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ABSTRACT

This study examines how relational instability and stability-seeking behaviors of unstable virtual teams affects team performance. We apply Structural Stability Theory (Heider, 1946) to understand virtual team (VT) performance. Structural stability theory provides for quantification of relational stability within a VT by measuring the mathematical properties of links between nodes in a team. Lack of stability is a source of unresolved tension. Structural Stability Theory (SST) states that unstable relationships are motivated to seek stability. Stability can be positive or negative, where certain members of a group are disliked by others. However, structural stability suggests the absence of turbulence within the relational dynamics of the group; that relationships are settled - good or bad. We propose that the degree of structural stability within a group measures unresolved relational tension within the group and may impact VT performance.

Keywords (Required)

Virtual Team, Social Network, Heider, Structural Stability Theory, Virtual Team Performance

INTRODUCTION

Modern business environment are highly-connected and no longer require close physical proximity of team members for collaboration. Consequently, pervasive connectivity has enabled a new organizational form: the virtual team (Jarvenpaa & Ives, 1994). In a virtual team, a group of people interact through interdependent tasks, guided by a common purpose (Lipnack & Stamps, 1997), with interactions being predominantly virtual rather than face-to-face. While conventional teams frequently use information and communication technology to support face-to-face communication (Dube & Pare, 2004); A VT makes it possible for organizations to bring together teams with very specific skills, knowledge, or expertise, to a task without the space and time synchronicity constraints of face-to-face meeting.

Virtual teams (VTs) afford organizations enormous flexibility and adaptability. Teams with specific expertise can be dynamically configured to address specific project requirements and disbanded once the work is complete. Thus, organizations leveraging VTs may configure or reconfigure organizational capabilities ad hoc to address changes in their environment (Potter, Balthazard, & Cooke, 2000; Lipnack et al., 1997; Duarte & Snyder, 1999; Haywood, 1998). Mowshowitz (1997) describes VTs as a way to structure and manage goal-oriented activities based on the categorical distinction between task requirements and the elements capable of satisfying them. He describes virtually organized tasks as goal-oriented activities, implemented through the appropriate assignment of "concrete satisfiers" to the abstract requirements of the task.

Resource allocation decisions are central to VT formation. Individuals or groups with distinct capabilities are brought together with the expectation that collectively, they are capable of effectively accomplishing a particular task. Organizations provision the resources needed to create requisite capacity, and form VTs to translate capability into VT performance. *However, this outcome is not always achieved* (Lipnack et al., 1997; Potter et al., 2000; Haywood, 1998), despite appropriate team membership skills. Sarker and Sahay (2002) suggest that VT performance derives from both the production structure (rules and resources) and social structure of the team emergent from team interactions. While one might argue that

organizations with sufficient resources can allocate capacity with the expectation of capability, VT performance depends on the emergent social structure in the VT.

Emergent social structure in VTs is recognized by researchers as important predicate of VT performance. Many VT researchers have considered socio-emotional processes and VT performance (Powell, Picolli, & Ives, 2004; Maznevski & Chudoba, 2000; Lurey & Raisinghani, 2001; Chidambaram, 1996; Sarker & Sahay, 2002). Powell et al.'s (2004) meta-analysis of VT research identifies 43 studies of VT adoption and use, many of whom seek to identify the variety of factors that influence the formation of social structure within VTs, and the difficulties imposed by their virtual-ness.

However, despite widespread interest in the factors which influence VT efficacy and social structure, extant research largely fails to consider relational dynamics in VTs from a social process perspective. This study seeks to illuminate that gap by analyzing the emergent social structure within VTs using Heider's (1946) Structural Stability Theory. SST provides a mechanism to quantify the relational stability within a VT by measuring the mathematical properties of the edges between nodes within the VT. Further, SST explains that unstable relationships are motivated to seek stability, leading to the emergence of structural stability within VTs. This is consistent with VT structuration identified by other researchers (Maznevski et al., 2000; Sarker et al., 2002; Chidambaram, 1996). Lack of relational stability in a VT is a source of unresolved tension. Thus, it is logical to examine whether relational instability and consequent stability-seeking behaviors of an unstable VT affect VT performance. Structural stability does not suggest within team relationships are necessarily positive. Stability can occur in cases in which certain members of a group are disliked by others. Thus, although relationships within a team might not be positive, structural stability suggests the absence of turbulence within the relational dynamics of the group; that relationships are settled - good or bad. The degree of structural stability within a group is therefore a measure of unresolved relational dynamics within the group.

