the alliance members for project-related matters (task and process); informal connections were defined as communication among the alliance members for nonproject-related matters (social). To ensure accuracy in collecting network data and to aid the participants in recalling their communication relationships, we provided the participants with an alphabetized directory of all *alliance* members listed by research team and institution. As such, we tested the extent of each participant's dyadic connections not only within her/his team toward only the end of the project but also to the alliance members as a whole. By collecting network centrality at T3 only, we are treating network position as an explanatory variable (Tarling, 2009) that defines each network member's connections as finite at a point in time. In the model, we use the current network (T3) position as the starting point to assess the changes that occurred to network members' attitudes about their team and their individual performance.

Network properties. We defined a network linkage as any reported connection in the alliance network directory between two network members, regardless of reciprocity. To provide a full range of perceived relationships in a network, a relationship did not have to be reciprocated for a connection to exist between two members. While prior network research has shown that asymmetric relationships can be unbalanced regarding the power held by members (cf. Johnson, 1993; Shah, 1998), the network calculations performed in UCINET 6.0 (Borgatti, Everett & Freeman, 2002) indicated 85.72 percent of the reported formal relationships and 83.98 percent of the informal relationships recorded in this study were reciprocated, minimizing any such concerns.

Degree Centrality. With UCINET 6.0, we calculated the normalized degree centrality – the degree of each member divided by the maximum possible degree expressed as a percentage. Because the network data is binary, we used the normalized values (Borgatti, et al., 2002). Degree centrality as we derived it and used it, offers a measure of each individual's dyadic contacts in the network, thereby showing how many people in the network each individual is directly connected to.[3]

Survey Measurement

Survey measures evaluated team members' perceptions of team cohesiveness and team conflict at two points in time: during first three months (early development stage) and last four months (late development stage) of the project. The measures of conflict and cohesion were individual reactions of team members' to their team. Participants indicated their level of agreement with each scale item on a five-choice metric (5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, and 1 = strongly disagree). A complete listing of survey items used is presented in Table 1.

Cohesion. Cohesion was measured using a nine-item scale adapted from Stokes (1983). Cohesion measures team members' perceptions of "closeness" among other team members and satisfaction with their team membership. The

[3] Considering the correlations among the centrality measures were high– all above .80– for both the formal and informal networks **(**the correlation between the formal and informal network measures is lower**)**, we selected degree over closeness and betweeness centrality because we were interested in capturing the extent each network member was connected to others in the network, given the teams were already geographically dispersed. In addition, perceived closeness seems to represent an important factor in cohesion (e.g., Pavitt, 1998), which is included as a major measure in this study.

reliability for the cohesion measure was $\alpha = .96$ and $\alpha = .90$ at T1 and T3, respectively.

Conflict. Conflict was measured using an eight-item scale developed specifically for this investigation. From the conflict themes identified by Jehn (1997), keywords were adapted to describe potential conflict concerning project-related work only. Specifically, terms from the "procedural conflict" and "task conflict" dimensions were utilized to develop each question. The reliability for the conflict measure was $\alpha = .95$ and $\alpha = .90$ at T1 and T3, respectively.

To ensure that the cohesion and conflict scales were psychometrically sound, we performed a principal components factor analysis with a Varimax rotation with the T1 data. The rotated matrix revealed two distinct factors explaining 75.29 percent of the variance, without any notable cross-loadings. The scale items demonstrated strong homogeneity within each scale and strong heterogeneity between the two scales. In concert with the reliability coefficients for each scale at T1 and T3 reported above, we believe the scales consistently measured the constructs presented (see Table 1).

Team-member individual performance. To assess individual-level performance, each team member rated his or her own performance, the performance of each team member, and his or her team leader. Along with the perceptual measures described above, these ratings were performed at two points in time: three months after the start of the project (T1 – early development stage) and during the last four months of the project (T3 – late development stage). Based on a 12-question rating form, individual performance scores for each participant were represented by the arithmetic mean of the combined ratings of his/her own performance, the ratings from his/her teammates, and the Director of the *Research Alliance* across all items using a five-point scale (5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, and 1 = strongly disagree). On a team of four members, each team member would be rated five times; this procedure provided a total of 333 matched performance evaluations at T1 and T3 for the 52 alliance participants. To check the measurement properties of this scale, we ran an exploratory factor analysis on the 12 items using the T1 data, which yielded a single factor in one iteration, explaining 79.94 percent of the variance. The Cronbach's α for the scale was .97, showing the raters reacted to and used the performance ratings consistently to evaluate fellow *alliance* members. A listing of the individual performance measures and the results of the factor analysis are presented in Table 4.

