FORMAL AND INFORMAL WORK GROUP RELATIONSHIPS WITH PERFORMANCE: A MODERATION MODEL USING SOCIAL NETWORK ANALYSIS

THESIS

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Abstract

Social networks have recently emerged in the management discipline as a unique way of studying individuals and groups in organizations. While traditionally used in the analysis of un-bounded networks, applying social network analysis techniques to bounded work groups and organizational teams has become increasingly popular. Past research has established relationships between in-degree social network centrality and individual performance as well as social network density and overall group performance. This field study, conducted at a military training course, attempted to further refine this social network–performance relationship by modeling characteristics of both the formal and informal work group networks in relation to performance at the individual as well as group levels. A sample of 406 students in 28 groups showed empirical evidence that individual performance is positively related to centrality in the formal social network while a negative relationship was found between performance and centrality in the informal social network.

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<div align="right">Benjamin R. Knost</div>

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ANALYSIS

1. Introduction

With more and more organizations adopting a team based organizational structure

to accomplish critical tasks, the understanding of group and team dynamics is at a

premium (Gersick, 1988; Jehn & Mannix, 2001). Group research dates back to the

Hawthorne studies of the late 1920's, which showed that the external working conditions

for the employees were not nearly as important as the psychological and social conditions

introduced by the establishment of a group (Roethlisberger & Dickson, 1939). A

different study involving coal miners undergoing a change from small close-knit work

groups to large separated work groups showed a sharp decline in productivity in the

absence of the established group dynamic (Trist & Bamforth, 1951). A third classic

study, by Coch and French (1948), showed that individual behavior and group

productivity are powerfully affected, for better or for worse, by organizational changes

that alter the group in which the individual works. These studies as well as countless

other empirical studies since then (for review see Guzo & Dickson, 1996) showed that

group structure has a direct impact on the performance of that group. Since then,

researchers have been attempting to pinpoint the specific variables that lead to work

group effectiveness (Hackman, 1973). Understanding the work group characteristics that

lead to higher performance is invaluable to organizations and managers who rely on these groups to accomplish their goals and objectives.

In recent years, social network research has surfaced in the management discipline as a way to look at individuals, groups and organizations in a unique way. Social network research utilizes a distinct perspective which focuses on the relationships between actors, whether they are individuals, work units, or organizations. Social network researchers argue that actors are embedded within a network of inter-connected social relationships that provide opportunities as well as constraints on behavior (Brass, Galaskiewicz, Greve & Tsai, 2004). Social network analysis examines the interactions between actors in given environments and has been used in a variety of social science domains such as psychology, sociology, anthropology, political science, and communications to include individual and group behavior (Renfro, 2001). While the bulk of social network research is concerned with networks that span group and organizational boundaries, there has recently been more emphasis on using these techniques to analyze the interactions within bounded groups such as work groups and organizational teams (Sparrowe, Wayne & Kraimer, 2001; Baldwin, Bedell & Johnson, 1997; Yang & Tang, 2004; Reagans & Zuckerman, 2001; Cummings & Cross, 2003).

The associations represented within the structure of social networks can encompass formal relationships such as office organizational structure or informal relationships such as who engages in social activities with whom after work. Documenting and distinguishing the relationships between members in a group in differing contexts is a crucial step for any organization wishing to understand and better manage itself and may provide organizational researchers with insight into the

characteristics that lead to positive or negative performance (Cross & Parker, 2004).

Knowledge, information, experience, positive and negative feelings can all flow through

the communication in a network, shaping the experience of the individuals involved, as

well as impacting how these individuals as well as the network as a whole perform

(Sparrowe et al, 2001).

Existing social network research demonstrates empirical relationships between a

variety of social network characteristics and instrumental outcomes in work groups. At

the individual level, centrality, or the degree to which an actor is connected with the rest

of the network, has shown to be positively related to performance (Baldwin et. al., 1997;

Sparrowe et. al., 2001; Yang & Tang, 2004). This idea is consistent with a group

research phenomenon termed "social capital" where the connections and relationships

that a person builds with those around them are assets that give that individual access to

knowledge and information they would not otherwise have (Putnam, 1993). At the group

level, the density of a social network, or the total connectedness between actors in a

network, characterizes the degree of cohesiveness between the members of that network.

Especially true of studies involving the networks within defined work groups, the density

characteristic parallels the construct of work group cohesion (Degenne & Forse, 1999)

which meta-analyses have shown to increase group performance (Evans & Dion, 1991;

Gully, Whitney & Devine, 1995; Carless & De Paola, 2000; Carron, Coloman, Wheeler,

& Stevens, 2002; Oliver, Harman, Hoover, Hayes & Pandhi, 1999).

While social network research has produced promising results in the study of

work group effectiveness, there is a lack of studies exploring the simultaneous effects that

different types of networks (formal and in-formal) have on a group's end performance.

To date, each study measuring social network characteristics in relation to work group performance (e.g., Yang & Tang, 2004; Cummings & Cross, 2003; Sparrowe et. al., 2001, Baldwin et. al., 1997), has considered only the basic relationship between an individuals' position in a network or a single network's characteristics and the individuals' or groups performance. While the type and complexity of tasks that actors in a network perform have historically been used as moderators in network research (Brass, 1981; Roberts & O'reilly, 1979), none of the intra-group network studies has explored the moderating effects that formal and in-formal social networks may have on one another.

The goal of this research is to further the use of social network analysis in the study of work groups by testing the interaction between formal and in-formal social networks in relation to both individual and group performance. A discussion of social network analysis, its use in studying groups, and the proposed interaction model and hypothesis is included in the following section.

2. Literature Review

2.1 Introduction

Before discussing social networks in the study of groups it is necessary to establish the fundamentals of social network analysis to ease the interpretation of future arguments and presentation of models.

2.2 Introduction to Social Networks

While group researchers view groups as entities, social network analysts view them as a series of relationships between members. Social network analysts and researchers have developed methods to quantify these connections and relationships between people. There are numerous network characteristics that have been quantified with the most prolific of these being degree centrality and density (Scott, 2000). Degree centrality is a measure of how central an individual is in the communication pattern within a network, while density is a measure of the overall communication between individuals in the network. Degree centrality can be viewed from the perspective of the ego (i.e., individual), meaning how many of the alters (i.e., group members) do they claim to have connections (i.e., degrees) with; this is known as out-degree centrality (Knoke & Burt, 1983). In-degree centrality is a measure of how many alters claim to have a connection with a given ego (Knoke & Burt, 1983). The greater number of connections that an actor has in a network, whether looking at in-degree or out- degree connections, the more central that person is said to be. Density is simply an aggregation of the connections within a network, expressed as a ratio or percentage of reported connections in a network divided by the number of possible connections (Degenne & Forse, 1999).