This paper seeks to identify the relation between structural stability and VT performance and asks the following research questions: "*is there a relationship between structural stability and virtual team performance within a project*", and "*which social factors of structural stability are significant to team performance*". We measure structural stability over multiple social factors and compare them with VT performance to establish if there is a relationship between structural stability and virtual team performance within a project.

LITERATURE REVIEW

VT Performance

Several studies examine VT performance. However, there is little consensus on the factors of VT performance to measure. Grzeda, Haq, & LeBasseur (2008) measure three aspects of VT performance: achievement of team goals, individual team member satisfaction, and individual team member development. Paul, Seetharaman, Samarah, & Mykytyn (2004) measure VT performance using four factors: member satisfaction, participation, group consensus, and decision quality. Stark and Bierly (2009) study member satisfaction as a measure of team performance. Kirkman, Rosen, Tesluk, & Gibson (2004) measure VT performance as process improvement and customer satisfaction. Wong and Burton (2000) measure VT performance using: days to complete task, rework volume, and coordination volume. These studies reveal *team member satisfaction* as a convergent measure of VT performance. This suggests that VT satisfaction depends on an underlying dynamic social process within the team.

Antecedents of VT Performance

Multiple studies examine the antecedents of VT performance. Grzeda et al. (2008) study a VT building exercise to understand VT performance and find that team processes positively impact VT performance. Kanawattanchai and Yoo (2007) analyze 38 VTs experimentally within an MBA course and reveal three behavioral dimensions of transitive memory systems: expertise location, coordination, and trust, and their impact performance over time. They find coordination becomes the main driver of performance over time. Paul et al.'s (2004) study the impact of heterogeneity on collaborative conflict and management style in a VT, and its impact on team performance. Experiments with both homogeneous and heterogeneous VTs find weak support for the impact of heterogeneity, but strong support for the impact of collaborative conflict management on performance.

Wong and Burton (2000) measure VT performance using simulation along three dimensions, days to task completion, rework volume, and coordination volume. They posit three VT characteristics which might impact VT performance: context, composition, and structure. Composition is the membership of the team, i.e. experienced programmer, veteran project manager. Context is team history and the novelty of the task. Structure is measured by levels of centrality and strength of ties between team members. They find that structure has the biggest impact on VT performance. Driskell, Radtke, & Salas

(2003) examine technology impacts team cohesion and team communication, and how those in-turn impact VT performance. Powell et al. (2004) provide a useful summary of factors applied by researchers to understand VT performance. They group these factors categorically as *task processes* and *socio-emotional processes*. Task processes include communication, coordination, and task-technology-structure fit. Socio-emotional processes include team cohesion, trust, and relationship building.

VT Process

Stark et al., (2009) measure the impact of process ‘virtualness’ on team member satisfaction. They define virtualness as the degree to which interaction takes place outside of face-to-face meetings. Their survey of 178 VTs finds that while virtualness hampers more traditional team performance measures such as conflict resolution, it improves member’s preference for group work. Similarly, Andres & Shipp (2010) consider how collaboration mode impacts team learning and team task performance. Their collaboration modes take one of two forms: face-to-face or virtual collaboration. They find that team learning helps the team form a shared mental model, which has a positive impact on team performance.

Furst, Blackburn, & Rosen (1999) argue that group effectiveness within a VT is a function of five variables: amount of organizational support, team member selection, group synergy, group processes, and available tools. They define group synergy as the way group members interact. Group processes are divided into two groups; group formation, and task performance.

Kirkman, Rosen, Gibson, Tesluk, & McPherson’s (2002) case study of 65 VTs within an organization find five challenges to VT performance including trust-building within the team, team cohesion, team selection, measurement of team performance, and conversion of existing team processes into virtual processes. Kirkman et al. (2004) study 35 VTs for the effect of team empowerment on VT performance. They define team empowerment as “increased task motivation due to team members’ collective positive assessment of their organizational tasks” (p.176). They measure VT performance along process improvement and customer satisfaction and find that team empowerment positively affects both dimensions of VT performance.

