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The Effects of Collaborative Critical Thinking Training on Trust Development and Effectiveness in Virtual Teams

Mark Grichanik
University of South Florida, mgrichanik@gmail.com

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by

Mark Grichanik

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Major Professor: Michael D. Coovert, Ph.D.
Michael T. Brannick, Ph.D.
Doug Rohrer, Ph.D.

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Abstract

Workers in modern teams that perform tasks over computer-mediated communication channels encounter challenges in building trust and performing effectively. Finding interventions to mitigate such losses could improve team performance. Collaborative critical thinking (CCT) training has the potential to improve trust, monitoring, and effectiveness in virtual teams. Using a simulated search-and-rescue task, the effects of CCT training, as compared with a control training, were evaluated in 105 three-member teams. No effects of CCT training were found on team positive or negative monitoring, team cognitive or affective trust, team efficacy, or team viability. However, teams trained in CCT reported consistently higher levels of team cooperation. Directions for future research are discussed so as to maximize the possibility that CCT might yet be an effective intervention.

Chapter 1: Introduction

Dynamic market conditions and enterprising enemies require that modern civilian and military organizations rapidly solve complex problems in the face of uncertainty. As a result, a majority of contemporary organizations have turned away from hierarchical personnel structures in favor of flatter configurations, which rely primarily on teams in order to accomplish organizational objectives. As communication technology has become more reliable and affordable, organizations have increasingly embraced virtual teams, in which team members work across geographic, temporal, or organizational boundaries.

While virtual teams allow organizations to quickly and inexpensively bring together cross-disciplinary expertise to solve problems, make decisions, and accomplish goals not realizable by individuals alone, teamwork is a fragile enterprise. Face-to-face teamwork requires strong interpersonal and communication skills, the demands for which are often amplified when virtual teams interact over sparse communication channels. In order for teammates to be able to effectively collaborate and share responsibilities, they must trust one another, and the development of such interpersonal trust is, among other things, dependent on keen social skills.

In order to make good decisions, teams must reduce situational uncertainty. One way teams can do this is by engaging in a process of collaborative critical thinking (CCT) wherein interdependent teammates break constrained group processes and thinking by collectively sharing siloed ideas, experience, knowledge, and information, critiquing assumptions, and generating alternative interpretations and solutions. I propose that the reduction of *situational* uncertainty through CCT is critically dependent on the reduction of *interpersonal* uncertainty (i.e., the development of trust). That is, teammates must trust one another if they are to share information.

If both trust development and good decision-making are pivotal determinants of team effectiveness, it is important to develop strategies to help teams enhance both of these processes. In the current study, I use a computer simulation of a search-and-rescue task to investigate how a collaborative critical thinking training intervention impacts trust development, attitudes, and performance in ad-hoc, virtual action teams. If teammates receive CCT training, this can create a norm of monitoring. While some forms of monitoring are associated with distrust, questioning one another's thinking and monitoring out of genuine care and concern for a teammate's performance, as is the goal in CCT, can be a signal of trust. Furthermore, if CCT training makes teams communicate more frequently, this will dilate the channel for the exchange of social and task-related information, both robust predictors of trust. I thus contend that the trust-CCT relationship is bidirectional; trust among teammates is necessary to engage in CCT, but partaking in CCT also builds trust.

The literature review for the current study begins with a description of the setting within which contemporary teams operate and progresses to covers topics related to virtual teams, trust development, decision-making, and collaborative critical thinking. Finally, I propose several hypotheses and a design for an empirical investigation of my hypotheses.

The Landscape of Contemporary Team Decision-Making

Market and technology changes have driven structural changes in organizations. Burns & Stalker (1961) describe two types of organizational structures. The first type of structure is called mechanistic. Mechanistic structures feature centralized decision-making, high standardization and formalization, low differentiation of tasks, and low levels of integration across, for example, divisions. This type of structure operates effectively and efficiently in a stable market environment where decisions, changes, and innovations don't necessarily need to be made quickly. The second type of structure is organic. Organic structures feature decentralized decision-making, little standardization and formalization, high differentiation of tasks, and high levels of integration across divisions. These structures are more useful in dynamic and uncertain environments because they allow information and knowledge to be propagated quickly through an organization. In turn, the organization can react quickly to changes. As Burns and Stalker indicated as early as 1961, organizations seem to be moving towards more organic structures in order to meet the ever-changing demands of consumers and clients as well as to respond to the sophisticated and dynamic strategies of competitors. Such fluid, flat organizations have less rigid boundaries around jobs roles and create jobs that require people to "thrive on chaos" and embrace change.