Social network data can be represented in a number of ways. Moreno (1934) began representing these networks through the use of sociograms. A sociogram is a pictoral representation of the interactions between actors in a network. The individual actors (be it individuals, groups of organizations) are termed nodes and are seen as circles whereas the relationships between them are termed ties and are seen as lines (Moreno, 1934). The ties between members of a network can be directed, undirected or valued (Scott, J., 2000). Directed sociograms include arrows on the tie between actors indicating the direction of the relationship. If X claims to have a relationship with Y, but Y does not claim to have a relationship with X, the arrow would be unidirectional; from X to Y. Should they claim a mutual relationship, the arrow would be bidirectional. Undirected graphs merely show a tie if either party indicates a relationship. In addition to direction, the strength of the relationship can be included by using a valued scale to elicit not only the existence of a relationship but the extent of it (Newman, 2004).

Social networks can be defined in a number of different ways, and can exist in a variety of contexts and on many different levels (Brass et. al., 2004). They can exist in the forms of sports teams, church groups, personal friends and past acquaintances amongst others. Within these network contexts, the strength and nature of the relationships may differ as well. A network comprised of past acquaintances will most likely be large compared to a network of close personal friends. A network defined as those from whom you seek personal advice may be different than one defined as those from whom you seek professional or career related advice. There is no set number of networks and the same individual may be a member of a number of different networks (Degenne & Forse, 1999). With the ability to analyze different types of networks

generated from the same group of individuals, social network analysis techniques will be used in this study to incorporate multiple networks into the same model.

While the criteria from which a social network can be formed are numerous, two major classifications exist in the social network literature: formal and informal (Scott, 2000). Formal networks represent the non-discretionary relationships that people are required to maintain in order to complete interdependent tasks in established organizational processes. Examples include personnel in a marketing department who are required to obtain approval from the legal department before running a new advertising campaign, or architects consulting with engineers before starting construction on a new building. In either case, these individuals are required to maintain relationships with others in order to satisfactorily complete the job that is required of them.

Informal networks represent discretionary relationships that actors seek out regardless of what the organizational chart or organizational policies say. Informal networks may exist between co-workers who share similar interests outside of work, or engage in the same extracurricular activities. Informal networks can also exist completely apart from the workplace. Members of a certain club may or may not work in the same profession.

Individuals may also be members in overlapping social networks. For example, while the architect and engineer are required to work together in the design and construction of a building, they may also play golf together on the weekends. Their interaction on the golf course would be a part of their informal network while their interaction at work would be a part of their formal network.

2.3 Social Networks and Individual Performance

While there is a large body of literature involving social networks and network analysis techniques, a summary of which would be beyond the scope of this thesis, there is a smaller subset of studies in the research stream involving social networks within defined work groups, or "intra-group networks" as they will be referred to in this study. Before introducing the model and hypotheses to be tested, a discussion of the existing literature on social networks is warranted.

At the individual level, studies have shown that an individual's position within a social network does relate to end performance. Baldwin, Bedell and Johnson (1997) studied 62 groups of M.B.A. students and showed that individual centrality in both friendship (type of informal network) and communication (type of formal network) networks were positively related to the students' grades. Central actors were also shown by Cummings and Cross (2003), in a study of 182 work groups within a global organization, to achieve better ratings from their supervisor than those on the periphery of the network. Sparrowe et al. (2001) found empirical evidence to support the positive relationship between individual centrality and performance in a study of 190 employees in 38 work groups spread throughout 5 organizations. Sparrowe et al. (2001) also looked at the hindrance network which is a network formulated by identifying which individuals hinder you from accomplishing work as opposed to facilitate it. As expected, centrality in the hindrance network was negatively related to individual performance. A study by Yang and Tang (2004) also found a significant positive correlation between centrality and the performance of members of project teams in an academic setting. This research

expects to find a similar relationship between centrality and performance, consistent with past empirical results:

> H1a: *Individual centrality in the informal work group network is positively related to individual performance.*

> H1b: *Individual centrality in the formal work group network is positively related to individual performance.*

2.4 Interaction at the Individual Level

Recently, a study by Casciaro and Lobo (2005) suggests that the psychological construct of interpersonal affect lay at the foundation of instrumental work ties between individuals. The study looked at whether individuals in a work-related setting sought out advice from others due to the competence of the person or due to how much they personally liked them (interpersonal affect). The empirical evidence showed a significant moderating relationship between the interpersonal affect and competence variables. The competence construct in this study was defined as the degree to which an individual possessed knowledge or experience which could be valuable to others (Casciaro & Lobo, 2005). Interpersonal affect is used in representing how much one individual likes another. Affect is generally seen in psychological literature as the mood state of an individual, and is consistent over time. Interpersonal affect in this case is not the overall mood of a person but the immediate reaction they have towards another. The same individual may feel positive and negative interpersonal affect depending on whom it is in relation to, whereas an individual's affect is consistent amongst a variety of different interactions.

The way that the competence and interpersonal affect constructs are defined in the Casciaro and Lobo (2005) study, they closely resemble the idea of formal and informal social interaction respectively, as defined in social network research (Cross & Parker, 2004; Scott, 2000). Relationships based on competence exist because one individual has the information that another needs to accomplish a task, thus this interaction becomes part of the group's formal social network. Relationships based on interpersonal affect exist due to the likeability of one actor to another and would exist regardless of the task at hand, thus relationships based on affect are classified as part of the groups informal social network. Casciaro and Lobo's (2005) study suggests that the task competence and interpersonal affect dimensions of relationships do not act in a mutually exclusive manner.