Analyses

Network data. The network relationships were recorded in a 52x 52 matrix, where a relationship between two individuals was recorded as a "1," and a nonrelationship was recorded as a "0." As noted above, the data matrix was symmetrized and analyzed using UCINET 6.0 (Borgatti, et al., 2002) to yield the normalized network degree centrality data.

Path Analysis. The model presented as Figure 1 and its related hypotheses were tested using maximum likelihood path analysis with the AMOS subroutine in SPSS version 23 to assess the proposed relationships among the variables. To account for measurement error, we fixed the proportion of error variance at 1.0 based on the high-scale reliabilities (Hayduk, 1987), and we allowed the exogenous variables, informal centrality and formal centrality, to co-vary in the model. We allowed the error terms to correlate among those specified in the model, with no unspecified relationships in the path model correlated in the model. The latent model was assessed for fit using global chi-square tests of difference and AGFI, NFI, and RMSEA fit statistics; the model was examined for significant deviations from the data, in that a good fit of the model to the data was characterized by nonsignificant deviations at the $p = .05$ level, AGFI and NFI statistics above .90, and RMSEA below .05. Finally, we examined the modification indices to ensure that unspecified (not hypothesized) links in the model were not significant influences that negatively impacted the models' fit to the data. Each path coefficient was tested for significance at the $p < .05$ level, by examining confidence intervals around the path coefficients.

Design Considerations

Common-method variance. To address the problem of common-method variance and subsequent percept-percept inflation, we collected data from several different sources (Campbell & Fiske, 1959; Crampton & Wagner, 1994). For the independent variables, *alliance* members provided perceptual data via a self-report instrument and communication network data using a communication network relationship directory. As such, the survey measures and the network measures collected different types of responses to the participants' perceptions of their team and the *alliance* participants. Specifically, the survey data provided a subjective interpretation of the participants' reactions to their teams and the work in the *Research Alliance*; the self-report communication network data provided an objective description of individuals' perceptions of their dyadic communication relationships (Richards, 1985).

The project sponsor collected the team-member performance data separately from the network and attitudinal data. As noted above, to measure individual performance as the outcome variable, each member's individual performance was created by aggregating the following: (1) self-reported performance, (2) performance ratings by team members (including the team leader), and (3) a performance rating conducted by the Director of the *Research Alliance.* The combination of self-report perceptual measures, along with more objective reports of communication relationships in concert with the multi-source individual performance data, led to the use of three distinct types of data in this investigation to minimize concerns that might arise from common-method variance.

<u>Data centering</u>. Because the analyses are conducted at the individual level, we recognized and accounted for the effects of performance based on team

membership in the *alliance.* To account for the unique variance at the team level, we centered the individual performance scores for each team member based on his/her team mean. This procedure was done because when we ran the intra-class correlations (ICC[1]; Bliese, 2000) on the data looking at the impact of team membership on individual performance, we discovered that a notable portion of the variance associated with individual performance was explained by team membership (ICC [1] = .21). Centering removed the effect of team membership from the individual performance scores (Heck, Thomas, and Tabata, 2012; Snijders & Bosker, 2012) and allowed us to model all the data at the individual level, with our final listwise sample of N = 44 respondents (Bommer, Rich, & Rubin, 2005).[4]

Change scores. One of our primary objectives was to assess how changes in team members' perceptions regarding their team related to changes in their performance over time. As such, we computed change scores for each participant's cohesion, conflict, and individual performance by subtracting his/her scores at T1 from T3 (henceforth referred to as Δ cohesion, Δ conflict, and Δ

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[4] As noted by an anonymous reviewer, this data set could be analyzed using hierarchical linear modeling (cf. Snijders & Bosker, 2012; Yuan, Fulk, Monge, and Contractor 2010). However, we elected to model the data at the individual level to preserve sample size and gauge individuals' reactions to, and individual performance in team-based work, and hence, we did not consider any team-level variables in our model.

individual performance, respectively). We did not collect communication network data at T1, so network centrality in the model represented the participants' extent of dyadic contacts at the close of the project (T3 only).

