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Trust Development in Distributed Teams: A Latent Change Score Model

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A Latent Change Score Model

by

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Abstract

Advances in collaborative work tools and communication technologies have made computer-mediated teams a part of virtually every organization. One of the challenges for members of virtual teams is the development of trust. This study examined the reciprocal relationship between trust and effectiveness in virtual teams, employing an input-process-output-input approach. Data were collected from 183 individuals comprising 61 teams. Teams participated in a computer-simulated search and rescue mission. Three alternative latent change score structural equation models were fit to the data to examine the bidirectional relationships between trust and effectiveness. Results revealed that the two factors of trust, cognition-based trust and affect-based trust, are always present, therefore examination of the trust-effectiveness relationship for each trust factor is warranted. The analyses revealed that generally, effectiveness has an impact on changes in trust, but trust does not influence the changes in effectiveness. Implications for organizations are discussed. Future research should examine the relationships between in trust and effectiveness on the team level. Additionally, research should explore the reciprocal relationship between each trust factors and effectiveness subtypes – attitudinal, behavioral, and performance effectiveness.

Chapter 1: Introduction

Teams are formed to accomplish tasks which cannot be achieved by a single individual. Employees face problems that are increasingly more complex, making teams crucial for organizations. This increasing complexity of work is transforming the workplace from a place where individual performance was central, to a setting where team performance is most valuable. This widespread adoption of teams has resulted in an increased interest in a variety of team outcomes. Various factors influence team performance including team composition (Peeters, Van Tuijl, Rutte, & Reymen, 2006) and communication environment (Thompson & Coovert, 2003). Due to the development of various communication technologies, employees have an unprecedented level of connectivity with each other. Employees are not restricted by their location or schedule, allowing for more flexibility than ever before. The widespread use of various communication technologies has allowed for the emergence of virtual teams, which are teams that communicate through technology. There are many advantages to virtual teams however, research reports that virtual team performance is often inferior to face-to-face team performance (Anderson, McEwan, Bal, & Carletta, 2007; Thompson & Coovert, 2006). One reason for this inferiority is that team constructs focal to teamwork, such as trust, cohesion, and shared understanding, are less developed in virtual teams because the quality of technology-mediated communication is lower compared to face-to-face communication. Work in a virtual environment is a reality in the modern workplace,

therefore the study of team variables and processes in this new environment is critical for team development and success.

Trust is one of the critical constructs associated with virtual team success. Trust development is particularly challenging for virtual teams because teams members are dispersed and lack informal, non-task related interactions, which facilitates the development of trust (Cohen & Gibson, 2003). Trust determines team performance, making its important to study how we can enhance trust between people in technology-mediated environments in order to achieve successful performance. First, we need to learn more about the evolution of team trust in computer-mediated settings. How do team members learn to trust each other? What are some conditions that facilitate or hinder the development of trust? What is the process of trust development? These are the kinds of questions that I will attempt to answer through this study.

In this paper, I will discuss several trust models that are widely used in the field of trust research and some of their deficiencies. I will then present a theoretical model which builds on existing research and addresses some of the deficiencies identified in previous models. Afterwards, I will review the relevant literature by discussing the role of teams and virtual teams in the workplace, focusing on the importance and development of trust, and highlighting some trust-outcome relationships. Lastly, I will outline and discuss the results of an experimental study that examines the plausibility of the proposed model of team trust development.

Model Development

Theories of Trust Development in Virtual Teams

There are several models available in the literature which describe trust (e.g., Costa, Roe, & Taillieu, 2001; McAllister, 1995; Sitkin & Roth, 1993; Smith & Barclay, 1997). Some of these models capture trust at a particular moment yet fail to account for temporal changes in trust, while others present trust as a dynamic construct. Over the last couple of decades, there has been an emphasis on examining trust as a dynamic process affected by time, and researchers are urging for the integration of time as a critical variable when modeling trust development (Jones & George, 1998).

The majority of models that examine trust and its development focus on traditional face-to-face teams. Results in the virtual team literature suggest that face-to-face teams and virtual teams are qualitatively different in terms of some underlying team processes, some of which could influence the development of trust, therefore it cannot be assumed that trust development is identical in face-to-face and virtual teams.

Two theories that have been widely used in attempts to explain change of trust over time in virtual teams are Time Interaction and Performance theory (TIP; McGrath, 1991) and Social Information Processing theory (SIP; Walther, 1992).

Time Interaction and Performance theory (McGrath, 1991) suggests that groups involve in many group processes and behaviors, which may or may not be task-relevant. According to TIP theory, members in computer-mediated teams spend less time interacting with one another leading to lower levels of trust compared to face-to-face

teams due to the lack of opportunities for informal communication. Given enough time to communicate both task related and non-related information, trust levels in virtual teams could become equal to trust levels in face-to-face teams.

Social Information Processing theory (Walther, 1992), on the other hand, posits that people communicating through technology will eventually adapt their communication patterns to their environment. Even though the medium of communication will not change, teams learn to overcome the obstacles presented by the technology. Additionally, the theory suggests that trust is based on knowledge of prior interaction. If prior interactions are positive/successful then trust is more likely to develop further, therefore variables of interest such as performance and satisfaction, should be positively affected.

Models of Trust Development

Here I will briefly discuss two models of trust development in teams. The first model was developed by Lewicki & Bunker (1996) and the second one was more recently put forth by Webber (2008).

Lewicki and Bunker (1996) propose that there are three types of trust: calculus-based, knowledge-based, and identity-based trust. Each of these types of trust emerges at a different stage of the development of a group. Calculus-based trust is the first type of trust that develops and formed on the base of the perceived costs and benefits that a member identifies to be associated with maintaining the relationships within the group. If members work well together and the team is productive, then calculus-based trust develops into knowledge-based trust. Knowledge-based trust is grounded in the belief that others have the competence and abilities needed to perform their role. This

knowledge allows members to anticipate each other's behaviors, which fosters trust. Identity-based trust develops out of knowledge-based trust in circumstances where members have worked together for a while, have performed well and now identify with the team and one another. Figure 1 illustrates the sequential development of trust as proposed by Lewicki and Bunker (1996).

In a more recent study, Webber (2008) proposes a similar stage model of trust development. Webber used the conceptualization of trust put forth by McAllister (1995), where trust is "the extent to which a person is confident in, and willing to act on the basis of, the words, actions, and decisions of another" (McAllister, 1995, pg. 25). Two foundations underlie trust: cognition and affect (McAllister, 1995). Webber proposed that in the early stages of team existence we observe the emergence of initial trust. Initial trust is closely related to what Javenpaa and Leidner (1999) call swift trust. It is developed on the basis of any available information that the team member possesses about each other. If sufficient information is not available, trust is based on various stereotypes (Kuo & Yu, 2009). After team members have worked together for a while, we see the emergence of cognition-based trust. Cognition-based trust is maintained through performance. If task performance is successful then cognition-based trust continues to grow, however if performance problems occur the maintenance of cognition-based trust becomes difficult (Webber, 2008). Once team members have worked together for sufficient amount of time, the second component of trust, affect-based trust, will emerge (Figure 2). Though affect-based trust takes longer to develop, it is easier to sustain compared to cognition-based trust. Webber's results unveiled two important factors. First, cognition-based trust

is predicted by initial trust and prior team performance; and second, affect-based trust is predicted by extra-role behaviors.

Research has examined the relationship between trust and performance in both directions: trust influencing performance, and performance influencing trust. Dirks and Ferrin (2001) summarized the research linking trust to performance both directly and indirectly. Their review reveals that in general trust has a direct positive effect on organizational citizenship behaviors, performance, and satisfaction. These results have been further supported on both the individual (e.g., Costa, 2003) and team (e.g., De Jong & Elfring, 2010) levels. Additionally, prior performance and team member interactions have been shown to have an effect on trust (Walther, 1992; McAllister, 1995; Webber, 2008).

Based on the results obtained by Webber (2008) and the knowledge that we have obtained so far concerning trust, a bidirectional relationship between trust and a variety of team outcomes can be expected. I propose a model of trust development which takes this synergetic nature of the relationship into account.

Proposed Model of Trust Development in Virtual Teams

The model I propose here builds upon the findings in the existing literature about the trust-performance relationship and situates them within the framework of Social Information Processing theory (Walther, 1992). Research has demonstrated that different forms of trust have different antecedents and outcomes (McAllister, 1995; Webber, 2008). Additionally, prior research indicates that trust has a positive relationship with team effectiveness (Costa, 2003). Team effectiveness is a multi-dimensional construct which encompasses numerous outcomes such as task performance, satisfaction, extra-

task behaviors, and time to complete the task, to name a few (Costa, 2003). Team effectiveness lends itself to being a better indicator of team success as compared to performance because of the interdependent relationships observed in a team. Therefore, I examine how trust and team effectiveness develop in virtual teams over time.

I propose that initially we will see the emergence of initial trust between team members. Initial trust will be based on any information that team members have about one another. Additionally, individual differences will be important predictors of initial trust. Once initial trust is established, team members will start working together. Based on the team effectiveness achieved through completion of the task at hand, team members will develop cognition-based trust. This qualitative change in trust will influence subsequent team effectiveness. The change in effectiveness will in turn influence trust again and we will observe the emergence of affect-based trust. According to SIP theory (Walther, 1992), once team members have worked together for a sufficient amount of time, they will start communicating non-task information which is necessary for development of affect-based trust. Figure 3 represents the model graphically. Given the concurrent dynamic change of trust and effectiveness, a Latent Change Score (LCS; Ferrer & McArdle, 2010) modeling approach will be employed.

Literature Review

Teams

As defined by Salas, Dickinson, Converse, and Tennenbaum (1992), a team is "a distinguishable set of two or more people who interact dynamically, interdependently, and adaptively toward a common and valued goal/object/mission, who have each been assigned specific roles or functions to perform, and who have a limited life span of

membership" (p. 126-127). Based on this definition there are three essential characteristics that make a group of people a team - task interdependence, shared outcomes, and interaction between members.

A key characteristic of a team is that team members need one another to successfully complete their tasks. In order for optimal levels of interdependence to be achieved, sufficient level of trust needs to be present within the team (Dirks & Ferrin, 2001). Trust influences a variety of factors that contribute to team performance including quality of the final product, participation of members in the team task, and membership retention (Bandow, 2001). Trust is necessary for satisfactory team performance because team members need to rely on each other and accept some amount of risk due to limited time to complete a task (Salas, Sims, & Burke, 2005). Research shows that teams where members trust each other have more open communication (Smith & Barcley, 1997) and share more information (Jones & George, 1998), facilitating understanding.

Trust, cohesion, and shared understanding are vital to team performance and effectiveness. Various models have been developed in an attempt to describe their relationships. Typically, team performance and its relevant constructs have been examined through models following an input-process-output (I-P-O) framework (Borrill & West, 2005; Dickinson & McIntyre, 1997; Durst & Kabel, 2001; Marks, Mathieu, & Zaccaro, 2001). Input is characterized by constructs pertaining to team characteristics, the task at hand, and context; throughput/process concerns various dynamic processes which take place and “convert” the inputs into outputs; and output consists of the outcome constructs of interest, such as team satisfaction and performance (Marks et al., 2001). A plethora of empirical research has examined the unique relationships between input and

process constructs as well as process and output constructs. A review of this research revealed that even the conceptualization of "team process" was not as unified and clear as expected. To address this issue, Marks and colleagues (2001) reviewed the relevant literature and proposed a taxonomy of team processes. First, they defined team process as "members' interdependent acts that convert inputs to outcomes through cognitive, verbal, and behavioral activities directed toward organizing taskwork to achieve collective goals" (Marks et al., 2001, pg 357). Furthermore, the authors propose that different team processes might be important at different points of the team's existence. In light of these expected differences, Marks and colleagues propose that a cyclic task episode framework is adopted to studying team behaviors. As described by Mathieu and Button (1992) task episodes are concrete periods of time when a task is being performed which are marked by a beginning and an end phase. The lifetime of a team will include a number of such task episodes and the team processes observed during every task episode will be dependent on a variety of factors (Marks et al., 2001). Marks and colleagues also proposed a taxonomy of team processes where they separated team processes into three phases: transition processes, action processes, and interpersonal processes. Transition processes are team processes which occur between the end of one task episode and the beginning of the next. Specific processes associated with the transition phase are analysis, formulation and planning, goal specification, and strategy formation. The second phase includes action processes which take place within the task episode. Action processes include monitoring progress towards goals, systems monitoring, team monitoring and backup behaviors, and coordination. The third phase includes interpersonal processes which take place during both the transition phase and the action phase. Interpersonal

processes include conflict management, motivating/confidence building, and affect management, and are key to facilitating the effectiveness of team processes in the transition and action phases (Marks et al., 2001). A review by Ilgen, Hollenbeck, Johnson, and Jundt (2005) further advocates the use of the task episode framework put forth by Marks and colleagues. Ilgen and colleagues (2005) argue that the I-P-O framework is deficient in its ability to capture the intricacies of teamwork and propose an iterative input-mediator-output-input framework, where every task episode is linked to the one prior.

It is evident from the brief description of the team processes above that communication within the team is critical for effective team process and successful team performance. Communication plays a vital role in team outcomes because many tasks related to achieving team goals (e.g. coordination, conflict management, strategy formation) depend heavily it. The overall communication process can be influenced by a number of variables, including the communication environment. Generally, when studying teams in terms of communication environment they can be broken down into traditional, face-to-face teams and technology-mediated, virtual teams.

Virtual Teams

A team is a group of individuals who depend on each other to complete their tasks, have a shared responsibility for results, and communicate with one another in order to achieve their goals (Salas et al., 1992). We can classify teams, based on the communication medium used for interaction between team members. Based on this criterion, teams can be classified as virtual and face-to-face teams (MacDonnell, O'Neill, Kline, & Hambley, 2009). A virtual team is a functioning team, whose members are

geographically or temporally dispersed and rely exclusively on technology-mediated communication rather than face-to-face interactions (Cohen & Gibson, 2003). Very rarely does a team communicate exclusively through technology or exclusively face-to-face. Therefore, Kirkman and Mathieu (2005) coined the term "team virtuality", conceptualized as "the extent to which team members use virtual tools to coordinate and execute team processes, the amount of information value provided by such tools, and the synchronicity of team member virtual interactions" (Kirkman & Mathieu, 2005, pg.702). Teams that stand somewhere along the continuum of team virtuality are often referred to as hybrid teams (Bjørn & Ngwenyama, 2009). Members of hybrid teams use technology to various degrees in order to achieve their tasks. Some teams are primarily face-to-face teams using technology only occasionally, while others communicate primarily via technology, meeting face-to-face only once or twice in the lifetime of the team. The focus of this paper is teams with high virtuality, where the interaction between team members is nearly exclusively technology-mediated. I will refer to these teams as virtual teams.

The rapid development of various communication tools has resulted in adoption of technology in numerous organizational contexts making the existence of virtual teams a reality. In a recent review, Thompson and Coovert (2006) classify available communication tools along three dimensions. The first dimension is the location of the interaction, collocated versus distributed interactions. Technology which supports collocated interactions typically has all the participants sharing the same location, often using individualized computer stations, and is usually used for group-decision making. Technology supporting distributed interactions, on the other hand, allows people to communicate when they are not in the same location. Email is an example of a distributed

interaction technology; the interaction can take place regardless of the location of the people involved in it. The second dimension for technology classification is based on the timing of the interactions, synchronous versus asynchronous interactions. Chat rooms, instant messaging, and the telephone are all examples of technology used for synchronous communication; all the parties involved in the interaction have to be available for it to take place. E-mail, messaging boards, and voicemail are all instances of asynchronous interactions, where communication can occur regardless of the availability of the parties involved. The third dimension for classification is the function of the technology itself, communication versus object sharing. Shared network drives and photo sharing websites are examples of object sharing technology. Team members can share various digital objects (e.g. files, pictures, videos) that can be accessed and manipulated by other members. Communication technologies, on the other hand, target communication facilitation between members, for example chat rooms and e-mail (Thompson & Coovert, 2006). It is important to note that these dimensions are not orthogonal to each other. Every instance of technology can be classified along all three dimensions. All of the technologies described above have been used in organizations to a various extent making virtual teams a reality.

When it comes to virtual teams and computer-supported work, there are positive and negative consequences that need to be considered. Often virtual and face-to-face teams are compared in terms of various performance aspects. Depending on the goals of the team, the adoption of technology could result in productivity increases. For instance, reduction of commuting time and decrease in the number of interruptions throughout the work day (LeMay, 2000), as well as the elimination of restrictions imposed by location

and time (Thompson & Coovert, 2006; Cheng, 2008) can facilitate a more productive work process. Members of the same team do not have to share the same location, which reduces cost associated with travel and office space (Thompson & Coovert, 2006). Additionally, members of the team can be in different locations within different time zones, making a 24-hour uninterrupted work cycle possible (LeMay, 2000). This freedom from time constraints allows for greater flexibility and is often compared to flextime arrangements where employees can develop their own schedule (DeRosa, Hantula, Kock, & D'Arcy, 2004). Moreover, the utilization of virtual teams can bring the organization closer to its clients (e.g. customer services) and it allows the company a greater access to experts in the field (LeMay, 2000). Organizations have the ability to recruit the best employees regardless of their location, which in additional to productivity gains, could also result in a more culturally diverse workforce (Thompson & Coovert, 2006). Research has shown that virtual teams generate more ideas than face-to-face teams in a brainstorming task (Dennis & Valacich, 1993), and people participate more in the communication exchange in chat-rooms than face-to-face settings (McDaniel, Olson, & Magee, 1996). Another advantage of virtual teams is the communication history that results from the interactions (e.g. emails, chat logs) which increase the amount of information available to team members for future reference (Thompson & Coovert, 2006).

Even though there are many advantages to virtual teams in the workplace, there are also disadvantages. Management of these teams poses a problem, since team behaviors and performance are harder to monitor (LeMay, 2000). Another problem stems from the technology used for interactions. Software can be complicated to use and

malfunctions still occur that hinder understanding and performance. Additionally, depending on the kind of technology used, some communication cues get lost, hindering understanding (LeMay, 2000; Thompson & Coovert, 2006). Moreover, because team members do not share the same location, they can feel isolated from the organization and one another. Informal communication is also greatly reduced which can result in loneliness, less commitment to the team, and less trust among team members (LeMay, 2000).

It is evident that there are advantages as well as drawbacks to computer-mediated communication. Often when studying teams, a construct of interest to both researchers and practitioners is team performance and/or team effectiveness. Before proceeding, a clear distinction should be made between these two similar but distinct outcome constructs. Team performance is defined as "a multilevel process (and not a product) arising as team members engage in managing their individual- and team-level taskwork and teamwork processes" (Salas, Cooke, & Rosen, 2008, pg 541). Team effectiveness, on the other hand, is "an evaluation of the outcomes of team performance relative to a set of criteria" (Salas, Cooke, & Rosen, 2008, pg 541). Team effectiveness contains a subjective appraisal component which is not a part of performance. In a study examining team trust and effectiveness Costa (2003) operationalized effectiveness in terms of perceived task performance, team satisfaction, and commitment to the organization.

In terms of virtual team performance, empirical research suggests that virtual teams are inferior compared to face-to-face teams (Thompson & Coovert, 2006). On average, virtual teams take longer to complete a task, there is more misunderstanding, and more time is spent clarifying ideas (Anderson et al., 2007). These findings suggest

that it is the limited amount of time that team have available that hinder performance. Major factors that influence process in virtual teams and team performance are trust, cohesion and shared awareness (Cohen & Gibson, 2003; Thompson & Coovert, 2006). Deficiencies in any one of these domains can be harmful to overall team effectiveness.

In a chapter on developing well-functioning virtual teams, Thompson and Coovert (2006) point out that one reason for performance inferiority of virtual teams is the lack of shared awareness. Shared awareness allows team members to have a common view of the problem at hand, monitor each other's progress, synchronize actions and activities, and execute other supporting activities which ultimately aid performance. Since virtual teams do not meet face-to-face and do not share a common environment there is a lack of common experiences among team members. This lack of shared awareness makes task coordination very difficult, resulting in less efficient team process. Empirical research further supports the notion that increasing shared awareness between virtual team members will positively affects performance (Fletcher & Major, 2006).

Both cohesion and trust among team members are also vital for team performance. Challenges associated with lack of common experiences and reduced interaction within the team have a great impact on interpersonal relations and lead to deterioration of trust, cohesion, satisfaction and commitment to the team (Paris, Salas, & Cannon-Bowers, 2000; Marks et al., 2001; Thompson & Coovert, 2006). In a study examining the effects of group level personality in face-to-face and virtual teams, MacDonnell, O'Neill, Kline, and Hambley (2009) compared performance and cohesion in face-to-face and video conferencing teams. Their results indicated that there was no significant difference in terms of performance. However, there was a significant

difference in team cohesion ratings, where face-to-face teams were significantly more cohesive than video conferencing teams. MacDonnell and colleagues stipulated that they did not find the performance differences that they expected because the video conferencing technology was close to face-to-face interaction. Results concerning cohesion indicated a difference between the two types of teams, showing that even though video conferencing and face-to-face interactions are so similar, there are still differences between the two in terms of team processes taking place. These results support the notion that interpersonal dynamics are important for team development and are affected by the communication medium used (MacDonnell et al., 2009).

Trust and cohesion are also closely related. Trust has been related to team member willingness to share information (Salas, Sims, & Burke, 2005), which affects shared understanding. Additionally, without trust ambiguous behaviors may be negatively misinterpreted by team members (Salas, Sims, & Burke, 2005), making it harder to achieve team cohesion. It is evident from the empirical research presented so far that trust is critical to team work. Moreover, the development of trust seems to be dependent on the communication between team members, which in turn is influenced by the communication environment. Therefore I expect that the communication environment (live or computer-mediated) will impact the development of trust. Trust, in turn, will have an effect on team processes and performance.

So far, I established that virtual teams in the workplace are temporally and/or spatially distributed teams that rely primarily on technology for communication. There are many positive aspects to virtual teams, including but not limited to flexibility in schedule and greater access to a diverse workforce. Even though there are many positive

aspects to computer-mediated teams, there are a number of drawbacks. A major issue concerns that virtual team effectiveness is inferior to face-to-face team effectiveness. This inequity has been attributed to the communication environment. Participants in a virtual communication environment lack the time and opportunities to establish personal relationships, resulting in lower levels of trust between team members. Additionally, because team members in virtual teams do not communicate face-to-face there is degradation of the information communicated between members which further contributes to lowered understanding and trust.

Trust

Trust is a critical factor to every relationship that people engage in, whether personal or professional. Without it society cannot function, making trust a social construct of imminent magnitude (Reina, 1994). I will first review some important relationships observed between trust and constructs of interest. I will then present some common conceptualizations of trust and its development, before discussing the role of trust in virtual teams.

Trust has been established as central to building selling alliances (Smith & Barclay, 1997), group participation (Bandow, 2001), and willingness to share information (Jones & George, 1998). Even though trust has been extensively studied, results regarding the effects of trust on variables of interest have not been conclusive (see Dirks & Ferrin, 2001 for an extensive review). The importance of trust for team effectiveness in face-to-face teams has been strongly supported (Costa, Roe, & Taillieu, 2001; Dirks, 1999; Langfred, 2004; Peters & Karren, 2009). Also the relationship between trust and performance has been established on an individual level (McAllister, 1995). However the

relationship between trust and team performance is not so clear. Some studies have found a positive relationship between these two constructs (Costa, Roe, & Taillieu, 2001; McAllister, 1995; Peters & Karren, 2009), while others have not found any relationship (Dirks, 1999). Often performance is not the only indicator of good team work. Attitudinal constructs such as satisfaction need also be considered. A study conducted by Cunningham and MacGregor (2000) revealed that in addition to performance, trust also predicted intention to quit and satisfaction in teams. Therefore expanding team outcomes of interest beyond performance is intuitive.

In a recent review of the interpersonal trust literature Lewicki, Tomlinson, and Gillespie (2006) delineate four distinct approaches to studying trust: behavioral approach, unidimensional psychological approach, two-dimensional psychological approach, and transitional psychological approach. The behavioral approach to studying trust defines trust in terms of behaviors observed during simulated interactions such as the Prisoner's Dilemma games (e.g., Axelrod, 1984 as cited in Lewicki et al, 2006). Trust is the result of rational choices people make and is usually assessed through cooperation behaviors. The behavioral approach to trust posits that trust starts at a zero point and subsequently changes as a function of reciprocated and cooperative behaviors on behalf of the trustee and the trustor (Lewicki, Tomlinson, & Gillspie, 2006).