While revealing the interaction of interpersonal affect and competence, Casciaro and Lobo take a dyadic relationship perspective versus a complete social network view. Furthermore, the revealed interaction between interpersonal affect and competence is not linked to performance. However, Casciaro and Lobo (2005) do call for further research into this phenomenon which analyzes the interpersonal affect and competence constructs at a network level. If the competence of an individual and the degree of positive affect felt toward that individual display a moderating relationship in the way that network ties develop, and the network ties between members of a group have been shown to impact performance, then we can expect a similar interaction between formal social networks and informal social networks when linked to performance. The theoretical moderation model to be tested is as follows:

Centrality in
Informal
Network

H2

Centrality in
Formal
Network

H1b

Individual
Performance
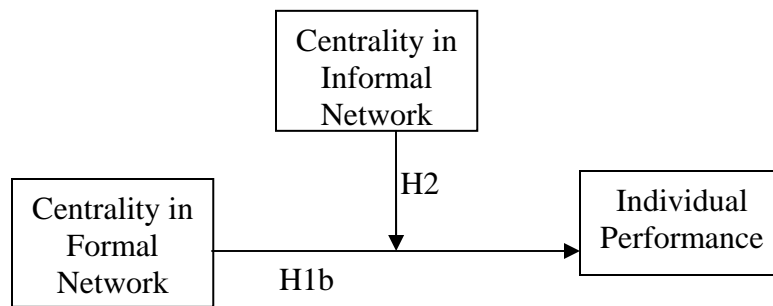
Figure 1: Theoretical model at the individual level

H2: *Individual centrality in the informal network moderates the relationship between formal centrality and individual performance such that an increase in informal centrality will increase the relationship between formal centrality and individual performance.*

2.5 Social Networks and Group Performance

At the group level, social network analysis is primarily concerned with the construct of density. Dense groups were found to perform better in Yang and Tangs' (2004) study of 25 undergraduate student groups engaged in team projects. Sparrowe et. al. (2001) expanded the concept of the hindrance network to the group level of analysis and found a negative relationship between hindrance density and group performance. Baldwin et al. (1997) found that the density of friendship networks within groups related positively to both the groups grade and the satisfaction of its members.

Further, theoretical and empirical support for these relationships is drawn from the research on cohesion. While density and cohesion are not exactly synonymous, several researchers have recognized the convergence of the constructs (e.g. Yang & Tang, 2004; Baldwin et al., 1997, Degenne & Forse, 1999) and have thus treated them similarly and even used the terms interchangeably. Cohesion is an attitudinal construct

defined as the attractiveness of the group for its members, or the interpersonal attraction between group members (Cartwright, 1968; Langfred, 1998; Beal, Cohen, Burke & McLendon, 2003). Social network density on the other hand, is a behavioral construct, operationalized as the amount of actual interaction between members. For this reason, empirical research on the relationship between group cohesion and performance is relevant to the discussion of intra-team social network density and performance.

The cohesion – performance literature is replete with meta-analyses (e.g. Olvier, Harman, Hoover, Hayes & Pandhi, 1999; Evans & Dion, 1991; Gulley, Whitney & Devine, 1995; Eys, 2002; Carron, Colman, Wheeler & Stevens, 2002; Windmeyer, Carron & Brawley, 1993), all of which indicate a relationship between group cohesiveness and group performance. A meta-analysis of 39 studies shows that cohesion results in desirable performance outcomes in military units (Oliver et al., 1999). Carron (1982, 1988) was involved in several studies which established cohesion amongst members of a sports team as important to the success of the team and the satisfaction of its members. Similar findings have been reported in other sports related studies (Windmeyer, Carron & Brawley, 1993; Eys, 2002) and validated in a meta-analysis of 46 studies (Carron, Colman, Wheeler & Stevens, 2002). Cohesion has been found an important factor in group performance within organizations as well. Carless and De Paola (2000) found a significant relationship between cohesion and performance in a team-based, Australian retail organization. Meta-analysis has suggested this relationship to exist in a number of other organizational settings as well (Evans & Dion, 1991; Gully, Whitney & Devine, 1995).

Just as social network analysts have recognized different types of social networks, so to have the cohesion researchers recognized different types of cohesion. As previously discussed, social networks can be divided into two main categories: formal and informal (Scott, 2000). Similar distinctions have been made between task and social cohesion (Mullen & Cooper, 1994; Carron, Widmeyer, & Brawley, 1985; Zaccaro & Lowe, 1986; Zaccaro & McCoy, 1988). Social cohesion has been defined as "interpersonal attraction to the team or group" and task cohesion has been defined as "group affiliation for the purpose of achieving task related outcomes" (McIntyre, Strobel, Hanner, Cunningham & Tedrow, 2003). A meta-analysis shows a positive and independent relationship between task cohesion and performance and social cohesion and performance (Beal et al., 2003). This move toward a multidimensional view of cohesion is consistent with the designation between formal and informal networks in the social network field (Scott, 2000). Baldwin et al (1997) showed significant but independent relationships between densities in formal (work related communication) networks and group performance and informal (friendship) networks and group performance. Given the breadth of empirical research on the relationship between formal and informal density and performance as well as social and task cohesion and performance, this research expects to produce consistent results.

H3a: *Social density in the work group is positively related to group performance.*

H3b: *Task density in the work group is positively related to group performance.*

2.6 Interaction at the Group Level

The social network and group cohesion studies discussed above focus on the relationship between a single network characteristic or cohesion sub-dimension and their

respective relationships with performance. While most studies analyzed a number of different individual or group characteristics independently against performance, none of them explored the interaction possibilities between these differing social network characteristics or between sub-dimensions of cohesion. At the group level, formal and informal densities as well as task and social cohesion were each related to group performance (e.g., Baldwin et. al., 1997; Mullen & Cooper, 1994; Beal et. al., 2003) but the inter-play between them and the effect that this has on performance has been ignored.

While Casciaro and Lobo's (2005) work focused on individual relationships, anything that affects how individuals interact within a group will ultimately affect the group as a whole. The moderation effects of interpersonal affect and competence in dyadic relationships may be seen at a group level of analysis as well. Social network research has shown independence between formal and informal networks, and likewise cohesion research has shown the independence of task (formal) and social (informal) dimensions (Mullen & Cooper, 1994) in relation to performance, however, how one affects the other is a question left unanswered.
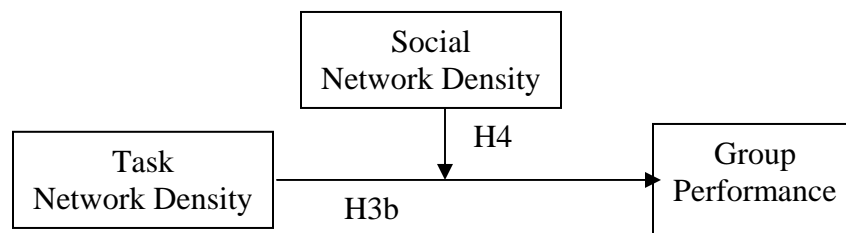