The decision to use change scores was not an easy one given the debate on how to model longitudinal data in studies of this type (Allison, 1990; McArdle, 2009). Because we are interested in looking at how the variables of interest changed over time and how they were connected to one another, we opted to follow the established process outlined by Allison (1990). Allison offers two main arguments against the use of change scores: they are (1) unreliable and (2) regress toward the mean from the pretest to the posttest. Since it's possible to calculate the reliability of change scores, we can determine if the change scores in our case are indeed reliable, and Kenny (1975) and Kenny and Cohen (1980) argued that when comparing two or more stable groups over time, regression toward the mean is not problematic. To ensure that our change scores were reliable, we calculated the reliability for our three change scores using the formula provided by Allison. First, the items must be consistently reliable (which we present above) and have similar variance, which we present in Table 3.

As depicted below, the formula calculates the reliability of $Y_3 - Y_1$ with Y as the variable of interest as T3 minus T1. The correlation between Y_3 and Y_1 (depicted as $\acute{p}_{13}$) is subtracted from the common reliability (depicted as $\acute{p}^1{}_y$; Cronbach's α from T1) in the numerator and divided by 1 minus the correlation between $\acute{p}_{13}$.

The reliability of the change scores is all very solid (Δ cohesion = .86, Δ conflict = .94, and Δ individual performance = .85), suggesting it is appropriate to use the change scores among these variables in subsequent analyses (Allison, 1990).

$$\boxed{\text{Reliability } \; Y_3 - Y_1 = \frac{\acute{p}^{1}_{y} - \acute{p}_{13}}{1 - \acute{p}_{13}}}$$

To further demonstrate the validity our statistical choice to use change scores per Allison's (1990) recommendation, we ran a set of eight regressions with performance as the outcome variable.

With <u>Regression 1,</u> we treated performance$_{t3}$ as the dependent variable, without using the change scores at all: first we entered cohesion$_{t1}$ and cohesion$_{t3}$ as the independent variables. This equation was marginally significant (F [2, 41] = 2.35, p = .10). The coefficient for cohesion$_{t1}$ was significant in model (Beta = .42, p = .05); the coefficient for cohesion$_{t3}$ was not (Beta = -.16, p = .46). We next entered performance$_{t1}$ as an independent variable into the model to control for the effect of performance$_{t1}$. This equation was significant (F [3, 40] = 26.35, p < .001). Neither cohesion$_{t1}$ nor cohesion$_{t3}$ were significant in this model with performance$_{t1}$ added in (Beta = -.16, p = .30 and Beta = .20, p = .11, for cohesion$_{t1}$ and cohesion $_{t3}$ respectively), but performance$_{t1}$ was significant (Beta = .85, p < .001).

With Regression 2, we entered performance$_{t3}$ as the dependent variable, using the change scores for the independent variable only: first we entered Δcohesion$_{t3-t1}$ as the independent variable. This equation was marginally significant (F [1, 42] = 2.64, p = .11, Beta = -24, p = .11); next, we entered performance$_{t1}$ as an independent variable in the model to control for the effect of performance$_{t1}$. This equation was significant (F [2, 41] = 40.83, p < .001). cohesion$_{t3-t1}$ was not significant in model (Beta = -.13, p = .20), but performance$_{t1}$ was significant (Beta = .87, p < .001).

Regression 1 and Regression 2 show that controlling for performance$_{t1}$ is beneficial. This procedure can be done by entering it into the equation as an independent variable or by subtracting the effect of T1 from T3 (our change scores).

For Regression 3, we treated performance$_{t3-t1}$ as the dependent variable, using the change scores for both the dependent variable and the independent variable (*tested and reported in Figure 2*); we entered Δcohesion$_{t3-t1}$ as the independent variable. This equation was significant (F [1, 42] = 9.17, p = .004), and the coefficient was significant in model (Beta = .42, p = .004, for cohesion$_{t3-t1}$).

Similarly for Regression 4, we treated performance$_{t3-t1}$ as the dependent variable, using the change score for the dependent variable, but not the independent variable: we entered cohesion$_{t1}$ and cohesion$_{t3}$ as the independent variables. This equation was significant (F [2, 41] = 4.52, p = .02). Both coefficients were significant in model (Beta = -.61, p = .005 and Beta = -.51, p = .02), for cohesion_{t1} and cohesion_{t3} respectively.

Regression 3 and Regression 4 yield comparable results, showing that controlling for performance at T1 through the change score is beneficial and consistent with Allison's (1990) assertions. Additionally, the model yields similar results whether cohesion is treated as $\Delta\text{cohesion}_{t3\text{-}t1}$ or cohesion_{t1} and cohesion_{t3} is used in the model, showing that cohesion at each time period or the change score produce a similar effect overall.