Additionally, Dess, Rasheed, McLaughlin, Priem, and Robinson (1995) suggest that, while boundaries are rigid in traditional companies, the once unidimensional roles of managers and employees are being replaced by "fluid, ambiguous and deliberately ill-defined tasks and roles." The previously bureaucratic, control-oriented, and hierarchical organizations are giving way to barrier/boundary free organizations (BFOs). In order to be viable, organizations need to quickly embrace the non-traditional structures that are more flexible, responsive, and highly tolerant of ambiguity. Furthermore, BFOs emphasize *results* over the maintenance of rigid internal relationships, which allows them to rapidly and continually adapt to dynamic world markets.

The evolution away from traditional, hierarchical, authoritarian, and mechanistic organizations towards permeable, organic organizations implies that the targets and modes of interaction, coordination, and control have also changed. That is, whereas before employees interacted primarily either with machinery or with those above or below them in a chain of command, the targets of interaction are now oriented more horizontally (e.g., teammates, other divisions) and externally (e.g., clients, customers, coalition partners). While Ferris, Davidson, and Perrewe (2010) point out that competing interests, scarce resources, and coalition building have always made organizations inherently social arenas, they also argue that the increased volume and variety of human interaction make employees with adept interpersonal skills, flexibility, and adaptability crucial in modern organizations.

Although having good communication skills and job knowledge has always been important in organizations, these alone are not enough to function in the highly collaborative, participative, and democratic environments characteristic of modern organizations. Networking, negotiating shared interests, building trust, and sharing resources are pivotal for working in self-managed teams, across parts of an organization (e.g., interdivisional task forces), and with external stakeholders (e.g., clients, customers) (Burns & Stalker, 1961; Dess et al., 1995; Ferris et al., 2010). In order to achieve results, employees must coordinate and cooperate with both internal and external constituencies to establish beneficial relationships and exercise influence over relevant targets over whom they do not necessarily have line authority, but in whose work they have a stake nonetheless. Furthermore, superiors issue instructions and decisions less frequently. Instead, knowledge is distributed across a network, and employees need to learn how to capture and share information, dispense advice, and coach others. Employees must also work with teammates and stakeholders to ensure that people stay unified, satisfied, and productive well as learn how to resolve conflicts without relying on mechanisms of traditional authority structures. Costa (2003) aptly summarizes that, "new emphasis [in contemporary organizations] is given on interpersonal and group dynamics at the workplace, where *trust* is seen as one of the critical elements" (italics added, p. 605). I later expand on Costa's idea and review interpersonal and team trust as a pivotal determinant of team processes and outcomes.

Teams

Challenged with the task of handling large of amounts of complex information in dynamic environments that require the collaboration of expertise across multiple areas, organizations have embraced teams as relevant and effective tools (Townsend, DeMarie, & Hendrickson, 1998). Teamwork requires team members to coordinate, share responsibilities, rely on one another, and participate in decision-making to accomplish personal and collective goals not otherwise achievable through individual effort (A.C. Costa, 2003). Furthermore, *virtual* teams have become nearly ubiquitous in contemporary organizations. In a recent investigation by the Economist's Intelligence Unit (2009), 78% of participants from a wide range of industries reported working in virtual teams currently or in the recent past. Virtual teams are teams whose members are geographically, temporally, and/or organizationally dispersed and who spend a substantial portion of their time collaborating through technology. The evolution from face-to-face to virtual teams has largely been an organic response to increased global competition and interdependency across departments and business units (The Economist Intelligence Unit, 2009). While virtual teams are a practical, effective, and cheap solution for organizational members to collaborate, there are some substantive differences in trust and performance outcomes when they are compared with face-to-face teams. Below, I define teams and virtual teams, discuss their necessity, and compare their effectiveness.

Defining teams and subtypes. A variety of definitions of teams have been proposed in the literature. For example, Costa (2003) defines work teams as "organizational groups, that have some goal or attainable outcome which team members contribute to and are responsible for, and where there is sufficient task interdependence such that individuals need to develop shared understandings and expected patterns of behavior." (p. 606) Salas, Dickinson, Converse, and Tannenbaum (1992) define a team as "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. 4). These two definitions complement one another; each argues that teams are goal-driven groups consisting of multiple members with distinct yet interdependent roles. The Costa (2003) definition additionally specifies that teams develop common mental frameworks, and Salas et al. (1992) adds that teams are temporary, meaning that they "work interdependently for an extended time to accomplish a common objective in a limited time span" (Webber, 2008).