Literature analysis reveals that the socio-emotional structuration of the VT is a central tenet in VT performance, yet not directly examined. The literature does not address the impact of VT structuration of the team and its impact on VT performance. Our research investigates the influence of within team structuration as structural stability from a sociological perspective to understand its impact on VT performance.

Social Structure of Virtual Teams

Small group research suggests co-located teams tend to develop cohesion and maturity with time and interaction, and that structural relationships and roles evolve within teams (Mennecke, Hoffer, & Wynne, 1992). While emergence of social structure within VT’s is well understood (Lipnack et al.,1997; Chidambaram, 1996; Maznevski et al.,2000), research regarding the stability of team structure and its impact on VT performance is sparse.

That social structures are motivated toward stability is well grounded in theory (Heider, 1946). Heider’s (1946) original examination of structural stability in social interactions examines dyadic relationships. Here, he posits that a balanced state exists between two people if they possess the same dynamic character. More simply, stability exists if people either like or dislike each other. Additionally, he finds that structural balance also exists in triad relationships where three people like each other, or two like one another and they both dislike the third person. Any other relationship is unbalanced and will be motivated to seek balance (Heider, 1946).

Positive and negative expressions of relationships, such as like or dislike, lend themselves to graph analysis, where people are represented as nodes and relationships as edges (Cartwright & Harary,1956). Their work captures structural balance within a network. Much current social network research is predicated on similar representations of network structure. Subsequent work provides a suitable foundation to explore structural balance in a VT (Cartwright & Harary, 1970; Newcomb, 1953). In this paper we examine the role of the structural stability using multiple factors of social relationships and structural stability’s impact on VT performance.

RESEARCH MODEL

Heider's (1946) model of structural stability within social dyads and triads is formed from the likes and dislikes of individual actors. Heider posits that in a triadic relationship, there are only two ways that a relationship can be stable: if everyone likes one another, or if two people who like one another dislike the third person. Any other relationship is unstable. Such an unbalanced relationship will be motivated to seek stability. Structural stability has been used to study international relationships (Moore, 1978; Antal, Krapivsky, & Redner, 2006) and on-line endorsements (Kunegis, Lommatzsch, & Bauckhage, 2009). Kunegis et al., (2009) explored how members of an on-line community are given "friend" endorsements based on their popularity within the network. Heider's SST has been used to analyze networks and is appropriate to examine the structural stability of relationships in a VT and its impact on the VT performance. However, Heider's theory does not provide guidance on the selection of the factors along which the structural stability of relationships can be examined.

Newcomb (1953) observes that different social characteristics other than like/dislike can be used to analyze the network stability. Our study examines the relationships across multiple factors posited to impact VT performance.

Works Collaboratively

Frey, Lohmeier, Lee, & Tollefson (2006) define collaboration as the "cooperative way that two or more entities work together toward a shared goal" (p.384). In their conceptual framework on VT trust, Peters and Manz (2007) suggest that collaboration has a positive impact on VT performance. Montoya-Weiss, Massey, & Song (2001) find that collaboration behavior has a positive impact on VT performance. We adopt Aram and Morgan's (1976) measures of collaborative problem solving to measure the perception of a team member's work collaboration habits. They use this measure to study the relationship between collaboration and individual effectiveness within an R&D setting. We also include an item from Campion, Medsker, & Higgs, (1993) study of work group effectiveness. We operationalize *Works Collaboratively* to measure VT structural stability as expressed by team members' opinions regarding others' willingness to collaborate within the VT.

Displays interpersonal skills

Holland and Baird (1968) define interpersonal skills as an "acquired ability for effective interaction" (p. 503). Balthazard, Potter, & Warren (2004) experimented with 63 VTs within an MBA program to study the impact of interpersonal skills and expertise on VT performance. They find partial evidence that interpersonal skills have a positive impact on VT performance. We adopt Holland and Baird's (1968) Interpersonal Competency Scale in this research to operationalize *Displays interpersonal skills* as a measure of the structural stability as expressed in the relationships among team members. We examine the team members' opinion regarding others' interpersonal skills on the structural stability within the VT.