To confirm these findings for conflict and performance, we ran Regressions 5-8 using the conflict variables. Results show that conflict is not significantly related to performance in any configuration. Controlling for performance at T1, however, was beneficial.

Results

Model Fit

The initial fit of the model, presented as Figure 2, was not strong overall (χ^2 [3] = 6.58, p = .09; AGFI = .73, NFI = .86, RMSEA = .17). While the χ^2 was not significant at the $p < .05$ level, the fit indices suggested an alternative model would provide a better fit to the data. A post-hoc examination of the modification indices suggested that we add a link between Δ cohesion and Δ conflict to the model. After adding this link in the model, the data fit the model quite well (χ^2

[2] = 1.04, p = .60; AGFI = .93, NFI = .98, RMSEA < .001). Descriptive statistics and correlations of the variables in the model are presented in Table 2 and the descriptive statistics and correlations of the variables in the model at T1 and T3 without the change scores are provided in Table 3.

Insert Figure 2 about Here

Insert Table 2 about Here

Insert Table 3 about Here

Hypothesis Tests

Degree centrality and changes in perceptions. In the revised model, informal degree centrality was positively but not significantly related to Δ cohesion (β = .18, *p* = .33), and positively but not significantly related to Δ conflict (β = .03, *p* = .87), thereby not providing support for Hypothesis 1a and Hypothesis 1b. Formal degree centrality was negatively and significantly related to Δ cohesion from T1 to T3 (β = -.42, p = .03), supporting Hypothesis 2a. Hypothesis 2b was not supported, as the link from formal centrality was not significantly related to Δ conflict (β = .04, *p* = .83).

As reported in Table 2, the mean formal degree centrality score across the participants was 35.46 ranging from a low of 4.80 to a high of 100, showing on average, network members communicated with 18.44 *alliance* members (.3546 * 52 members) to conduct their project work; the mean informal degree centrality score across the network was 20.31 ranging from a low of 2.33 to a high of 51.16, showing on average, network members communicated with 10.56 *alliance* members (.2031 * 52 members), representing a generally low level of informal connections in the network. [5,6] In the final model, informal and formal degree

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[5] We completed a one-way ANOVA with a multiple range Duncan test to determine if formal degree centrality differed notably across the 12 geographically dispersed teams in the *Research Alliance* and to identify any significant effects. Formal degree centrality was significantly different across the 12 teams at the $p < .001$ level (F [11, 32] = 5.06, $p < .001$), with means ranging from 15.12 to 92.97. A closer look through the Duncan multiple range tests revealed that the significant difference emerged from the team of project administrators, who had significantly more communication interaction in the *alliance* by design (92.97). The other 11 teams did not differ significantly from one another at the $p < .05$ level. In addition, we examined the communication interaction for the 12 team leaders in the network compared to the nonteam leaders for all the variables at T1, T3, and the ΔT3-T1. As one would expect (c.f., Galanes, 2003; Zaccaro, Rittman, & Marks, 2001), the team leaders, on average, had a higher level of both formal and informal degree centrality in the network compared to the team members (formal: t [42] = -2.53, p = .02; M = 48.33 and M = 30.62, for team leaders and team members, respectively and informal: t [42] = -3.40, p = .001; M = 30.04 and M = 16.67, for team leaders and team members, respectively). Team leaders and nonteam leaders did not differ significantly on any of the other measures at the $p < .05$ level.

centrality explained 11 percent of the variance (reported as R^2) in Δ cohesion and 15 percent of the variance in Δ conflict.

As noted in Table 3, at the individual level, cohesion went up from T1 (M = 3.13) to T3 (M = 3.44) and conflict went down from T1 (M = 3.00) to T3 (M = 2.23), which was reflected in the change scores presented in Table 2 (M Δ cohesion = .31; M Δ conflict = -.78). This finding shows that over time, individuals perceived more cohesion in their groups while they perceived less project-related work conflict.

Changes in perceptions and changes in performance. Hypothesis 3 was fully supported as the link between Δ cohesion and Δ individual performance was positively and significantly related ($\beta = .47$, $p < .001$). Hypothesis 4 was not supported as the link between Δ conflict and Δ individual performance was not significant ($\beta = .13$, $p = .39$). While the average score for Δ individual performance was modest (M=.24) in the final model, Δ cohesion and Δ conflict explained 19 percent of the variance in Δ individual performance.