Teams are often assembled to accomplish a specific goal and are disbanded when their purpose has been served. Due to the ever-changing composition of talent, teammates often have not had an opportunity to collaborate with one another in the past; such groups are called ad-hoc teams (Stone, Kaminka, Kraus, & Rosenschein, 2010). For instance, when disasters strike, governments and relief agencies need to quickly assemble ad hoc teams or even teams-of-teams (J. M. Schraagen & van de Ven, 2008; J. M. Schraagen & van de Ven, 2011). Members of crisis management teams are typically unfamiliar with one another due to the infrequency of large-scale catastrophic events, and are unlikely to work together again in the future (Jarvenpaa & Leidner, 1998). Furthermore, such teams can be characterized as action teams wherein, "expertise, information, and tasks are distributed across specialized individuals, [and] team effectiveness depends on rapid, complex, and coordinated task behavior, and the ability to dynamically adapt to the shifting demands of the situation" (Ferris et al., 1996, p. 254).

It is unlikely that a central individual can effectively manage all facets of the complex processes characteristic of modern organizations. Organizations have thus become flatter such that hierarchical choreography is often replaced with the horizontal interactions characteristic of self-managing teams, which are groups of "interdependent individual[s] that can *self-regulate* on relatively whole tasks" (emphasis added; Cohen, Ledford, & Spreitzer, 1996 from Langfred, 2004). Finally, all of the aforementioned team subtypes are critically dependent on effective collaboration processes. Hess, Freeman, and Coovert (2008) define collaboration as a "social process by which people exchange information and perspectives, create knowledge and discuss and integrate the implications of these processes" (p. 241). Collaboration thus creates an atmosphere of constructive dissent where members of self-governing teams are encouraged to cultivate independent thought and freely express ideas in order to generate novel knowledge (Olivares, 2005).

Information age warfare. While the transition from top-down control processes to team-based structures in civilian organizations can largely be attributed to market and technology changes, a parallel transformation has occurred in military organizations as a result of information-driven warfare (Alberts, Garstka, Hayes, & Signori, 2001). New and rapidly changing adversaries have necessitated structural and technological changes in command and control (C2) environments. Relatively impermeable boundaries and the restrictive, top-down control characteristic of traditional C2 structures allows for stable and dependable operations in the face of static adversaries. However, such structures are not conducive to the rapid reconfiguration of personnel and resources required for engaging the cunning and unconventional enemies innate to asymmetric warfare (Rosen, Fiore, Salas, Letsky, & Warner, 2008).

Modern command and control environments are thus advanced socio-technical systems underpinned by relatively unstructured, agile teams (Cooke, Gorman, & Winner, 2007). Teams in modern C2 are often composed of heterogeneous (e.g., multidisciplinary, multicultural), rotating members with little to no previous joint experience. The teams must operate and adapt in time-pressured environments to accomplish highly interdependent missions. Tasked with solving ad-hoc, short duration problems, teams are required to make accelerated decisions and take decisive action in the face of ambiguous cues and large amounts of complex, dynamic, and uncertain information (M. Letsky, 2007; M. P. Letsky, Warner, Fiore, Rosen, & Salas, 2007). Military command and control settings are thus natural habitats for the types of teams previously described (e.g., self-managing, ad hoc, mission-critical, action teams), albeit with intensified stress and stakes. The present study simulates an emergency search-and-rescue operation, which is often undertaken by military teams (e.g., Coast Guard). Although no enemies are present, teammates unfamiliar with one another will be faced with uncertainty, a common objective, and high task interdependence. Team members will be required to coordinate, collaborate, and problem solve in a complex and rapidly evolving environment.

Virtual teams. Another dimension along which teams can differ is the communication medium subserving team interactions. While teams have traditionally met face-to-face (FtF), military and civilian organizations are increasingly composing teams that are geographically, temporally, and organizationally distributed (Jarvenpaa & Leidner, 1998). As product cycles have become compressed and as companies have distributed and globalized their work through offshoring and outsourcing activities, building and managing virtual teams (VTs) has become an attractive option to overcome the space, time, and relational constraints that burden FtF teams (Jarvenpaa & Leidner, 1998; Kirkman, Rosen, Tesluk, & Gibson, 2004; M. Letsky, 2007; Townsend et al., 1998; Warkentin, Sayeed, & Hightower, 1997). Enabled by developments in information and communication technologies (ICTs; Robert, Denis, & Hung, 2009), VTs are enticing because they offer the "flexibility, responsiveness, lower costs, and improved resource utilization necessary to meet ever-changing task requirements in highly turbulent and dynamic global business environments" (Jarvenpaa & Leidner, 1998, p. 791).

