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Evolution of Trust in Distributed Software Development Teams: A Punctuated Equilibrium Model

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ABSTRACT

A significant body of literature has addressed trust in distributed teams; however the issues of 1) trust in *distributed software development teams*, 2) the *evolution of trust*, and 3) the *role of communication media in trust development*; have not been adequately addressed. The objective of this paper is to examine the evolution of cognitive trust, and to test a hypothesized model using pilot data from distributed US-Norway software development teams. This study contributes to the rich body of trust literature by *integrating* research on trust and team development, and by identifying the role played by communication media on trust development. It also contributes to practice by identifying stages in a software development project during which managerial intervention can help elevate trust levels.

Keywords

Punctuated equilibrium, trust evolution, distributed teams

INTRODUCTION

Today, advancements in information/communication technologies (ICTs) are enabling the increased use of distributed teams consisting of geographically, temporally, and even organizationally dispersed members (Carmel and Agarwal, 2001). However, due to the use of impersonal communication media, the social context is often missing in such teams (Sproull and Keisler, 1986), rendering them more vulnerable to uncertainties (Lewis and Weigert, 1985). Jarvenpaa and Leidner (1999) argue that "trust" is what enables such teams to better deal with these uncertainties. While a significant amount of research has been conducted on trust, most of it has focused on understanding the antecedents of trust (i.e., Jarvenpaa, Knoll and Leidner, 1998), or the different bases of trust (i.e., McKnight, Cummings and Chervany, 1998). While many researchers have investigated the way in which teams develop (i.e., Chang, Bordia and Duck, 2003; Gersick, 1988), no known research has examined whether trust also follows an evolutionary pattern and whether different bases of trust are critical at different stages of the team's development.

The objective of this paper is to fill this gap by exploring *the development of trust* in distributed teams. Further, given the critical role played by the communication media in such teams, we also seek to examine the effects of media used within a team on trust development. Finally, the study also examines the effect of trust on project outcomes such as perceived cohesion and satisfaction.

THE CONCEPTUAL MODEL

Trust

Drawing on prior research, we define trust in distributed teams as the collection of beliefs of an individual towards his/her remote team members that they will deliver actions agreed upon and will hold themselves accountable to one another (i.e., Mayer, Davis and Schoorman, 1995; Jarvenpaa et al., 1998). While review of the literature reveals many different bases of trust, (i.e., personality, institutional), in this study, we focus on cognitive trust, since unlike personality-based and institutional trust which tend to remain stable over the life of the project, cognitive trust (which depends on social cues and interactions amongst the members) is more likely to change over time (as the team and the project mature).

Punctuated equilibrium and trust development

In understanding the evolution of trust, we draw upon the "punctuated equilibrium model" of team development (Gersick, 1988) that has been shown to be appropriate for project teams that are task-focused and have a short temporal scope (such as distributed software development teams). Gersick (1988) argued that groups do not go through orderly stages in their development, but rather go through a "punctuated equilibrium," characterized by an initial period of stability lasting until the midpoint of the group's existence. At this point, different triggers (i.e., pressure to meet project deadlines) cause a dramatic change in the team, leading to a concluding period of stability in which the team's functions differ from those in the initial phase. We believe that such "punctuated equilibria" not only occur with respect to a team's task performance, but also in its trust development. In the early phases, individuals will develop cognitive trust mainly based on unit grouping and team members' prior reputation. Towards the mid-point of the project, time pressures and increased communication will cause dramatic changes in trust. As, team members gain more information about one another, they will form more accurate trust beliefs which will be different from the initial cognitive trust formed in the early phase of the project (see Figure 1). Further, not only will the extent of trust be different in the two phases, we believe that the bases determining cognitive trust in either phase will also be different (discussed below).