Post-hoc analyses. As suggested by the modification indices, the link between Δ cohesion and Δ conflict was negative and significant ($\beta = -.36$, p

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[6] As with formal degree centrality, we completed a one-way ANOVA with a multiple range Duncan test to examine if informal degree centrality differed notably among the teams. Informal degree centrality was not significantly different across the 12 teams at the $p < .05$ level (F [11, 32] = 2.05, $p = .06$), with means ranging from 6.98 to 37.30.

= .02). The addition of this post-hoc link increased the variance explained in Δ conflict from an R^2 = .03 to an R^2 = .15 and slightly decreased the variance explained in Δ individual performance from an R^2 = .22 to an R^2 = .19. As noted above, this additional link significantly improved the overall fit of our model. The implications of this additional link will be addressed below.

Discussion

Through this study, we examined the interaction of a set of researchers from 12 intact project teams representing 11 universities collaborating on interuniversity projects. A model of team-member interaction was presented and tested at the individual level to include an examination of team member's communication network relationships, individual perceptions of teamwork and the team process, and team member performance over time. The slightly revised model presented as Figure 2 produced a solid fit to the data and identified the magnitude and significance of the posited relationships in the model.

Communication Network Influences

The static network variables of informal and formal degree centrality, as measured, showed mixed results as antecedents of changes in cohesion and conflict. Formal degree centrality had a significant effect in the model, showing that those who had lower centrality scores at T3 reported an increase in cohesion from T1. Consistent with Granovetter's (1973) weak-ties argument, this finding might suggest that limiting ones' connections to others in the network allows members to interact more frequently, intensely, intimately, and reciprocally in existing project team-based relationships, thereby providing a more cohesive network. This set of findings show that connections to others in the *alliance* for nonproject-related communication had little impact on how the team members characterized relationships with one another and dealt with disagreements in their teams.

Communication networks and performance. Even though our network measures of formal and informal degree centrality were not modeled to directly influence team member performance (and were not significantly correlated, r = -.14 and r = -.25, for informal and formal centrality, respectively), several studies have found a strong connection between network position and performance. Specifically, Cross and Cummings (2004) found that as team members become embedded in the network in a number of different ways, network centrality relates positively to individual performance. Jen (2013) found that central individuals in a task conflict network had higher job performance (actual and perceived) than individuals with lower centrality. Sarker et al.'s (2011) research indicated that trust centrality related positively to performance and mediated the relationship between individual communication centrality and performance in globally distributed teams. In short, work groups that communicate frequently, both within and outside its group, demonstrate higher performance than groups with less intragroup and external communication (Cummings, 2008). Therefore, communication network relationships remain an important part of the team process and should continue to be examined in future studies.

Team Members' Perceptions

Δ cohesion and Δ individual performance. Changes in cohesion from T1 to T3 proved to be a significant antecedent of Δ individual performance. This result shows that as team members built cohesion over the course of completing their project work, team members' individual performance increased as well. This finding is consistent with other research that confirms a positive relationship between team cohesion and individual performance in self-managed teams (Stewart, et al., 2012), team cohesion and team productivity (Stvilia et al., 2011) and team performance in project teams (Yang & Tang, 2004), supporting Stokes' (1983) early contention that cohesion is often associated with instrumentality in teams. As team members perceive high levels of closeness to one another, members might have a strong desire to exchange information and exert the required work effort, thereby creating valued interaction among team members that positively influences the outcome of such exchanges (Feeley, 2000; Haythornthwaite & Wellman, 1998; Seers, 1989).

Because many of the project team participants were geographically dispersed and rarely, if ever, met in settings that facilitated direct face-to-face communication, the participants relied mainly on conference calls and e-mail to conduct their team activities. Despite the communication challenges associated with distributed teams, members can perform well in such situations if they model effective communication practices and have high teamwork self-efficacy (Staples & Webster, 2007). Given the geographic dispersion of team members and the notable difference in how informal degree centrality and formal degree centrality related to cohesion and conflict among these team members, task-based cohesion rather than interpersonal cohesion is most likely driving the noted relationships with the team members.

