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Individual Factors in Virtual Teams: A TIP Theory Perspective

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ABSTRACT

In the pursuit of rapid software development, globally distributed information systems development teams are a growing phenomena in many organization. In order to be successful, these teams must have members who will be high degree of unity and are satisfied upon completion of the project. In order to test some possible factors that may be important in distributed team selection we must first understand individual’s contribution to the team. McGrath’s Time, Interaction and Performance (TIP) Theory is proposed as a framework to evaluate possible individual characteristics which may influence a member’s satisfaction and unity in development projects. This preliminary cross-sectional study tests TIP Theory while also identifying possible factors that may lead to increased group unity and group satisfaction. Implications for the selection of distributed development teams are discussed.

Keywords

Virtual Teams, Distributed Teams, Time, Interaction and Performance Theory

INTRODUCTION

With globalization of the world marketplace, organizations strive for better ways to collaborate. Technology has provided the infrastructure necessary to support these new means of collaboration. The technology improvements have made it possible for distributed groups to be viable, widespread and successful (Constant Sproull and Kiesler 1996). Consequently, many organizations have adopted or plan to adopt distributed teams in the near future (McDonough Kahn and Barczak 2001). To understand the complexity of distributed teams we compare distributed teams with conventional teams on four different dimensions (see Table 1 below) (Bell and Kozlowski 2002). Temporariness refers to the length of time a particular team spends leading up to the project and after the conclusion of the project. Traditional teams are permanent and therefore have shared norms and are structurally intact from project to project. Distributed teams are intact for only the duration of the project and then disbanded.

In this study the focus will narrow to examine individual factors that positivity affects distributed teams in information systems software development. Distributed software development teams promise the flexibility, responsiveness, lower costs, and improved resource utilization necessary to meet ever-changing task requirements in highly dynamic global business environments (Jarvenpaa and Leidner 1998b). In software development the emergence of communication networks makes it possible for distributed teams to be an effective alternative to co-located teams (Monge and Contractor 2001).

Dimension	Conventional team	Distributed team
Temporariness	Permanent team	Short term ad hoc project team
Physical distribution	Collocated team	Space (and time) distributed team
Cross boundary distribution	Single organizational unit	Cross-organizational
Media	Face-to-face	computer mediated

Table 1. Dimensions of Distributed Teams

The goal of this preliminary study is examine the individual factors that may affect a distributed team members’ satisfaction and unity while also examining a possible framework that may inform how groups function in a distributed constellation. For this reason, a seminal theory in group research McGrath’s Time, Interaction and Performance theory is explored. Further, the

past literature will be examined to provide individual factors that may impact group satisfaction and group unity. Next the extant literature will be reviewed, followed by the research design narrative and finally results and limitations are discussed.

LITERATURE REVIEW

Undoubtedly, distributed teams face similar problems as traditional teams; we argue that the unique technology conditions, mentioned previously, create inimitable challenges for distributed teams. This thought stems from belief that media (such as video conference, e-mail, chat, and so on) used in distributed teams communication across space, time and organization boundaries represent, “their own advantages, disadvantages, social dynamics, problems, and opportunities” (Hiltz and Turoff 1993). In spite of cutting edge technology, a host of problems still exists that are not found in a traditional group setting (Kayworth and Leidner 2000). It is important to note that this study only focuses on the individual level factors and not contribution to the group. This study does not measure nor does it suggest group level outcomes. The following will first outline the theoretical underpinning for the dependant variables used in this study, next we will review Time, Interaction and Performance theory for use as an over arching frame work and finally the literature on team members’ communication and technology abilities is examined.