Defining virtual teams. After reviewing and integrating many definitions of virtual teams, Martins, Gilson, and Maynard (2004) define virtual teams as "teams whose members use technology to varying degrees in working across locational, temporal, and relational boundaries to accomplish an interdependent task" (p. 808). This definition is particularly useful because it supplements but does not change the definition of teams proposed above. That is, a virtual team is, first and foremost, a team – it is temporary, goal-driven, has interdependent roles, and involves shared responsibility (MacDonnell, O'Neill, Kline, & Hambley, 2009). The difference, then, between a colocated team (i.e., FtF) and a *virtual* team is the presence of technology-supported "virtualness" as a team characteristic. In the Martins et al. (2004) definition, the locational boundary refers to the physical separation of team members (e.g., separated workstations within a single workplace, one workstation in India and another in China). The temporal boundary refers to the separation of communication and performance times across team members (e.g., differences in shifts or time zones, differences in team lifecycle). Finally, the relational boundary refers to differences in culture and the permeability of organizational boundaries (e.g., teams choosing teammates based on "what they know" rather than "who they know") (Martins et al., 2004).

Virtuality. Forming relationships, communicating, interacting, and completing work in distributed teams requires members to utilize ICT networks (Aubert & Kelsey, 2003; MacDonnell et al., 2009) to engage in computer-mediated communication (CMC), also commonly referred to as computer supported cooperative work (CSCW; Coovert & Foster-Thompson, 2001; Thompson & Coovert, 2006). Laboratory-based research has often dichotomized face-to-face and virtual teams. That is, teams in these studies are operationalized such that they either *exclusively* interact virtually or face-to-face. However, it is important to note that Martins et al.'s (2004) definition does not specify that a team must solely rely on ICTs to function. In fact, it explicitly states that VTs "use technology to *varying* degrees" (italics mine). In application, teams are often hybrids, which utilize a combination of face-to-face and virtual interactions (Bjørn & Ngwenyama, 2009; Griffith & Neale, 2001; Maznevski & Chudoba, 2000). Therefore, while former definitions reserved the "virtual" label only for those teams that never met face-to-face, current treatments typically described a team's virtuality as a matter of degree or otherwise necessitate that electronic communication represent a substantial or majority portion of team interactions (e.g., Gibson & Cohen, 2003; MacDonnell et al., 2009; Maznevski & Chudoba, 2000).

Many technologies are available to support virtual team communication and performance. For example, whereas virtual teams previously had to rely on "lean" communication technologies such as text-based chat and e-mail, more advanced groupware, such as tele- and video-conferencing, are now available (MacDonnell et al., 2009; Thompson & Coovert, 2006). These higher fidelity options allow for increased social bandwidth in electronic communication, and yet are still affordable enough to offset the travel and infrastructure costs associated with face-to-face work (Thompson & Coovert, 2006). Furthermore, ICTs allow multiple parties to simultaneously participate (MacDonnell et al., 2009), for records to be kept of all communications, for synchronous or asynchronous communication (Warkentin et al., 1997), and for the incorporation of collaboration and productivity tools that assist team members in the decision-making process and the "sophisticated collection, processing, management, retrieval, transmission, and display of data and knowledge" (MacDonnell et al., 2009, p. 2).

Although most accounts of virtuality focus exclusively on the extent to which a team uses ICTs to communicate and accomplish tasks, Kirkman & Mathieu (2005) propose an expanded framework for evaluating team virtuality. The model consists of three non-orthogonal dimensions – extent of use of virtual tools, informational value, and synchronicity. The first dimension is the extent of use of virtual tools, as discussed above in Martins et al.'s (2004) definition of VTs. The second dimension is informational value. This is based on the idea of media richness (Daft & Lengel, 1986; Venkatesh & Johnson, 2002), which differentiates between "lean" and "rich" ICTs based on their information-carrying capacity. With respect to *communication* technology, text chat is considered a lean channel (i.e., high virtuality) while videoconferencing is considered a rich channel (i.e., low virtuality) because it provides both verbal *and* nonverbal information. Technology for *conveying data* can also be categorized along a low-high virtuality continuum. For instance, providing a verbal description of a restaurant design may be considered highly virtual, whereas constructing and sharing a 3D "walk-through" is considered less virtual. Kirkman & Mathieu's (2005) final dimension, synchronicity, refers to whether exchanges are lagged (off-line communication, more virtual) or real-time (on-line communication, less virtual) such that members can simultaneously exchange information. Whether asynchronous or synchronous exchanges are preferred depends on the task team members are engaged in. For example, when reviewing a written product for quality assurance, asynchronous communication may be preferred so that a team member has time to process it and craft feedback without the pressure of a "hovering" teammate. On the other hand, it would be dangerous to use asynchronous communication when decisions need to be made quickly about a target during a combat operation.

The present study makes use of synchronous communication technology because the search-and-rescue task requires participants to problem-solve under time pressure. Participants must also use "on-line" communication to coordinate their strategies. Although a voice chat client is available in the simulation system, participants will only be allowed to communicate through a text-based chat window. Although this is perhaps one of the most impoverished ICTs, it will allow me to investigate the lower-boundary (i.e., highest degree of virtuality) of virtual collaborative critical thinking effectiveness.