The psychological trust approach encompasses the three remaining approaches: the unidimensional, two-dimensional, and transformational approach. The unidimensional psychological approach argues that trust and distrust are both ends on the same continuum, thus trust can range from distrust to high trust (e.g., McAllister, 1995). Trust is defined in terms of one's expectations and willingness to be vulnerable. This

approach posits that there is no definite beginning point of trust; some argue that it starts at zero, while others propose that trust can start at a higher level. Trust changes as a function of communication and trustee qualities among other factors (Lewicki, Tomlinson, & Gillspie, 2006).

The second psychological approach to trust postulates that trust is a two-dimensional construct where trust and distrust are two separate dimensions, making it possible for a trustor to range on each of the two dimensions (e.g., McAllister, Lewicki, & Bies, 2000 as cited in Lewicki, Tomlinson, & Gillspie, 2006). Trust is defined on the basis of expectations and a trustor usually starts at both low trust and distrust levels. Both trust and distrust change as a function of the interactions between the parties involved (Lewicki, Tomlinson, & Gillspie, 2006).

Lastly, the third psychological approach, the transformational approach, suggests that over time trust changes qualitatively (e.g., Shapiro et al., 1992 and Lewkicki & Bunker, 1995, as cited in Lewicki, Tomlinson, & Gillspie, 2006). Trust is defined in terms of what it is based on (e.g. knowledge, values, identity), it originates from one's reputation, and it changes as a function of history between the trustee and the trustor (Lewicki, Tomlinson, & Gillspie, 2006).

Within every approach to studying trust, there is a variety of definitions describing it. Henttonen and Blomqvist (2005) define trust as "an actor's expectation of the other actors' capability, goodwill and self-reference visible in mutually beneficial behaviors enabling cooperation under risk" (pg. 108). Rousseau, Sitkin, Burt, and Camerer (1998) conceptualize trust in terms of its association with risk and argue that two major components of trust are risk and reliance. Wilson, Straus and McEvily (2006),

on the other hand, disregard the concept of risk and define trust as "confident positive expectations about the conduct of another" (pg. 18). Based on these definitions trust is defined either in terms of cognition and/or affective factors based on expectations, or in terms of risk and/or willingness to engage in behaviors involving risk (Smith & Barclay, 1997).

Besides differences in definitions there are also variations in the underlying components of the construct. Generally, trust is investigated as either a one-factor construct (Blomqvist, 2002) or a multi-faceted construct (Cook & Wall, 1980; McAllister, 1995; Smith & Barclay, 1995; Webber 2008). The multi-faceted view of trust is more prevalent. Cook and Wall (1980) propose that one trust component is "faith in the trustworthy intentions of others" and the other one is "confidence in the ability of others, yielding aspirations of capability and reliability" (pg. 40). Henttonen and Blomqvist (2005) distinguish between four distinct trust components – behavior, good-will (morality and positive intentions), capability (technological, business and cooperation) and self-reference (clear identity and decision-making skills). Lewicki and Bunker (1996) hypothesize a three-faceted view of trust – calculus-based, knowledge-based, and identity-based.

McAllister (1995) also proposed two components of trust, cognition-based and affect-based trust. A recent article by McEvily and Tortoriello (2011) reviewed the measures most widely used to access trust. Their review identified that there is a proliferation of trust measures available. They identified 129 unique trust measurement instruments most of which have not been replicated more than once. The most replicated measure, replicated 12 times, was McAllister's trust measure. Because the trust

assessment developed by McAllister (1995) is the most widely studied one, it was adopted for this study.

So far, I have reviewed some of the more prevalent definitions and conceptualization of trust. In the following paragraphs I will review some of the literature addressing the relationship between trust and outcomes of interest.

Smith and Barclay (1997) studied the role of trust in selling partner relationships. They stipulate that trust plays a central role is building selling alliances and propose that the only way to achieve an effective collaborative relationship is through mutual trust. The authors separate trust into two major components: mutual perceived trustworthiness and mutual trusting behaviors, where mutual perceived trustworthiness is required in order to achieve mutual trusting behaviors. Empirical testing of this model revealed that the trustworthiness dimension had a direct effect on the outcome variables of interest, namely satisfaction. Smith and Barclay suggested that trust should be conceptualized in terms of member trustworthiness, which emerged to have three distinct dimensions – character/motives (perceived personal attributed and intentions), competence (perceived knowledge and ability), and judgment (belief that each partner acts in the best interest of the team). Additionally, the results obtained suggested that trust may be context and role dependent, thus further investigation of its development was deemed necessary (Smith & Barclay, 1997).

Based on the idea that both one's perceptions and observed behaviors comprise trust, Costa, Roe, and Taillieu (2001) defined trust as " a psychological state that manifests itself in the behaviors towards others, is based on the expectations made upon behaviors of these others, and on the perceived motives and intentions in the situations

entailing risk for the relationship with those others." (pg. 228). Costa and colleagues proposed a four-component model of trust involving propensity to trust, perceived trustworthiness, cooperative behaviors, and monitoring behaviors. They examine the effect of trust on task performance, satisfaction, relationship commitment, and stress in a team setting. Based on empirical data, most of the variance was accounted for by only two of the components - trustworthiness and cooperative behaviors. Additionally, Costa and colleagues demonstrated that trust was positively related to task performance, team satisfaction and commitment and negatively related to stress (Costa, Roe, & Taillieu, 2001) and continuance commitment (Costa, 2003).

Unlike the models described above, McAllister (1995) proposed a two-component model of trust which did not focus on differences in perceptions and behaviors, but on the mechanisms involved in the development of trust. McAllister conceptualized trust as "the extent to which a person is confident in, and willing to act on the basis of, the words, actions and decisions of another" (pg. 25). He developed a model that outlined the role of trust and interpersonal relationships in an organization in an effort to explain the development of trust in manager-professional dyads (Figure 4). According to this model, interpersonal trust has two distinct components – cognition-based trust and affect-based trust. Cognition-based trust is generally derived from knowledge possessed about the entity to be trusted; affect-based trust captures the emotional ties between the one trusting and the one being trusted. Empirical investigation of the model, confirmed this two-factor structure of trust. Furthermore, each factor had a distinct association with various antecedents and outcomes. Reliable peer performance, cultural and ethnic similarity as well as professional credentials were identified as unique factors that facilitate the

development of cognition-based trust. Cognition-based trust, in turn, had a direct influence on control-based monitoring and defensive behaviors and related to manager performance. Affect-based trust, on the other hand, was uniquely predicted by interaction frequency and citizenship behaviors. Affect-based trust influenced citizenship behaviors as well as need-based monitoring. Need-based monitoring and citizenship behaviors then impacted both peer and manager performance. Results also revealed that a certain level of cognition-based trust needs to be achieved in order for affect-based trust to develop (McAllister, 1995). Due to its strong empirical support (e.g., Webber, 2008; Wilson, Straus, & McEvily, 2006; McEvily and Tortoriello, 2011), McAllister's two-factor model of trust has become very influential in the field of trust research.

It is evident from the literature described above that trust is critical when task completion involves working with other people, making it not surprising that trust is a central construct of interest when discussing teams and their performance and effectiveness. In a framework describing team effectiveness, Salas, Sims, and Burke (2005) propose that mutual trust is a vital mechanism for effective team performance. If trust levels are insufficient within the team, more time will be spent on non-task behaviors (monitoring and inspecting), and team members will cooperate less. Additionally, when there is less trust between team members, ambiguous behaviors is interpreted more negatively, fostering conflict and misunderstanding. Team trust is also closely related to leadership acceptance, where effective team leadership is hindered by the lack of mutual trust (Salas, Sims, & Burke, 2005).

When it comes to trust, one problem involves the approaches to studying its development. Trust is a dynamic construct which changes over time (Jones & George,

1998) thus the effects of time on trust development need to be taken into account. In an effort to understand trust development in teams, Webber (2008) proposed a model of team trust evolution. She proposed that in order for the two components of trust (cognition- and affect-based trust) to emerge, team members need to spent sufficient time working together. Moreover, Webber proposed a model rooted in the transitional approach, where trust begins as a construct with one component and over time the two factors of trust defined by McAllister emerge. Webber examined the performance of 78 student teams on a class project at three different time points over a ten-week period. Based on the results of the study Webber concluded that initially trust emerges as a construct with one factor, and over time, it develops into the two components of cognition- and affective-based trust (Figure 2). Additionally, even though initial, cognition-based, and affect-based trust were related to each other, they did have unique antecedents and were differential predictors of team performance. Results further suggested that initial trust developed based on prior familiarity, affect-based trust was driven by helping behaviors and expressed interest, and cognition-based trust was driven by the interaction of initial trust and team performance (Webber, 2008). The results obtained by Webber (2008) provide empirical support to the argument that time is an essential variable when examining the evolution of trust.

Trust in Virtual Teams. Various theories have been used in an attempt to explain the underperformance of virtual teams compared to face-to-face teams. Here, I will present the four theories that are most commonly used to explain differences between face-to-face and technology-mediated teams – Media Richness Theory (MRT; Daft & Lengel, 1986), Social Presence Theory (Short, Williams, & Christie, 1976), Time

Interaction Performance Theory (TIP; McGrath, 1991), and Social Information Processing Theory (SIP; Walther, 1992).

Media Richness Theory (Daft & Lengel, 1986). According to MRT, different communication technologies have different capabilities in transmitting communication cues between the participants in the interaction. Tools for communication can be described on a continuum ranging from lean to rich depending on the amount and types of communication cues that can be transmitted (Figure 5). The theory posits that the more cues are transmitted during the communication process, the clearer and more easily understood the transmitted message will be. Consequently, the deficiencies observed in virtual teams are due to the shortage of communication cues due to the use of technology. According to the theory, we should observe higher levels of trust in teams who communicate via telephone, for instance, compared to teams who communicated exclusively via email. Email is leaner in terms of cues communicated compared to a telephone interaction because more cues are communicated by voice than written text.

Social Presence Theory (Short, Williams, & Christie, 1976). Social Presence Theory resembles MRT in its focus on the characteristics of the technology used for communication. Unlike MRT though, Social Presence Theory focuses on the ability of the communication medium to convey awareness of the participants in the interaction based on the cues communicated. Deficiencies that we observe in virtual teams are therefore due to the team members not being aware of each other's behaviors.

Both MRT and Social Presence Theory present the characteristics of technology as stable overtime, where experience with the communication medium does not influence the interaction.

Time Interaction and Performance Theory (TIP; McGrath, 1991). Time Interaction and Performance Theory suggests that groups involve in many group processes and behaviors, which may or may not be task related. Task related activities are crucial for performance, while non-task related activities are as vital for team process because they facilitate the development of relationships among team members, and provide a way to ensure their well-being. The amount of time that team members spend together and interact with each other will influence both task and non-task related activities, which in turn will have an effect on performance, satisfaction, and trust. According to TIP theory, then, we see lower levels of trust in virtual teams due to the limited time that team members spend interacting. Given enough time to communicate both task-relevant and task irrelevant information, trust levels in virtual teams will become equal to trust levels in face-to-face teams, influencing outcome variables such as performance.

Social Information Processing Theory (SIP; Walther, 1992). Social Information Processing Theory posits that even though the characteristics of the communication medium are fixed, teams can learn to overcome the obstacles of the technology. According to the theory, team members will adapt to their communication environment given enough time. Over time they will share relational information with each other, which will foster trust between members. Additionally, the theory suggests that trust is based on knowledge of prior interaction. If prior interactions were positive, then trust is more likely to further develop and in turn variables of interest such as performance and satisfaction, will be positively affected.

Both TIP and SIP theories are dynamic theories and consider the effect of time on trust development. Trust is a dynamic construct, making the inclusion of a time factor in the study of trust a most relevant one.

It is evident from the descriptions above that the four different theories emphasize different aspects of the technology and the interaction between technology and users to develop the rationale behind why we observe a specific phenomenon. In light knowledge about virtual teams, team trust, team effectiveness and their interactions, it was determined that these constructs and their relationship can be best interpreted within the framework of Social Processing Information Theory (Walther, 1992). Therefore I chose to examine trust development within the SIP theory framework.

The presence of virtual teams in organizations has made their research more prevalent in various types of fields including organizational science, information systems, and management. Henttonen and Blomqvist (2005) conducted a case study to examine the factors of importance for trust development in virtual teams. They studied a 23-member virtual team where team members worked in multiple time zones at different company sites throughout the USA, Asia, Europe, and Australia. According to Henttonen and Blomqvist (2005) the antecedents to building trust in virtual teams are no different than the ones observed in traditional face-to-face teams, namely reputation, social similarity, personal conversation, joint goals, commitment, care and concern for the well-being of other team members. They suggest that in virtual teams, the emergence of swift trust is based on the first impression that the team members perceive from the interaction. Additionally, they stipulate that stereotypes may be used to form this first impression if not enough information is available. Henttonen and Blomqvist (2005) operationalize trust

it terms of behaviors, capabilities, good-will, and self-reference. Their case study revealed that all trust components were important for building trust in virtual teams. Team members were able to gather sufficient information regarding capabilities, behaviors, and good-will of others, but not enough to establish the self-reference component, which inhibited trust from reaching the levels observed in face-to-face teams. Therefore, Henttonen and Blomqvist (2005) suggest that special attention be dedicated to establishing relational connections between team members so that they identified with the team on a greater level. The results from this case study suggest that there may be required elements for trust to develop.

A year later, Wilson, Straus, and McEvily (2006) conducted a quantitative study examining the evolution of trust in distributed teams. Unlike Henttonen and Blomqvist (2005), they adopted the two-factor view of trust developed by McAllister (1995). They examined the development of trust over a three-week period. Additionally, they looked at changes in trust as a function of change in the communication medium. Results of the study revealed that at Time 1 trust was lower for virtual teams compared to face-to-face teams, by Time 3, though, there were no differences in both cognition-based and affect-based trust between teams. Results also suggested that a change in the communication medium at Time 2 from face-to-face to virtual and vice versa influences the trajectory of trust development. A switch to face-to-face communication resulted in an increase in trust, where as a switch to virtual interactions did not change trust, suggesting that once a certain level of trust is established, it is relatively stable. When looking at developmental rates for the two factors of trust, cognition-based and affect-based, Wilson and colleagues found no differences. This particular finding is inconsistent with the results obtained by

Webber (2008), which showed that cognition-based trust needed to develop to a certain level in order for affect-based trust to emerge. Additionally, Wilson, Straus, and McEvily (2006), suggest that the environment where the virtual team performs may have its unique effect on trust development and suggest examining scenarios in such environments.

In their review discussing the role of trust in organizations, Dirks and Ferrin (2001) propose that trust may have direct effect on outcome variables of interest such as performance, attitudes, and levels of cooperation. Moreover, they argue that trust could also have a moderating effect on the relationships between variables of interest. As we can see from this review, there is no one unified model that fully explains the development of trust in a virtual team setting. Here, I propose a model of trust development that integrates the knowledge obtained thus far and positions it within the Social Information Processing Theory framework.

The Present Study

In this study I will examine how the changes in team trust and team effectiveness influence each other over time. Most of what we know about team trust so far is based on the traditional, face-to-face teams. More recently, we have seen the emergence of studies that examine exclusively technology-mediated teams. In this study I will explore the development of trust in virtual teams and argue that team effectiveness is a factor of importance for trust development as well as an important outcome which is influenced by trust.

Model Development. There has been a call in the field urging researchers to investigate team processes in a longitudinal manner, where team processes are studies

with task episodes that the team engages in (LePine, Piccolo, Jackson, Mathieu, & Saul, 2008). This type of episodic approach lends itself well to the study of process and construct development, and in particular the study of how trust and team effectiveness develop over time as a function of each other. It is possible that the relationships between trust and effectiveness vary depending on the amount of time team members have spent together. Examining the development of these two constructs by utilizing the task-episode approach will allow for the examination of such possibilities.

I propose that trust and effectiveness will develop in such a way that changes in one will drive changes in the other. First, I expect that trust development will be partially driven by time elapsed between measurements (Lewicki & Bunker, 1996; Webber, 2008), therefore trust during one task episode will be predicted by trust during the prior task episode. In figure 3, the paths between Trust at time 1 and Trust at time 2, and Trust at time 2 and Trust at time 3 will be significant. Additionally, the paths between the trust constructs and the trust change construct will be significant. The change in trust (Δ Trust 1) will be driven by intra-construct relationships: already established trust (Trust at time 1), and rapidity of development (Trust slope), as well as inter-construct relationships, namely effectiveness achieved during the task episode (Effectiveness at time 1), as described by SIP theory (Walther, 1992) and suggested by prior research (McAllister, 1995). The same relationships are expected to be observed for the change in trust between the second and third task episode. Similarly, I expect that the development of effectiveness will be partially driven by time, because with practice performance on the task will improve, the Effectiveness at time 1 to Effectiveness at time 2 path and Effectiveness at time 2 to Effectiveness at time 3 path will be significant (Figure 3). The

change in effectiveness (Δ Effectiveness 1) will be driven by prior effectiveness (Effectiveness at time 1), the growth rate of effectiveness (Effectiveness slope), as well as trust levels during the task episode (Trust at time 2). The same relationships will be observed for the second change in effectiveness between Effectiveness at time 2 and Effectiveness at time 3. A specific prediction as to the direction on the above described relationships is harder to hypothesize. Social Information Theory stipulates that given successful performance, trust will increase (Walther, 1992). If teams are generally successful in achieving their goals, this success will propagate trust development, which will influence effectiveness, resulting in positive path coefficients. If team performance is not successful, it will have 1) a negative effect on trust (trust will decrease) or 2) no effect (trust will not change), then the above described paths will be 1) negative or 2) non-significant.

Development of Hypotheses. Research suggests that when team members unacquainted with each other are placed on a team, they develop initial trust based on any information they have available, such as stereotypes, stories, and shared information (Javenpaa & Leidner, 1999; Kuo & Yu, 2009; Webber, 2008). Also individual differences can play an important role in trust development (Costa, Roe, & Taillieu, 2001). It is expected that people who are predisposed to be more trusting in terms of personality traits will trust their teammates more from the very beginning. Therefore it is hypothesized that:

> *H1: Individual trust will predict initial trust in team members.*

Additionally, research suggests that trust and cooperation are interconnected (Tanghe, Wisse, & van der Flier, 2010), thus it is expected that cooperation, assessed on the facet level, will be related to initial trust levels. I hypothesized that:

H2: Individual cooperation will predict initial trust in team members.

Moreover, research suggests that if team members have never worked together, they use information available to them in order to form initial trust (Henttonen, & Blomqvist, 2005; Webber, 2008). Sometimes though, virtual team members have no information about each other; therefore I am interested in exploring the basis for development of initial trust when no information is available. Most of the empirical research assesses trust once people have started working together (e.g., Costa, 2003; Webber, 2008; De Jong & Elfring, 2010). However little is known about the basis of trust in virtual teams prior to interactions, especially when to information is available regarding one's team member. I will examine the sources of information for the trust assessment each member makes for her teammates as a research question.

RQ1: What type of information do virtual team members use as a basis for initial trust?

Once team members start working together, they will develop cognition-based trust on the basis of task-related communication and positive effectiveness outcomes. Over time, we will see the emergence of affect-based trust based on cognition-based trust, effectiveness outcomes, and relational information communicated (Kuo & Yu, 2009; Webber, 2008). Building on what we know so far about the development of trust in both

virtual and face-to-face teams, I propose a dynamic model of trust development (Figure 3).

The model stipulates that trust development and team effectiveness are closely connected with each other and they should be studied together. Methodologically, the model is a Latent Change Score (LCS) model (Ferrer & McArdle, 2010) and is theoretically positioned within Social Information Processing theory (Walther, 1992). Based on SIP theory, interactions between team members influence the development of trust. Thus it is expected that if prior interactions were successful, trust would increase; if they were not, it would not change or it might even decrease. Therefore, based on the proposed model it is expected that:

> *H3: Team effectiveness will influence trust development, such that changes in trust (ΔTrust 1 and ΔTrust 2) will be impacted by effectiveness.*

It is expected that when effectiveness levels are high there will be an increase in trust from Time 1 to Time 2. If effectiveness levels are low, on the other hand, there will be no change or even a decrease of trust from Time 1 to Time 2 (Figure 6). Additionally, the changes in trust will have an influence on effectiveness.

> *H4: Team trust will influence team effectiveness, such that change in effectiveness (ΔEffectiveness 1 and ΔEffectiveness 2) will be influenced by trust.*

Namely, it is expected that if trust is high at Time 2, we will observe an increase in effectiveness from Time 1 to Time 2; if trust is low, effectiveness may not change (Figure 7).

In terms of trust development, it is expected that trust will develop according to the sequence reported by Webber (2008). In the beginning, trust will be a one-factor construct which captures initial trust between team members. As team members work together, initial trust will develop into cognition-based trust, and over time we will see the emergence of affect-based trust. Therefore, it is expected that:

> *H5: Affect-based trust will take longer to develop than cognition-based trust.*

Because I am proposing a dynamic model, time is a variable that should be considered. Webster (2008) argued that for the emergence of affect-based trust to occur, teams need a substantial amount of time to work together. The teams that she studied worked together for 10 weeks. However, Wilson, Straus, and McEvily (2006), observed the emergence of affect-based trust after the first team interaction in both face-to-face and virtual teams, suggesting that cognition-based trust may not be a prerequisite for affect-based trust. Therefore it is possible that the development of affect-based trust does not take as much time as one might expect.

This study will benefit the field in several ways. First, to the best of my knowledge, this is the first time that the reciprocal relationship between trust and team effectiveness is considered within one unifying framework. Understanding how these two variables interact has significant practical value. Organizations strive to have teams that are highly effective, because these teams perform well and turnover is low (Kuo & Yu, 2009). Some levels of trust are necessary in order to facilitate teamwork (Lewicki & Bunker, 1996; McAllister, 1995). Identifying the relationships between trust and effectiveness over time will allow for improved teamwork. Employing a task episode

approach will allow to pinpoint when is trust more important for team effectiveness in virtual teams. If trust indeed has consequences for effectiveness, interventions can be constructed to facilitate its development.

Second, this study will add to the growing number of empirical investigations of the structure of trust in virtual teams. It is generally expected that the two components of trust, cognition-based and affect-based, will be observed. Social Information Theory posits that given enough time team members will learn how overcome the shortcomings of the communication media that they are using and will start exchanging both task relevant and task non-relevant information which influences cognition-based and affect-based trust, respectively (Walther, 1992). This study will reveal if the two factors of trust emerge in short-term teams.

Third, this study will explore potential predictors of trust in a virtual environment. Antecedents of trust have been most often examined in face-to-face conditions and they include prior experience with the person, information obtained from others, or stereotypes. Many of the sources of information used to make this evaluative judgment of trust may not be available due to the communication medium. Therefore I will explore some possibilities for antecedents of trust in a virtual environment.

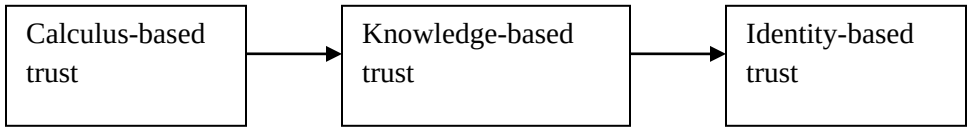


Figure 1. Development of trust in a group as proposed by Lewicki and Bunker (1996).

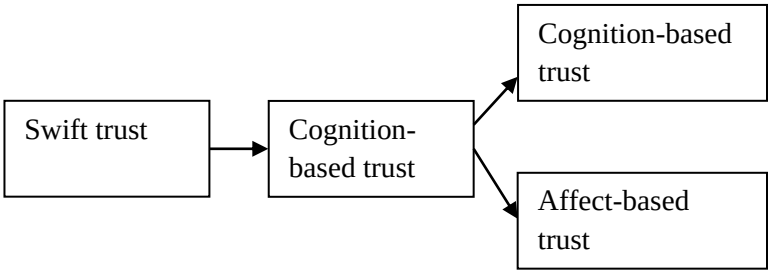


Figure 2. Trust development in teams as proposed by Webber (2008).