Dependent Variables

Commonly, virtual team suffer from problems of low satisfaction levels for team members and group member feeling lack of cohesion with the team (Lipnack and Stamps 1997, 2000; Sarker Valacich and Sarker 2005; Saunders 2000). For this reason we will center this study on two individual-level outcome variables that are common in the distributed team environment. First, a group member’s satisfaction is often used in distributed team research (Lipnack and Stamps 1997, 2000; Sarker Valacich and Sarker 2005; Saunders 2000). The second individual factor which is often used in distributed team research is the individual’s perception of group cohesion (Lipnack et al. 1997, 2000; Sarker et al. 2005; Saunders 2000). For our research we too will use both an individual’s satisfaction and an individual’s perception of group unity as the dependent variables. Next, TIP Theory will be examined as a possible framework to explain the function in distributed team projects. Figure 1 represents our overall research model.

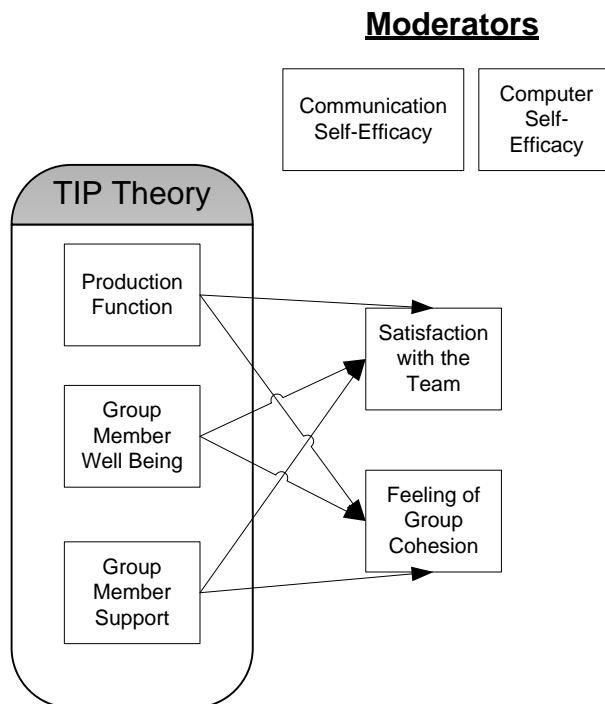


Figure 1. Research Model

Time, Interaction and Performance Theory

In order to test some possible factors that may be important for distributed team member satisfaction and feeling of group cohesion, we must first understand the different ways an individual can contribute to a team. McGrath's Time, Interaction and Performance (TIP) Theory is utilized as a framework to understand the important individual contribution that are needed to complete successful development projects. We will draw on McGrath's (1991) TIP theory to propose processes central in a distributed team environment. TIP posits that within groups, there are three simultaneous functions that influence the group's outcomes. The first is the production function. This includes a how individual's accomplish tasks within the project (e.g., performing the assign job, solving the problem, exploiting a new opportunities, and so on) (McGrath 1991). For this reason we propose:

H1a: An individual's production function will influence the individual's level of satisfaction with the distributed team.

H1b: An individual's production function will influence an individual's perceived degree of unison within the distributed team.

The second construct that contributes to the distributed team is group member well-being. Group member well-being is a reflexive process in which the individuals move towards a continuing social structure. This process assumes roles and develops behavior norms. Because of this, the group enables and constrains the actions of group members through their characterization of the organizational culture (Orlikowski 1996). For this reason we propose:

H2a: An individual's group member well-being contribution will influence an individual's level of satisfaction with the distributed team.

H2b: An individual's group member well-being contribution will influence an individual's perceived degree of unison within the distributed team.

The third process in TIP theory, group member support, is where individuals contribute to relationships within the group structure. This is also a reflexive process in which group members enter into relationships with each other. For this reason we propose:

H3a: An individual's group member support contribution will influence an individual's level of satisfaction with the distributed team.

H3b: An individual's group member support contribution will influence an individual's perceived degree of unison within the distributed team.

Within these three processes (production, group member well-being, or group member support); TIP theory proposes that groups engage in four modes: inception, technical problem solving, conflict resolution, and execution. These modes are neither temporal nor prerequisite in nature. Rather groups can engage in these modes in any order, at any time. The temporal aspect will not be explored in this research as it is beyond the scope of study.