Figure 2: Theoretical model at the group level

> H4: *Social density moderates the relationship between task density and group*
> *performance such that an increase in social density will increase the relationship*
> *between task density and group performance.*

3. Methodology

3.1 Sample

The population studied consisted of students at the Air Force's Senior Non-Commissioned Officer Academy (SNCOA). The SNCOA is a 7 week training course attended by enlisted personnel achieving the rank of Senior Master Sergeant. A total of 406 students were divided into 28 groups, each led by a different instructor. Each group contained between 12 and 16 people. Groups were comprised of individuals from all across the Air Force, without any previous relationships or work experience. Administrators at the SNCOA consider demographics in assigning students to groups. Therefore, the membership of each group was diverse in terms of career background and mirrors the demographic makeup of the student population as a whole. Each flight receives daily instruction based on a standardized curriculum and each student's performance is evaluated in several different categories.

This type of structure and consistency between groups allowed for meaningful comparisons between the characteristics of these individuals and groups and their performance. The degree of uniformity between flights also allowed for control in regards to nuisance variables. This is not to say that the experience was identical in each group. While the differences between instructors and students in each group creates a different experience for each individual, the variation that did exist will be accounted for through the analytical technique selected by the researchers, and will be discussed in a subsequent section.

3.2 Demographics

The respondent's ages ranged from 32-55 with an average age of 40 years. Males comprised 87% of the sample. In regards to race, 74% were Caucasian, 16% were African American, 5% declined to provide racial information, 2% were Asian, 1% were Pacific Islanders and the remainder were of mixed descent. There was a variety of educational backgrounds as well. All respondents had at least a high school education, with 53% having an associates degree, 20% with a bachelors, and 8% with a masters degree or higher. Of the remainder, all but 4% had received some type of college credit. The participants came from a wide variety of career fields throughout the Air Force. The make-up of individuals attending training was similar to that of the Air Force as a whole in regard to gender, race, and education (USAF Almanac, 2003).

3.3 Procedure

The social network survey was administered weekly throughout the training. The questionnaires were distributed by the on-site researcher to each instructor, who administered the questionnaire to his or her students during a morning class session. Students completed and sealed questionnaires in an envelope provided by the researcher. The first survey occurred on the second day of the course and was designed to determine any previous relationships between flight members, as well as some basic demographic data. The subsequent surveys were used to elicit social network information as well as responses regarding the respondent's personality and the perceptions of leadership within the flight.

3.4 Measures

3.4.1 Network Characteristics

In degree centrality and density were measured using a technique presented by Wasserman and Faust (1994). Each participant received a package that listed the names of each group member. Then, each participant was asked to consider each person, indicating how often each of four statements was true with regards to that person on a scale of one to five; one being "not at all" and five being "frequently." Formal network relationships were represented by the items "I spend time on work-related tasks with this person (projects, studying etc…)," and, "I go to this person for work-oriented advice." Informal networks were represented by the items, "I spend time in social-oriented activities with this person (dining out, movies, sports, etc..)," and "I enjoy hanging out with this person."

In-degree centrality was used as the variable of analysis at the individual level. Using in-degree variables means that the centrality of each individual is calculated using the responses of other group members as opposed to the individuals own responses, thus minimizing self-report bias (Schwab, 2005). Density in each network is calculated as the sum of all responses divided by the number of actual respondents.

3.4.2 Performance

The overall academic performance of each individual was the result of his or her grades on one written test, two papers and two oral presentations, accomplished throughout the course of the training. The academic performance variable was computed by aggregating the individual's scores in these respective areas. In addition, subjective overall ratings were provided by instructors and peers. The academic data due to its

objective nature and consistency in measurement was chosen to represent performance.
Group level performance was taken as the average academic scores of all flight members.

3.4.3 Control Variables

In addition to the independent variables used in testing the theoretical model,
several control variables were used as well. The two control variables included in the
models were education and group size. Education was used exclusively at the individual
level and was created to account for the differences that individuals' had in terms of prior
formal education before entering the SNCOA. Each individual fell into one of four
categories: High school education, associates degree, bachelors degree, and masters
degree of higher. Values of one, two, three, and four were assigned to these respective
educational categories. With demographic data being a function of the individual and not
the group, the group level analysis only controlled for the size of the group. The group
size variable was entered simply as the number of people belonging to a given flight.
This variable was included due to the effect that a smaller or larger group might have on
the communication between these individuals.

3.5 Response Rate

Social network research generally requires a response rate greater than 80% to
yield valid analysis (Wasserman & Faust, 1994). This study measured network
relationships at total of five times, with respective response rates of 91 percent, 92
percent, 97 percent, 89 percent, 86 percent and 79 percent. The lower response rate for
the last measure was due to two of the groups choosing not to participate. These two
groups were excluded from the analysis at this time.

3.6 Reliability

Some social network studies form networks based on responses to a single item due to the nature of social network data which requires the respondent to answer each item in regard to every other person in the network which can sometimes be quite large. Therefore, each additional social network item added to a measure significantly increases the time it takes for the respondent to complete the survey as well as the amount of data to be managed by the researcher. This study formed networks through the use of two item measures, allowing for scale reliabilities to be calculated, improving the validity of results. The consistency of these two items was tested using the coefficient alpha. Each scale proved reliable by exceeding the .7 cutoff suggested by Nunnally (1978). The coefficient alpha was determined to be .72 for the informal network measure and .74 for the formal network measure.

3.7 Missing Data

While all flights had enough overall responses to be considered in analysis there were some missing data points throughout. If a response was missing to either of the two items representing formal social networks or informal social networks, that point was excluded from the network all together. The calculations for both centrality and density were averaged by the number of actual responses received as opposed to just the total number of flight members. For instance, in a flight with 15 members, should there be 12 responses regarding an individual's position in the competency network but 15 responses regarding their position in the interpersonal affect network, the score for competence is averaged over 12, while interpersonal affect is averaged over 15. This procedure allows for meaningful comparisons regardless of variation in response rates between flights.