Virtual team effectiveness. Many studies have investigated whether virtual teams are more effective than face-to-face teams. Some advantages of virtual teams are that they can increase the range, capacity, depth, and speed of information dissemination, access, and exchange (Warkentin et al., 1997). They can also mitigate process losses that occur in face-to-face settings. For example, virtual interactions can be more intimate and encourage more participation than face-to-face interactions since virtual team members can be less formal and less concerned with etiquette (e.g., turn-taking, formalities, impressions) (Thompson & Coovert, 2006). This, in turn, can reduce anxiety about judgment by others and embolden team members to defend opinions and consider alternatives that may otherwise not get discussed in face-to-face teams as a result of evaluation apprehension (Dubrovsky, Kiesler, & Sethna, 1991; Kiesler & Cummings, 2002). Furthermore, asynchronous virtual communication can reduce stress and distractions, while increasing privacy for team members and allowing them the time to "put their best face forward" (e.g., carefully crafting an email).

There are also many limitations to virtual teams. For example, team members must learn and adapt to new information and communication technologies, while a fear of electronic monitoring and the existence of a communications archive may inhibit some discussion (Townsend et al., 1998). Warkentin et al. (1997) summarize that, in many instances, teams using ICTs communicate less effectively than colocated teams. He attributes a large portion of the deficiency to an insufficient amount of paraverbal (e.g., vocal inflection) and non-verbal (e.g., body language) context cues, which regulate the "give-and-take" orderliness of interaction (e.g., conversation flow, turn-taking, feedback acceptance). He acknowledges, though, that the deficit depends on the particular ICT. Whereas the lag in asynchronous communication can cause difficulty in maintaining a "train of thought", synchronous VT discussions can get out-of-sync as a function of differences in team member reading or typing proficiencies as well information overload due to simultaneous discussions, which itself can lead to difficulties in building consensus (Walther & Burgoon, 1992). Jarvenpaa & Leidner (1998) also emphasizes the limitations of virtual work, explaining that, "low individual commitment, role overload, role ambiguity, absenteeism, and social loafing may be exaggerated in a virtual context." (p. 791).

Although a comprehensive review of the empirical work examining virtual team benefits and deficits is beyond the scope of this paper (see Martins et al., 2004 for a thorough summary), it seems that virtual team efficaciousness, when compared with colocated teams, depends on a variety of input parameters (e.g., task, technology, team size and composition). For example, Colquitt, Hollenbeck, Ilgen, LePine, and Sheppard (2002) found that team composition interacted with communication medium in predicting decision-making performance. Only those teams composed of members high in openness to experience were able to reap the benefits of a computer-assisted communication strategy. In an important review of VT advantages and disadvantages, Thompson & Coovert (2006) conclude that the three most pressing challenges for virtual teams are: 1) ineffective and inefficient communication as a result of the low quality and quantity of exchanges, 2) difficulties in maintaining shared situational awareness, and 3) difficulties in developing cohesive and trusting interpersonal relationships.

Thompson & Coovert's (2006) three challenges interact with one another. For example, monitoring teammates and controlling their resources is often not feasible in virtual teams (Aubert & Kelsey, 2003) as a result of impoverished communication and information channels (Challenge 1), yet teammate observation is critical for the formation of shared mental models (Challenge 2). These first two challenges are particularly relevant for collaborative critical thinking, a major focus of this study. If teammates have difficulty transmitting mission information or developing a shared mental framework, it may also be challenging for them to engage in collaborative critical thinking. Challenge 3 is also critical because the development of quality interpersonal relationships has been associated with a variety of positive outcomes such as enhanced motivation, creativity, morale, and performance, another important outcome in the present study (Walther & Burgoon, 1992). Also, since it takes more effort to engage in computer-mediated communication, task-related communication is often more focused than in face-to-face teams (Challenge 1; Spears & Lea, 1994). While focused task-related communication may be positive, an increased communication threshold means that less social-emotional data is exchanged among team members, thus retarding the development of relational links (Challenge 2, Chidambaram, 1996) such as trust, another major focus of the current study that I expand on below.

Trust

Trust has been studied in a variety of different contexts and using various levels of analysis. These approaches have come from diverse fields such as sociology (e.g., Shapiro, 1990; Lewis & Weigert, 1985), anthropology (e.g., Hewlett, Lamb, & Scholmerick, 2000), economics (e.g., Rigdon, McCabe, & Smith, 2007), and psychology, and have included the study of interpersonal trust (e.g., McAllister, 1995), trust in teams (Langfred, 2004), trust in leaders (Dirks & Ferrin, 2002), and trust in organizations (Koufaris & Hampton-Sosa, 2004). This study evaluates how trusting individual team members are of their teams as a whole. While I specifically explore trust at the team level, the team trust approach is grounded in interpersonal trust since teams are composed of interacting individuals.