Exercises task-relevant expertise

According to Hollingshead (2000), when tasks are matched up with individual expertise, the team performs more effectively. Moreland and Myaskovsky (2000) argue that as teams spend more time together, they can identify specific expertise within the team. Thomas-Hunt, Ogden, & Neale, (2003) study the impact of perceived expertise and social status on shared knowledge within a team. Employing experimental design on a mix of business and engineering students, they used their perception of other student's majors as an indication of expertise. Similarly, we collect individual perceptions of team member expertise. We operationalize *Exercises task-relevant expertise* as a measure of VT structural stability as expressed in the opinion of team members regarding others' exercise of task-relevant expertise within the VT.

Demonstrates commitment to work

Lincoln and Kalleberg (1985) study organizational commitment among US and Japanese workers and how that relates to worker satisfaction. Their items examine worker's drive to see the organization succeed and how their values align with the organization's values. In our study, we are not measuring the student's commitment to a single organization but to their work on particular project. In order to measure the perception of a team member's commitment to work, we use Morrow and Wirth's (1989) measure of job involvement. The items they employ consist of questions about the person's drive for perfection and the job satisfaction. We operationalize *Demonstrates commitment to work* as a measure of VT structural stability as expressed in the opinion of team members regarding others' commitment to work within the VT.

Exhibits Social Loafing

Social loafing (Latané, Williams, & Harkins, 1979) is an observable group phenomenon where individuals do not work as hard on assigned group tasks as they would on individually assigned tasks. Social loafing has negative implications for group processes. The presence of social loafers means that other team members must work harder to compensate for lost productivity so that the team will meet its goals. A recent theory (Price & Harrison, 2006) holds that the lack of overt individual group member evaluation techniques imposed by authoritative outsiders to the group, or by other members of the

group, can possibly contribute to a lack of participation by individuals in the group, particularly when individual self-identity is subverted in favor of a group identity. This explanation for social loafing is based on the idea that people can get away with poor performance when their individual contribution is not identifiable (Jackson & Harkins, 1985). In other words, if the group will receive an evaluation based on total collective performance, such as a single grade given to a group of students working together on an assignment, then members of the group are likely to put in less individual effort, secure in the knowledge that they will not be held personally accountable for their subpar efforts. Yet another explanation of social loafing is that individual members expect other team members to loaf; and therefore by reducing their own efforts, they seek to establish an equitable division of labor (Jackson et al., 1995). Latané, et al, (1979) state that when group members experience a loss of individual identity while participating in group activities, social loafing behavior is more likely to arise because individual members believe that their personal effort outcomes will be diluted into the outcomes of the group as a whole and therefore will be more difficult to trace back to a particular member. If a member believes they will not receive individual credit for work, then their likelihood of loafing increases. Feelings of unequal credit or compensation for group efforts will cause members to loaf as an unspoken form of passive-aggressive protest against what members view as an unjust or biased rewards system which favors the wrong group members (Piezon & Donaldson, 2005). The lack of group cohesion is likely to lead to loafing as members of a non-cohesive group do not feel much if any loyalty towards one another (Piezon et al., 2005).

We adopt Latané et al.'s (1979) definition of social loafing, and operationalize *Exhibits social loafing* as a measure of the VT's structural stability as expressed in the opinion of team members regarding social loafing of other team members.

VT Performance

This study collects both exogenous and endogenous measures of team performance. We measure team performance exogenously using the instructor's grade, based on the project deliverables list that was generated by the team. Survey data provides endogenous assessment of their team's performance. Taken together, these measures allow reasonable assessment of team performance. For endogenous assessment, we adopt items from Potter et al.'s (2000) study of VT's group interaction style and performance.

Figure 1 illustrates our conceptualization of the potential impact of structural balance on VT performance.