3.8 Analysis

Responses to social network survey items were viewed in the form of an adjacency matrix. Items on social network instruments are designed to elicit responses in regard to each of the other individuals in the network. For instance, the item "I go to this person for work oriented advice," was asked in order to capture the task related social structure of a groups' network. Each actor gave his or her response specific to each of the other actors in the network and the data was displayed in an N x N matrix with identical names displayed in both the first column and first row. An example adjacency matrix is provided in Figure 3:

Question: "I go to this person for work oriented advice"

1 – never   2- once in a while 3 – sometimes 4- fairly often 5 – frequently

	Mike	Kelly	Gary
Mike		2	3
Kelly	3		1
Gary	4	4	

Figure 3: Example adjacency matrix

The matrix presents out-degree scores in the columns and in-degree scores in the rows. Meaning, Kelly seeks work related advice from Gary fairly often while Gary never seeks work related advice from Kelly. Gary's in-degree centrality would be represented by the third row in the matrix and his out-degree centrality would be represented by the third column.

Survey responses from each flight were entered into a spreadsheet as four adjacency matrices, one for each question. The matrices representing task relationships were averaged to leave a single matrix representing formal relationships, with the same procedure being followed to create a matrix for informal relationships. These two matrices in each flight were used to calculate the variables used in analysis. Given an N x N adjacency matrix, the centrality variable was calculated as the sum of each row, divided by the number of responses in that row. Density was the sum of all responses in the matrix divided by the number of responses in that matrix.

3.8.1 Individual Level Analysis

This study will draw on advances in multilevel statistical theory by using hierarchical linear modeling (HLM, Byrk and Raudenbush, 1992). Each individual was embedded within a group; therefore, the variation in characteristics between these groups is important to take into account when analyzing individual level constructs. For example, in a group with very high social density, the relationship between an individual's centrality and his or her performance could have been different than in a group in which less emphasis was placed on social interaction. Using multilevel analysis allows the researcher to control for the variance between groups by simultaneously estimating several regression equations for the dependent measure.

3.8.1.1 Individual Level Model 1

In testing the first individual level hypothesis, that network centrality would positively affect performance; the level one model to be tested was as follows:

$$Y_i = \beta_0 + \beta_1(\text{Informal Centrality})_i + \beta_2(\text{Formal Centrality})_i + \beta_3(\text{Education})_i + \varepsilon$$

where Y_i is the academic score of individual i; β_0 represents the intercept of the regression line, or the baseline academic score of i individuals; β_1 represents the effect that individual i's informal centrality has on their academic performance; β_2 represents the effect that individual i's formal centrality has on their academic performance; β_3 represents the effect that level of previous education has on academic performance and ε represents the individual error term. While there are other control variables that could be included other than education (i.e race, gender, ethnicity), these variables showed little significance in preliminary analysis and so were not included in the final model. With performance being measured strictly by academic score, prior formal education, as a representation of time spent in academic settings, is the most relevant control variable and thus was included in the individual level model.

The second level equations use level one β coefficients as the dependent variables and use group level characteristics as independent variables. These equations provide γ coefficients which test the significance of β's while controlling for the differences in group characteristics. The significance of these γ coefficients is what determines if the hypotheses at the individual level were supported. The second level equations used in model one are:

$$\beta_0 = \gamma_{00} + \mu_0$$

$$\beta_1 = \gamma_{10} + \gamma_{11} (\text{Social Density})_j + \mu_1$$

$$\beta_2 = \gamma_{20} + \gamma_{21} (\text{Task Density})_j + \mu_2$$

$$\beta_3 = \gamma_{30} + \mu_3$$

where γ_{00} represents the grand mean of all individual academic scores; γ_{10}, γ_{20} and γ_{30} represent the effect that informal centrality, formal centrality and education have

respectively on an individuals academic performance controlling for which flight the individual is a member of; γ_{11} and γ_{21} represent the cross level effect that social density and task density have on the relationship between informal centrality and performance and formal centrality and performance respectively; and the μ terms represent the portion of the level one error term attributed to the respective predictors.

3.8.1.2 Individual Level Model 2

The second individual level hypothesis, that the interaction of formal and informal centrality will significantly impact performance, will be tested by adding an interaction term to the previous model. This interaction term is calculated by multiplying the informal centrality (C_I) and formal centrality (C_F) scores together for each individual and will be added to form model two such that:

$$Y_i = \beta_0 + \beta_1(C_I)_i + \beta_2(C_F)_i + \beta_3(Ed)_i + \beta_3(C_I \times C_F)_i + \varepsilon$$

The interaction term were also reflected in the second level HLM equations below:

$$\beta_0 = \gamma_{00} + \mu_0$$

$$\beta_1 = \gamma_{10} + \gamma_{11}(D_S)_j + \mu_1$$

$$\beta_2 = \gamma_{20} + \gamma_{21}(D_T)_j + \mu_2$$

$$\beta_3 = \gamma_{30} + \mu_3$$

$$\beta_4 = \gamma_{40} + \gamma_{41}(D_S \times D_T)_j + \mu_2$$

HLM coefficients were standardized by multiplying the raw coefficient by the standard deviation of the predictor, then dividing by the standard deviation of the outcome variable. This standardization puts each regression coefficient in standard deviation units (Hox, 2002) and allows comparisons between the strengths of the coefficients.

3.8.2 Group Level Analysis

With the flight being the broadest level of analysis, there are no second level effects to take into account; therefore multiple linear regression was replaced HLM as the means of analysis at the group level.

3.8.2.1 Group Level Model 1

The regression equation used to test the first group level hypothesis, that network density will positively affect performance, will be tested with model three:

$$Y_j = \beta_0 + \beta_1(D_S)_j + \beta_2(D_T)_j + \beta_3(Size)_j + \varepsilon$$

where Y_j represents flight j's average academic score; β_0 represents the intercept of the regression line, or the baseline academic score between all flights; β_1 represents the effect that the social density of flight j has on that flights performance; β_2 represents the effect that task density of flight j has on flight j's academic performance; β_3 represents the effect that the size of the flight has on its performance and ε represents the group level error term.

3.8.2.2 Group Level Model 2

To test the moderation model, the interaction term between task and social density was calculated by multiplying the two scores together for each flight, forming a new variable for inclusion in the regression. Model four is as follows:

$$Y_j = \beta_0 + \beta_1(D_S)_j + \beta_2(D_T)_j + \beta_3(Size)_j + \beta_4(D_S \times D_T)_j + \varepsilon$$

3.9 Group Development

Social network data was collected weekly throughout the training using identical measures each time, and each week's data were analyzed. With each group being comprised of individuals from all over the Air Force, it was assumed that it would take

several weeks before group members really got to know one another and established relationships. This group formation and dissipation process has been studied at length (examples see Hare, 1976; LaCoursiere, 1980; McGrath, 1984) with the most common model being that proposed by Tuckman (1965).