Individual Factors

Many studies have looked at the factors that influence the processes in distributed team work. Some researchers have suggested that there are several factors that each having a different levels of affect to the outcomes at different stages of the project (Norton and Smith 1998; O'Leary 1998; Piccoli and Ives 2000; Saunders 2000). There are two prevalent individual factors that influence distributed team project outcomes in the extant literature. Although others constructs undoubtedly exist (e.g. trust, training, culture awareness, and so on) communication efficacy and technology efficacy are common individual factors in the literature (Chudoba and Maznevski 1996; Jarvenpaa Knoll and Leidner 1998a; Jarvenpaa and Leidner 1999; Lipnack et al. 1997; Majchrzak Rice Malhotra King and Ba 2000; Markus Manville and Agres 2000; Piccoli et al. 2000; Sproull and Kiesler 1995; Venkatraman and Henderson 1998). Due to space limitation all of the candidate factors cannot be discussed. Table 2 outlines where these two factors are placed within the information systems literature. The following two sections will give a brief background of communication skills efficacy and technology efficacy.

Type of Challenge	Description
Communication	Traditional social structures are lost (Townsend DeMarie and Hendrickson 1998) Communication cues are changed or altered (Kiesler and Sproull 1992) Trust Building Suffers (Jarvenpaa et al. 1998b) Communication norms are dysfunctional (Sarker and Sahay 2003a) Culture misunderstands (Kayworth and Leidner 2002; Sarker et al. 2003a)
Technology Efficacy	Technology Fit (Powell Piccoli and Ives 2004) Domain Expertise (Faraj 1998; Kayworth et al. 2002; Sarker et al. 2003a; Sarker and Sahay 2004)

Table 2. Challenges of Distributed Teams

Communication Efficacy

Communication is central to any distributed team production. Stated by Hulnick, “if technology is the foundation of the [distributed] business relationship, communication is the cement” (2000). The distributed environment creates considerable challenges including time delays in feedback, common frames of reference, interpretation of written text and computer mediated communication, and the participation of remote team members (Sproull and Kiesler 1991). Thus, teams operating in a distributed environment need a specific way to mitigate communication difficulties and foster an information sharing culture. One study examined a company that created rewards for system developers that create and foster culture (Suchan and Hayzak 2001). In another organizational study, it was found that team members needed to do more than one type of information sharing (Maznevski and Chudoba 2000).

Communication also is an important aspect of coordination. Coordination has been linked directly to team performance although much research has described the difficulties that team members undergo when they are subjected to different time zones, culture differences and different frames of reference (Kayworth et al. 2000) (Sarker et al. 2003a). Sarker and colleagues (Sarker Lau and Sahay 2001) also found that communication needed to be developed for teams to be consistent and coherent in the members’ contributions. For this reason we propose:

H4a: An individual’s communication self-efficacy will influence an individual’s satisfaction with the group.

H4b: An individual’s communication self-efficacy will influence an individual’s perception of group cohesion.

Technology Efficacy

Exceptional team members are often described as interdisciplinary as they integrate application domain and the computational knowledge. This technology knowledge is crucial in software development teams as it is an explicit element of expertise that is critical for positive outcomes in distributed software (Faraj and Sproull 2000). Research has also shown that in expertise in based on contextual technology knowledge. Due to this finding, technology efficacy, not surprisingly, has been investigated in distributed teams (Kayworth et al. 2002; Sarker et al. 2001) in terms of technical skills. Team members’ technical expertise has been found to be related to satisfaction and performance. Specifically, a lack of expertise has a negative effect on individual satisfaction and performance (Kayworth et al. 2002). Conversely, when team members have technical expertise, high trust develops (Jarvenpaa et al. 1999). For this reason we propose:

H5a: An individual’s computer self-efficacy will influence an individual’s satisfaction with the group.