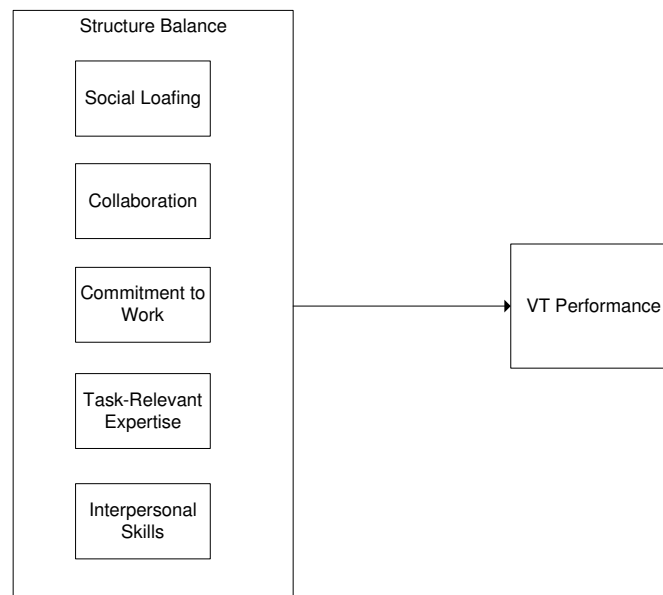


Figure 1: Research Model

METHODOLOGY

This study will be conducted using student VTs participating in capstone projects. Each team has 3 members and performs most work in a virtual setting (i.e. over email and team wikis and group discussion boards, file-sharing). To determine the structural stability of the teams, we evaluate relationships using a survey instrument which measures the five factors outlined

in figure 1. Additionally, participants are asked to evaluate team performance, so that relation between structural stability and team performance can be evaluated by contrasting them against measures of team efficacy. The next section discusses how stability is determined along these five factors.

Stability Evaluation

To calculate factor stability, we rely upon Heider's (1946) analysis of network structure stability. Heider posits that within a triadic relationship, there are two possible stable and two unstable states (shown in Figures 2, 3). Relational structure is stable if there are positive relationships between all three actors, or if two actors have a positive relationship between them and have a negative relationship with the third member. The structure is unstable if all three actors have negative relationships or if there is one negative relationship between two of the actors.

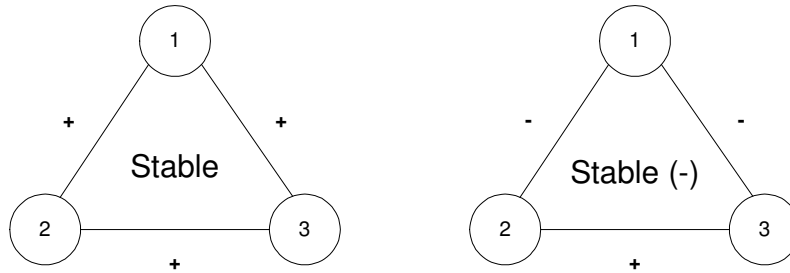


Figure 2: Stable States

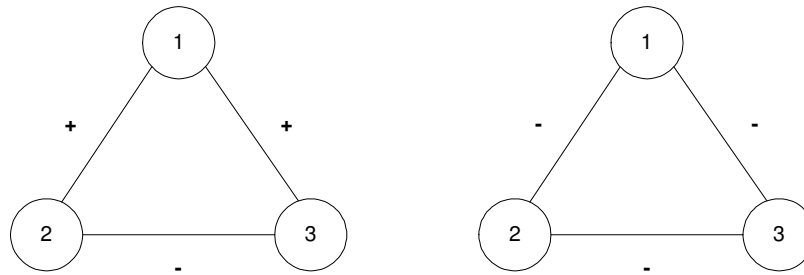


Figure 3: Unstable States

Relationships are bi-directional. Each triadic relationship is formed of three dyads. The polarity of a dyad is dependent upon the opinions of both actors. A negative dyadic relationship indicates that the actors' overall evaluation of the measured factor is negative. The inverse is true for positive relationships. Consistent with Heider's (1946) theory, when relationships are conflicted or unformed, they are treated as unstable or negative. These bi-directional relationships are subsequently represented in a signed unidirectional graph to facilitate a structural balance analysis.