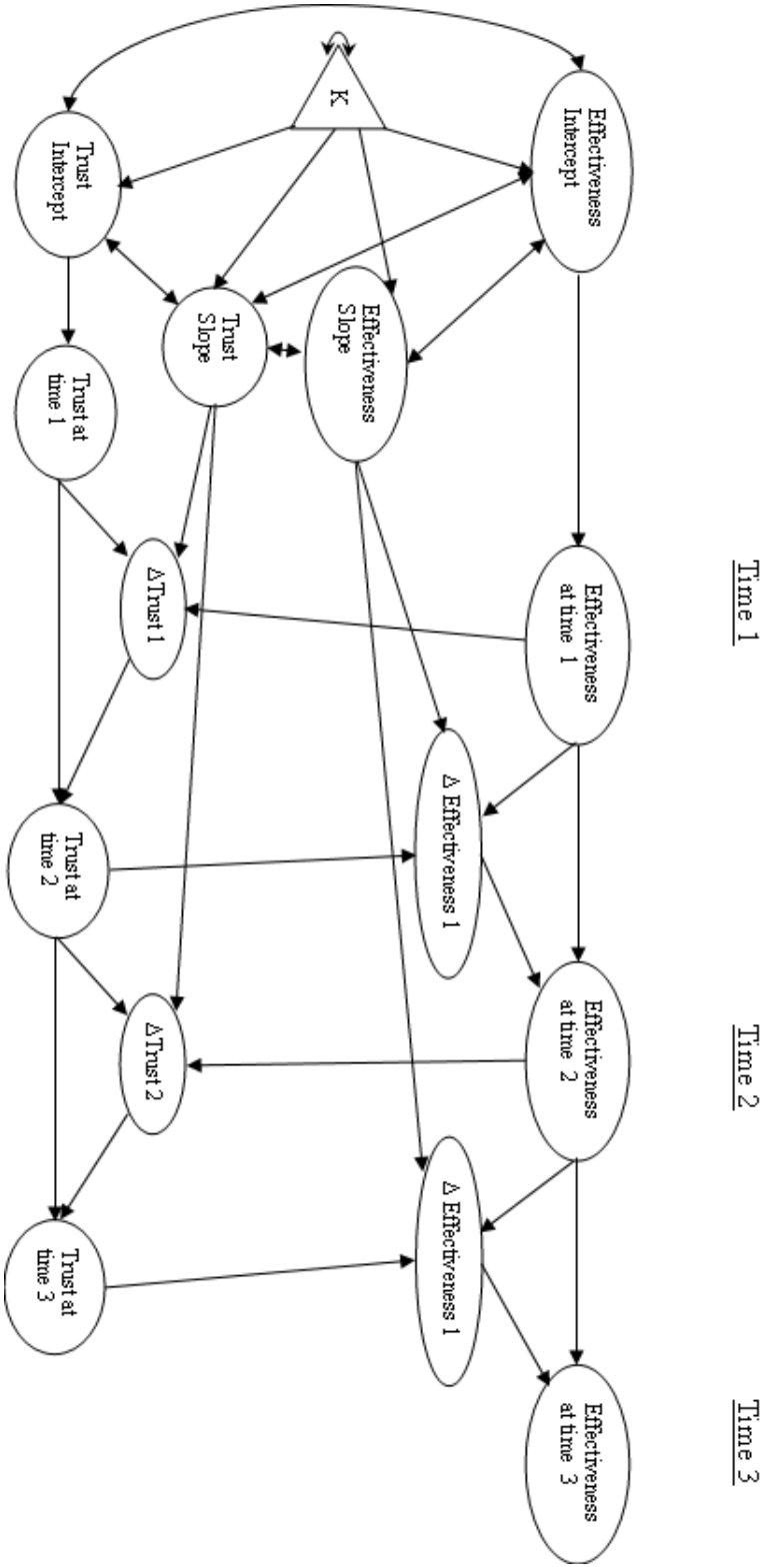


Figure 3. Proposed LCS model of trust development.

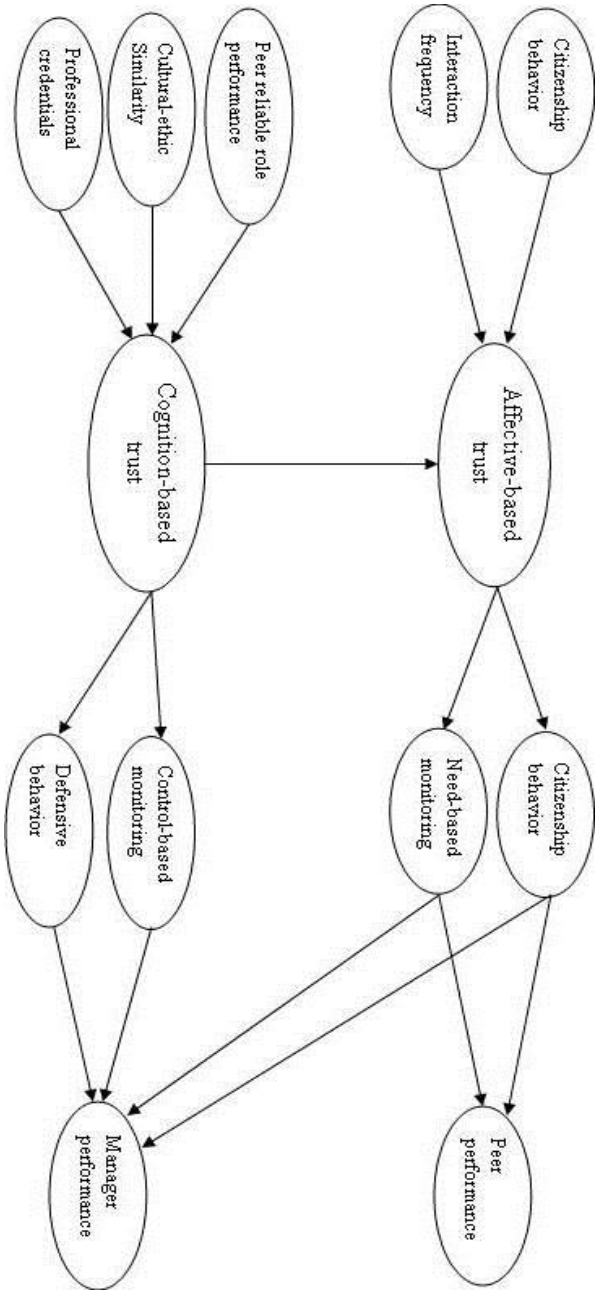


Figure 4. Theoretical model outlining the role of trust in interpersonal relationships in organizations (McAllister, 1995, pg 27).

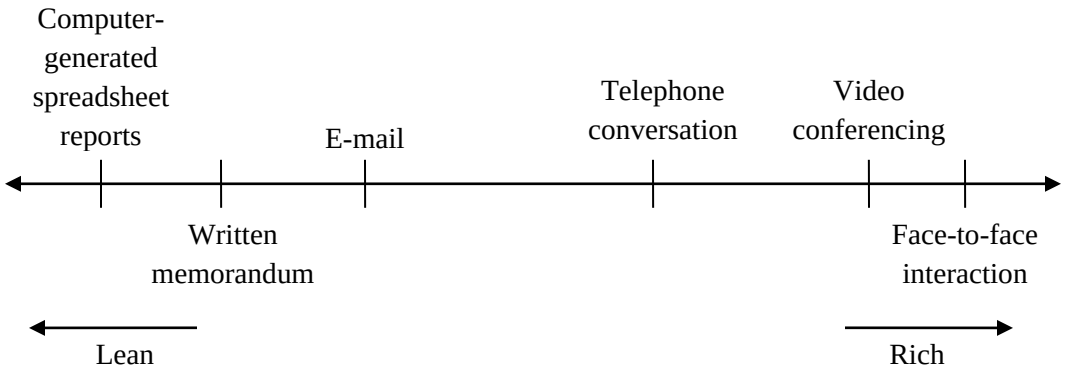


Figure 5. Media richness theory. Adapted from Daft, Lengel, and Trevino (1987).

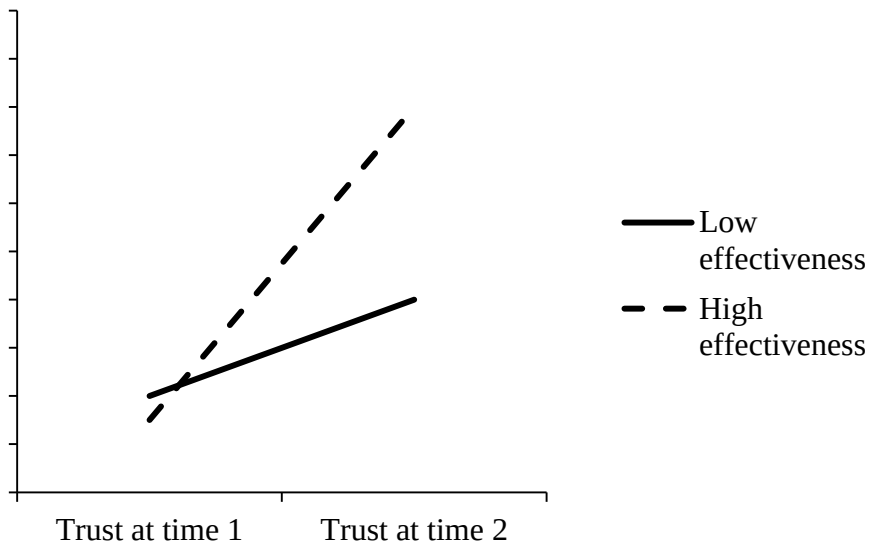


Figure 6. Expected pattern of results for Hypothesis 3.

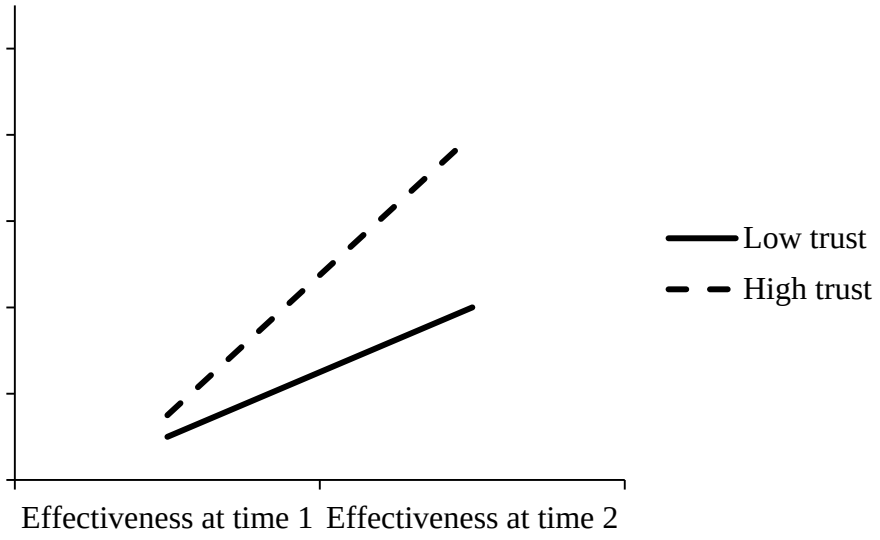


Figure 7. Expected pattern of results for Hypothesis 4.

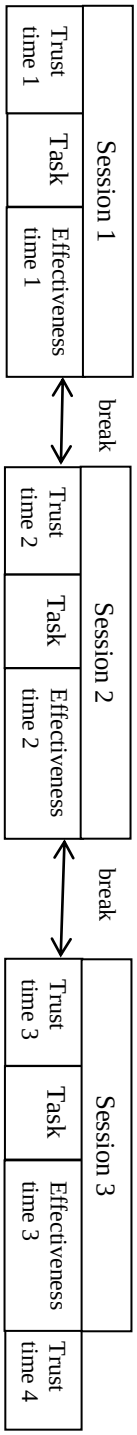


Figure 8. Measurements nested within task episodes.

Chapter 2: Method

Participants

Two hundred and thirty six (N=236) participants took part in the study, composing a total of 73 teams. Each teams had two, three or four team members. After all the data were collected, data from 2-person teams as well as incomplete data due to technical issues were removed resulting in data for 61 teams (183 participants) being retained. The final sample was 76% female with a mean age of 21.22 years (*SD* = 4.21). Forty-five percent of the participants identified themselves as Caucasian, 13 % as Black, 19% as Hispanic, 18% as Other and 5% did not report their ethnicity. Participants were undergraduate students at a large south-eastern research university. All participants received class credit for taking part in the study.

Materials

DDD Task. The task used was a distributed team performance task, DDD 4.1, developed by Aptima, Inc. and it is widely used for team research. Participants were a part of a computer-simulated search and rescue mission. The task required team members to collaborate in order to achieve their mission. The missions generally involved rescuing a lost party of people. Every team completed three separate missions. Mission completion required the team to complete three objectives – find the lost party, find the lost object (e.g. UAV), and find and fix a satellite. The three missions used for the study differed in the map placement of the objects described above. The order of missions was

counterbalanced across teams. Every team member possessed a limited amount of resources in the form of medical, mechanical and navigational skills, needed to complete the mission. There was also a limited supply of extra resources. Member resources were the same across team members as well as across missions. Based on prior task calibration, the available resources were more than sufficient to complete each mission. Team members used their resources to gather information which facilitated mission completion. Additionally, there were side actions that team members had to complete. Every team member earned points for completing the side actions as well as gathering outside information. There were four participants per team, three team members (red, green, and purple) were responsible for accomplishing the task at hand, while the fourth team member (blue) was responsible for conveying external information and providing extra resources when they were requested. In the cases when there were three participants per team, the role of the blue member was filled by a research assistant. Refer to Appendix A for a more detailed sample scenario description. A video demonstration of the task is also available at http://www.danehlers.com/scenario_demo.wmv.

Personality Survey. A personality survey assessed two personality constructs - trust and cooperation (both facets of agreeableness). Items from the IPIP were used (Goldberg et al., 2006). The scales for both constructs contained ten items each. Both the trust and the cooperation scale exhibited good internal consistency in the current sample ($\alpha = .87$ and $\alpha = .75$, respectively). Items for each scale are located in Appendix B.

Demographic Survey. Information regarding participant age, gender, and ethnicity was collected. Additionally, participants were asked to answer two open-ended questions to assess the information they used to make the initial trust judgments.

Team Satisfaction. Team satisfaction was assessed using a team satisfaction scale adapted from Lancellotti and Boyd (2008). The scale contained three items which assessed individual desire to be a part of the team. Respondents had to indicate their level of agreement with the presented items on a 7-point Likert scale. Reliability of the scale is α = .85-.88 across the three measurement periods. Scale items are located in Table 5, rows S1, S2, and S3.

Team Trust. Team trust was assessed using the trust scale developed by McAllister (1995). The scale assessed trust on two dimensions – affect-based trust and cognition-based trust. Cognition-based trust was assessed with five items (Table 5, row I5-I9), while affect-based trust was assessed using four items (Table 5, rows I1-I4). Participants indicated their responses on a 5-point Likert scale. Reliabilities for affect-based and cognition-based trust across measurement points varied within acceptable levels, α=.8-.9 and α = .84-.93, respectively.

Design

Latent change score models require at least two measurement points to detect change in the underlying variables. A minimum of three measurement points are required to detect linkage between those variables. Additionally, LCS models assume that the time lag between measurement events is equivalent (Ferrer & McArdle, 2010). In this study the measurement interval was 45 minutes long. Based on the assumptions of the LCS model, the present study employed a longitudinal design with three measurement points during the study session. Trust was measured at the beginning of the assessment session and is referred to as Time 1, Time 2, and Time 3 measures (Figure 8). After the last

mission was completed, trust was assessed one last time (Time 4), however that assessment was not included in the models tested.

Procedure

Participants were recruited via a university online recruiting system and signed up for a study session of their choice. Interaction between the participants prior to the study was kept to a minimum. Once participants arrived in the lab for the study, they went over the consent form that outlined the assessments and the task used in the study. After consent was obtained the participants completed the personality assessment as well as the first trust assessment (Trust at time 1). Then, participants watched an instructional video about the search and rescue simulation which lasted 10 minutes. The video covered functionality of the computer-simulation and the role of every participant. Following the training video participants completed the demographic survey. Afterwards, the participants completed a training mission that allowed them to become more comfortable with the controls of the simulation. The training mission lasted no longer than 15 minutes. Once training was completed, the first mission commenced. The participants had 40 minutes to complete the mission. Upon mission completion or when time ran out, participants filled out the team satisfaction assessment. The measurement period was complete once the participants completed the satisfaction survey. The second measurement period commenced when participants filled out the second trust assessment (Time 2), followed by the second mission and team satisfaction survey. The third measurement period was identical to the second one. At the end of the third measurement period the participants filled out the trust assessment (Trust at time 4) one last time, then they were debriefed and thanked for their participation.

Data Manipulation

Performance scores were standardized across missions. Every participant obtained an individual score at the end of the mission that reflected tasks completed during the mission. There were three different mission scenarios that every team completed. Performance scores were standardized within scenario. The individual's z-scores were used as a measure of performance for every mission.

Chapter 3: Results

Data Descriptives

The data were collected from 236 participants comprising 73 teams. All data were examined on the individual level. Incomplete observations were due to less than three members being on the team and were excluded from the analysis. Removal of incomplete cases resulted in data from 183 participants (61 teams) being used in the analyses. In the set of 183 participants, two participants had failed to answer one of the satisfaction items. These values were imputed using the series mean for each variable. The imputation had no effect on the overall distribution.

Data was collected over three separate sessions. First, the participants completed the personality measures and the first trust assessment, then participants received training on the task. After training the first mission was conducted resulting in the first performance score (performance T1). Following the mission, the participants filled out the satisfaction survey, which captured their satisfaction with their team after the first mission (satisfaction T1). The second session commenced with the second trust assessment (trust T2), followed by the second mission, resulting in the second performance score (performance T2), and finally satisfaction with the team was assessed again (satisfaction T2). Afterwards the third measurement period commenced again with assessment of trust (trust T3), followed by the third mission (performance T3) and the

last satisfaction assessment (satisfaction T3). Once the third measurement period was competed, trust was assessed one last time (trust T4).

Data for two types of teams were used, 3-participant and 1-confederate teams, and 4-participant teams. The use of a confederate was necessary when a participant failed to keep their appointment. It was expected that having the confederate would have no effect on the data because the role of the confederate was always the same - provide resources to the other participants when requested as well as relay outside information. In teams where no confederate was necessary, one of the four participants performed the above described function. Data for this player was not included in the analyses. The means for the participants in the two types of teams were compared. Means for all the participants in each type of team (3-participant-1-confederate and 4-participant teams) were compared across all the variables using an independent samples t-test. None of the comparisons were significant indicating that no differences due to team configuration, therefore data aggregation across both types of teams was appropriate.

Trust observations at Time 4 (N=132) were fewer compared to the other three trust measurements (N=183). The trust measure at Time 4 was included once data collection had already commenced, when the study team realized that the trust measurement after the last mission would not interfere with the protocol. Even though the fourth trust measurement is not included in the models discussed below, if provides the ability to examine the development of trust over a longer period. Analyses including trust measures at Time 4 were performed using the subset of data which had Time 4 measures available.

Table 1 contains the descriptive statistics for all the examined variables at the individual level. Average trust at every measurement point ranged between one and five. The initial mean (Trust T1) was within the expected range, M_{T1}=3.19 (SD_{T1}=.9). A repeated measures ANOVA (N=132) determined that the trust means were significantly different from each other, $F(3, 387)=30.98$, $p<.001$, $\eta^2=.19$. A post hoc test with Bonferroni correction revealed significant differences between the following trust means: time 1 (M_{T1}=3.04, SD_{T1}=.9) and time 3 (M_{T3}=3.46, SD_{T3}=.75), time 1 and time 4 (M_{T4}=3.57, SD_{T4}=.85), time 2 (M_{T2}=3.15, SD_{T2}=.71) and time 3, time 2 and time 4, and time3 and time 4 (Figure 9). Overall trust increased over time as anticipated, though the speed of this increase differed across measurement periods. The trust data were further broken down into cognition-based (CB trust) and affect-based trust (AB trust) where similar increase in trust over time was observed, $F(3, 387)=26.78$, $p<.001$, $\eta^2=.16$ and $F(3, 393)=25.32$, $p<.001$, $\eta^2=.17$, respectively. Post hoc tests with Bonferroni correction revealed significant differences in cognition-based means for the following measurements: time 1 (M_{CBT1}=3.12, SD_{CBT1}=.08) and time 3 (M_{CBT3}=3.53, SD_{CBT3}=.07), time 1 and time 4 (M_{CBT4}=3.68, SD_{CBT4}=.07), time 2 (M_{CBT2}=3.29, SD_{CBT2}=.07) and time 3, time 2 and time 4, and time 3 and time 4 (Figure 10). Cognition-based trust steadily increased over time. Examination of the differences in affect-based trust means revealed significant differences only between means at time 1 (M_{ABT1}=2.93, SD_{ABT1}=.09) and time 3 (M_{ABT3}=3.38, SD_{ABT3}=.08), time 1 and time 4 (M_{ABT4}=3.45, SD_{ABT4}=.09), time 2 (M_{ABT2}=2.97, SD_{ABT2}=.08) and time 3, and time 2 and time 4 (Figure 11). Even though affect-based trust increased, its growth trajectory is not as stable as the growth trajectory for cognition-based trust. The skewness statistics for trust at all time periods indicates

that the trust data are normal with the exception of the first measurement period which has a significant negative skew, $z = -4.17$, $p<.05$ (Tabachnick & Fidell, 2007). The kurtosis statistics are within the norm indicating mesokurtic trust distributions.

The performance scores presented in Table 1 - score T1, score T2, score T3 - are the standardized performance scores. Individual performance is based on the score that every team member earned during every mission. The number of tasks a player completed during the mission determine the player's score. Performance scores are standardized within mission scenarios to facilitate comparisons across missions. As anticipated, performance on the task increased over time, $M_{Sc1} = -.3$ ($SD_{Sc1} = .89$), $M_{Sc2} = .1$ ($SD_{Sc2} = 1$), and $M_{Sc3} = .21$ ($SD_{Sc3} = 1.02$), as indicated by Figure 12. A repeated measures ANOVA revealed that the means were significantly different from each other, $F(2, 364) = 21.46$, $p<.01$, $\eta^2=.11$. The post hoc analysis with Bonferroni correction revealed that performance at time 1 ($M_{Sc1} = -.3$, $SD_{Sc1} = .89$) and time 2 ($M_{Sc2} = .1$, $SD_{Sc2} = 1$), as well as performance at time 1 and time 3 ($M_{Sc3} = .21$, $SD_{Sc3} = 1.02$) are significantly different from each other (Figure 12). Performance data are normally distributed, with the exception of the scores at Time 1 (score T1, Table 1) which are leptokurtic, $z=4.64$, $p<.01$.

Satisfaction with the team was assessed at the end of every mission. These scores capture the willingness of every team member to continue working with the team. Satisfaction scores ranged between one and seven. The initial mean satisfaction with the team is slightly higher than the expected average, $M_{S1} = 4.85$ ($SD_{S1} = 1.35$). Similarly to trust and performance, satisfaction with the team also increased over time: $M_{S1} = 4.85$ ($SD_{S1} = 1.35$), $M_{S2} = 5.0$ ($SD_{S2} = 1.42$), and $M_{S3} = 5.12$ ($SD_{S3} = 1.53$), see Figure 13. A

repeated measures ANOVA revealed that the means were significantly different from each other, $F(2, 360) = 5.81$, $p<.01$, $\eta^2=.03$. A post hoc test with Bonferroni correction revealed that only the satisfactions means at time 1 and time 3 are significantly different from each other. The satisfaction scores are negatively skewed as indicated by the significance of the skewness statistics at all three measurement points, $z_1=-2.67$, $p<.01$, $z_2=-3.39$, $p<.01$ $z_3=-4.33$, $p<.01$. The kurtosis statistics indicated that the data for all three measurement periods are mesokurtic.

Lastly, the two personality constructs the means for personality trust and cooperation were $M_T = 36.42$ ($SD_T = 6.2$), and $M_C = 38.87$ ($SD_C = 5.38$), respectively. The trust distribution has a slight positive skew, $z_T=3.56$, $p<.01$ and is mesokurtic. The cooperation score are normally distributed (Tabachnick & Fidell, 2007).