H5b: An individual’s computer self-efficacy will influence an individual’s perception of group cohesion.

METHODS

To test our hypothesis we initiated a number of virtual projects for a senior level MIS class in two locations. One group of students was from a large North America university and the other groups of students were from a large university in Europe. There were a total of 7 groups of over 60 students. Students worked in self-directed and self-managed virtual teams of approximately eight students (about five or six students from U of North America and two to three students from University of Europe) to perform the analysis and detailed design of an information system for an actual organizational client. Students

were encouraged to follow the project steps in the systems development life cycle, but students may have adapted other methodologies (e.g., prototyping) as appropriate in each step. The project teams conducted all activities and produce all major work products associated with the project (that is, no work was "sub-contracted"). The project was a major part of the students' grade for this course (See Appendix A below for complete project outline). Students were directed to use certain technology tools when communicating. They include: Microsoft Project Server, Blackboard Discussion Board, Blackboard File Management, Blackboard Virtual Chat area and Blackboard Group Email. Students were reminded to use only the prescribed means of collaboration to complete the project. This was done so that the researcher team could track and evaluate all the communication and collaboration between team members.

After the teams were randomly formed and before the project teams met for the first time, subjects were given a short survey about their perceived communication ability, their computer self-efficacy. These instruments are used often in virtual team research (Compeau and Higgins 1995; Sarker Valacich and Sarker 2003b). The project was then initiated and students completed the project. After completion of the project, subjects were asked to evaluate their satisfaction with their respective groups (See Appendix B for complete instrument).

During the project two independent evaluators, that were separate from the research team, went through all of the communication transcripts including chat, discussion boards, posted documents, emails and so on. The independent raters then evaluated each group members on their: 1) contribution to the production function of the project, 2) on their contribution to the group well-being, 3) their contribution to member support and 4) finally their unity within the group.

All of these measurements were done at the individual level and rated on a 7-Point LIKERT Scale (1 being no contribution and 7 being outstanding contribution to the construct). Before the raters evaluated the transcripts they were trained on the strict definitions of the constructs according to McGrath's TIP Theory (1991). Further, group unison was defined and discussed at length. The raters training had taken place over several sessions with a world expert on groups. Also, experts were used as raters in this study. Specifically, both raters had over 5 years experience in the distributed development industry.

Inter-rater reliability was tested using Cohen's Kappa which was appropriate when two raters are used (Cohen 1960). It is often difficult to gain an acceptable Cohen's Kappa with a large amount of categories (e.g., 7 categories). In this case, Cohen's Kappa was .48 which is moderate agreement (Landis and Koch 1977). For our preliminary study this is an adequate Kappa statistic.

Multiple analysis of covariance (MANCOVA), using SPSS 16.0, was conducted to determine the effects of production function (PROD), group member support (GMS), group member well-being (GMWB) on member satisfaction (SAT) and group unity (UNITY). The descriptive statistics showed normal distribution for all factors. Both Computer Self-Efficacy (CSE) and Communication Self-Efficacy (Comm) were tested as covariates. Prior to the test, the instrument was tested for discriminant and convergent properties. An exploratory factor analysis was conducted in SPSS 16.0 using maximum likelihood estimation in a varimax rotation. The results suggest that the items relate to each factor appropriately for this preliminary study (See Appendix C). Further, Cronbach's alpha was measured and deemed acceptable.

The MANCOVA results revealed that the model was significant and provided an adjusted r-squared value of .533. Further, all three functions according to TIP Theory did play a statistically significant role in the group unity and/or group member's satisfaction. As expected the production function was a statistically significant influence on both group unity ($F=3.46$) and group member satisfaction ($F=39.10$). For group member support was also a statistically significant influence on both group unity ($F=4.80$) and group member satisfaction ($F=3.66$). Finally, this study suggested that group member well-being statistically affected group unity ($F=3.37$) but did not statistically influence group satisfaction ($F=2.09$). For a summary of the hypothesis results see Table 3 below. For the individual moderators, communication efficacy was a statistically significant covariate for group unity ($F=4.48$) but not for group satisfaction ($F=0.09$). Also, an individual's computer self efficacy was also a significant factor for group unity ($F=4.48$) but not group satisfaction ($F=0.41$). For complete results including interaction tests see Appendix D below.