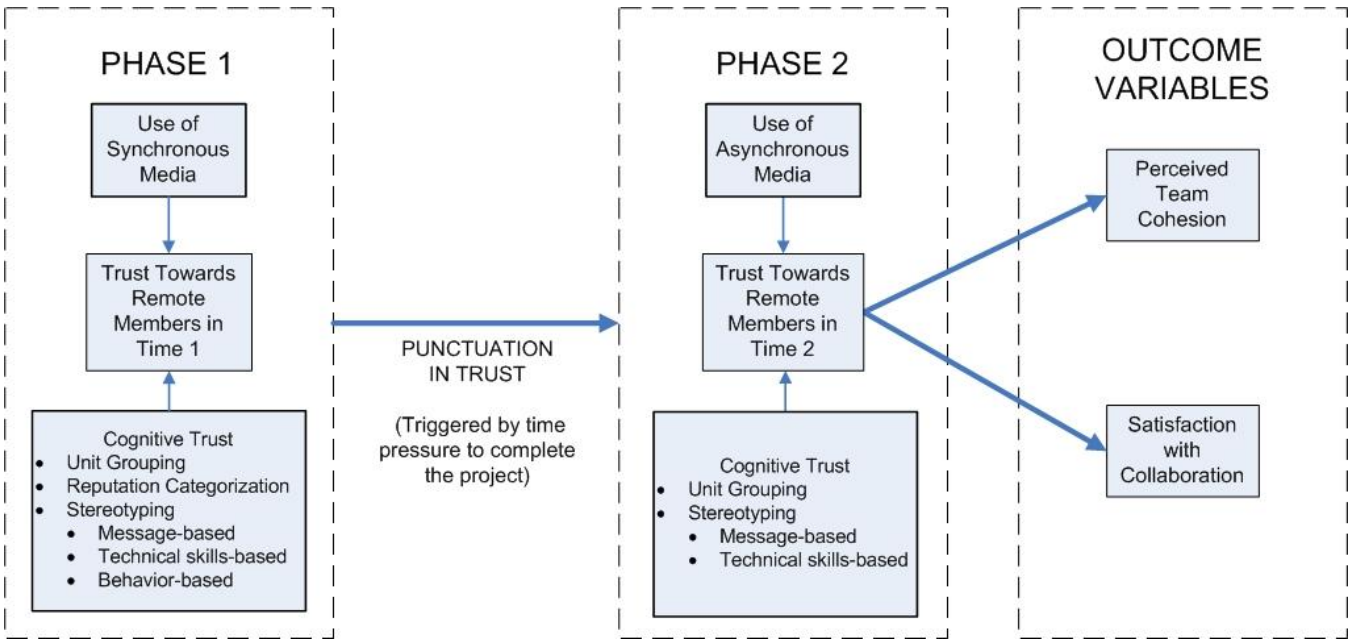

Figure 1. Conceptual Model

Cognition-Based Interpersonal Trust (Cognitive Trust)

Cognitive trust has been described as trust that "relies on rapid cognitive cues" (Lewis and Weigert, 1985). Once people gather information about one another, they use these cognitive cues to form schemas and stereotypes, which lead to their trust formation (Fiske and Taylor, 1991). In a distributed team, trust towards remote members will develop based on task-related communication and as a result of social interactions including humor and personal anecdotes exchanged over the electronic communication media (Sarker et al., 2003). McKnight et al. (1998) suggest that a person may use three types of categorization processes to develop cognitive trust: (1) unit grouping (2) reputation categorization, and (3) stereotyping. Other researchers have decomposed stereotyping in distributed software development teams to three types: message-based, behavior-based, and technical skills-based (Sarker et al., 2003).

The Initial Trust Equilibrium

In the initial phase of the project, team members will have limited knowledge about their remote members and will rely primarily on unit grouping and reputation categorization to form their cognitive trust.

Unit grouping will help in cognitive trust formation because those who are grouped together tend to share common goals and values, and this perception of commonality positively affects trust (McKnight et al., 1998). Members in a distributed team

will perceive remote members to share the same goals with them (i.e., success of the project), which will in turn positively shape their cognitive trust.

Reputation categorization suggests that people with good reputation are trusted. In the initial phase of the project, due to the absence of extended interaction with remote members, an individual's cognitive trust towards his/her remote counterparts will be formed based on the prior reputation of the remote members (McKnight et al., 1998).

In this phase, cognitive trust formation will also be affected by stereotyping. Limited interaction through the electronic media, will lead to the formation of first impressions/initial stereotypes. These will be based on the tone/frequency of the messages received from remote members, the humor/enthusiasm inherent in the messages (i.e., behavior-based), and perceptions regarding the technology-related knowledge/skills of the remote members (i.e., technical skills-based stereotyping) (see Figure 1).