Trust Development Model

The proposed model was tested to examine the relationship between trust and effectiveness as it develops over time (Figure 3). The trust measurement always preceded the effectiveness measurement (Figure 8). The nature of the effectiveness latent variable was re-conceptualized once data collection began. Originally, I conceptualized performance scores, satisfaction ratings, and task completion times as indicators of effectiveness. The data collection procedure revealed that the time allotted for each mission (40 minutes) was insufficient for mission completion, thus the amount of time for teams to perform was equivalent across teams and task episodes. Because there was no variance in the time variable, I did not include it as an indicator of effectiveness, leaving only satisfaction and individual performance as effectiveness indicators. This decision is consistent with prior research (LePine, Piccolo, Jackson, Mathieu, & Saul, 2008).

It was expected that the relationship between trust and team effectiveness would be bidirectional in such a way that changes in trust will influence effectiveness and changes in effectiveness will impact trust (Figure 3). Methodologically, a latent change score (LCS) model is utilized to fit the model to the data. The application of an LCS model is preferred to other modeling techniques for several reasons. First, as a structural equation model, it allows for the study of latent variable-measurement variable relationship. One of the goals of this study is to examine the structure of trust over time, if and how that structure changes over time, which the LCS technique allows for. Second, through latent change score modeling I can examine possible sources of the changes in the constructs of interest. Third, LCS models include coupling parameters that capture the time-dependent effect of one construct on the change of another, therefore allowing for the examination of dynamic processes (McArdle, 2009). Given that the goal of this study is to examine the changes in trust and team effectiveness as they take place, a latent change score model is the most appropriate to utilize.

The proposed structural model contained 14 latent variables: three latent variables indicating trust at each of the tree measurement points (Trust at time 1, Trust at time 2, and Trust at time 3), three latent variables indicating effectiveness at each measurements point (Effectiveness at time 1, Effectiveness at time 2, and Effectiveness at time 3), two latent variables capturing the changes in trust between time measurements (ΔTrust 1, and ΔTrust 2), two capturing the changes in effectiveness between measurement points (ΔEffectiveness 1, and ΔEffectiveness 2), and four latent variables capturing the slopes (Trust slope, and Effectiveness slope) and the intercepts (Trust intercept and Effectiveness intercept) for trust and effectiveness, respectively (Figure 3). Items from

the McAllister (1995) trust assessment scale measured the trust latent variables at every measurement period. The team satisfaction scale (Lancellotti & Boyd, 2008) and the performance scores assessed the effectiveness latent variables at every measurement point. The slope latent variables captured systematic constant changes in trust and effectiveness over time (McArdle, 2009), while the intercept latent variables captured the differences in means across individuals (Schumacher & Lomax, 2010). The model also includes a constant (K) set to equal 1, used to estimate the means and intercepts (Ferrer & McArdle, 2010).

Notation across all the models is kept consistent. Every item is modeled as a unique indicator of a latent variable. Overall, there are nine measured variables assessing trust, I1 through I9, three measured variables assessing satisfaction with the team, S1 through S3, and one measured variable per measurement period assessing performance, SC1 – SC3. Details regarding the correspondence between item labels and item content are available in Table 5.

Three models are fit to the data to examine the relationships between trust development and team effectiveness. All the models are estimated using Unweighted Least Squares (ULS) estimation. Unweighted Least Squares estimates are scale-dependent, consistent, and have no distribution assumptions. As previously discussed, the distributions of the data were not always normally, making ULS estimation more appropriate than maximum likelihood (Schumacker & Lomax, 2010). Non-normality in the data can inflate the estimated chi-square, therefore it has been recommended that alternative fit indices are examined (e.g. TLI, CFI, ECVI, AIC) instead of the traditional

absolute fit indices (e.g. RMSEA) since comparative and incremental indices can be less affected by the non-normality of data.

The Tucker-Lewis index (TLI or NNFI, in LISREL) examines the discrepancy between the tested model and the null model. The values of the TLI range between 0 and 1, where 0 indicates that the model does not fit the data, and 1 indicates perfect fit. Similarly to the TLI, the CFI examines the discrepancy between the null model and the model being tested. Its values range between 0 and 1 as well and are interpreted like the TLI. For both indices values above .9 indicate good model-data fit (Schumacker & Lomax, 2010). The Akaike Information Criterion (AIC) indicates both model fit and model parsimony. The model with the smallest AIC index has the best fit. By convention only two AIC indices are reported: Model AIC, and Independence AIC (Schumacker & Lomax, 2010). The expected cross-validation index (ECVI; Browne & Cudeck, 1993) is used to compare alternative models using a single data sample. Smaller ECVI values signify better model-data fit (Schumacker & Lomax, 2010).

All analyses used the correlation matrix (McArdle, 2009; Table 2). All latent variables were scaled by setting one item loading parameter to equal 1.00. All models were analyzed using LISREL 8.53.

Overall Trust Model. Initially trust was conceptualized as a one-dimensional construct. Each latent trust construct had nine distinct indicators (I1-I9) at each measurement point, and each latent effectiveness construct had four distinct indicators, satisfaction with the team (S1-S3) and performance (SC1, SC2, SC3) at each measurement point. Both the trust and effectiveness loadings were held invariant across measurement periods, stating that neither construct would qualitatively change over the

span of the study. A total of 99 parameters were estimated, signifying that the model was over-identified. The model-data fit was acceptable, χ^2=2029.56, df=721 (p<.001), ECVI = 12.24 [11.5 13.00], TLI=.98, CFI=.98, model AIC = 2227.56. The model is presented graphically along with parameter estimates in Figure 14. Information about all fit indices is available in Table 4, in the row labeled "Overall trust (1)".

To improve model-data fit one theoretically-driven modification was made concerning the measurement errors across time periods. Given that the measurement instruments used at every measurement points are identical, it is inherent to the assessment that the measurement errors across assessments are related. Therefore the measurement errors for indicators are allowed to covary across measurement occasions. The second model (Figure 15) had same latent structure where overall trust and effectiveness changed together over time. In terms of measurement structure, both the effectiveness and trust loading are invariant across measurement points and the measurement errors covaried when appropriate (Figure 15). The fit of the model did improve, χ^2=1435.99, df=682 (p<.001), ECVI = 9.41 [8.83 10.03], TLI=.99, CFI=.991, model AIC= 1711.99, suggesting that the theoretical modification was further empirically supported. Refer to tested Table 4, Overall trust (2) for all the fit indices. A graphical representation of the model along with parameter estimates is presented in Figure 15.

Both models, where measurement errors do and do not correlate, capture trust and effectiveness as constructs with a stable structure that does not change over time. However, theory suggests that trust changes over time both in terms of its magnitude, indicated by mean changes, as well as in its structure, indicated by difference in item loadings (Lewicki & Bunker, 1996; Webber, 2008). The invariance across measurement

points assumed so far does not account for those changes (McArdle, 2009). Restricting item loadings to be equal across measurement points does not capture the qualitative changes in the latent constructs. In order to account for possible changes in the constructs the item loadings should be freely estimated for every measurement. Therefore in a third model, all the item loadings were freely estimated independent of each other (Figure 16). The fit of model slightly improved over the previous one, χ^2=1281.74, df=660 (p<.001), ECVI = 8.80 [8.26 9.38], TLI=.996, CFI=.996, model AIC= 1601.74. Refer to tested Table 4, Overall trust (3) for all the fit indices. The improvement in fit is significant, χ^2=154.25, df=62, α=.05 (crit. χ^2=81.38), therefore the model is retained as the final model. A graphical representation of the model along with parameter estimates is presented in Figure 16. The paths between the individual latent variables were examined. The path between the trust measurements were initially positive and significant, $\beta_{TR1->TR2}$=.65 (.13), but later on the relationship between trust and prior trust diminished, $\beta_{TR2->TR3}$=.39 (1.05) indicating that over time the predictive ability of trust weakens. Trust means, as indicated by the trust intercept, predicted initial trust levels, $\beta_{I(TR)->TR1}$=.29 (.08). The trust change relationships were also examined. The first change in trust, ΔTrust 1, did not have a significant relationship with subsequent trust, $\beta_{\Delta TR1->TR2}$ = .42 (.22). The relationship between change in trust later on (ΔTrust 2) and trust at time 3 followed the same pattern, $\beta_{\Delta TR2->TR3}$ = .86 (1.42). The relationships within the effectiveness construct were also examined. Prior effectiveness predicted subsequent effectiveness, $\beta_{Eff1->Eff2}$ =1.37 (.35) and $\beta_{Eff2->Eff3}$ = .65 (.11), as anticipated. The effectiveness means predicted initial effectiveness, $\beta_{I(Eff)->Eff1}$=.92 (.3). The change relationships were also examined. The first change in effectiveness, ΔEffectiveness 1, had no relationship with effectiveness

at time 2. Change in effectiveness later on, ΔEffectiveness 2, was influenced solely by the effectiveness growth trajectory, $\beta_{S(Eff)\text{->}\Delta Eff2}$ = -.52 (.24), and $\beta_{\Delta Eff2\text{->}Eff3}$ = .42 (.14). These results suggest that there is no relationship between trust and effectiveness. Even though some of the coupling paths were significant, namely the ones going from effectiveness to the changes in trust, the subsequent paths between the latent change constructs and the constructs later on were not significant. A possible explanation for these results is that effectiveness is influencing one of the trust dimensions more than the other and these changes get convoluted because the two dimensions are considered together. An examination of the cognition-based trust-effectiveness relationships separately from the affect-based trust relationships will address that possibility.

The teams in this study did not have share prior work experience and they worked together for a limited amount of time. Some would argue that the two dimensions of trust would not emerge by the end of the third mission (Webber, 2008). To examine the differential relationships between the two components of trust and effectiveness, first the dimensionality of trust was evaluated using a confirmatory factor analysis approach. Additionally, the investigation of dimensionality of trust will address concerns regarding comparing qualitatively different constructs as it has been suggested by some (Lewicki & Bunker, 1996; Webber, 2008). If trust develops by starting as a single-factor construct and later separating into the two factors of cognition-based and affective-based trust, then the trust construct at every measurement point is conceptually different than the other ones, making the comparisons unfitting, because the constructs are structurally different (McArdle, 2009). In order to examine this potential structural change in the construct,

one- and two-factor models were fit to the trust data at each of the three measurement points.

Trust Dimensionality. A confirmatory factor analysis was performed on the trust assessments at every measurement point. These analyses are necessary in light of the literature on trust development. Theory suggests that trust initially emerges as a one-factor construct, and over time its two components, cognition-based and affect-based trust, emerge (Webber, 2008). Therefore it is expected that a one-factor (overall trust) model will fit the data better for the first and possibly second trust measurements, while a two-factor (affect-based and cognition-based trust) model will the data better for the third measurement. A confirmatory factor analysis was performed where both the one-factor and two-factor models were fit to the data at each measurement point. LISREL 8.53 was used to evaluate fit. Parameter estimates were obtained using maximum likelihood (ML) estimation. A power analysis revealed that a sample size of 156 was necessary to evaluate the fit for the CFA models, df=26, α=.05, power=.8 (MacCullum, Browne, & Sugawara, 1996; Preacher & Coffman, 2006). Based on the power analysis, the present sample size of 183 is sufficient to evaluate fit for both the one-factor (min. N=151) and two-factor (min. N=156) models. For the one-factor model, all the trust items at that measurement point loaded on the same factor, while for the two-factor model, items 1 through 4 loaded on one factor and items 5 through 9 loaded on the second factor. The classification of items was based on item content as described in McAllister (1995). The two factors were allowed to correlate as suggested by empirical findings.

Table 3 summarized the fit of both models at every measurement point. It was expected that at the first measurement point (Time 1, models X1 and X2) all trust items

would load on the same factor. The one-factor solution, X1, did not fit the data well, χ^2= 115.51, df=27 (p<.01), RMSEA = .13 [.11 .16], p<.01, ECVI = .83 [.67 1.04], TLI = .97. Adding the second factor, model X2, improved fit substantially, χ^2= 40.38, df=26 (p<.01), RMSEA = .05 [.01 .05], p=.42 ECVI = .42 [.35 .54], TLI = .99 indicating that the two-factor trust model fits the data better. Similarly, at time 2 to time 1, the two-factor model fit (model Y2) the data better, χ^2= 62.35, df=26 (p<.01), RMSEA = .09 [.07 .12], p<.05, ECVI = .58 [.47 .73], TLI = .96, than the one-factor one (model Y1), χ^2= 133.52, df=27 (p<.01), RMSEA = .16 [.14 .18], p<.01, ECVI = 1.04 [.84 1.27],TLI = .89.

Lastly, it is expected that by time 3, trust would have developed sufficiently allowing for its two components to emerge. Once again, the two-factor model (model Z2) fit the data better, χ^2= 132.89, df=26 (p<.01), RMSEA = .15 [.12 .18], p<.01, ECVI = .93 [.76 1.15], TLI = .82, than the one-factor model (model Z1), χ^2= 251.72, df=27 (p<.01), RMSEA = .23 [.2 .25], p<.01, ECVI = 1.75 [1.47 2.06], TLI = .91. The conclusion drawn based on these analyses, is that the two-dimensional model fits the data better than the one-dimensional model at all measurement points, making the examination of the unique relationships between cognition-based trust and effectiveness and affective-based trust and effectiveness appropriate. Additionally, these analyses suggest that trust has two components from the very beginning of the team's existence. I anticipated that initially trust would start as a one-factor construct and over time it would qualitative change into trust cognition-based and affect-based trust, mirroring results obtained by Webber (2008). However, the analyses suggest that trust does not undergo these qualitative changes. Both factors of trust seem to be present from the start and they appear to change quantitatively with experience.

The following analyses examined the relationships between effectiveness and cognition-based and affect-based trust, respectively. Each type of trust has been shown to have unique relationships with a variety of criteria (McAllister, 1995). Additionally, based on the confirmatory factor analyses, the factor loadings were set to be invariant across measurement periods, stating that changes in both trust components are due to quantitative changes taking place and not changes in the nature of the construct. The latent structure of the models is identical to the overall trust model tested above.

Cognition-based Trust Model. The relationships between cognition-based trust and effectiveness were examined. Research suggests that cognition-based trust is a pre-requisite for affect-based trust to develop, (McAllister, 1995; Webber, 2008; Lewicki & Bunker, 1996), thus it is anticipated that the mean cognition-based trust levels will be slightly higher than mean affect-based trust levels. For the cognition-based model tested, cognition-based trust had five indicators (I5-I9), and effectiveness had the same four indicators (SC1/2/3, S1-S3). Indicator loadings were restricted to be invariant across measurement periods and measurement errors covaried where appropriate. The model-data fit was acceptable, χ^2= 360.13, df=298 ($p<.01$), ECVI = 4.4 [4.06 4.79], TLI=.995, CFI=.996, model AIC=576.13. Refer to tested Table 4, CB trust for all the fit indices. A graphical representation of the model along with parameter estimates is presented in Figure 17.

The individual parameter estimates were examined. The direct trust relationships were positive and significant as anticipated, $\beta_{TR1\text{->}TR2}$=.53 (.07) and $\beta_{TR2\text{->}TR3}$=.74 (.17) indicating that trust was directly impacted by prior trust. The trust change relationships were subsequently examined. The first change in trust, Δ Trust 1, was significantly

influenced by initial level of effectiveness, $\beta_{Eff1->\Delta TR1}$= .68 (.08), suggesting that effectiveness at time 1 impacts the development of trust, $\beta_{\Delta TR1->TR2}$ = .68 (.25). Trust at time 1 also had a significant, though negative relationship with change in trust, $\beta_{TR1->\Delta TR1}$=-.37 (.08), indicating that change is dependent on initial trust levels. Later change in trust (Δ Trust 2) was directly affected by prior trust, $\beta_{TR2->\Delta TR2}$ = .25 (.1), and individual trust growth trajectories, $\beta_{S(TR)->\Delta TR2}$ = .67 (.17). Thus the change in trust from time 2 to time 3 was not influenced but effectiveness and was primarily due to time, $\beta_{\Delta TR2->TR3}$ = .38 (.15). The relationships within the effectiveness construct were also examined. Similarly to trust, prior effectiveness predicted subsequent effectiveness, $\beta_{Eff1->Eff2}$ =1.05 (.41) and $\beta_{Eff2->Eff3}$ = .9 (.25), and difference between individual effectiveness means as captured by the effectiveness intercept variable, did not predict initial effectiveness. The effectiveness change relationships were examined. The first change in effectiveness, Δ Effectiveness 1, was influenced by the individual effectiveness growth trajectory, $\beta_{S(Eff)->\Delta Eff}$ = -.72 (.24) and $\beta_{\Delta Eff1->Eff2}$ = .69 (.24). Change in effectiveness later on, Δ Effectiveness 2, did not have a significant relationship with effectiveness at time 3, $\beta_{\Delta Eff2->Eff3}$ = .13 (.13), therefore the only predictor of effectiveness at time 3 was prior effectiveness. The results suggest that the relationship between cognition-based trust and effectiveness is unidirectional and time sensitive. Effectiveness seems to facilitate the development of cognition-based trust in the early stages of teamwork, but not later on. Cognition-based trust though did not influence the development of effectiveness.

These results are supported by the available literature. Social Information Processing Theory (Walther, 1992), posits that trust development is dependent on prior interactions. Information obtained from prior interactions (e.g. performance information)

is expected to have an effect on trust in subsequent interactions. Moreover, McAllister (1995) identified that peer performance does predict cognition-based trust. In this study, team members received information about each other's performance which may have led to the subsequent changes in trust.

Affect-based Trust Model. Similarly to cognitive-based trust, the unique relationships between affect-based trust and effectiveness were examined. The latent structure of the affect-based trust model was the same as previously discussed. Affect-based trust had four indicators (I1-I4) and effectiveness had the same four indicators (S1-S3, SC1/2/3). The model was tested under the assumption that affect-based trust does not change qualitatively over time, therefore item loadings were fixed to be equal across time measurements. The model fit the data well, χ^2=391.4, df=225 ($p<.01$), ECVI = 3.25 [2.97 3.57], TLI=.989, CFI=.991, model AIC=591.4. Refer to tested Table 4, AB trust for all the fit indices. A graphical representation of the model along with parameter estimates can be found in Figure 18.

The direct affect-based trust relationships were all significant and positive, $\beta_{TR1->TR2}$=.97 (.07) and $\beta_{TR2->TR3}$=.88 (.1), indicating that prior affect-based trust predicts subsequent affect-based trust. Group mean trust as captured by the trust intercept significantly predicted trust at time 1, $\beta_{I(TR)->TR1}$=.32 (.09). The trust change relationships were subsequently examined. The first change in trust, Δ Trust 1, was predicted by prior affect-based trust, $\beta_{TR1->\Delta TR1}$= -.89 (.1), trust growth trajectory as captured by the trust slope, $\beta_{S(TR)->\Delta TR1}$=-.19 (.04) and effectiveness at time 1, $\beta_{Eff1->\Delta TR1}$= .32 (.12). Thus prior trust and effectiveness contributed to the changes in affect-based trust, $\beta_{\Delta TR->TR2}$= .77 (.07). Similarly, later change in trust (Δ Trust 2) was affected by trust slope, $\beta_{S(TR)->\Delta TR2}$ =

.53 (.11), prior trust, $\beta_{TR1\text{->}\Delta TR1}$= -.44 (.19), and effectiveness at time 2, $\beta_{Eff2\text{->}\Delta TR2}$ = 1.02 (.29), indicating that the development of affect-based trust was partly driven by both effectiveness and trust, $\beta_{\Delta TR2\text{->}TR3}$ = .83 (.36). The relationships within the effectiveness construct were also examined. Prior effectiveness predicted subsequent effectiveness, $\beta_{Eff1\text{->}Eff2}$ =1.00 (.16) and $\beta_{Eff2\text{->}Eff3}$ =.87 (.09). The group mean effectiveness trust as captured by the effectiveness intercept predicted initial effectiveness, $\beta_{I(Eff)\text{->}TR1}$=.77 (.1). When the first change in effectiveness was examined, ΔEfftiveness 1, only the growth trajectory of effectiveness itself was related to subsequent effectiveness, $\beta_{S(Eff)\text{->}\Delta Eff1}$ =-.94 (.44), and $\beta_{\Delta Eff1\text{->}Eff2}$ = .33 (.15). Later change in effectiveness did not influence effectiveness at time 3, $\beta_{\Delta Eff2\text{->}Eff3}$=.75 (.4). Similarly to the results observed for cognition-based trust, effectiveness had an influence on the development of affect-based trust, but trust did not influence changes in effectiveness. Unlike cognition-based trust though, effectiveness seems to influence the development of affect-based trust over a longer period as indicated by the significance of both effectiveness to change in trust parameters. The observed relationships do fit theoretically with Social Information Processing theory.

Testing of Hypotheses

In addition to the above-discussed models five hypotheses were proposed. Hypothesis 1 posited that individual trust would predict initial trust in team members. Trust at time 1 was regressed on the personality trust scores. Personality trust significantly predicted initial trust, b=.19, t(181) = 2.63, p <.05. Personality trust also explained a significant portion of the variance in initial trust scores, R^2 = .19, F(1, 180) = 6.92, p <.05. Thus, Hypothesis 1 was supported.

Hypothesis 2 postulated that individual cooperation would predict initial trust in team members. Trust at time 1 was regressed on the personality cooperation scores. Personality cooperation did not predict initial trust, b=.01, t(181) = .14, p =.89. Therefore, hypothesis 2 was not supported.

In hypothesis 3 the relationship between trust and effectiveness was examined. In particular, it was hypothesized that team effectiveness would influence the change in trust. More specifically, it was expected that the coupling parameters between the effectiveness constructs (Effectiveness at time 1 and Effectiveness at time 2) and the trust change constructs (Δ Trust 1 and Δ Trust 2) would be significant. Because the analyses above indicated that the relationships between cognition-based trust and effectiveness are different than the ones between affect-based trust and effectiveness parameters from both models were examined. Effectiveness had a continuous, significant effect on the change in affect-based trust, $\beta_{Eff1\text{->}\Delta TR1}$ = .32 (.12) and $\beta_{Eff2\text{->}\Delta TR2}$ = 1.02 (.29). In the case of cognition-based trust, however, only early changes were due to effectiveness, $\beta_{Eff1\text{->}\Delta TR1}$ = .68 (.08). Overall, effectiveness does impact the change in trust and the relationship between effectiveness and change in trust is positive and significant; this trust-effectiveness link though is dependent on type of trust.

Hypothesis 4 stipulated that trust would influence the change in effectiveness. The significance of the paths between trust (Trust at time 2 and Trust at time 3) and change in effectiveness (ΔEffectiveness 1 and ΔEffectiveness 2) were examined in both the cognition-based and affect-based models. The trust-effectiveness change relationships were not significant in either model. Therefore hypothesis 4 was not supported.

Hypothesis 5 proposed that affect-based trust would take longer to develop than cognition-based trust. Therefore it was expected that cognition-based trust would emerge before affect-based trust. However, the confirmatory factor analysis revealed that at every measurement point a two-factor model fits the trust data better than a one-factor model (Table 3), leading me to conclude that both cognition-based and affect-based trust emerge concurrently and develop parallel to one another. In order to examine the extent of both cognition-based and affect-based trust developed, the final means for cognition-based (CB time 4) and affect-based (AB time 4) trust were compared. The comparison revealed a significant difference between the means, $F(1, 128)=7.92$, $p<.01$, after controlling for initial level of trust though the difference was no longer significant, $F(1, 128)=2.81$, $p=.1$, indicating that both types of trust had developed to the same extent in the same amount of time and refuting hypothesis 5.

Finally, I explored one research question. The question aimed at assessing the type of information people use in order to make the initial judgment of whether they should trust the teammates that they will be working with. In a face-to-face environment, people are exposed to a variety of relevant and non-relevant cues which are subsequently used to make an initial trust judgment; often people rely on their stereotypes (Kuo & Yu, 2009) or some prior information. However, frequently in a computer-mediated environment there is a scarcity of cues available, if any. In the current study participant interaction prior to the study was kept minimal. Additionally, participants did not interact in any way prior to making their initial trust assessments. Participants were asked to indicate how they made the trust assessment. The goal was to start identifying some underlying themes in participant answers. Figure 19 summarizes the results. The majority

of respondents, 51%, reported that they based their trust assessment of the current team on previous experiences associated with team work. The answers indicated that the participants had a variety of teamwork experiences such as work teams, sports teams, and student project teams. Another significant portion of the respondents, 20%, identified knowledge of their teammates as the basis for their assessment. A third group of participants, 13% indicated that they used their personal beliefs about people and their intuition in order to make the trust assessment, followed by teamwork expectations, 10% of participants. Lastly, a small number of participants, 6%, indicated that they assumed that their teammates were like them and based their assessments on that assumption.