To identify the interactions between the three functions within TIP a full factorial design in the MANCOVA analysis was executed. Although these interactions were not hypothesized, we can see that group member support interacts with both the production function and group member well-being to statistically significantly affect group unity (See Appendix D). This is an intuitive yet interesting post hoc finding.

Hypothesis	Description	Results
H1a	An individual's production function will influence the individual's level of satisfaction with the distributed team.	Supported
H1b	An individual's production function will influence an individual's perceived degree of unison within the distributed team.	Supported
H2a	An individual's group member well-being contribution will influence an individual's level of satisfaction with the distributed team.	Supported
H2b	An individual's group member well-being contribution will influence an individual's perceived degree of unison within the distributed team.	Partially Supported
H3a	An individual's group member support contribution will influence an individual's level of satisfaction with the distributed team.	Supported
H3b	An individual's group member support contribution will influence an individual's perceived degree of unison within the distributed team.	Supported
H4a	An individual's communication self-efficacy will influence an individual's satisfaction with the group.	Not supported
H4b	An individual's communication self-efficacy will influence an individual's perception of group cohesion.	Supported
H5a	An individual's computer self-efficacy will influence an individual's satisfaction with the group.	Not supported
H5b	An individual's computer self-efficacy will influence an individual's perception of group cohesion.	Supported

Table 3. Summary of the Hypothesis Results

DISCUSSION

With this study, the implications are three-fold. First, this paper tests a theoretical framework that we can use to evaluate individuals in distributed teams. With this model further research can be undertaken to provide other causal linkages that can influence the group function as outlined by TIP Theory. Also, the results of these empirical findings can fine-tune the model and provide evidence of the antecedents to the contributing factors in the three functions of TIP Theory.

Secondly, this manuscript provides a unified framework that can predict the impact of individual level factors in a distributed team environment (e.g., computer self-efficacy and communication self-efficacy). This framework's prediction power is the most intriguing as it could not only explain what contributions are important to an individual's satisfaction, but it can also predict the factors that improve group unity.

Finally, this research offers a prescription for managers designing distributed teams. Managers can draw from a list of characteristics that are related to individual communication self and computer self efficacy. These characteristics can be formed into a list in which can then be used as a ubiquitous tool that will aid in the alignment of distributed teams to organizational goals. With further research into other components management might soon know exactly what they are getting when forming a distributed team.

In every study there are limitations. This study was no exception. First, as with other distributed team research, this sample was rather small. Due to this small size there are limited types of analyses that could have been undertaken. Second, even though the subjects on the distributed teams were working on an actual consulting project they still were students. Although the sample is appropriate for this preliminary study, actual developers would be suggested for any follow-up work. Third, the

study is limited to understanding how only communication efficacy and computer self efficacy affect the TIP functions. There are many other constructs that could be added. For example, need for affiliation and social relationships (Burke Beukelman Ball and Horn 2002) or a group member's need for achievement and a desire to receive praise or avoid criticism by performing a given task well (Locke and Latham 2002) or a learning goal orientation focusing an individual's behavior on acquiring the knowledge and resources to master an unfamiliar task (Locke et al. 2002) and so on.

Additional characteristics that could contribute to the functions include need for cognition, perceived cohesiveness, and perceived entitativity. The final limitation deals with the choice of the dependent variable. Although it is important to include objective evaluations of the group's deliverable this would provide a cross-level of analysis problem in that the project would represent the group's work and not the individual's contribution. This aspect of the study is currently being evaluated and should be included in the next generation of this research.