For participating teams, members are asked to evaluate within-team relationships for the five factors of stability along a 7-point Likert scale. Average response for each factor is used to establish a cut point with which to determine the polarity of a relationship (Hanneman & Riddle, 2005). The cut point for this study is 6. Thus, any response below 6 constitutes a negative relationship while values of 6 or more are positive. While choosing 6 as a cut-off point creates methodological vulnerabilities in the results, the cut-off point allows for richer analysis and explanation of results as an illustrative example. We recognize that in our future work a more rigorous derivation of the cut-off point is needed. Figures 4 and 5 demonstrate calculation of structural stability for a triad based on the data in Table 1.

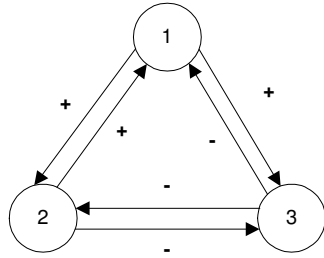


Figure 4: Bi-directional graph

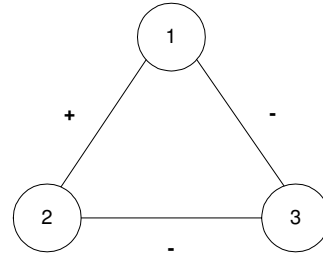


Figure 5: Converted unary graph

		Member score recipient		
		Member 1	Member 2	Member 3
Member providing score	Member 1	n/a	6.33	6.67
	Member 2	6.00	n/a	5.67
	Member 3	4.67	1	n/a

Table 1: Example result for single factor

Data from Table 1 is scored for each relationship to derive its polarity as shown in Figure 4. Graphs are converted from bi-directional relationships into unary relationship as displayed in Figure 5, which exhibits structural stability. The next section applies this methodology to collected data.

RESULTS

Structural stability results for three teams measured at project inception are shown in Table 2. Three relational states are reported, Stable, Unstable, and Stable (-). Figure 2 illustrates the two possible stable states. Of the teams measured, team A appears stable for the greatest number of factors. Team A is also the only team which reports its project as on schedule. Teams B & C each express some degree of instability, with team C being consistently unstable across the greatest number of factors. Teams B & C self-assess their projects as behind schedule. Team B, although stable across 50% of the factors measured, is Stable (-) in both Collaboration and Expertise. Additionally, table 2 includes team self-assessment using Heider’s original measure, a single item which asks whether teammates like or dislike one another.

Team	Collaboration	Expertise	Commitment	Interpersonal	Social Loafing	Heider’s Original Measure
A	Stable	Unstable	Stable	Stable	Stable	Stable
B	Stable (-)	Stable (-)	Unstable	Stable	Unstable	Unstable
C	Unstable	Unstable	Unstable	Unstable	Stable (-)	Stable

Table 2: Results

Team performance results for the three teams are indicative of the relative state of project completion as indicated by the team members.

Team	Self-Assessed Performance

A	On schedule
B	Behind schedule
C	Behind schedule

Table 3: Team performance

DISCUSSION

Initial results indicate that stability across structural balance measures does relate to the self-assessed performance of the teams. Further examinations of the relationships in team A for example indicate stable measures and the team believes it is on schedule. Lack of stability in expertise may be an evolutionary relationship between time in the project and skill development. Team B presents a diametrically opposite example where most relationships are either unstable or negatively stable; and as expected the team believes it is behind schedule. Team C has predominantly unstable relationships, but for the original Heider assessment. As posited, team C assesses itself to be behind schedule.

Initial results indicate the viability of the research model developed in this study, and warrant further investigation into second and third order responses to explain the relationships within the teams. In addition, further investigation of the evolution of structural relations within the teams over time is needed to understand the emergent structural stability and its relationship with VT performance. As pointed out by a reviewer, there are threats to internal validity given the size of the sample which does not allow us to control for pre-existing relationships between team members. These are under examination in our current and future work where we will control for and incorporate individual effects. We measure structural stability over multiple social factors and compare them with VT performance to establish if there is a relationship between structural stability and virtual team performance within a project. This is pre-requisite to identification of social factors of structural stability that are significant to team performance, which is under-investigation in our on-going work.

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