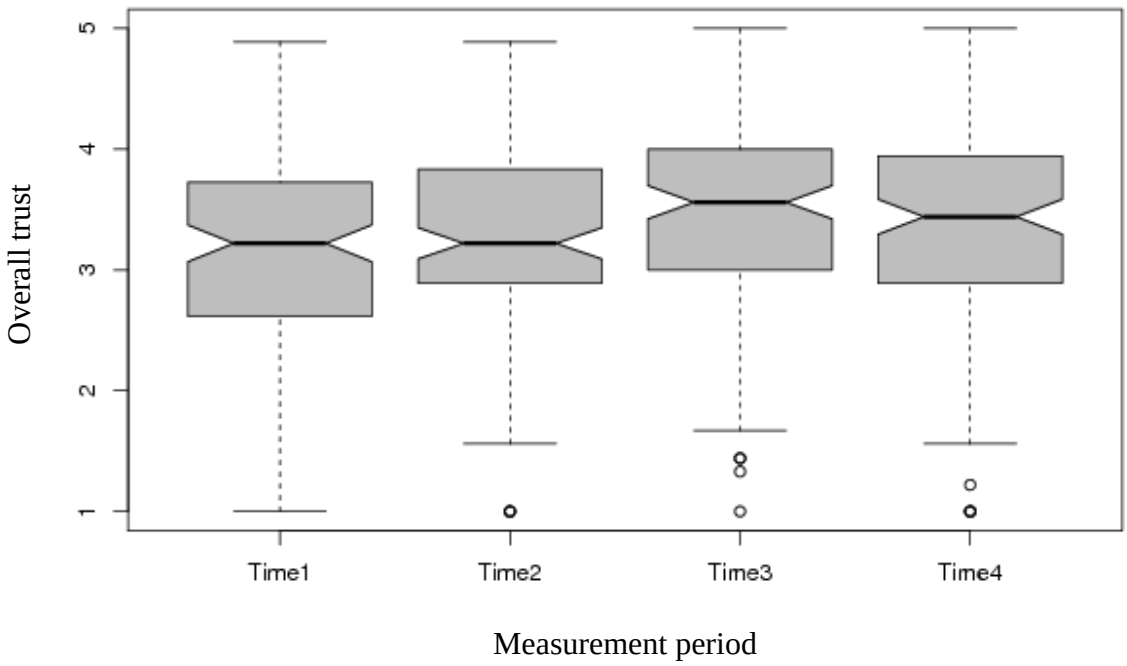


Figure 9. Boxplots for overall trust (N=132) measured at four different points in time. Time 1 represents the assessment of trust prior any interaction. Trust at time 2 – time 4 represents the assessment of trust after each of the three missions that the teams completed.
The differences in mean overall trust are significant between the following measurements: time 1 (M=3.04) – time 3(M=3.46); time 1 – time 4 (M=3.57); time 2 (M=3.15) – time 3; time 2 – time 4; time 3 – time 4.

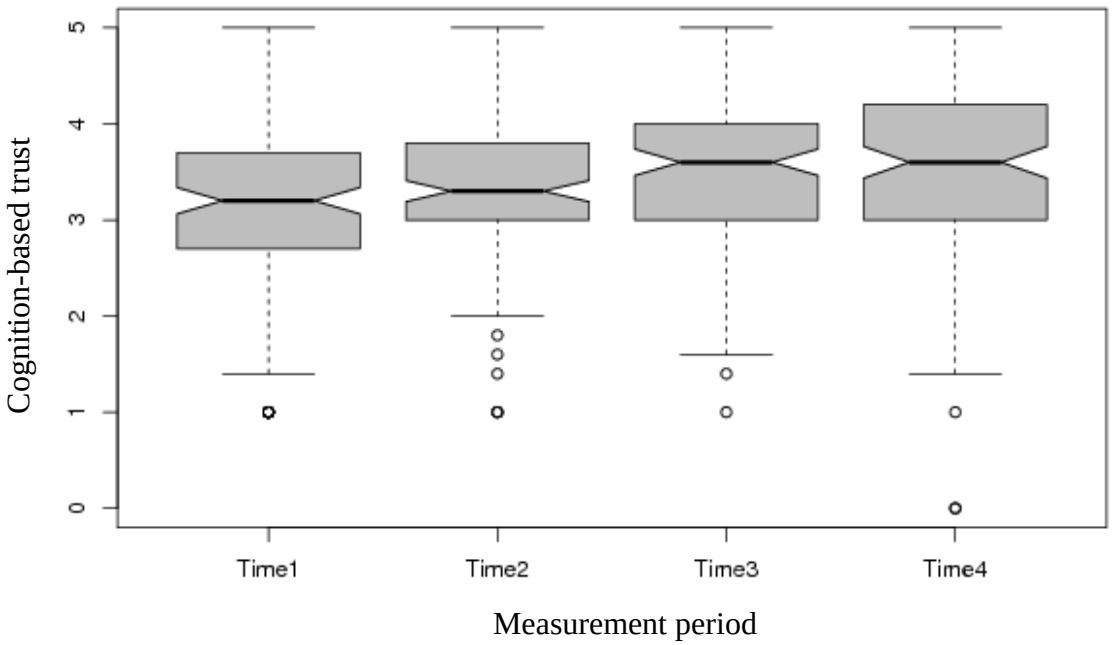


Figure 10. Boxplots for cognition-based trust (N=132) measured at four different points in time. Time 1 represents the assessment of trust prior any interaction. Trust at time 2 – time 4 represents the assessment of trust after each of the three missions that the teams completed.
The differences in mean cognition-based trust are significant between the following measurements: time 1 (M_{CBT1}=3.12) – time 3(M_{CBT3}=3.53); time 1 – time 4 (M_{CBT4}=3.68); time 2 (M_{CBT2}=3.29) – time 3; time 2 – time 4; time 3 – time 4.

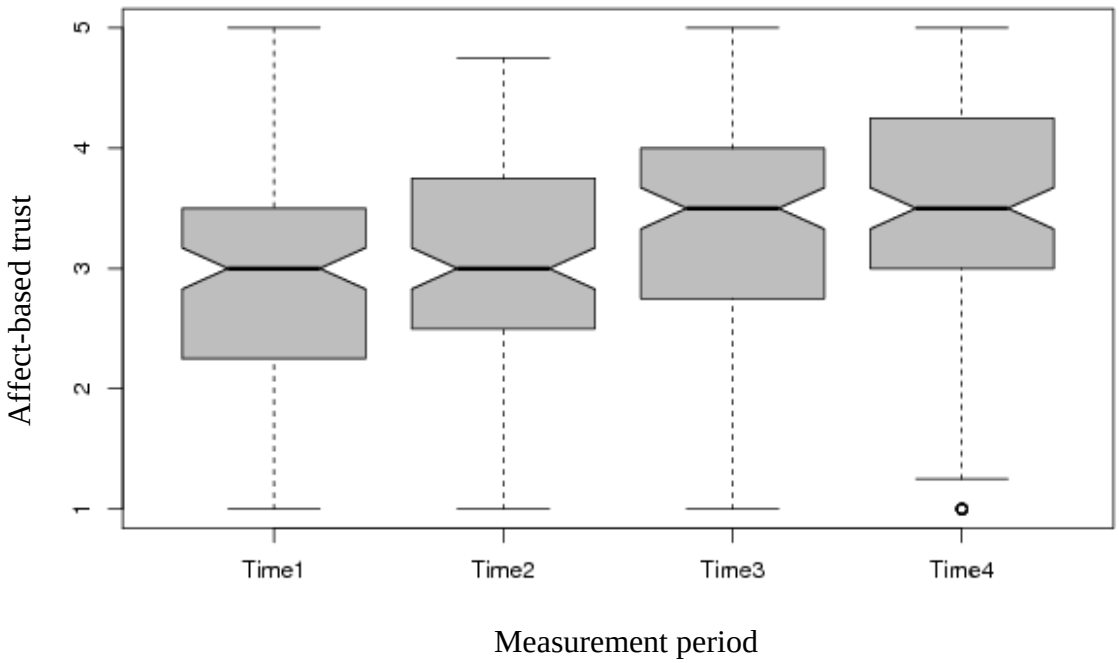


Figure 11. Boxplots for affect-based trust (N=132) measured at four different points in time. Time 1 represents the assessment of trust prior any interaction. Trust at time 2 – time 4 represents the assessment of trust after each of the three missions that the teams completed.
The differences in mean affect-based trust are significant between the following measurements: time 1 (M_{ABT1}=2.93) – time 3 (M_{ABT3}=3.38); time 1 – time 4 (M_{ABT4}=3.45); time 2 (M_{ABT2}=3.38) – time 3; time 2 – time 4.

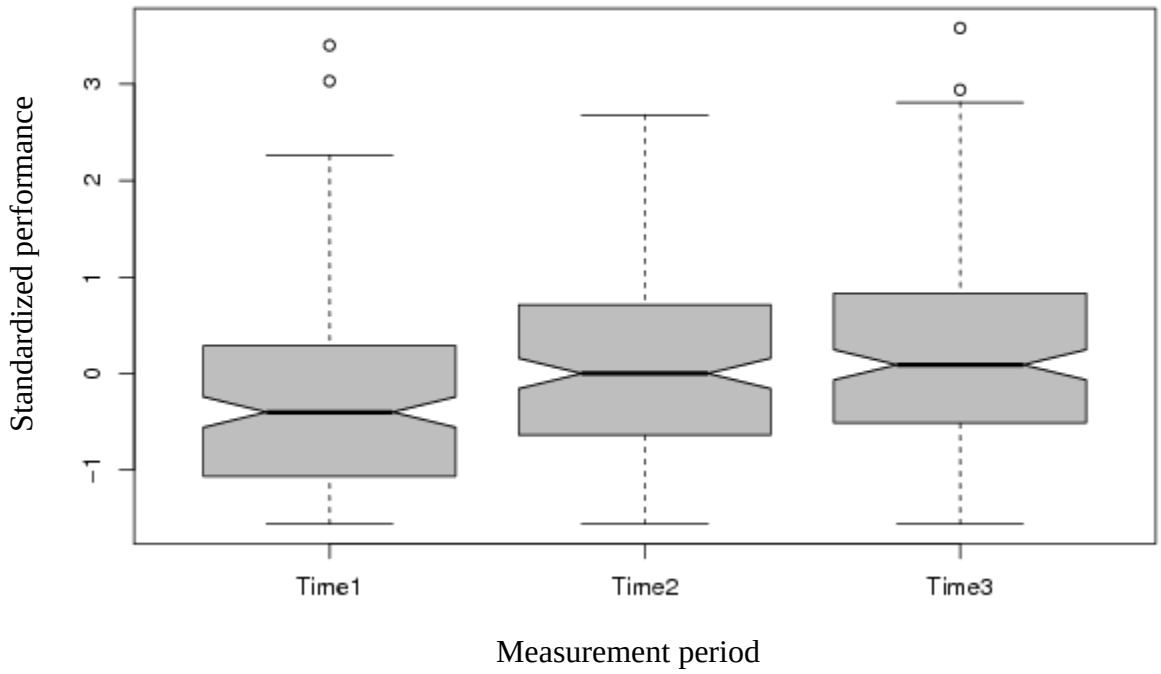


Figure 12. Boxplots for individual performance (N=183) assessed at the end of each of the missions. Performance scores were standardized across missions.
The differences in mean performance scores are significant for the following measurements: time 1 (M_{Sc1} = -.3) – time 2 (M_{Sc2} = .1); time 1 – time 3 (M_{Sc1} = .21).

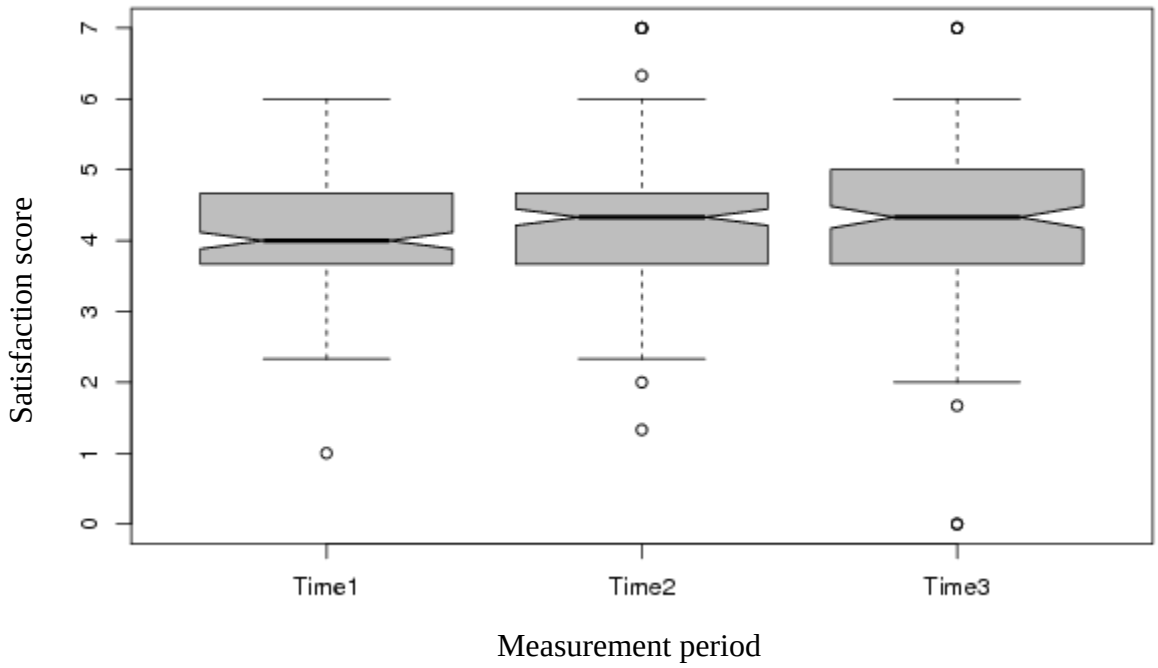
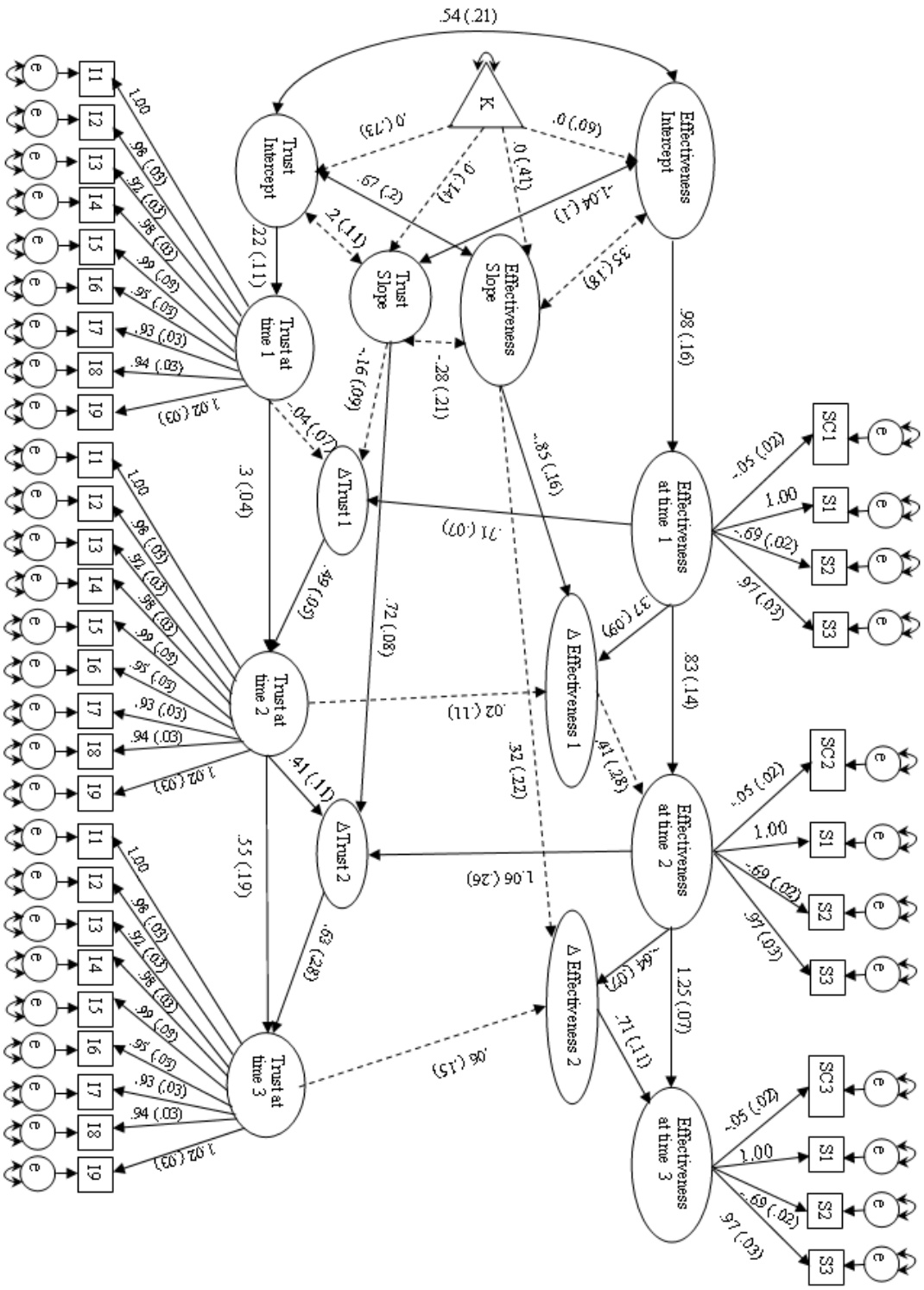
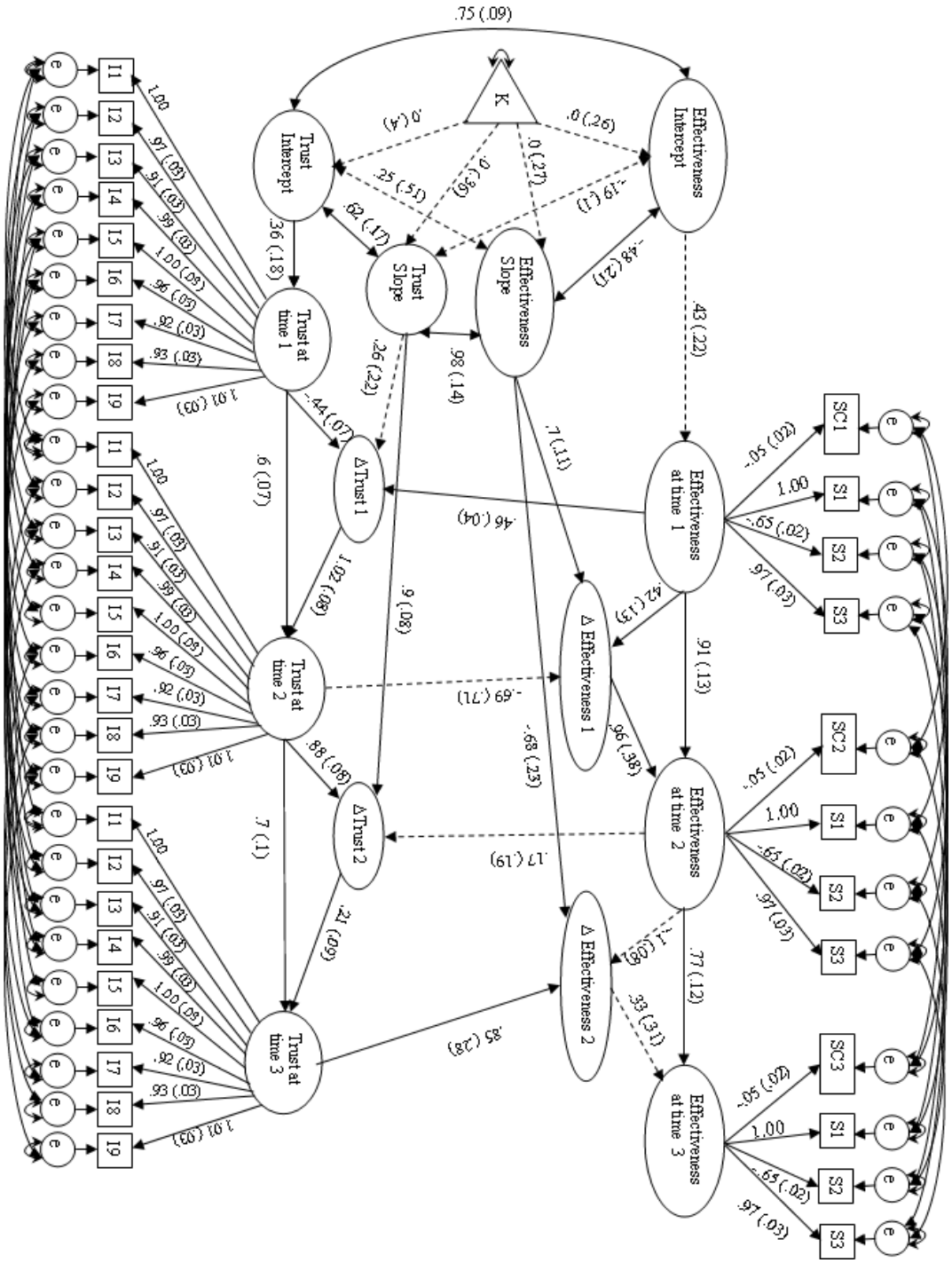


Figure 13. Boxplots for satisfaction with team members (N=183) assessed after each of the three missions. The differences in means are significant between the following measurements: time 1 (M_{S1} = 4.85) – time 3 (M_{S3} = 5.12).



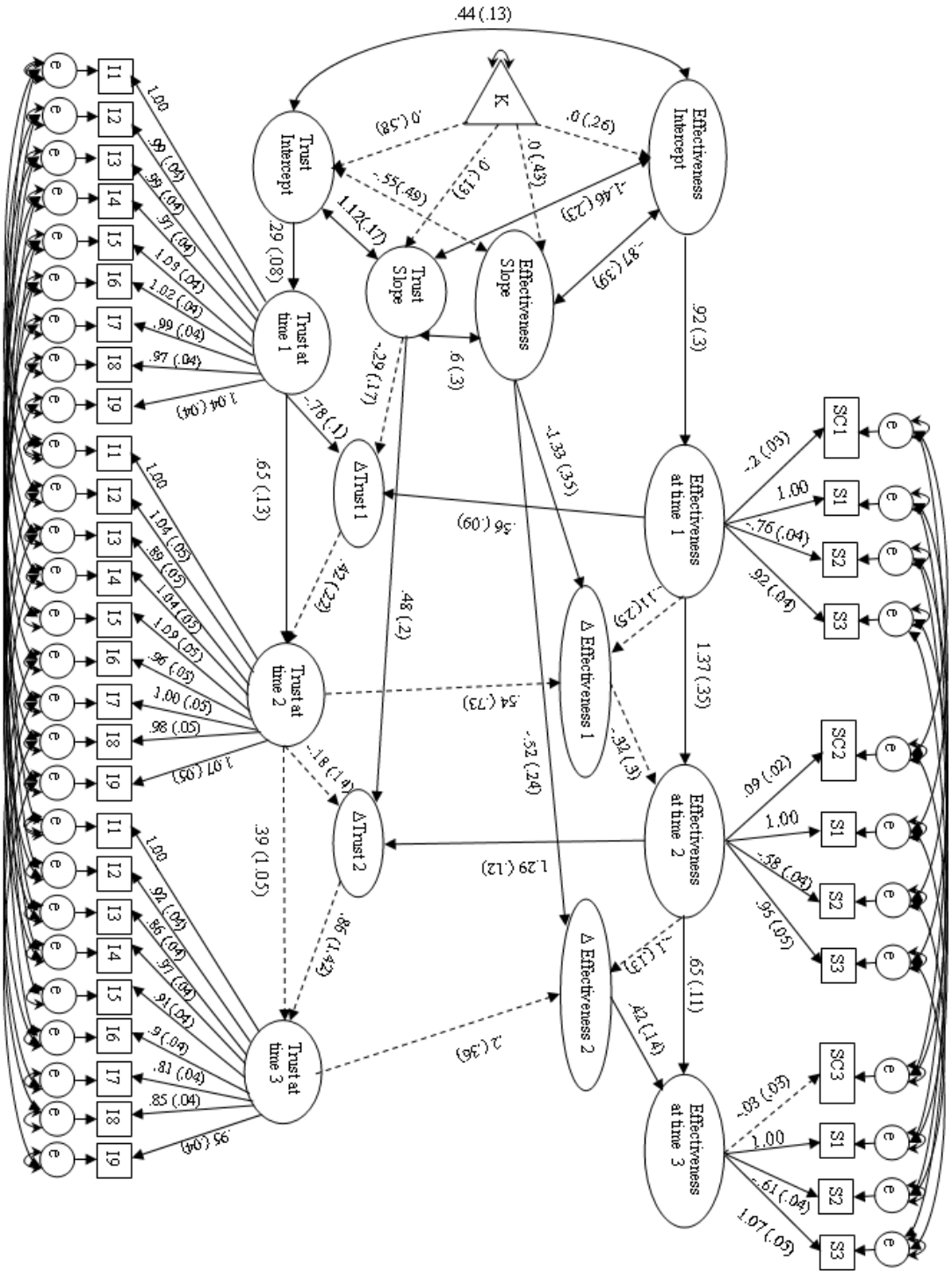
χ^2	df	ECVI 90% CI	TLI	Model AIC	Independence AIC	RMSEA 90% CI
2029.56	721	12.24 [11.5 13.00]	0.978	2227.56	16929.98	.1 [.095 .11]

Figure 14. Overall trust (1) model - relationships between overall trust and effectiveness; factor loadings are invariant across measurement points. Refer to Table 5 for scale items.