Tuckman's model shows four stages of group development: forming, storming, norming and performing. Every group is different, but generally, after being formed, groups go through a period of conflict or non-communication while members are hesitant to speak up and may not trust one another. After group members get to know one another, they start to establish roles within the group, and finally these members fulfill their roles to accomplish the tasks assigned to the group.

Since the survey given on day one of training was used primarily to gather demographic and personality data, the first social network measure occurred at time two, on the third day of training. Social network surveys were then given one week apart for a total of five measurements. With Tuckman's model in mind, it is most likely that the measurements taken at time two and time three will be during the forming and storming stages of group development. Those surveys taken in times four, five and six may be more likely to capture the networks during the norming and performing stages of group development. Social networks at each time will be analyzed and the results will be tracked over time to see how the results change as the groups go through the development process.

4. Results

4.1 Introduction

As suggested earlier in the discussion of the group development process, analysis

conducted with networks elicited at time two and time three produced no significant

results at either the individual or group level, suggesting that the groups were still in the

forming and storming stages, thus the relationships at these times were not indicative of

how they would eventually stabilize. For this reason, the remainder of the analysis

discussion will center on the results from surveys at times four, five, and six.

4.2 Individual Level Analysis

At the individual level, the descriptive statistics for all variables used in analysis

as well as the correlations between these variables are included in Table 1.

Table 1: Individual Level Correlations

	Variable	Mean	S.D	1	2	3	4	5
1	Academic Score	316.31	16.73					
2	Education	2.34	0.70	.14** .14** .14**				
3	Informal Centrality (C_I)	2.65 2.61 2.72	0.45 0.51 0.42	.07 .14** .12**	.01 .03 .05			
4	Formal Centrality (C_F)	2.52 2.60 2.61	0.41 0.49 0.52	.11** .14** .19**	.06 .07 .07	.77** .62** .76**		
5	Interaction (C_I x C_F)	6.82 6.90 7.26	2.10 2.42 2.30	.08 .14** .15**	.03 .05 .06	.93** .94** .91**	.94** .94** .95**	

* = p< .1, ** = p<.05
For variables with more than one entry, values represent (from top to bottom) the value at times 4, 5 and 6 respectively

Bi-variate correlations indicated that an individual's formal centrality in the work group network was significantly related to performance at Time 4, and at Times five, and six, the position in the informal networks as well as the interaction between the two also prove significant in relation to performance. It is important to note that bi-variate correlations at the individual level do not take into account group level characteristics and variance. While these correlations may show general trends in relationships, the lack of control for group level effects makes them a less robust analysis than HLM.

4.2.1 Hypotheses 1a and 1b

Hypothesis 1 suggests a positive relationship between performance and both informal (H1a) and formal (H1b) centrality. It was tested with the first HLM model specified previously. The coefficients resulting from this analysis are summarized in Table 4.

Table 2: Model 1 - Basic Individual Model

| HLM Coefficients | Individual Academic Score | | | | | |
| | Time 4 | | Time 5 | | Time 6 | |
	Raw	Std	Raw	Std	Raw	Std
Intercept, γ_{00}	284.34	-	283.95	-	281.32	-
Informal Centrality, γ_{10}	-12.29*	-.33	-30.19**	-.87	-11.83**	-.30
Formal Centrality, γ_{20}	31.42**	.77	47.87**	1.35	32.72**	1.18
Education, γ_{30}	2.99**	.12	3.03**	.13	3.17**	.13
Social Density x Informal Centrality Cross-level Interaction, γ_{11}	2.12	-	7.44**	.18	2.93**	.06
Task Density x Formal Centrality Cross-level Interaction, γ_{21}	-5.68**	.12	-10.47**	.23	-6.79**	.17

* = p<.10, ** = p<.05

Results showed significant relationships between both formal and informal relationships and performance at Times four, five and six, however the direction of some of these relationships were not as hypothesized. Formal centrality, for instance, did display a positive relationship with performance. Increasing formal centrality from a score of two to three for example increased an individual's academic score by 31.42, 47.87, and 32.72 points respectively. However, informal centrality failed to display the relationship in the expected direction, instead decreasing performance by 12.29, 30.19, and 11.83 points respectively for the same unit increase in centrality; thus H1a was not supported.

4.2.2 Hypothesis 2

To test H2, the individual level interaction term was added to the model as previously described, and the following coefficients were found:

Table 3: Model 2 – Individual Model with Interaction

HLM Coefficients	Individual Academic Score					
	Time 4		Time 5		Time 6	
	Raw	Std	Raw	Std	Raw	Std
Intercept, γ_{00}	285.79	-	284.59	-	270.60	-
Informal Centrality, γ_{10}	-12.42	-	-30.46**	-.87	-15.70**	-.40
Formal Centrality, γ_{20}	29.84**	.73	49.71**	1.46	36.40**	1.13
Education, γ_{30}	2.99**	.12	3.03**	.13	3.17**	.13
Interaction (Formal x Informal), γ_{40}	3.99	-	-5.24	-	6.57	-
Social Density x Informal Centrality Cross-level Interaction, γ_{11}	2.05	-	7.44**	.18	3.58*	.09
Task Density x Formal Centrality Cross-level Interaction, γ_{21}	-5.04**	.12	-11.20**	-.24	-7.87**	.17
$(D_{S} \times D_{T}) \times (C_{I} \times C_{F})$ Cross-level Interaction, γ_{31}	-46.59	-	25.27**	.26	-22.96**	-.26

* = p<.10, ** = p<.05

In this model, the interaction term was non-significant throughout the course of the

training, providing no support for H2.

4.3 Group Level Analysis

The descriptive statistics for variables used in group level analysis are included in

Table 4 along with their correlations.

Table 4: Group Level Correlations

	Variable	Mean	S.D	1	2	3	4	5
1	Average Academic Score	316.09	6.42					
2	Group Size	14.43	1.40	.37** .37** .37**				
3	Social Density (D_S)	2.63 2.61 2.71	0.37 0.43 0.33	.07 .30* .15	-.08 -.02 -.16			
4	Task Density (D_T)	2.53 2.57 2.62	0.33 0.43 0.42	-.03** .07 .19	-.30* -.03 -.20	.76** .82** .87**		
5	Interaction $(D_S {}_x D_T)$	6.74 6.84 7.22	1.73 2.17 1.91	.01 .18 .15	-.17 -.02 -.17	.94** .95** .96**	.94** .95** .97**	

* = p< .1, ** = p<.05
For variables with more than one entry, values represent (from top to bottom) the value at
times 4, 5 and 6 respectively

This correlation analysis shows little support for the idea that group density impacts the

overall performance of the group. The groups' average score is only significantly

correlated to the social density of the group at time five.