Δ conflict and Δ individual performance. Changes in team conflict from T1 to T3 were not significantly related to team member performance in the model, contrary to expectations and previous findings in the literature (c.f. De Dreu & Weingart, 2003; although the meta-analysis examined team performance, not individual team member performance). What emerged from the analyses was a significant inverse relationship between Δ cohesion and Δ conflict. Consistent with our findings, De Dreu and Weingart found a strong negative connection between task conflict and team member satisfaction, which is a proxy for team member cohesion (Stokes, 1983). From a practical standpoint, the relationship makes sense. As team members in the *Research Alliance* built cohesion from T1 to T3, they likely experienced less conflict at the same time. While Δ conflict itself was not predictive of performance in our model, it acted as a gauge of how cohesion was developing over time for the team members. Because changes in cohesion, conflict and performance were not perfectly correlated, the study benefitted from having different metrics to capture team member's reactions to their team and teamwork over time.

Δ cohesion and Δ conflict

The post-hoc link between Δ cohesion and Δ conflict was significant in the model, showing a strong inverse relationship between changes in cohesion and conflict over time. Considering team cohesion tends to increase when team members develop more trust in globally distributed teams (Garrison e al., 2010) and team conflict is more likely to exist in low trust situations (Simons & Peterson, 2000), trust might influence both of these team processes. Furthermore, among top management teams, affective conflict–framed as personal disagreements among team members–related negatively to team member cohesion (Ensley, Pearson, & Amason, 2002), and among sports teams, negative conflict styles–criticism and topic shifting– related negatively to team members' intra-team cohesion (Sullivan & Feltz, 2001). Overall, our findings from the post-hoc analyses suggest that team task conflict and cohesion measure different but related team processes and should be modeled as such.

Limitations

The project sponsor formed the *Research Alliance* and its membership to meet particular goals, which was not designed specifically for us to conduct this investigation. Because we conducted a field study, we could not directly control the size and breadth of the sample, resulting in a relatively small final sample of

12 teams and 44 participants, using listwise deletion of missing cases. To strengthen the power of our study, we would have preferred a larger set of teams that would allow for analysis at the team level.

Considering we chose to examine the data at the individual level to maximize the sample size for the analyses, we are unable to draw conclusions for certain elements from the team-based and network-based interaction. It is likely that multi-level analyses—as in the study conducted by Yuan et al. (2010)—could offer even greater insight into the functioning and interaction within and between the project teams we studied.

Because we were interested in examining the relationship among individuals' network position, perceived cohesion and conflict, and performance, we could have bolstered the explanatory power of each participant's network position by collecting information from her/him on the strength of each network relationship. It is quite possible that signed or weighted communication connections could have better described team members' perceptions of both cohesion and conflict in our model. Future investigations of this type should consider collecting richer network data to better model the influence of both formal and informal network connections.

Last, with this longitudinal data, and how we modeled it, we were hypothesizing that communication network connections at the end of the project (T3) are connected to network members' changes up to that point. The network connections each member holds at T3 can be causally related to changes that occur at that point. In doing so, we treated network position as an explanatory variable in our model (Tarling, 2009), which can vary over time, but tends to be more static or representative of a condition rather than a state (other examples of explanatory variables in longitudinal research are elements such as marital or employment status). Our model does not reflect how the network changed for each member, which represents a limitation in this investigation. Collecting network data at T1 could have provided additional insight about these changes. We do, however, capture how network members' attitudes and performance changed relative to their static network position captured at T3.

Conclusion

This investigation examined individuals' team-based interaction from three distinct yet interrelated perspectives. By looking at dyadic communication network structure, longitudinal measures of team members' individual perceptions of their teams and team processes, and longitudinal measures of team member performance, we found three significant findings to further our understanding about how individuals engage in a network of geographically distributed project teams:

First, formal degree centrality was negatively related to changes in team members' perceptions of cohesiveness with their team. This finding shows that increases in degree centrality in the formal project network lead to smaller changes in cohesion within their team—a likely outcome when individuals interact with more members in the network beyond their immediate team membership. Although having weak ties outside one's team can provide access to new information and relate positively with individual performance over time, for individuals in geographically distributed teams (Odom-Reed, 2007), these ties can reduce cohesion by decreasing members' attachment to their group (McPherson et al., 1992).

Second, changes in cohesion were strongly and inversely related to changes in team conflict. While we did not initially hypothesize this link in our model, this post-hoc relationship suggests that as project teams develop over time, the team members develop concord with their teammates and perceive less potential conflict about their team project work.

Finally, individuals' perceived team cohesion related positively with team members' performance over time, showing that team members' performance improved and stabilized as perceptions of cohesion increased. This finding is consistent with other studies of teams (cf. Stewart, et al., 2012; Stvilia et al., 2011; Yang & Tang, 2004), thereby suggesting that individuals' perceptions of "closeness" and satisfaction with their teams might serve as a valuable mechanism in enhancing individual performance.