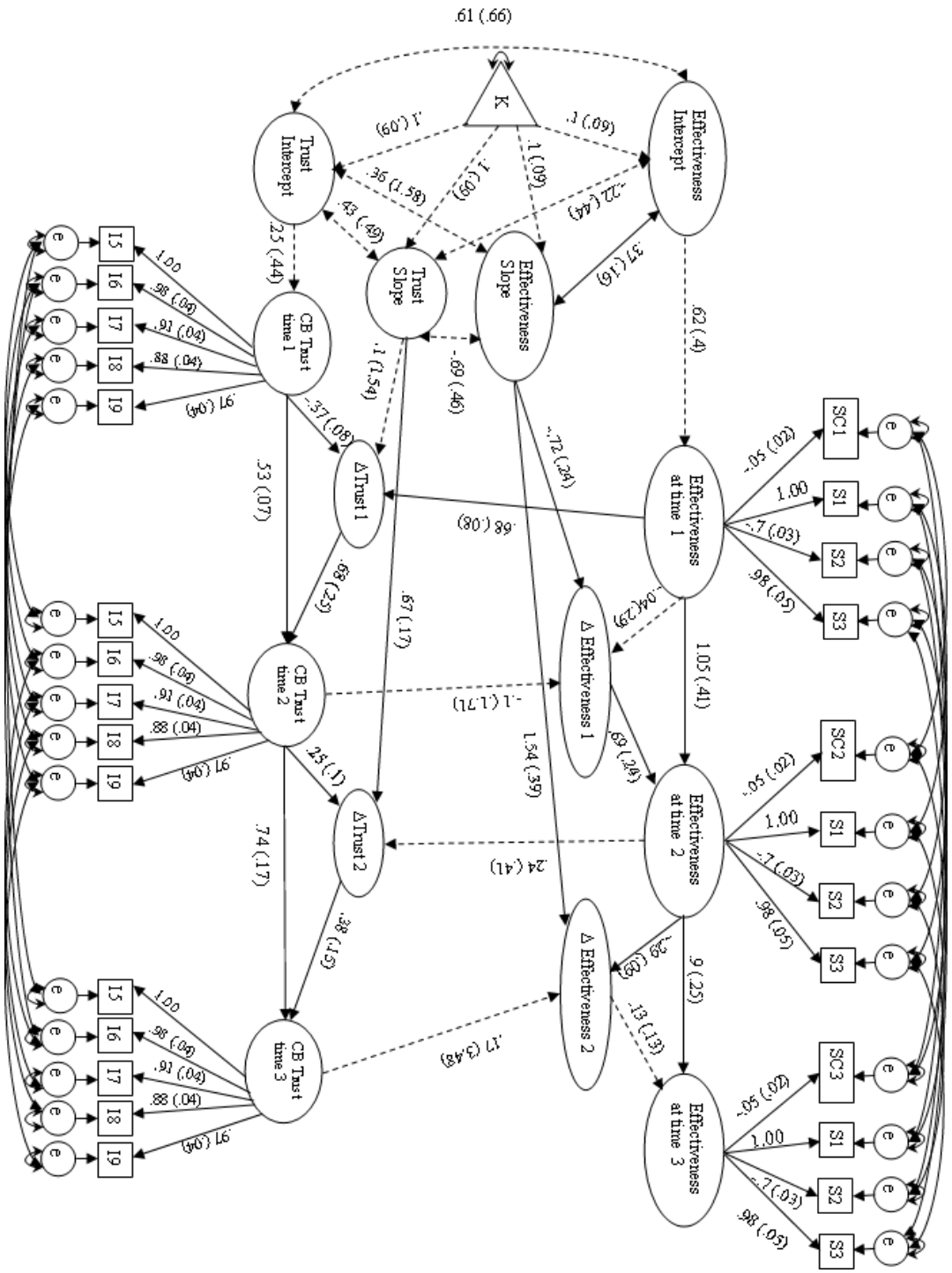
χ^2	df	ECVI 90% CI	TLI	Model AIC	Independence AIC	RMSEA 90% CI
1435.99	682	9.41 [8.83 10.03]	0.990	1711.99	16929.98	.078 [.072 .084]

Figure 15. Overall trust (2) model - relationships between overall trust and effectiveness; item loadings are invariant across measurement points; errors across measurement periods were correlated. Refer to Table 5 for scale items.



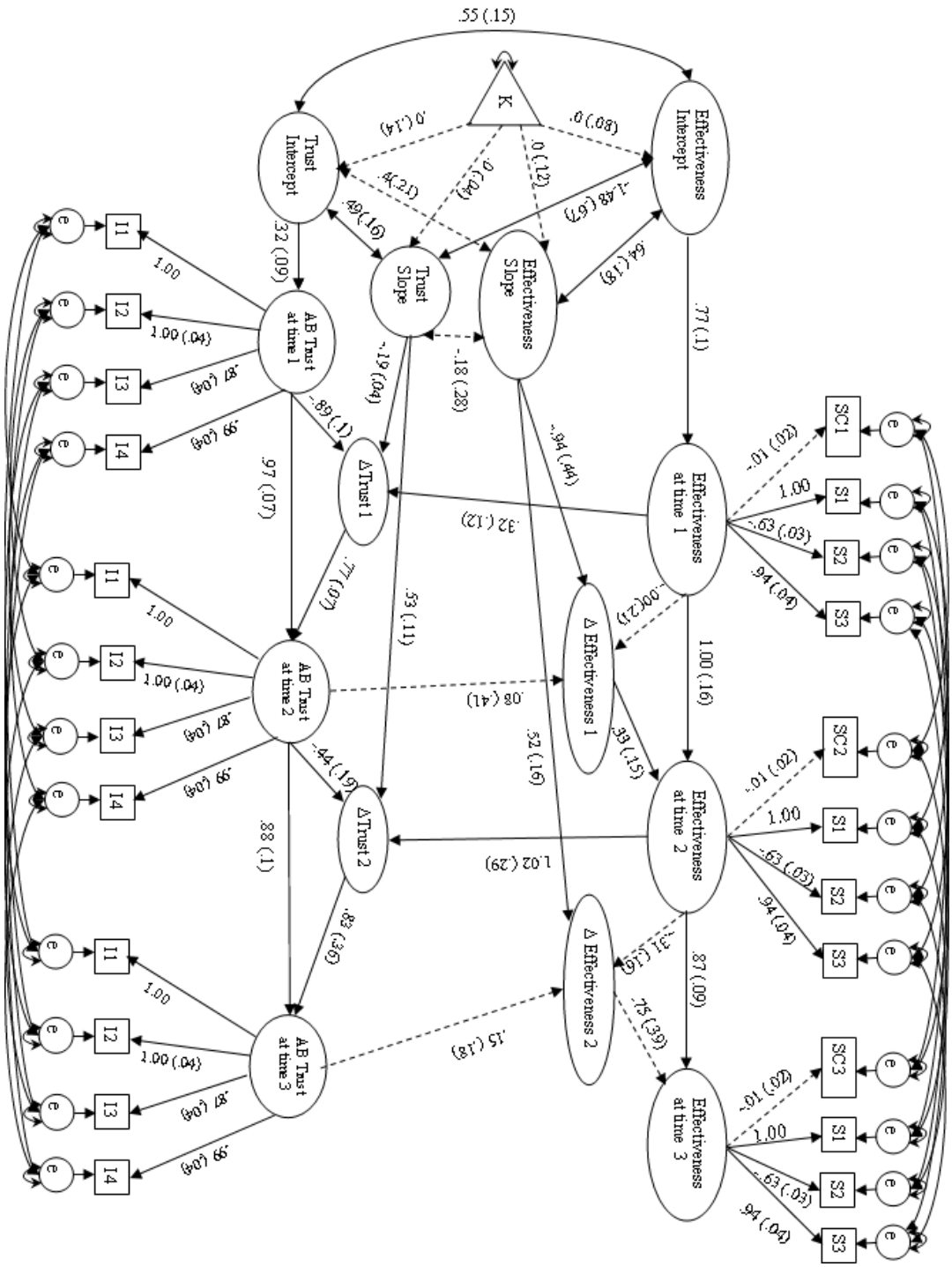
χ^2	df	ECVI 90% CI	TLI	CFI	Model AIC	Independence AIC	RMSEA 90% CI
1281.74	660	8.80 [8.26 9.38]	0.996	0.996	1601.74	16929.98	.072 [.066 .079]

Figure 16. Overall trust (3) model - relationships between overall trust and effectiveness; factor loadings are freely estimated; errors across measurement periods are correlated. Refer to Table 5 for scale items.



χ^2	df	ECVI 90% CI	TLI	Model AIC	Independence AIC	RMSEA 90% CI
360.13	298	4.4 [4.06 4.79]	0.995	576.13	6027.62	.04 [.022 .054]

Figure 17. Cognition-based trust model – relationships between cognition-based trust and effectiveness; factor loadings are invariant across measurement points; errors across measurement periods are correlated. Refer to Table 5 for scale items.



χ^2	df	ECVI 90% CI	TLI	Model AIC	Independence AIC	RMSEA 90% CI
391.4	225	3.25 [2.97 3.57]	0.989	591.4	6984.84	.064 [.053 .074]

Figure 18. Affect-based trust model – relationships between affect-based trust and effectiveness; factor loadings are invariant across measurement points; errors across measurement periods are correlated. Refer to Table 5 for scale items

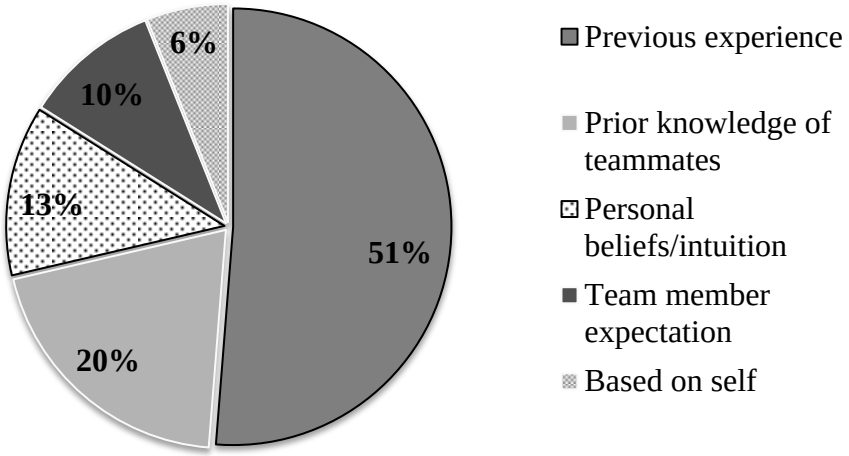


Figure 19. Types of information participants reported to have used to make their initial assessment of trust in their team members.

Table 1

Descriptive statistics for observed variables.

Variable	N	Min	Max	Mean	Median	SD	Skewness [SD error]	Kurtosis [SD error]
Trust T1	183	1	5	3.19	3.33	0.9	-.75 [.18]	.5 [.36]
Trust T2	183	1	5	3.18	3.22	0.71	-.31 [.18]	.68 [.36]
Trust T3	183	1	5	3.45	3.44	0.75	-.39 [.18]	.30 [36]
Trust T4	132	1	5	3.57	3.67	0.85	-.53 [.21]	.19 [.42]
CB Trust T1	183	1	5	3.26	3.4	0.9	-86 [.18]	.82 [.36]
CB Trust T2	183	1	5	3.36	3.4	0.72	-.50 [.18]	1.33 [.36]
CB Trust T3	183	1	5	3.56	3.6	0.74	-.41 [.18]	.68 [.36]
CB Trust T4	132	1	5	3.68	3.6	0.84	-.40 [.21]	.18 [.42]
AB Trust T1	183	1	5	3.1	3.25	1	-.44 [.18]	-.31 [.36]
AB Trust T2	183	1	5	2.95	3	0.89	-.29 [.18]	-.19 [36]
AB Trust T3	183	1	5	3.32	3.5	0.94	-.45 [.18]	-.16 [36]
AB Trust T4	130	1	5	3.45	3.5	0.99	-.66 [.21]	.08 [.42]
Score T1	183	-1.6	3.4	-0.3	-0.39	0.89	.95 [.18]	1.68 [.36]
Score T2	183	-1.6	2.7	0.10	0	1	.52 [.18]	-.38 [.36]
Score T3	183	1.56	3.6	0.21	0.09	1.02	.44 [.18]	.18 [.36]
Team Sat. T1	183	1	6	4.15	4	0.71	-.37 [.18]	1.48 [.36]
Team Sat. T2	183	1.33	7	4.2	4.33	0.84	.20 [.18]	1.59 [.36]
Team Sat. T3	183	1.67	7	4.26	4.33	0.86	.11 [18]	.93 [.36]
Trust (personality)	183	18	49	36.42	32	6.2	-.64 [.18]	.08 [.36]
Cooperation (personality)	183	20	50	38.87	27	5.38	-.37 [.18]	.04 [.36]

Note: The following variable notation was used:
T1 – measurements at time 1
T2 – measurements at time 2
T3 – measurements at time 3
T4 – measurements at time 4
CB – cognition-based trust
AB – affect-based trust

Table 2

Measured variable correlation matrix (N=183).

	M	SD	t11	t12	t13	t14	t15	t16	t17	t18	t19	t21	t22	t23
t11	3.31	1.14	1.00											
t12	3.05	1.15	0.71	1.00										
t13	2.91	1.19	0.59	0.71	1.00									
t14	3.14	1.09	0.65	0.77	0.68	1.00								
t15	3.37	0.99	0.67	0.61	0.59	0.68	1.00							
t16	3.29	1.01	0.60	0.64	0.65	0.64	0.75	1.00						
t17	3.17	1.11	0.58	0.59	0.58	0.59	0.70	0.75	1.00					
t18	3.23	1.00	0.60	0.64	0.62	0.69	0.72	0.71	0.66	1.00				
t19	3.26	0.95	0.65	0.66	0.64	0.71	0.77	0.76	0.71	0.78	1.00			
t21	3.01	1.23	0.31	0.23	0.20	0.12	0.12	0.18	0.17	0.10	0.11	1.00		
t22	3.23	1.18	0.33	0.31	0.26	0.23	0.14	0.15	0.14	0.16	0.17	0.59	1.00	
t23	2.40	0.97	0.20	0.20	0.37	0.14	0.11	0.16	0.17	0.14	0.16	0.44	0.43	1.00
t24	3.16	1.12	0.22	0.16	0.21	0.17	0.14	0.13	0.14	0.12	0.14	0.48	0.63	0.46
t25	3.56	0.86	0.15	0.12	0.25	0.10	0.19	0.17	0.19	0.19	0.17	0.35	0.44	0.35
t26	3.51	0.95	0.18	0.11	0.16	0.09	0.19	0.20	0.19	0.14	0.17	0.36	0.34	0.28
t27	3.35	1.02	0.29	0.16	0.26	0.18	0.31	0.26	0.36	0.21	0.28	0.40	0.35	0.35
t28	3.17	0.88	0.40	0.34	0.38	0.28	0.37	0.36	0.37	0.42	0.42	0.35	0.36	0.40
t29	3.21	0.88	0.30	0.18	0.30	0.20	0.28	0.25	0.29	0.32	0.36	0.43	0.44	0.42
t31	3.51	1.15	0.38	0.29	0.31	0.23	0.23	0.27	0.30	0.18	0.19	0.60	0.56	0.39
t32	3.58	1.10	0.23	0.28	0.26	0.20	0.16	0.15	0.18	0.19	0.16	0.42	0.66	0.37
t33	2.74	1.10	0.24	0.23	0.34	0.17	0.17	0.19	0.20	0.15	0.21	0.41	0.35	0.64
t34	3.46	1.12	0.34	0.28	0.27	0.28	0.19	0.23	0.23	0.19	0.24	0.55	0.58	0.39
t35	3.73	0.87	0.19	0.13	0.19	0.14	0.15	0.13	0.19	0.15	0.17	0.32	0.39	0.23
t36	3.76	0.95	0.19	0.15	0.15	0.10	0.13	0.16	0.20	0.12	0.13	0.36	0.34	0.22
t37	3.62	1.08	0.21	0.15	0.18	0.16	0.24	0.22	0.36	0.17	0.20	0.39	0.34	0.21
t38	3.32	0.86	0.33	0.23	0.26	0.20	0.29	0.27	0.38	0.33	0.33	0.32	0.35	0.44
t39	3.38	0.85	0.40	0.25	0.29	0.29	0.39	0.34	0.35	0.39	0.42	0.36	0.40	0.42
s11	4.72	1.54	0.19	0.09	0.20	0.07	0.12	0.09	0.12	0.08	0.09	0.46	0.39	0.41
s12	2.95	1.56	-0.06	-0.01	-0.15	0.05	-0.01	0.04	0.01	0.08	0.06	-0.39	-0.34	-0.28
s13	4.78	1.47	0.17	0.13	0.21	0.10	0.17	0.14	0.19	0.11	0.10	0.40	0.31	0.34
s21	4.96	1.60	0.12	0.11	0.20	0.01	0.04	0.03	0.06	-0.08	-0.01	0.39	0.40	0.33
s22	2.79	1.70	-0.08	-0.04	-0.09	0.03	-0.05	-0.03	-0.06	0.03	0.05	-0.20	-0.17	-0.17
s23	4.85	1.57	0.13	0.12	0.10	0.04	0.10	0.05	0.12	-0.03	0.03	0.39	0.40	0.29
s31	5.13	1.68	0.11	0.11	0.20	0.03	0.02	0.01	0.10	-0.02	0.01	0.33	0.34	0.39
s32	2.72	1.77	-0.11	-0.08	-0.18	0.03	0.00	0.01	-0.07	-0.03	0.06	-0.22	-0.17	-0.23
s33	4.94	1.67	0.17	0.19	0.24	0.09	0.08	0.09	0.17	0.06	0.07	0.36	0.34	0.37
sc1	-0.30	0.89	-0.17	-0.19	-0.13	-0.19	-0.27	-0.18	-0.11	-0.10	-0.17	-0.08	-0.09	-0.02
sc2	0.10	1.00	-0.11	-0.16	-0.08	-0.07	-0.10	-0.14	-0.08	-0.08	-0.12	0.07	0.08	0.03
sc3	0.21	1.02	-0.06	-0.04	-0.03	-0.07	-0.09	-0.03	0.00	-0.09	-0.09	0.06	-0.04	-0.11
K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 2

Measured variable correlation matrix (N=183).(continued)

	t24	t25	t26	t27	t28	t29	t31	t32	t33	t34	t35	t36	t37	t38
t11														
t12														
t13														
t14														
t15														
t16														
t17														
t18														
t19														
t21														
t22														
t23														
t24	1.00													
t25	0.46	1.00												
t26	0.31	0.60	1.00											
t27	0.35	0.50	0.52	1.00										
t28	0.33	0.47	0.43	0.45	1.00									
t29	0.36	0.52	0.49	0.47	0.70	1.00								
t31	0.56	0.47	0.34	0.33	0.38	0.41	1.00							
t32	0.60	0.47	0.27	0.30	0.30	0.40	0.72	1.00						
t33	0.52	0.36	0.32	0.35	0.37	0.34	0.49	0.45	1.00					
t34	0.65	0.38	0.27	0.34	0.32	0.35	0.74	0.71	0.57	1.00				
t35	0.38	0.56	0.48	0.42	0.39	0.44	0.48	0.45	0.45	0.49	1.00			
t36	0.30	0.56	0.59	0.44	0.38	0.43	0.46	0.41	0.43	0.44	0.78	1.00		
t37	0.35	0.42	0.45	0.61	0.30	0.26	0.43	0.44	0.36	0.43	0.56	0.57	1.00	
t38	0.41	0.49	0.42	0.42	0.69	0.66	0.43	0.39	0.43	0.44	0.49	0.45	0.41	1.00
t39	0.48	0.47	0.45	0.47	0.63	0.69	0.46	0.40	0.46	0.52	0.50	0.50	0.39	0.76
s11	0.41	0.43	0.43	0.44	0.31	0.44	0.44	0.36	0.36	0.37	0.35	0.38	0.38	0.24
s12	-0.29	-0.29	-0.35	-0.31	-0.19	-0.30	-0.32	-0.27	-0.33	-0.26	-0.36	-0.38	-0.28	-0.16
s13	0.32	0.40	0.40	0.43	0.26	0.32	0.34	0.30	0.33	0.31	0.33	0.40	0.41	0.26
s21	0.45	0.44	0.37	0.32	0.19	0.30	0.56	0.53	0.45	0.52	0.46	0.49	0.41	0.23
s22	-0.12	-0.26	-0.25	-0.23	-0.18	-0.20	-0.26	-0.19	-0.14	-0.18	-0.32	-0.33	-0.20	-0.16
s23	0.44	0.39	0.36	0.29	0.19	0.31	0.51	0.49	0.43	0.53	0.45	0.50	0.43	0.28
s31	0.39	0.38	0.29	0.31	0.18	0.30	0.49	0.49	0.46	0.44	0.39	0.40	0.34	0.21
s32	-0.17	-0.23	-0.27	-0.25	-0.12	-0.15	-0.20	-0.23	-0.21	-0.16	-0.21	-0.23	-0.18	-0.04
s33	0.40	0.38	0.30	0.31	0.22	0.36	0.49	0.50	0.49	0.44	0.44	0.43	0.37	0.26
sc1	-0.03	-0.12	-0.30	-0.13	-0.08	-0.11	-0.04	-0.01	-0.09	-0.02	-0.20	-0.20	-0.23	-0.10
sc2	0.09	-0.02	-0.14	-0.01	-0.08	-0.03	-0.04	0.15	0.02	0.14	-0.03	0.02	0.01	0.02
sc3	0.08	-0.09	-0.14	0.02	-0.09	-0.11	-0.04	-0.01	-0.03	0.02	-0.03	-0.03	0.00	-0.07
K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 2

Measured variable correlation matrix (N=183).(continued)

	t39	s11	s12	s13	s21	s22	s23	s31	s32	s33	sc1	sc2	sc3	K
t11														
t12														
t13														
t14														
t15														
t16														
t17														
t18														
t19														
t21														
t22														
t23														
t24														
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t26														
t27														
t28														
t29														
t31														
t32														
t33														
t34														
t35														
t36														
t37														
t38														
t39	1.00													
s11	0.34	1.00												
s12	-0.20	-0.70	1.00											
s13	0.36	0.79	-0.57	1.00										
s21	0.32	0.73	-0.59	0.69	1.00									
s22	-0.23	-0.48	0.51	-0.51	-0.58	1.00								
s23	0.37	0.68	-0.55	0.69	0.88	-0.52	1.00							
s31	0.28	0.63	-0.58	0.56	0.76	-0.42	0.63	1.00						
s32	-0.13	-0.51	0.53	-0.45	-0.48	0.55	-0.37	-0.63	1.00					
s33	0.32	0.63	-0.58	0.60	0.77	-0.47	0.69	0.92	-0.59	1.00				
sc1	-0.09	-0.06	0.08	-0.05	-0.09	0.13	-0.11	-0.07	0.07	-0.11	1.00			
sc2	0.03	0.06	-0.08	0.12	0.11	-0.11	0.11	0.10	-0.04	0.09	0.41	1.00		
sc3	-0.08	0.02	0.00	0.06	0.01	-0.02	0.00	0.02	0.00	0.01	0.28	0.37	1.00	
K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

Table 3

Fit statistics for one- and two-dimensional CFA models for trust at time 1, time 2, and time 3.