4.3.1 Hypotheses 3a and 3b

The group level analysis began by testing the first group hypothesis (H3a and

H3b) with the regression model previously discussed. Regression coefficients are

summarized in Table 5.

Table 5: Model 3 – Basic Group Model

| Regression Coefficients | Group Average Academic Score | | | | | |
| | Time 4 | | Time 5 | | Time 6 | |
	B	β	B	β	B	β
Intercept, β_0	286.77	-	283.21	-	285.01	-
Social Density, β_1	1.97	-.33	10.73**	.72	-2.09	-
Task Density, β_2	-.268	-	-7.60*	-.51	5.31	-
Flight Size, β_3	1.72*	.38	1.70*	.37	1.60*	.34
Adjusted R^2 of the Model	.04		.23		.03	

* = $p<.1$, ** = $p<.05$
B = raw regression coefficients
β = standardized regression coefficients

It appears that the relationships between social and task network density and performance were found to be significant at time five. Again, the direction of these relationships is not always as expected. There is a positive relationship between social density and performance, supporting H2a. The relationship between task density and performance is opposite the expected direction, thus not supporting H2b.

4.3.2 Hypothesis 4

The interaction term was added to the regression model to test the interaction model (H4) and results were as follows:

Table 6: Model 4 – Group Model with Interaction

Regression Coefficients	Group Average Academic Score					
	Time 4		Time 5		Time 6	
	B	β	B	β	B	β
Intercept, β_0	286.77	-	283.21	-	285.01	-
Social Density, β_1	1.97	-.33	10.73**	.72	-2.09	-
Task Density, β_2	-.268	-	-7.60*	-.51	5.31	-
Flight Size, β_3	1.72*	.38	1.70*	.37	1.60*	.34
Interaction, β_4	-21.37*	-5.76	-3.56	-	-11.27*	-3.42
Adjusted R^2 of the Model	.123		.207		.115	

* = $p<.1$, ** = $p<.05$
B = raw regression coefficients
β = standardized regression coefficients

The interaction term in this model found significant results at time four and time six.

While the hypothesized interaction model suggested a positive relationship between the

interaction term and performance, these interaction terms both display a negative

relationship, thus H4 was not supported.

5. Discussion

5.1 Introduction

The purpose of this research was to determine how formal and informal interactions within work groups impacted the performance of the group as well as the performance of the individuals within that group. The study also sought to establish how these formal and informal interaction patterns affected one another in determining end performance at both the individual and group levels. Previous research has established relationships between the social network characteristic of centrality and performance (e.g., Baldwin et al., 1997; Cummings & Cross, 2001; Yang & Tang, 2004) at the individual level. The individual level hypotheses in this research predicted that formal and informal centrality in the work group network would each improve individual performance and that the interaction of these network centralities would further bolster individual performance. At a group level, the social network characteristic of density has been related to the performance of the network (Baldwin et al., 1997; Sparrowe et al., 2001; Yang & Tang, 2004) as has the cohesiveness of the group been related to performance (see, Mullen & Cooper, 1994; Oliver et al., 2001; Beal et al., 2003). Group level hypotheses predicted a positive relationship between both social and task density and group performance independently and that the interaction of these two network characteristics would also increase group performance.

5.2 Individual Level Conclusions

The results in the individual models displayed an interesting trend. Formal centrality showed a consistently positive relationship with performance over time whereas informal centrality displayed a consistently negative relationship with

performance over time. This suggests that while interaction among members of a work group is important and can improve performance, the *type* of interaction is just as important. Individuals who use their network connections to communicate about task related matters and focus the power of their social network toward obtaining knowledge and advice from others are more successful than those who use their network connections to engage in extracurricular social activity.

One possible explanation for this result is the environment in which the data were obtained. With the SNCOA being an in residence course, the students are in a state of heightened social interaction while attending the training. At their home base, the students may spend time attending to family obligations, as well as with friends outside of those individuals that they work with. Without these day to day activities that they are accustomed to, there is the possibility of spending more social related time with co-workers than might otherwise occur. In an isolated training environment, group members may go out to lunch, dinner, and movies with other group members more often than they normally would because of the desire to be seen as a team player and not be labeled as "anti-social." This environment of increased social interaction is combined with the fact that the AFSNCOA is a compact and intense curriculum in which much material is covered in a short period of time and students are required to produce work quickly. For this reason, those who engage in the increased socialization opportunities most likely do so at the expense of falling behind their peers who are spending the same amount of time working on assignments and studying for tests.

The negative impact that informal centrality had on individual's performance in this study has ramifications for any ad-hoc work group faced with an intense task. Many

work groups, especially in today's organizations are comprised of individuals whom are not familiar with one another and are expected to accomplish a task in a short amount of time. The trend seen in this research as to the role that informal communication plays in these situations is important to consider for both individuals who belong to such groups as well as individuals who manage them.

In a more traditional, long-term work group, individuals have ample time to engage in both formal and informal interaction, and the impact that informal interaction has on the group may be different. While this informal interaction may not directly add value to the work of the individuals, it may boost satisfaction of the individuals involved, increase morale and improve loyalty to the group. In a long term setting, these intangible qualities which come from informal interaction may prove to be important in the individual's ability to work effectively over these longer periods of time. In a compressed six week training course, however, the actors in work group networks have a limited amount of time in which to build relationships. In this environment it may be that time devoted towards social relationships comes at the expense of time devoted toward task related relationships.

In addition, the performance measure consisting of strictly academic scores, lends itself to being affected more through formal centrality than informal. In a work group where the desired performance is more abstract in nature, the role of informal centrality may play an important role. For example, if a work group is formed by an organization to achieve creativity in problem solving, is evaluated according to the quality of decision making, or required consensus between members as part of the task, then the informal

relationships between members might have more of a direct impact on these performance measures.