Defining trust. Many definitions of trust have been proposed. For example, McAllister (1995) defines 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" Wilson, Straus, and McEvily (2006) define trust as "confident positive expectations about the conduct of another." (p. 18). Henttonen & 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). Although the trust literature has not converged on a single definition of trust, two elements appear consistently across definitions. The first is an anticipation of positive behavior from others (A.C. Costa, 2003; Lewicki & Bunker, 1995, 1996), and the second is a willingness to assume vulnerability (A.C. Costa, 2003; Mayer, Davis, & Schoorman, 1995; Zand, 1972). That is, the trustor subjects him or herself to risk or uncertainty under the assumption that the trustee will attempt to mitigate negative outcomes (e.g., not fulfilling commitments, disclosing confidential information) through well-intentioned behavior. Imperfect knowledge and risk thus create the opportunity for trust, the belief that one can act confident that another party won't take advantage (McAllister, 1995; Rousseau, Sitkin, Burt, & Camerer, 1998; Wilson et al., 2006). For example, if a teammate has *perfect knowledge* about a colleague, then trust is unnecessary because no risk is involved. In situations of *perfect ignorance*, trust is also irrelevant as the trustor is unable to make any rational predictions of trustee behavior (Lewis & Weigert, 1985; McAllister, 1995).

While the previous definitions of trust focus on trust between two individuals, Mayer et al.'s (1995) definition accommodates a wider variety of trust relationships. Mayer et al. (1995) define trust as "a willingness to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" (p. 712). Mayer et al.'s (1995) definition is particularly useful because it not only captures the drivers of interpersonal trust, but the use of "party" makes the definition sufficiently broad to capture trust in teams-of-teams, employees and clients with organizations, supervisors with their work units, and team members with their teams. In these cases, trust is not a function of a one-to-one relationship between individuals, but rather is dependent on the reciprocal interactions of one-to-many and many-to-one. As such, Langfred (2004) adds to the definition of trust to account for these complex, emergent phenomena. He defines intrateam trust as an "aggregate perception of trustworthiness that team members have about one another" (p. 386).

Models of trust. Team functioning can be characterized in terms of an Input-Process-Output (IPO) model (Hackman & Morris, 1975). With respect to teams, Inputs represent the starting conditions of a group (e.g., team size, task, technology, composition). Processes are dynamic cognitive, verbal, and behavioral activities among team members that convert inputs to outcomes to achieve a collective goal (e.g., goal setting, communication, monitoring, participation). Finally, outcomes represent the consequences of a team's activities (e.g., team member satisfaction, performance; Martins et al., 2004). Although theories disagree on basal levels of trust in relationships as well as the antecedents of trust, they all agree that initial trust, whether high or low, can always be characterized. That is, individuals don't interact in a trust or distrust vacuum. These levels of trust in turn can predict team processes such as team reflexivity and effort (De Jong & Elfring, 2010; McAllister, 1995), which in turn inform team outputs. Therefore, while Martins et al. (2004) characterizes trust as an interpersonal team *process* along with conflict, informality, cohesiveness, and group identity, other research considers trust as a team *input* (De Jong & Elfring, 2010; Dirks, 1999). It is conceivable that antecedents of trust such as team composition and team member characteristics can be considered inputs, trust a process, and performance or satisfaction, outcomes. However, the current study's focus on collaborative critical thinking as a process to convert team trust into team performance is more concordant with the latter view of trust as an input.

In a comprehensive review of models of interpersonal trust development, Lewicki, Tomlinson, and Gillespie (2006) summarize three major theoretical conceptions of *psychological* trust – unidimensional, two-dimensional, and transformational. While the *behavioral* approach is briefly discussed, Lewicki et al. (2006) largely dismiss this notion of trust because the operationalization of trust as cooperation or defection in economic games (e.g., a prisoner's dilemma; Axelrod, 1984) is potentially confounded with other factors unrelated to trust such as boredom or decision error. The psychological approaches differ in how trust is defined, measured, the level at which trust begins, and what drives change in trust over time.

The unidimensional approach treats trust and distrust as opposing ends of a single continuum. Unidimensional trust (e.g., Lewis & Weigert, 1985; Mayer et al., 1995; McAllister, 1995; Rousseau et al., 1998) is underpinned by two major processes. First, trust is derived from positive expectations about the intentions and behaviors of another party. Second, a trustor assumes risk and liability in the actions of the trustee. It is important to note that although trust is theoretically unidimensional in these models (i.e., you either trust or distrust), trust is often further subdivided into multiple components such as cognitive trust, affective trust, and, occasionally, behavioral intentions (Cummings & Bromiley, 1996). Trust can begin either at zero or from a moderate-high level and forms, initially, as a result of antecedents such as personality, reputation, and roles. The further development of unidimensional trust then depends on factors such as communication with the trustee and violations of positive expectations, among others.