Model	χ^2	df	p close	p exact	RMSEA [90% CI]	ECVI [90% CI]	TLI	CFI	RMR
X1 (1 D, T1)	115.51	27	0	0	.13 [.11 .16]	.83 [.67 1.04]	0.97	0.97	0.041
X2 (2 D, T1)	40.38	26	0.42	0.04	.05 [.01 .09]	.42 [.35 .54]	0.99	1	0.02
Y1 (1 D, T2)	133.52	27	0	0	.16 [.14 .18]	1.04 [.84 1.27]	0.89	0.91	0.076
Y2 (2 D, T2)	62.35	26	0.01	0	0.09 [.07 .12]	.58 [.47 .73]	0.96	0.97	0.05
Z1 (1 D, T3)	251.72	27	0	0	.23 [.2 .25]	1.75 [1.47 2.06]	0.82	0.86	0.09
Z2 (2 D, T3)	132.89	26	0	0	.15 [.12 .18]	.93 [.76 1.15]	0.91	0.94	0.08

Note: The following notation was used:

X1 – one-dimensional model fit to the trust data at time 1

X2 – two-dimensional model fit to the trust data at time 1

Y1 – one-dimensional model fit to the trust data at time 2

Y2 – two-dimensional model fit to the trust data at time 2

Z1 – one-dimensional model fit to the trust data at time 3

Z2 – two-dimensional model fit to the trust data at time 3

Table 4

Fit statistics for all latent change score models exploring the interaction between trust and effectiveness.

Model	χ^2	df	P exact	ECVI 90% CI	TLI	CFI	Model AIC	Independence AIC	RMSEA 90% CI	P close	RMR
Overall trust (1)	2029.56	721	0	12.24 [11.5 13.00]	0.978	0.979	2227.6	16929.98	.1 [.095 .11]	0	0.084
Overall trust (2)	1435.99	682	0	9.41 [8.83 10.03]	0.990	0.991	1712	16929.98	.078 [.072 .084]	0	0.074
Overall trust (3)	1281.74	660	0	8.80 [8.26 9.38]	0.996	0.996	1601.7	16929.98	.072 [.066 .079]	0	0.069
CB trust	360.13	298	0.01	4.4 [4.06 4.79]	0.995	0.996	576.13	6027.62	.04 [.022 .054]	0.87	0.077
AB trust	391.4	225	0	3.25 [2.97 3.57]	0.989	0.991	591.4	6984.84	.064 [.053 .074]	0.02	0.069

Note:
Overall trust – models exploring the relationship between overall trust and effectiveness
CB trust – model exploring the relationship between cognition-based trust and effectiveness; factor loadings are invariant across measurement points; errors across measurement periods are correlated
AB trust – model exploring the relationship between affect-based trust and effectiveness; factor loadings are invariant across measurement points; errors across measurement periods are correlate

Table 5

Scale items used and their corresponding labeling.

Label	Scale	Item
I1	Affect-based trust	We have a sharing relationship. We can freely share our ideas, feelings, and hopes.
I2	Affect-based trust	I can talk freely to other teammates about difficulties I am having at work and know that they will want to listen.
I3	Affect-based trust	We would all feel a sense of loss if one of use was transferred and we could no longer work together.
I4	Affect-based trust	If I share my problems with other teammates, I know they would respond constructively and caringly.
I5	Cognition-based trust	My teammates approach their jobs with professionalism and dedication.
I6	Cognition-based trust	Given my teammates' track record, I see no reason to doubt their competence and preparation for our job
I7	Cognition-based trust	I can rely on my teammates not to make my job more difficult by careless work.
I8	Cognition-based trust	Most people, even those who aren't close friends of my teammates, trust and respect them as coworkers.
I9	Cognition-based trust	Other work associates who must interact with my teammates consider them to be trustworthy.
S1	Satisfaction	I would be willing to work with this team on another project.
S2	Satisfaction	I would avoid being on a team project with this group again. *(reverse)*
S3	Satisfaction	I would welcome a chance to do another project with this team.
SC1	Performance	Score on mission 1
SC2	Performance	Score on mission 2
SC3	Performance	Score on mission 3

Chapter 4: Discussion

The purpose of this study was threefold. The first goal was to examine the reciprocal relationship between trust and team effectiveness in virtual teams and to study how these two constructs influence one another over time. Second, the study examined the development of trust in virtual teams. A variety of trust models have been described in the literature discussing the nature of trust, however few have received sufficient empirical validation (Lewicki, Tomlinson, & Gillespie, 2006), and even fewer have been examined in computer-mediated environments. Third, potential antecedents of initial trust in virtual teams were explored.

Nearly all work requires a team approach. Organizations face complex problems, which require employees with a variety of skillsets. Getting the best employees in a field is not always easy. Often location limits the applicant pool for a particular organization. The use of various communication and work-sharing tools has opened up a larger pool of applicants from which organizations can hire. Virtual work tools allow organizations to recruit talented employees beyond those locally available, ensuring that they hire the best employees for the job. The availability of virtual tools, coupled with the complexity of organizational problems requiring a team approach has made the "virtual team" a reality.

There is a common notion that trust is a necessary prerequisite for successful team performance. A lot of research has been conducted in the area, which results in inconsistent findings. Some studies have found significant relationships between trust and

performance (e.g., McAllister, 1995, Webber, 2008, Peters & Karren, 2009, De Jong & Elfring, 2010), while others have observed no relationship (e,g., Aubert & Kelsey, 2003).

The present study examined in detail three alternative models which capture the relationships between trust and effectiveness. Model-data fit statistics indicate that all models except one are plausible. I will focus on the following models: 1) the overall trust model, where the factor loadings across measurement occasions were invariant, and the measurement errors across measurement periods were correlated (Figure 15), 2) the cognition-based trust model (Figure 17) and 3) affect-based trust model (Figure 18). For all three models, the factor loadings are invariant across measurement periods, based on the confirmatory factor analysis results. The confirmatory factor analysis revealed that a two-factor structure fit better than a one-factor structure for all trust measurement points, suggesting that trust changes quantitatively, but not qualitatively. Specifically, the levels of trust change over time, but not structure of trust. Based on the analysis, I concluded that both components of trust are present from the beginning of the team's existence. Research has identified that the two factors of trust have different relationships with team outcomes of interest (McAllister, 1995), therefore I examined the unique relationships between the two components of trust and effectiveness separately. Both the cognition-based trust model and the affect-based trust model fit the data better than the overall trust model as indicated by smaller values of the fit indices (χ^2, ECVI, RMSEA, and AIC). Additionally, examination of the individual parameters in both the cognition-based and the affect-based trust models revealed that they are not identical, suggesting that the two components of trust indeed have differential relationships with effectiveness. These results provide further support to the notion that different components of trust can have

different relationships with outcomes of interest, thus when studying trust, researchers should consider the relationships with the individual trust components (Martins, Gilson, & Maynard, 2004). The two factors of trust are closely related to one another, however they do have unique relationships with other constructs (McAllister, 1995). Because of these unique relationships, the cognition-based trust model and the affect-based trust model are not competing models, but complementary ones, where each model captures a different aspect of the relationship between trust and effectiveness.

Close examination of the two trust models (cognition-based trust model, Figure 17, and affect-based trust model, Figure 18) reveals that, in general, effectiveness facilitates changes in trust, but trust does not determine changes in effectiveness. When examining cognition-based trust, effectiveness and prior cognition-based trust are the primary causes for early changes in trust. Prior cognition-based trust has a negative relationship with initial changes in trust, while effectiveness has a positive one. The cognition-based trust means at time 1 and time 2 were not significantly different from each other. This could be due to the opposing effects that prior trust and effectiveness have on changes in cognition-based trust. The mean initial trust in the sample was relatively high. It is possible that once the participants were primed to think about trust through the first trust assessment, they underwent a process of downward trust readjustment because they realized that there was no solid basis for the trust judgment. Participating and completing the team task, on the other hand, may have counteracted this downward trust adjustment; after the first mission the participants knew more about each other, which may have lead to higher trust. The combined effects of these two processes may result in seemingly level cognition-based trust.

Later changes in cognition-based trust seem driven exclusively by the prior trust and the natural development of trust as captured by the slope parameter. Cognition-based trust grew over time, but effectiveness did not influence its development. Similarly, both changes in trust due to time, as well as changes due to effectiveness influenced affect-based trust. It appears that processes similar to the readjustment in cognition-based trust are also at play for affect-based trust. First, participants adjusted their affect-based trust downward to reflect more realistic, lower trust levels. Then, they adjusted their trust levels upwards to reflect the new knowledge obtained from their most recent interactions with one another. Initially the positive impact of effectiveness counteracted the downward trust adjustment. The combined effect of these two processes resulted in a negligible increase in affect-based trust as indicated by the non-significant difference in affect-based trust means at time 1 and time 2. Later changes in affect-based trust were influenced by the same constructs, however the effect of time on trust was positive (the path between the trust slope and change in trust), adding to the positive influence of effectiveness and therefore resulting in significant increase in affect-based trust.

The development of effectiveness with respect to cognition-based and affect-based trust appears to be identical; neither type of trust influences its development. Research suggests that various team processes mediate the effects of trust on performance. Indeed de Jong and Elfring (2010) identified that team trust positively influenced performance through team monitoring and team effort. Adding team process variables as mediators in the current model could capture the relationship from trust to effectiveness and should therefore be included in the model in order to further explore these relationships.

The results of the two models suggest the trust does not facilitate changes in effectiveness in short-term virtual teams, which echoes findings by Aubert and Kelsey (2003). It appears that as long as team members are motivated to complete the task at hand, they will work together towards achieving their goal, regardless of trust. Short-term teams are often formed because a project needs to be completed quickly. Because frequently these types of teams have a very limited amount of time, spending time on activities to facilitate higher trust may not be possible. The results obtained here suggest that spending time on such activities may not necessarily result in higher team effectiveness.

The second aim of the study is to examine the development of trust in virtual teams. Specifically, I expected that trust would unfold as described by Webber (2008); trust will start as a one-factor construct and over time its two factors will emerge. The results of this study reveal that both components of trust, cognition-based and affect-based, are present from the beginning of the team's lifetime. My conclusions support findings by Wilson and colleagues (2006), who also observed the presence of both trust components early in the team's existence. These results suggest that, in the beginning of a team's lifetime, the amount of trust between team members can change, however, the structure of trust as a construct does not change. Wilson and colleagues identified this two-factor structure of trust in both traditional, face-to-face teams and virtual teams. Theoretically, these results fit with Social Information Processing theory; given time, team members of a virtual team will interact and work with each other, which will increase both cognition-based and affect-based trust.

The third goal of the study was to identify possible antecedents of initial trust in virtual teams. Often, when people have to assess trust quickly, they use a variety of information available to make that assessment including knowledge about the person (Kramer, 1999) as well as surface-level characteristics, such as gender and ethnicity (Kuo & Yu, 2009). In a technology-mediated environment these characteristics are not always readily available, therefore they cannot always be used as a source of information regarding the members of a virtual team.

This study revealed that more than half of the participants based their assessment of trust in their teammates on their previous experiences with teams in a variety of contexts. The expectations that participants had of their teammates were influenced by their own experiences. If prior experiences were negative, expectations of the new team would be negative, while if prior experiences were positive, expectations of the new team would be positive. It will be beneficial to make team members aware of this phenomenon, especially if team members have had prior negative experiences with membership in virtual teams.

Contributions and Implications for the Trust Literature

This study contributes to the trust literature in three distinct ways. First, the present study is the first one to examine the simultaneous reciprocal relationship between trust and effectiveness over time. Second, the results add to a growing body of literature on the beginning levels of trust, and demonstrate that trust does not begin at a zero level, even when team members have no knowledge of each other. Third, findings from this study provide support to the view that trust is a two-factor construct, regardless of the amount of time that team members have worked together.

First, the major goal of this study is to investigate the bi-directional relationship between trust and effectiveness and how they influence each other over time. The analyses revealed that effectiveness drives changes in trust, but the reverse is not true. Neither cognition-based nor affect-based trust has a direct influence on effectiveness as captured by performance and satisfaction.

There is a common assumption that more trust leads to better team outcomes, such as satisfaction and performance. The results presented here do not support this view. Much of the literature examining relationships between trust and effectiveness has focused on established teams (e.g., Costa, Roe, & Taillieu, 2001; Webber, 2008; de Jong & Elfring, 2010). By the time that trust was assessed, team members had become familiar with one another and interacted frequently. In this study, the focus was on short-term teams who have no prior working history. The present results corroborate earlier research that revealed minimal effects of trust on performance in short-term teams (Dirks, 1999; Aubert & Kinsey, 2003); in short-term teams, neither cognition-based, nor affect-based trust influence effectiveness. Trust may not be a necessity for team effectiveness when team members are aware that they will work together for a limited amount of time. These results support prior findings, which show that once sufficient levels of trust are achieved changes in trust do not result in changes in effectiveness (Aubert & Kelsey, 2003).

Second, the results of the study add to the body of literature supporting that trust does exist prior to participant interactions (Yuki, Maddux, Brewer, & Tekemura, 2005). Even when people on a virtual team have no prior history together and no formal knowledge of one another, they still trust each other. In other words, a person's trust in her teammates does not start at zero. In a review on interpersonal trust, Lewicki,

Tomlinson, and Gillespie (2006) cite results from Kramer (1994), Jones and George (1998) and McKnight, Cummings, and Charvany (1998) among others, who argue that initial levels of trust among people are medium to high, due to a variety of factors including personality predispositions and organizational characteristics. Although many cues that people use to make trust assessments in face-to-face interaction are lacking when team members interact through technology, trust levels seem to remain sufficiently high. These results are in concert with findings by Brewer and colleagues (Yuki et al., 2005), which stipulate that unifying characteristics, such as belonging to the same organization and being selected to be on the particular team, are sufficient to foster trust between team members.

Additionally, the results of this study provide further support to the notion that particular personality traits play an important role in determining initial trust levels. Specifically, an individual's predisposition to trust, as captured by the trust personality facet of agreeableness, predicts initial trust in one's team members (hypothesis 1). Cooperation, on the other hand, did not predict initial levels of trust (hypothesis 2). Both trust and cooperation are facets of agreeableness, which have different relationships with initial trust, suggesting that some personality facets are more important to trust formation than others. Furthermore, the results further support the recommendations by Dudley, Orvis, Lebiecki, and Cortina (2006), who urged researchers to examine personality beyond the trait level and focus on personality facets.

Third, the results of this study add evidence which helps address the structure of early trust. On one hand, some argue that early trust has one factor, initial trust, and its components emerge over time as the familiarity between trustor and trustee increases

(Lewicki & Bunker, 1996; Webber, 2008); others argue that the two factors of trust, cognition-based and affect-based, are present from the beginning of the interaction between the trustee and the trustor (Wilson, Straus, & McEvily, 2006).

The results of this study support the latter view. The analyses revealed that two trust factors explain the data better than one trust factor, consistent with the Wilson and colleagues (2006) findings. Further the present results support the notion that as teams develop there are differences in the mean levels of cognition-based and affect-based trust, though both components of trust are always present.

Methodological Considerations

The application of latent change score (LCS) models is a relatively new practice in the field of industrial and organizational psychology. LCS models allow us to capture dynamic changes in constructs which unfold over time and have been demonstrated to be useful in capturing relationships between a variety of constructs, such as child behaviors and divorce (Malone, Lansford, Castellino, Berlin, Dodge, Bates, & Pettit, 2004), or memory and brain structures (McArdle, Hamagami, Jones, Jolesz, Kikinis, Spiro, & Albert, 2004). LCS models have an advantage over other longitudinal analysis techniques because they allow for different measurement instruments at different measurement points (McArdle, Grimm, Hamagami, Bowles, & Meredith, 2009). Often longitudinal data sets contain different measures for the same construct, because of measure availability at the time of data collection, or the adoption of measures with better psychometric properties once data collection had commenced.

Additionally, the technique allows us to explore various reasons for change in the construct; changes due to growth can be isolated from changes caused by other variables.

In this study, the use of LCS models revealed that changes in trust in short-term virtual teams are due to natural growth patterns as well as effectiveness of the team members. Changes in effectiveness, on the other hand, were driven solely by individual growth patterns and trust had no effect.

Latent change score models have thus far been applied to individual level data as was the case in the analyses here. In this study, data collection took place within a team context which raises concerns about independence of observations. For the purposes of this study the clustering of participants within teams was ignored. This could potentially cause underestimation of the standard errors, resulting higher Type I error rates.

To evaluate this issue, the extent of data clustering for every variable at every measurement point was evaluated using a one-way random effects ICC model. Table 6 contains the intraclass correlation coefficients and their significance for each variable. The intraclass correlations reveal that the data for some trust variables (trust at time 3) and satisfaction variables (satisfaction at time 1 and satisfaction at time 2) are significantly clustered. This clustering could result in underestimation of the factor loadings and their standard errors in the latent change score models. Two separate approaches to alleviate the effect of clustering are available. First, bootstrapping of the parameter estimates and standard errors has been recommended when there are violations of distributional assumptions. Bootstrapping will result in more accurate estimates of both parameters and standard errors (Schumacker & Lomax, 2010). Alternatively, a three-level model can be fit to the data. The models examined here are two-level models, which capture observations clustered within participants. A three-level model would include observations clustered within people, as well as people clustered within teams. A

three-level model allows for the dynamic study of the relationships between trust and effectiveness, while accounting for variance on both the individual and team levels.

Implications for Organizations

The results of this study have practical implications for organizations. Short-term teams are often utilized in organizational environments. For example, in the case of a major disaster such as a hurricane or an earthquake, quick response teams are formed for search and rescue missions. Members of such a team could include a team on site to work on retrieving survivors, one person at a control station monitoring environmental conditions, and another in a helicopter gathering information about the terrain and possible dangers. In order to achieve the goal of saving survivors, the team members need to work cooperatively. Often such teams did not exist before the event and team members will not necessarily have prior working history with one another. The success of this team requires similar processes as the ones elicited in the simulation used for this study. Team members communicate through technology in order to gain enough information about the situation, be aware of possible dangers, and devise a plan of action. The results of this study suggest that initial levels of trust in the team members are sufficient for performance and task completion.

Moreover, the results obtained here suggest that practices aimed at enhancing effectiveness in short-term teams should differ from practices utilized to enhance effectiveness in long-term, ongoing teams. Results by De Jong and Elfring (2010) demonstrated that high levels of trust are important for performance in long-term teams, and one way to facilitate performance in those teams is to facilitate the development of trust within the team. On the other hand, the results of this study propose that the impact

of trust on effectiveness might be negligible in short-term teams. Consequently if trust within a team increases, team effectiveness may not change. This suggests that organizations should consider different mechanisms and interventions when working with short-term and long-term teams. Future research should examine effectiveness enhancement interventions exclusively designed for short-term virtual teams.

Additionally, a lot of communication within organizations takes place through technological media. Employees can utilize text, voice, and video to communicate with one another and according to Media Richness Theory, the technology transmitting the most communication cues will be the most effective.

In this study, team members communicated via a text-based, synchronous communication chat tool. This type of communication medium is widely used in organizations for a number of reasons including its convenience and cost effectiveness. Text chat tools are inexpensive, widely available, and utilize less bandwidth compared to other tools, such as video-conferencing, which makes them attractive as a communication tool. Even though text-based chat tools are located toward the lean end of the media richness spectrum (Figure 5), the results of the present study suggest that they are still an effective communication tool. Team members were able to complete their tasks as well as establish relationships with one another as indicated by their increasing trust scores.

Limitations

As the sample of this study consisted of undergraduate students, caution should be exercised when generalizing these findings to an organizational setting. It is possible that participant motivation to complete the task was not high. Throughout the study, the research team monitored the teams' progress to ensure that all players participated in the

mission, however their degree of motivation and effort could not be assessed. Based on participant reactions during the debriefing sessions, the participants generally found the task engaging and appeared to have done their best. Replication of the study with teams in a higher-stakes environment is advisable.

Another potential limitation of the study stems for the use of technology itself. Throughout the study technical difficulties occurred, resulting in discarded data. Technical difficulties are often encountered in the applied world, and laboratory studies such as this one, are not an exception. Virtual teams are entirely dependent on technology for communication and task completion making reliability of the technology key to team success. Unreliability of the technology can be detrimental to team performance and team processes therefore it is crucial to test the technology prior to system implementation.

Another limitation stems from the task used in the study. The literature suggests that trust is necessary for successful team performance where tasks are highly interdependent (Salas, Sims, & Burke, 2005). In the present study, team members were encouraged to collaborate to achieve their mission. In order to achieve the missions though, the team members had to perform a variety of supplemental actions (e.g. gather information) which did not require the cooperation of other team players. Even though collaboration was required for ultimate mission success, the overall task was not highly interdependent, which may explain why trust did not impact effectiveness. Increasing the level of task interdependence will necessitate greater collaboration between team members and potentially reveal that trust does influence effectiveness.

In this study I examined trust as a psychological construct which develops between people based on their experiences and interactions with one another. In virtual

teams however, two types of trust are of importance – interpersonal trust and trust in the utilized technology. This study examined the former and did not address the latter. According to a model proposed by Lee and See (2004), trust impacts a person's reliance on automation and technology. Lee and See argue that as the complexity of technology grows so will the importance of trust in technology. As complex technology is layered onto human interactions trust in both the human agent as well as in the technology become critical for effective system design and subsequent interactions. Future studies should examine the effects of both trust in team members and trust in technology on team outcomes.

Future Research

The focus of this study was to examine the direct relationships between trust and team effectiveness and how it unfolds over time. The study revealed that effectiveness influences the development of trust in short-term teams, however trust appeared to have no consequences for the development of effectiveness. Prior studies have found that the relationship between trust and effectiveness could be mediated through different team processes (de Jong & Elfring, 2010). Future studies should examine how trust interacts with these team processes in order to increase effectiveness. In particular, communication has been identified to be important to teamwork (Picolli, Powell, & Ives, 2004), therefore examining patterns of communication as well as information sharing is warranted.

Studies should also examine the role of trust for different effectiveness indicators. Cohen and Bailey (1997) postulate that effectiveness breaks down into performance, behavioral, and attitudinal effectiveness. Examining the relationship trust has with sub-factors of effectiveness may reveal that the trust-effectiveness relationship is moderated

by the type of effectiveness. I examined the relationships between trust, performance, and satisfaction separately, in order to test potential unique relationships between the two trust components and types of effectiveness. The preliminary results support the view that cognition-based and affect-based trust have distinct relationships with different effectiveness types. The cognition-based trust and performance model (Appendix C) indicates that performance effectiveness impacts the development of trust, as illustrated by the significant paths between the effectiveness latent variables and the change in trust latent variables. These relationships are similar to the ones observed between cognition-based trust and effectiveness (Figure 17). Unlike the cognition-based trust and effectiveness model, here the second path between cognition-based trust and change in effectiveness (CB trust at time 3 to Δ Effectiveness 2) is also significant. This suggests that cognition-based trust influences the development of effectiveness, such that, higher levels of cognition-based trust will lead to greater changes in performance effectiveness. Similarly, examination of the relationship between affect-based trust and performance effectiveness (Appendix D) reveals that affect-based trust influences the change in performance effectiveness. These results should be interpreted with caution, because power was not sufficient to produce a proper solution, therefore the convergence criterion was increased to .01, which is quite larger compared to the standard solution convergence criterion (.00001).

I also considered the relationships between trust and attitudinal effectiveness, as indicated by satisfaction with the team. Both the cognition-based trust and satisfaction model (Appendix E) and the affect-based trust and satisfaction model (Appendix F) revealed no bi-directional relationship between cognition-based trust and satisfaction.