Finally, this study is executed using individual level data which can be problematic when evaluating the overall group. Caution must be taken when evaluating the results presented in this paper as we examined only an individual's perspectives on the group not the outcomes of the group itself. Further research is needed to examine the group level implication of TIP theory and the individual factors tested.

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APPENDIX A: Project Description

You will work in self-directed and self-managed virtual teams of approximately ten students (about four students from XXX University in North America, and two students from Switzerland) to perform the analysis and detailed design (including screen shots) of an information system for an actual organizational client.

The project steps are scheduled to follow the *systems development life cycle* as taught in your respective courses, but you may adapt other methodologies (e.g., prototyping) as appropriate into each step (but you must follow the project milestones and deliverables as specified in this document). Your project team will conduct all activities and produce all major work products associated with the project (that is, you cannot "sub-contract" work). If your project is part of and dependent on a bigger project in the organization, you must clearly state what your project produces relative to the larger work.

You must use automated tools to design and develop your system (e.g., Visio, PowerPoint, etc.) and are also strongly encouraged to use a calendaring or project management system (e.g., MS Project) for project management. At the conclusion of your work, you will prepare a comprehensive, high-quality project team report containing the results of your analysis and design efforts.

APPENDIX B: Instruments

PRE-PROJECT

Computer Self-Efficacy adapted from Compeau & Higgins 1995

I could complete this software development project if...	Strongly Disagree						Strongly Agree
a. There was no one around to tell me what to do	1	2	3	4	5	6	7

- b. If I only had the software manuals 1 2 3 4 5 6 7
- c. If I had seen someone else using it before trying it myself 1 2 3 4 5 6 7
- d. If I could call someone for help if I got stuck 1 2 3 4 5 6 7

Communication Efficacy adapted from Sarker, Valacich, Sarker 2003

COMM1: My ability to understand the points of view of others.

1 (Not at all) 2 3 4 5 6 7 (To a great extent)

COMM2: My ability to explain myself to others who do not understand my assumptions.

1 (Not at all) 2 3 4 5 6 7 (To a great extent)

COMM3: My ability to convince other who do not initially agree with my proposed solution/course of action in the work/course related issues.

1 (Not at all) 2 3 4 5 6 7 (To a great extent)

POST PROJECT:

Satisfaction adapted from Sarker, Valacich, Sarker 2003

SAT1: I was able to add value to the team’s work.

1 (Strongly Disagree) 2 3 4 5 6 7 (Strongly Agree)

SAT2: I found this project challenging.

1 (Strongly Disagree) 2 3 4 5 6 7 (Strongly Agree)

SAT3: I gain intrinsic reward and satisfaction from doing a good job on this project.

1 (Strongly Disagree) 2 3 4 5 6 7 (Strongly Agree)

APPENDIX C. EFA of the Perception Factors

	Component		
	1	2	3
CSE1	0.910	0.205	
CSE3	0.811		
CSE2	0.865	0.147	
CSE4	0.760	0.350	-0.111
SAT3	0.204	0.862	0.311
SAT2		0.817	
SAT1	0.250	0.694	-0.2716
Comm1			0.824
Comm3	0.312		0.742
Comm2	0.428	0.209	0.698

APPENDIX D. MANCOVA Results

	DVs	F	Sig.
Corrected Model (Adjusted R Squared = .533)	Unity	3.677	.000
	Sat	26.736	.000
Intercept	Unity	.001	.981
	Sat	54.417	.000
Comm	Unity	4.482	.040
	Sat	.091	.764
CSE	Unity	4.577	.038
	Sat	.414	.524
Prod	Unity	3.459	.015
	Sat	39.104	.000
GMS	Unity	4.800	.003
	Sat	3.661	.012
GMWB	Unity	3.366	.006
	Sat	2.098	.064
Prod * GMS	Unity	5.657	.022
	Sat	.477	.493
Prod * GMWB	Unity	.486	.489
	Sat	.033	.858
GMS * GMWB	Unity	14.821	.000
	Sat	.188	.667