The Later Cognitive Trust Equilibrium

In the later phase of the project, continuous interactions among remote members will lead to an even more important role of stereotyping on cognitive trust formation. Given the team's focus on technical issues (i.e., programming, testing), and with project deadlines approaching, cognitive trust towards remote members will be formed based on technical skills-based stereotyping and message-based stereotyping. Furthermore, given the commonality in the goals, unit grouping will continue to affect cognitive trust formation.

Trust and Media Use

The type of communication medium used by a team could have a significant effect on the trust formation (Burgoon, Buller, Hale and DeTurck, 1984). Prior research has differentiated media based on their "richness" (i.e., Daft and Lengel, 1986) or their ability to provide social presence. Short, Williams and Christie (1976) define social presence as the extent to which a person is perceived as a "real person" in mediated communication. Some media (i.e., face-to-face) have greater social presence than others (i.e., email). More recently, the channel expansion theory (Carlson and Zmud, 1999) argues that it is not so much the characteristics, but the experiences users have with the channel and their communication partner that provide media with the ability to exhibit social presence. Thus, in the initial phase, due to limited experience with each other, members' trust towards remote counterparts will be positively affected by the extent of use of synchronous media (i.e., chat) which has higher levels of social presence. However, towards the later phase, due to experience with the remote members, trust could be positively affected even by asynchronous media (i.e., e-mail, discussion board).

Trust and Member Outcomes in a Distributed Team

Trust has been assumed to be one of the key ingredients necessary for virtual team success and shown to increase cohesion and performance (Cohen and Bailey, 1997). Team members in cohesive groups have been shown to engage in more positive, personal and favorable communication interactions (Hogg, 1992). Trust has previously been linked to increased satisfaction (Driscoll, 1978). Researchers have also shown that virtual teams rely on trust more than traditional teams do (Morris, Marshall and Rainer, 2002).

RESEARCH METHODOLOGY

Data collection

A pilot study was conducted to validate the instruments and to test the research model. The sample for the study consisted of 8 distributed US-Norway student teams (with approximately 5 team members from each location) working on a software development project that lasted for one semester (end of January to early May). After removing participants who did not complete the questionnaire in both time periods, the usable sample size consisted of 47 participants (32 males and 15 females with average age of 18-25 years). Teams were responsible for developing information systems for "real" organizational clients. Communication between the distributed members occurred using the synchronous chat of WebCT and two asynchronous media (discussion board of WebCT and email). Data for the study was collected at two different times (each member was asked to respond to the questionnaire with respect to his/her remote team members (Figure 2): at the end of the first month (time t1), and at the end of the project (time t2).

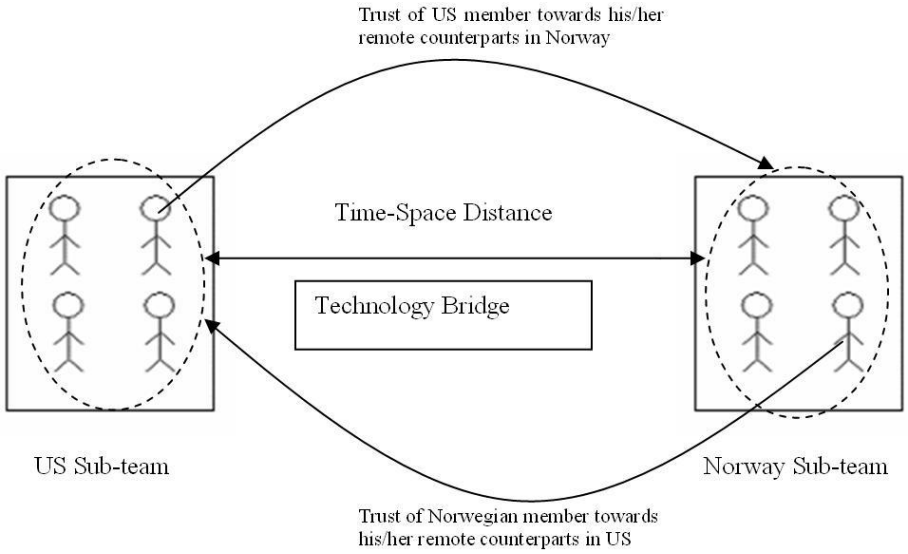

Figure 2. Representation of the measurement of trust towards remote members

Analysis

Measures of the different bases of cognitive trust were adapted from a previous instrument (Sarker et al., 2003). Perceived cohesion was measured using Seashore's (1954) items, and satisfaction with the collaboration was measured using two new items that asked participants to specify the extent to which they were satisfied with the collaboration, and perceived it to be effective. PLS Graph 3.0 was used to analyze the data. All items that had a significant loading of >= .60 on their respective constructs were retained for the analysis. Composite reliability of the constructs was above .70, suggesting good convergent validity of the measures. In addition, the square root of the Average Variance Extracted (AVE) of all the constructs (except one in Time 2) was greater than the correlations between that and other constructs, suggesting good discriminant validity (Gefen, Straub and Boudreau, 2000) (see tables 1 and 2). Preliminary results provide support for our model (see Figure 3).