Altogether, this longitudinal sample of individuals from geographically dispersed project teams provided us with an opportunity to examine how individuals interacted with one another to engage in their project-related work.

Our study seems to suggest that certain perceptions, particularly one's closeness with other team members, are connected to team member performance over time.

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Table 1

Attitudinal Survey Items and Factor Loadings

	Factor 1	Factor 2
Cohesion Items [a]		
1. Most of my team members fit what I believe to be the ideal team member.	**.82**	-.28
2. I feel that I am sufficiently included by my team in all the team's activities.	**.77**	-.41
3. I find most of the activities in which I participate as a member of this team rewarding.	**.82**	-.33
4. If the members of my team decided to dissolve the team by leaving, I would you try to dissuade them.	**.79**	-.28
5. If asked to participate in another project like this one, I would like to be with the same people who are in my current team.	**.82**	-.25
6. Currently, I like the team I am working with.	**.86**	-.29
7. I think our team meets frequently enough.	**.75**	-.35
8. I feel that working with this particular team enables me to attain my personal goals for which the team was formed.	**.88**	-.23
9. Compared to other teams, my team works well together.	**.80**	-.34
Conflict Items [b]		
1. I often disagree with my research team members' decisions made on our project.	-.34	**.73**
2. My team consistently agrees upon the goals of our project. [b]	-.38	**.74**
3. My team shares a similar viewpoint regarding the tasks performed on our project. [b]	-.24	**.87**
4. Team members are encouraged to freely express their opinions regarding our project.	-.26	**.80**
5. I believe that the workload is fairly distributed among my team members on this project. [b]	-.45	**.73**
6. My team members disagree about each member's individual project responsibilities.	-.32	**.82**
7. Each team member's responsibilities on our project are clearly established. [b]	-.39	**.81**
8. My team members frequently contradict one another in regard to our team project.	-.16	**.88**

Notes: Listwise N = 44**;** [a] Adapted from Stokes 1983; [b] Denotes an item asked in reverse format

Table 2
Descriptive Statistics and Correlations

Variable	Mean	SD.	(1)	(2)	(3)	(4)	(5)
(1) Informal Degree Centrality	20.31	12.97	-				
(2) Formal Degree Centrality	35.45	22.23	.65**	-			
(3) Δ Cohesion (T3-T1)	.31	.67	-.09	-.30*	-		
(4) Δ Conflict (T3-T1)	-.78	.99	.09	.17	-.38*	-	
(5) Δ Individual Performance (T3-T1)	.24	.55	-.14	-25	.42**	-.05	-

Listwise N = 44

* = p < .05

** = p < .01

Table 3

Descriptive Statistics and Correlations of the Variables at T1 and T3

Variable	Mean	SD.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Informal Degree Centrality	20.31	12.97	-							
(2) Formal Degree Centrality	35.45	22.23	.65**	-						
(3) Cohesion T1	3.13	.94	.42**	.38*	-					
(4) Cohesion T3	3.44	.85	.40**	.18	-.72**	-				
(5) Conflict T1	3.00	.89	-.26	-.25	-.65**	-.46**	-			
(6) Conflict T3	2.22	.59	-.24	-.08	-.40**	-.57**	.13	-		
(7) Individual Performance T1	4.08	.92	.20	.34*	.37*	.07	-.30	-.20	-	
(8) Individual Performance T3	4.32	.69	.16	.25	.30*	.14	-.29	-.18	.81**	-

Note: The network centrality measures were only collected at T3; Listwise N = 44; * = $p < .05$, ** = $p < .01$

Table 4 – Team Member Individual Performance Items

To what extent does/did this team member:	Factor Loadings
1. Communicate information clearly?	.86
2. Offer constructive criticism?	.85
3 Remain current in their self-stated area of expertise?	.88
4. Make valuable contributions to team discussions?	.94
5. Accept constructive criticism well?	.92
6. Meet deadlines?	.83
7. Allocate sufficient time to work on the *Research Alliance* project?	.91
8. Regularly attend team conference calls/meetings?	.89
9. Provide useful solutions to research related questions?	.94
10. Contribute equitably to the research proposal development process?	.95
11. Equitably contribute to the research plan development process?	.92
12. Contribute to the overall team success?	.85

Note: N = 333 performance ratings. A single factor emerged explaining 79.94 percent of the variance; the solution was not rotated because only one factor emerged.