A second trend was that at the individual level, while the hypothesized interaction between formal and informal centrality did not prove significant as specified, there did appear to be an interaction between these centralities and the respective densities of the group. While these cross level effects were not important in the theoretical model under study in this research, their significance shows that group characteristics did have a significant effect on the relationships between variables at the individual level, and controlling for these characteristics was an important element of the analysis.

5.3 Group Level Conclusions

The group level analysis showed that while task and social density were both hypothesized to improve performance, only social density displayed this relationship, and task density actually had the opposite effect. This result suggests that in groups where task related interaction is dominant, the overall performance of the group suffers. This may be due to the fact that in groups with a higher degree of social density, the individuals are more comfortable with one another, and there is a better flow of communication within the group. The better that group members get along, the more trust there will be, communication will occur easier and the group as a whole will share knowledge and information better. Groups focusing on only task related interaction may indeed be interacting but the value of this interaction will not be as great as when the individuals also get along at an interpersonal level.

5.4 Limitations and Future Research

The structure of the training and similarities between flights which allowed researchers to more accurately control for nuisance variables also produced limitations in terms of generalizability. The training attended by the students is such a unique environment that the results may not be typical of these same groups of people in different situations. As discussed earlier, the role of formal and informal relationships in work group may have behaved differently in this study due to the compressed training schedule. While research has been done on team performance, the way these teams are designed and how they are comprised (for review see Stewart, 2006), in today's flatter organizations teams are formed to perform specific tasks and may exist only as long as it takes to accomplish this task. Research done specifically to pinpoint how group development processes behave when faced with differing life spans would be valuable to organizations that use work groups and teams in their day to day operations. If a group is formed with a pre-established duration, it may be that the members of this group act differently towards one another than if they are placed in a group for an indefinite period of time, or if they know that the group will exist for as long as it takes to accomplish the task. Research is needed in analyzing the formal and informal relationships of groups in these different settings and over different periods of time to accurately capture the nature and impact of these relationships on work group performance.

Future research is also needed to further clarify the similarities and differences between network density and cohesion. This study treated the two interchangeably as some researchers historically have (Baldwin et al., 1997; Degene & Forse, 1999). While cohesion has been prolific in group research (Carless & De Paola, 2000; Langfred, 1998;

Oliver et. al., 1999), it is a concept that is difficult to capture empirically (Siebold ,1999),

and has been operationalized in a variety of ways (Carless & De Paola, 2000). The

biggest obstacle in cohesion research has been definition and measurement of the

construct (Levine & Moreland, 1990; Guzzo & Dickson, 1996), and the use of social

network measures in the study of cohesion offers a rich and unique data source.

Cohesion measures have historically been self-report, attitudinal based

questionnaires based on individual team member perceptions of the group. This type of

data is subject to the self-report bias which plagues survey research (Schwab, 2005), and

is likely to contain responses based on the social desirability of cohesiveness. If

cohesiveness is viewed as a desirable trait, then the members of the group are likely to

claim that it exists regardless of whether it does or not. Simply belonging to a team or a

group brings certain expectations with it, as viewed in the Hawthorne Studies

(Roethlisburger & Dickinson, 1939). Group members feel that they should be interacting

with others in the group, thus are obligated to report this on a survey. These

measurement issues may have helped through the use of network questions which

measure actual interaction instead of perception with questions such as, "I seek work

related advice from this person?" as opposed to, "how do you feel about the advice you

receive from other group members?" A study incorporating both social network and

traditional cohesion measures could be used in determining which type of data collection

and construct operationalization produces more accurate predictions of individual and

group performance.

5.5 Summary

This study tested the effect that formal and informal relationships within work groups had on individual and group performance. It has been shown that these types of communication within groups independently impact performance (Mullen & Cooper, 1994; Cummings & Cross, 2001). The interaction between these types of interactions was also tested to determine the effect that one had on the other in relation sot performance at both the individual and group level of analysis. This study confirmed previous findings that formal interaction increased performance at the individual level but found that informal interaction detracted from individual performance. The group level analysis revealed that the social cohesiveness in a group allowed for greater information flow within the group and thus better performance at the group level.

Appendix A. Social Network Survey

Survey

<u>Study Title</u>: Predictors and Consequences of Social Network Structure

<u>Participation</u>: Your participation in this survey is completely voluntary. However, consider that the greater the participation in each flight, the more insightful and useful the data will be for researchers.

<u>Anonymity</u>: We greatly appreciate your participation. All of your responses and information provided in this survey are confidential. Although names are necessary for the collection of some of the data, after all the data has been collected, the names are erased from the database.

<u>Contact Information</u>: If you have any questions about the survey, please contact Maj Kent Halverson, DSN 785-255-3636x4709 or at <u>kent.halverson@afit.edu</u>.

<u>Survey Instructions</u>:

- There are no right or wrong answers, so don't dwell on any one question—just answer honestly what first comes to mind.

- Please do not discuss your answers with other flight members—your responses should be independent. We don't want your opinions and responses to influence other participants.

Name: _____

Flight: _____

Date: _____

DIRECTIONS: This section is used to describe your relationships with other flight members **during the past week**. Using the scale below, **write a number in each block** to indicate the applicability of each statement in regards to each flight member.

Not at all	Once in a while	Sometimes	Fairly often	Frequently
1	2	3	4	5

Flight Member Names	I spend time on work-related tasks with this person (projects, studying, etc.)	I spend time in social-oriented activities with this person (dining out, movies, sports, etc.)	I go to this person for work-oriented advice.	I enjoy hanging out with this person.	I have difficulty working with this person.
Student 01					
Student 02					
Student 03					
Student 04					
Student 05					
Student 06					
Student 07					
Student 08					
Student 09					
Student 10					
Student 11					
Student 12					
Student 13					
Student 14					
Student 15					
Instructor					

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14. ABSTRACT

 Social networks have recently emerged in the management discipline as a unique way of studying individuals groups in organizations. While traditionally used in the analysis of un-bounded networks, applying social network analysis techniques to bounded work groups and organizational teams has become increasingly popular. Past research has established relationships between in-degree social network centrality and individual performance as well as social network density and overall group performance. This field study, conducted at a military training course, attempted to further refine this social network–performance relationship by modeling characteristics of both the formal and informal work group networks in relation to performance at the individual as well as group level. A sample of 406 students in 28 groups showed that individual performance is positively related to centrality in the formal social network while a negative relationship was found between performance and centrality in the informal social network.

15. SUBJECT TERMS   Social Networks, Work Group Development, Group Cohesion, Hierarchical Linear Modeling, Group Dynamics

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