Post-hoc Analysis

A post-hoc analysis revealed a significant moderation effect of the extent of synchronous media use on behavior-based stereotyping at time 1. With this additional relationship, the variance explained in cognitive trust at time 1 increases to 62.8% significantly improving the model. We would like to note however, that due to the availability of a small sample size, and given that moderation relationships require the inclusion of product-indicator terms (in PLS), we were unable to test all of the moderating relationships at this time and as such plan to conduct the full analysis of moderating effects in the future.

Constructs	Composite reliability	X1	X2	X3	X4	X5	X6	X7
Cognitive Trust in time 1 (X1)	.932	.906						
Unit grouping (X2)	.844	.576	.759					
Reputation categorization (X3)	.890	.532	.722	.819				
Behavior-based stereotyping (X4)	.775	.613	.387	.523	.796			
Message-based stereotyping (X5)	.928	.613	.381	.452	.521	.786		
Technical skills-based stereotyping (X6)	.836	.469	.492	.713	.448	.485	.794	
Extent of use of synchronous media (X7)	1.00	.214	.044	.120	.339	.407	.222	1.00

Table 1. Results of instrument validation – Time 1[1]

[1] The main diagonal presents the AVEs of the constructs, while the correlations between the constructs are reported on the off-diagonals.

Constructs	Composite reliability	X1	X2	X3	X4	X5	X6	X7	X8
Cognitive Trust in time 2 (X1)	.969	.955							
Cognitive Trust in time 1 (X2)	.926	.147	.899						
Unit grouping (X3)	.853	.780	.290	.771					
Message-based stereotyping (X4)	.968	.793	.263	.734	.889				
Technical skills-based stereotyping (X5)	.906	.674	.159	.738	.560	.873			
Extent of use of Asynchronous media (X6)	.782	.080	.091	.109	.099	.043	.805		
Perceived cohesion (X7)	.882	.598	.242	.513	.608	.538	.250	.846	
Satisfaction with collaboration (X8)	.939	.618	.151	.608	.711	.474	.120	.612	.940

Table 2. Results of instrument validation – Time 2[1]