Figure 1

Hypothesized Model of Project Team Interaction

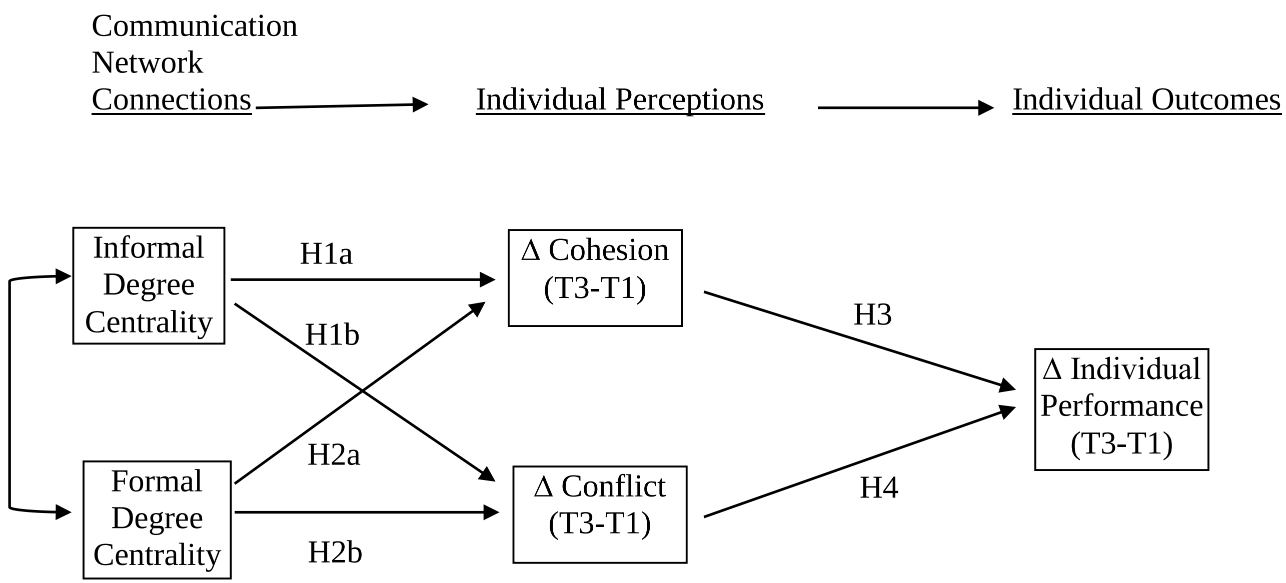
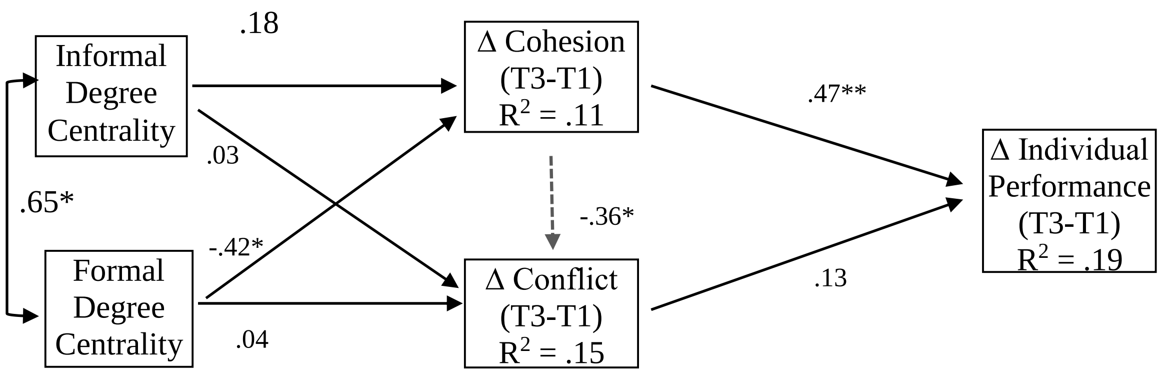


Figure 2
Tested Model of Team Interaction



Note: Path coefficients are standardized; the adjusted R^2 appears inside the box below the variable name, indicating the amount of variance explained in the variable by its antecedents. The dashed line between conflict and cohesion was added as a result of the post-hoc analyses. Listwise N = 44

* = $p < .05$
** = $p < .01$