McAllister (1995) proposed perhaps the most well-known model of unidimensional trust. His model features two principal forms of trust, cognitive-based (CBT) and affect-based trust (ABT). The former is derived from trustor beliefs about trustee competence, reliability, capability, and dependability while the latter is grounded in emotional bonds of care and concern between individuals and the trustworthy intentions of others (Cook & Wall, 1980). ABT develops as a result of a trustee's altruistic or extra-role citizenship behavior (similar to benevolence in the Mayer et al., 1995 model) as well as the interaction frequency of a trustor and trustee such that the more social data is exchanged between the parties, the more confident a trustor's attributions become. Webber (2008) also found that citizenship behavior is positively related to ABT, but did not find evidence of interaction frequency as a predictor. ABT generally takes a longer time to develop than CBT (McAllister, 1995; Williams, 2001), and the two forms of trust are distinct; each has its own developmental trajectories, antecedents, and relationships with outcomes. However, CBT is an antecedent of ABT, particularly at the beginning of relationships.

More recent work has addressed the development of unidimensional trust over time in teams (e.g., Jones & George, 1998). For example, Aubert & Kelsey (2003) used virtual and face-to-face (FtF) teams to test Mayer et al.'s (1995) propositions that antecedents of trust would change over time. They found no evidence that integrity is more important than benevolence during the beginning stages of relationships nor that the effect of benevolence on trust increases over time. Arguing that the large amount of cross-sectional research had neglected the important developmental aspects of trust over time (e.g., Rousseau et al., 1998) and that previous research failed to allow sufficient time for a two-factor (i.e., CBT and ABT) trust solution to emerge (Dirks, 1999; Ferrin & Dirks, 2003), Webber (2008) used semester-long student project teams in her study. She demonstrated that trust emerges as one factor early on during the life-span of a team ("early trust"), but that cognitive and affective trust later emerge as separate components, each with their own predictors. For example, prior team member familiarity only predicts early trust, presumably because team members can rely on more telling behaviors observed throughout the course of teamwork for later forms of trust. Although Webber (2008) found no direct relationship between previous reliable project performance and cognitive based trust, she did find that cognition-based trust was driven by an interaction of performance and early trust such that reliable performance only affects cognitive trust in the presence of high early trust.

Two-dimensional trust assumes that trust relationships are multi-faceted, and thus, trust and distrust can be measured separately. For example, the trustor can trust the trustee in one setting (e.g., to engage a target), but can simultaneously distrust the same person in another domain (e.g., conducting surveillance). This model assumes that trust and distrust both begin at low levels, and that they develop as a function of support or violations of expectations in a various settings and circumstances (Lewicki et al., 2006).

Finally, the transformational approach suggests that the nature of trust itself changes over time. For example, Lewicki & Bunker (1995, 1996) propose that relationships begin with calculus-based trust (i.e., mitigating risk and maximizing benefits), progress to knowledge-based trust (i.e., being able to predict behavior), and if the trust relationship continues to develop successfully, arrive at identification-based trust (i.e., identifying with the other party). Since the development of a trust relationship begins with calculus-based trust, trust is initially built upon reputation as well as deterrents against defecting and rewards for cooperating or being trustworthy. Finally, although some relationships may only develop as far as the calculus-based or knowledge-based stages (e.g., a casual, transactive relationship with a cashier), others can achieve identification-based trust as a result of positive interactions, emotional bonding, and reliable predictions about the trustee's behaviors and intentions. Although this conceptualization is attractive because it explicitly addresses the development of trust over time, it has received little empirical attention.

The present study adopts the unidimensional model of trust (McAllister, 1995), which incorporates both elements commonly found in trust definitions – a willingness to assume risk and positive expectations about the behavior of others. The unidimensional approach also remains the most robust model of trust. In their meta-analysis of trust in leadership, Dirks & Ferrin (2002) found that 94% of studies were based on a unidimensional definition of trust (Webber, 2008) and that the measures used to assess it are the most frequently used and well-validated trust instruments available (McEvily & Tortoriello, 2011). Although it was originally developed to model interpersonal trust in dyads of managers, it generalizes well to team settings (e.g., Wilson et al., 2006) because it assesses trust in horizontal (i.e., peer) relationships.