The preliminary results from the four models provide empirical evidence that distinction between effectiveness criteria is important, because trust appears to have distinct relationships with different effectiveness criteria. It appears that combining effectiveness criteria in one latent variable attenuates the relationships between trust and effectiveness. Future research should examine the distinct relationships between trust components and the three effectiveness factors where multiple indicators are utilized for each factor.

Additionally, the use of the intraclass correlation as an indicator for team effectiveness can be explored. Theoretically, a high performing team is comprised of individuals who are high performers. The team members know how to perform the tasks they have and they will perform them well. Moreover, team members will be able to complement one another, facilitating each other's performance. Then team member performance scores will be closely related to each other, resulting in high ICC. A less effective team, on the other hand, will have a lower ICC compared to a high effective team, because team members do not complement one another to achieve the tasks at hand. Future studies should examine the use of the intraclass correlation as a team effectiveness indicator.

Lastly, future research should explore the effect of multiple behaviors on the development of trust. This study examined the development of trust and effectiveness in a naturalistic setting with no trust manipulations. Team members were encouraged to work together and be cooperative. However, team dynamics change as a function of team member behaviors, and in turn influence trust and team performance. Future studies should examine how competition influences the development of the relationships between trust and effectiveness in virtual teams.

Conclusions

This study examined the development of trust and overall effectiveness in computer-mediated teams. A latent change score model was fit to the data to test the effects of trust on effectiveness over time as well as the influence of effectiveness on trust over time. The model revealed that trust, regardless of type, does not impact the development of effectiveness in short-term virtual teams. Effectiveness, on the other hand, influenced the development of both cognition- and affect-based trust. The results from the study support earlier findings that high levels of trust do not necessarily translate to higher effectiveness levels as it pertains to short-term virtual teams. Future research should examined the relationships between the components of trust and the three sub-types of effectiveness, as it appears that trust has distinct relationships with each one sub-type individually.

Table 6

Intraclass correlations for all variables measured at every measurement point.

Variable	ICC	95 % CI	*p*
Trust at time 1	0.05	[-.09 .22]	0.235
Trust at time 2	0.081	[-.06 .25]	0.137
Trust at time 3	0.165	[.014 .336]	0.015
Satisfaction at time 1	0.167	[.015 .339]	0.015
Satisfaction at time 2	0.244	[.086 .414]	0.001
Satisfaction at time 3	0.086	[-.057 .257]	0.126
Performance at time 1	-0.18	[-.275 -.047]	0.995
Performance at time 2	-0.075	[-.193 .078]	0.842
Performance at time 3	-0.064	[-.183 .091]	0.801

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Appendices

Appendix A

Sample Distributed Dynamic Decision-making task scenario

TIME: October 10, 2010

LOCATION: STATION BLUE, SOUTH POLE

Your crew is preparing to winter-over at Station Blue. Different members of your 25 person crew and several other smaller research teams will be conducting meteorological, geological, communication, astrophysical, and medical/biological observations and experiments during the eight-month wintering-over period. You know that the Antarctic is an inherently dangerous place.

Station Blue is located 10 km inland on an ice sheet at an altitude of 1,530 meters. The station is equipped with specially designed Snow Cats that can navigate the terrain in all but the most severe weather. Protocol requires that when tasks have to be performed outside the station, a work team or teams of four persons each are formed for protection and safety. **You** are the leader of one of the work teams. The other players are leaders of other work teams. Each team leader is assigned a specific Snow Cat, which is identified by color.

INCIDENT:

A team departed the station yesterday for the Hazard Mountains on a 36-hour mission to:

(1) install a new antenna, and (2) recover a UAV. This new antenna needs to be installed for the critical purpose of tracking meteors that may penetrate the earth's atmosphere within 96 hours and may collide with earth. It has been reported that the UAV has crashed containing classified data and equipment, which must be recovered and transported back to home base.

MISSION:

You are to work with the other three team leaders to plan and carry out the search and rescue mission, to mount the antenna as planned, and to complete recovering the UAV. The usual search and rescue plan is to have three teams out on the search and one team at Base Station Blue coordinating satellite search activities.

The **Green, Red and Purple** Teams will be sent out on snowcats to search for the lost party and to complete their mission. **Blue** will remain at the Base Station.

Green, Red, Purple: Your mission is to locate and aid the lost party, as well as to complete their mission of installing the antenna and recovering the UAV.

Blue: Your mission is to manage the information and share important satellite messages with the other team leaders. Blue must also assist the vehicles with refueling and replenishing resources. Note that if a vehicle runs out of fuel, everyone on that vehicle will perish. Blue must also help guide the vehicles through the terrain and coordinate processing of tasks as he sees fit.

THE ENVIRONMENT AND RESOURCES:

Satellite. The satellite provides relatively high-quality information. The satellite is searching for man-made objects or other geological clues that may indicate the direction the lost team went or their actual whereabouts. Satellites will be giving lots of information, not all of which may be relevant to your mission.

Personnel. Each vehicle carries medical personnel, mechanics, communication technicians, and scouts. Medical capability is the ability to tend to injuries. Mechanical ability refers to the expertise to repair vehicles. Communication technician ability can repair a vehicle's communication gear. Scout ability helps interpret clues and evaluate hazards. Some tasks may require a higher number of processing units than is present on board a single snowcat. To complete these tasks, you may have to request assistance from another snowcat and pool resources. Note that resources will be depleted with use.

Seismic monitors. Seismic monitors monitor the ice sheet for geologic activity, but also can tell you whether a vehicle has passed, if so, when, and the direction in which it was heading.

Clues. Clues indicate certain pieces of information that can help you in your search. Not all messages will be helpful or accurate, because teams other than the lost party may have left the clues.

TASKS:

Time-critical Emergency Tasks. Occasionally you may be called upon to render critical emergency assistance to another team. There will be severe penalties if you do not attend to these emergency tasks.

Non-critical medical tasks. Other medical aid requests may occur that are not so critical or time sensitive, but your assistance would be greatly appreciated by those in need.

Repair tasks. You may also encounter people in need of mechanical help in order to repair equipment or machinery that has broken down. It is considered professionally responsible to render aid when you encounter these repair requests.

Fuel depot/tanker. If your vehicle runs out of fuel everyone on your vehicle perishes! You can refuel ONCE by movable fuel tanker. To do this you need to communicate with Blue and request refuel assistance. Your remaining fuel can be monitored.

SCORING:

Score. You will be able to see your team's score in the main window. This score gives you an idea of how well your team is doing in terms of locating the lost party and the antenna.

Your goal is to find the lost party and install the antenna as quickly as possible due to the impending storm. When you have completed all tasks, your points and time to complete the task will be compared with those of the best team to date.

Important points to remember:

It is important that you complete ALL the tasks. It is important to *maintain fuel levels* and to refuel when necessary. If your vehicle runs out of fuel, everyone on your vehicle will perish and you will be out of the game.

You will encounter many challenges on the way and it is important to remember that you will need to ***apply at least the required amount of resources*** to complete the seismic monitor and medical/repair tasks. Remember, if the task requires more expertise than you have on board your cat, you can request another team to help by combining their resources with yours.

GOOD LUCK!

Adapted from Coovert, M. (2010). USF Antarctic Search and Rescue Scenarios:

Instructions For Distributed Dynamic Decision-making.

Appendix B

Personality assessment (Goldberg et al., 2006)

Please indicate how accurately each statement describes you. Use a scale from 1 to 5, where *1=Very Inaccurate, 2= Moderately Inaccurate, 3= Neither Inaccurate or Accurate, 4=Moderately Accurate* and *5= Very Accurate.*

Trust

1. I trust others.

2. I believe that others have good intentions.

3. I trust what people say.

4. I believe that people are basically moral.

5. I believe in human goodness.

6. I think that all will be well.

7. I distrust people.

8. I suspect hidden motives in others.

9. I am wary of others.

10. I believe that people are essentially evil.

1. I am easy to satisfy.

2. I can't stand confrontations.

3. I hate to seem pushy.

4. I contradict others.

5. I love a good fight.

6. I have a sharp tongue.

7. I yell at people.

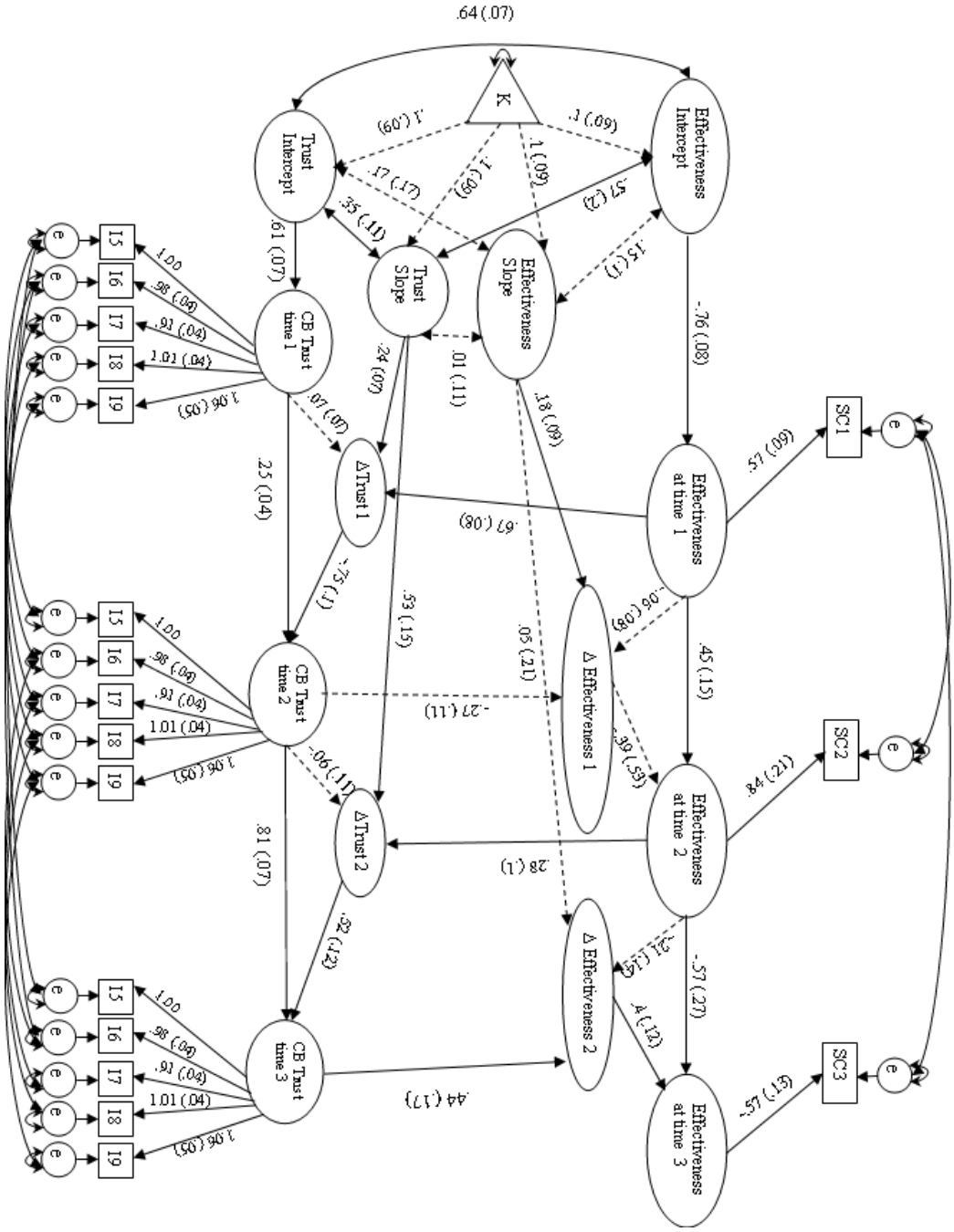
8. I insult people.

9. I get back at others.

10. I hold a grudge.

Cooperation

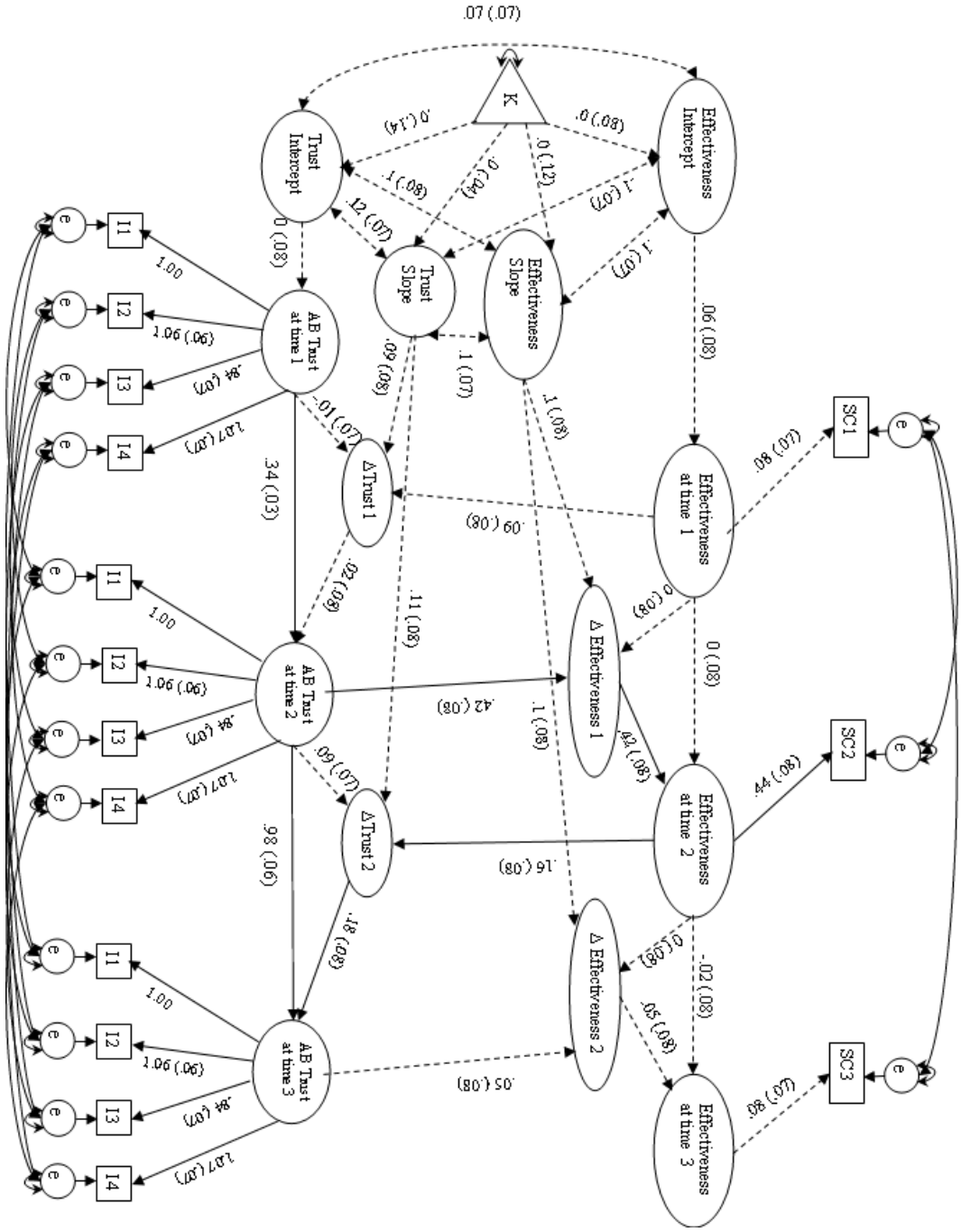
Appendix C



χ^2	df	P close	P exact	RMSEA 90% CI	ECVI 90% CI	TLI	CFI	RMR
148.48	100	.42	.001	.052 [.033 .068]	1.81 [1.65 2.01]	.984	.991	.063

Cognition-based trust and performance model - trust factor loadings are invariant across measurement points; errors across measurement periods are correlated.

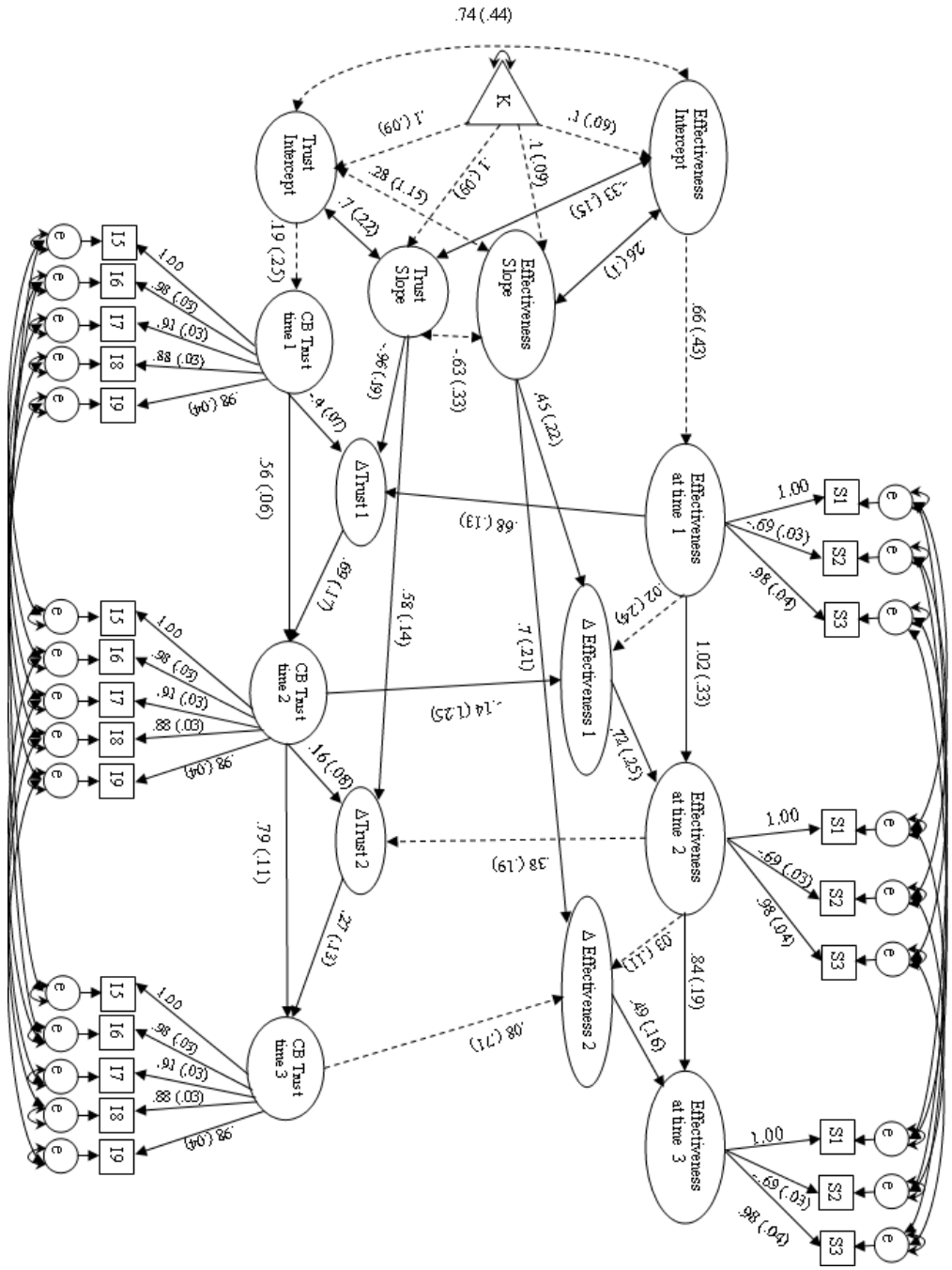
Appendix D



χ^2	df	P close	P exact	RMSEA	90% CI	ECVI	90% CI	TLI	CFI	RMR
55.37	53	.95	.39	.016	[0 .05]	1.22	[1.2 1.34]	.97	.99	.06

Affect-based trust and performance model - trust factor loadings are invariant across measurement points; errors across measurement periods are correlated.

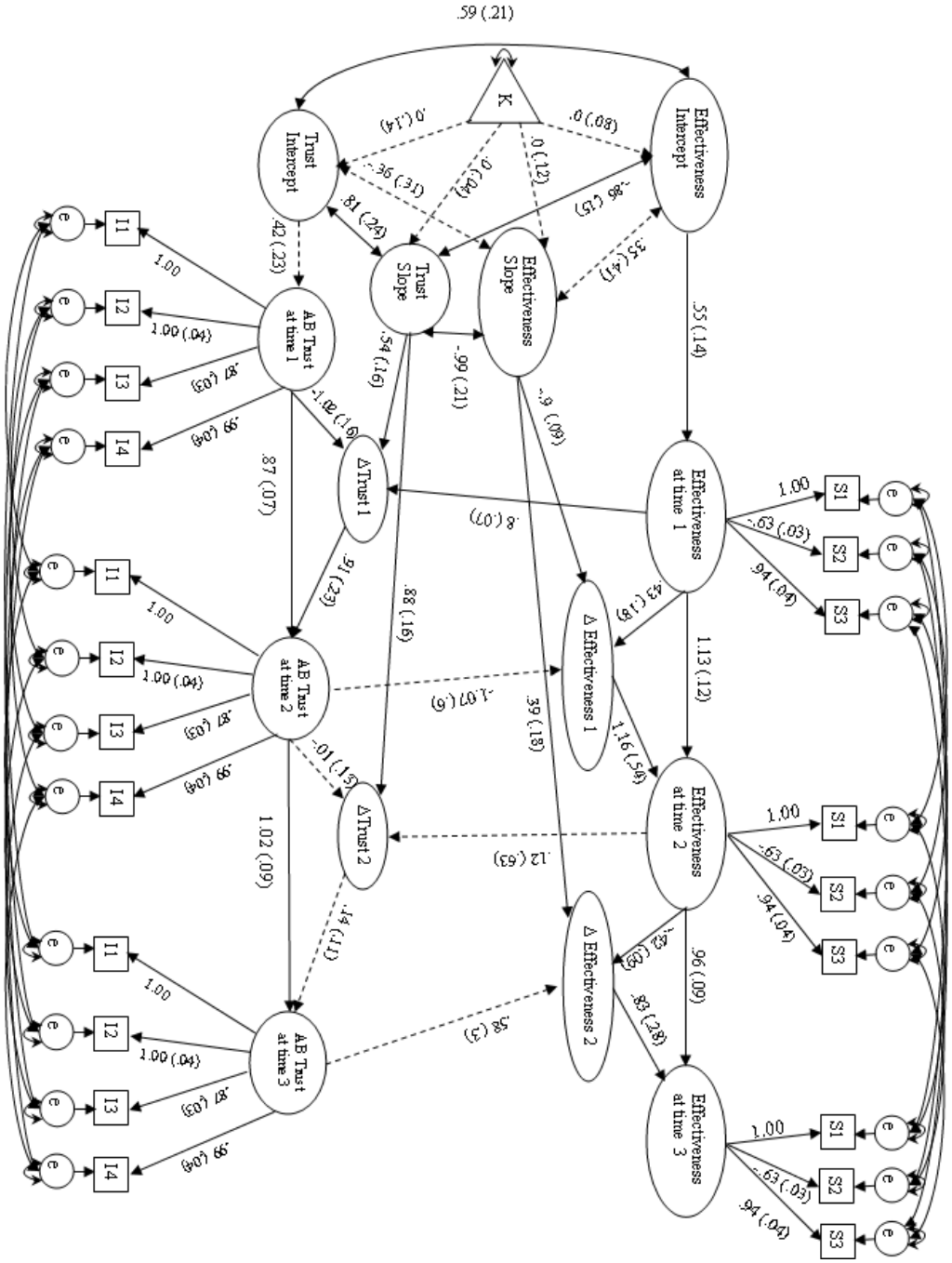
Appendix E



χ^2	df	P close	P exact	RMSEA 90% CI	ECVI 90% CI	TLI	CFI	RMR
372.98	224	.06	0	.061 [.05 .07]	3.16 [2.89 3.47]	.997	.998	.064

Cognition-based trust and satisfaction model - factor loadings are invariant across measurement points; errors across measurement periods are correlated

Appendix F



χ^2	df	P close	P exact	RMSEA 90% CI	ECVI 90% CI	TLI	CFI	RMR
292.14	159	.01	0	.068 [.056 .08]	2.64 [2.4 2.92]	1	1	.053

Affect-based trust and satisfaction model - factor loadings are invariant across measurement points; errors across measurement periods are correlated