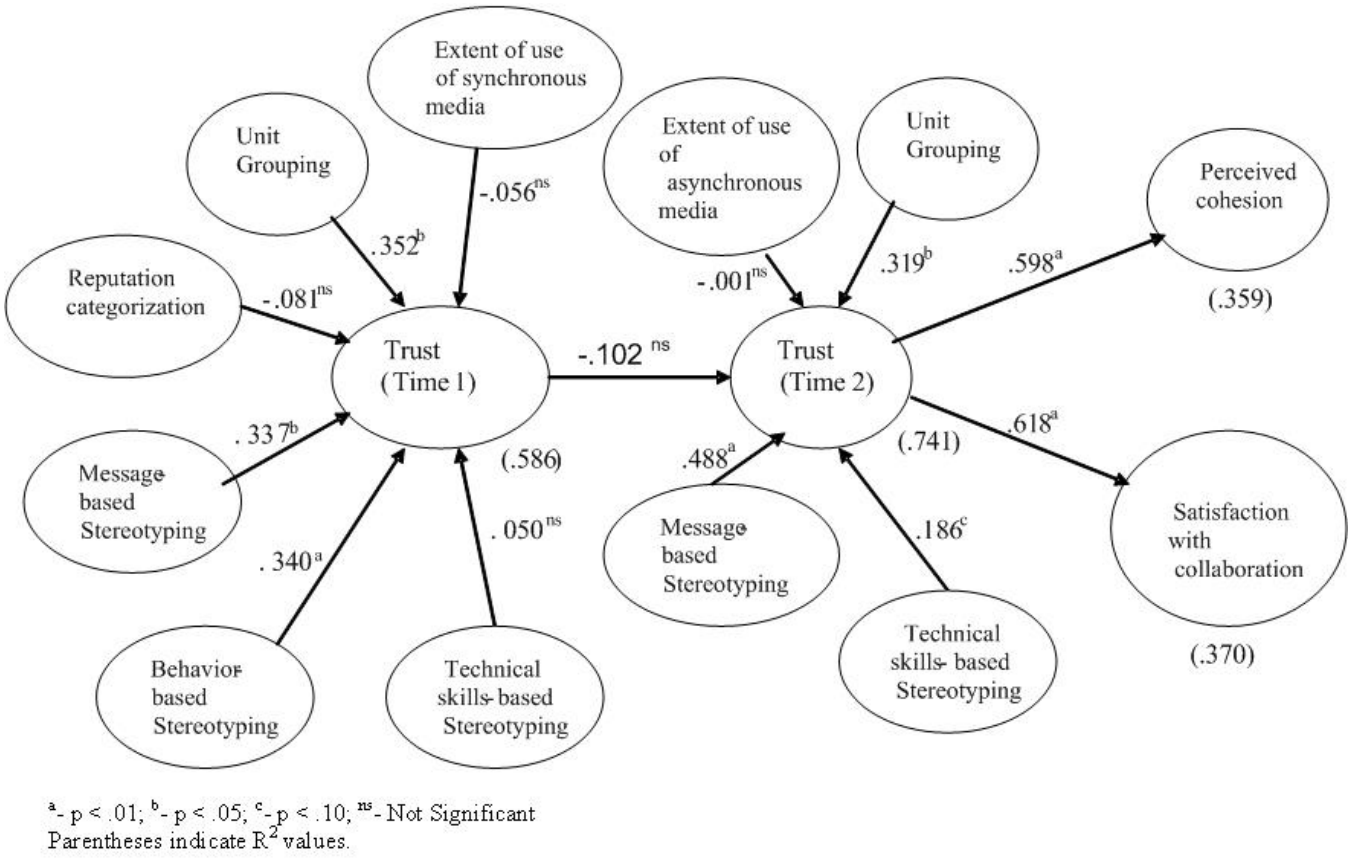

Figure 3. Research model with results

Qualitative Analysis

To understand whether "punctuation" occurred, we turned to qualitative data (discussion postings on the WebCT). Selected quotes from team discussions posted at the mid-point of the project are provided below:

Member from team 3: *"…We need to start writing weekly reports of what we have accomplished and what we are working on. This would keep everyone informed on the project and help build trust between team members seeing that everyone is contributing to the goal…"*

Another member from team 3: *"… it is rules like this that can make a project like this work… I hope the communication is going to get better. I guess we should have done this much earlier…"*

Team 2 showed similar signs of transition.

Member from team 2: *"BTW: I believe everybody should look at the project calendar. We don't have that much time in terms of working days!!!"*

CONTRIBUTIONS

While our proposed model was tested using pilot data, we believe the results are very encouraging (the model explains 58% and 74% of variance in trust in the two phases respectively). Specifically, the study highlights the following:

- Cognitive trust in distributed systems development teams follows an evolutionary pattern consistent with the predictions of the punctuated equilibrium model.
- Different bases affect cognitive trust formation in the two phases: behavior-based and message-based stereotyping, and unit grouping are important in the initial phase when the members have little information about their remote counterparts and base their trust formation on first impressions, while unit grouping, message-based and technical skills-based stereotyping become important in the later phase during the technical development.
- Based on our study, it appears that reputation categorization does not have an effect on cognitive trust in distributed teams, where members are not co-located and therefore may have little information about each other's prior reputation.
- Cognitive trust at the end of the project has a significant effect on members' satisfaction and perceptions of cohesion.

LIMITATIONS

One of the limitations of our research is the use of dyadic student teams. While this configuration is frequently used in systems development teams (Nicholson and Sahay, 2001), studies involving teams with members in multiple locations will need to be conducted.

FUTURE PLANS

Our future plans include conducting a study involving a larger number of participants. We would also like to qualitatively assess the evolution of trust (i.e., the types of teams in which initial trust is low but increases to higher levels after a punctuation and vice versa), and the implications of this pattern of trust evolution on the final team outcomes. Additionally, we would like to explore the moderating effects of media on cognitive trust in more detail.

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