Trust development in virtual teams. There are many reasons to believe that the development of trust in VTs is more challenging than in FtF teams. This creates a catch-22 in VTs since the loose coupling of virtual team members makes trust even more critical, while opportunities for close relations through colocation (Lewicki & Bunker, 1996) and monitoring are heavily restricted (Wilson et al., 2006). For example, in VTs team members often lack a shared social context and do not expect to work together in the future. The lack of colocation makes teammates less likely to be heedful of the shadow-of-the-future (Powell, 1993) and to appreciate the shared values and social similarities pivotal to the development of trust (Jarvenpaa & Leidner, 1998). As Jarvenpaa and Leidner (1998) eloquently summarize, "the heart of Handy's argument centers on trust and a belief that 'trust needs touch'. Paradoxically though, only trust can prevent the geographical and organizational distances of global team members from becoming psychological distances: trust allows people to take part in risky activities that they cannot control or monitor and yet where they may be disappointed by the actions of others" (p. 792).

Multiple theories argue that CMC and FtF teams differ *qualitatively* in their development of trust. For example, Media Richness Theory (Daft & Lengel, 1986; Daft, Lengel, & Trevino, 1987), Social Presence Theory (Short, Williams, & Christie, 1976), and Time, Interaction, and Performance Theory (TIP; Mcgrath, 1991) all broadly argue that not all communication mediums are created equal. Leaner communication technologies (e.g., chat client) convey less social information than richer mediums (e.g., videoconferencing, face-to-face communication). Since the technology channels used by distributed teams constrict the bandwidth for the communication of pivotal social cues that reveal intention such as facial expressions, vocal inflections, gestures, warmth, attentiveness, and physical appearance, trust development in CMC teams will be stunted relative to FtF teams. Finally, Cues-Filtered-Out Theory also argues that the decreased amount of social context cues in CMC teams makes trust development in these teams qualitatively different than in FtF teams, such that FtF teams demonstrate higher levels of trust than CMC teams (Culnan & Markus, 1987; Rousseau et al., 1998; Wilson et al., 2006). Lean communication technology thus leads to a paucity of non-verbal feedback cues, which in turn results in deindividualization and difficulty in developing close personal relationships with less salient/aware communication partners. For instance, Connolly, Jessup, and Valacich (1990) found that CMC group communication was more task-oriented and less personal than FtF team interaction. In summary, these theories question the prospect of relationship development, and as a corollary, trust development in VTs.

Meyerson, Weick, and Kramer (1996) explored how it is that temporary face-to-face teams (e.g., film crews, flight crews) develop trust. Since these teams have limited lifespans, there isn’t much time to build relationships, yet the people still need to rely on one another to accomplish common tasks. He claimed that temporary teams develop “swift trust”, which is initially based on positive stereotypes and is subsequently maintained through a "highly active, proactive, enthusiastic, generative style of action" (Meyerson et al., 1996, p. 180). That is, swift trust is based less on interpersonal trust and more first on imported, category-driven social information and subsequently on performance. This supports Lea and Spears' (1992) Social Identification/Deindividuation Theory (SIDE), which suggests that in the absence of individuating information, as is the case in lean communication mediums, people rely on categorical in-group/out-group impressions.

Jarvenpaa and Leidner (1998) studied swift trust in *virtual* teams. He found that first impressions are crucial and that few teams who started off with low trust ever developed to high trust. However, he also found that initial trust levels are not only imported as suggested by Meyerson et al. (1996), but are also dependent on early outgoing and incoming communication behaviors, which demonstrate task commitment and enthusiasm. Communication conveying support for the project and tasks serves to maintain trust, and social communication not at the expense of task-related communication serves to enhance trust. Jarvenpaa and Leidner's (1998) research thus suggests that swift trust development is not as depersonalized as Meyerson et al. (1996) proposed. While this study did not directly compare face-to-face and virtual teams, Jarvenpaa & Leidner's (1998) findings are important because they demonstrate that individuating information can be communicated very early on in the presence of an extremely lean medium (i.e., email) and that this social cue information is critical for trust formation. This data is therefore less consistent with the stereotype accounts of Lea & Spears' (1992) SIDE and Meyerson et al.'s (1996) swift trust, but is instead more consistent with Mcgrath's (1991) TIP where factors such as member-support (i.e., relational links between members) and group well-being (e.g., links between member and the rest of the group) are important for ad-hoc teams with no shared history.

Unlike the previous approaches, Social Information Processing Theory (SIP) argues that the differences between trust development in virtual and face-to-face teams are a matter of *quantity* rather than quality. Specifically, time is a conduit for social information (Harrison, Price, Gavin, & Florey, 2002 in Wilson et al., 2006) and given sufficient time, distributed teammates come to trust one another in the same way FtF teammates do. While SIP acknowledges that technology can retard the rate of social information exchange, the theory assumes that people are uniformly driven to develop social relationships regardless of the communication medium. Thus, team members will still "test their assumptions about others over time, refine their impressions, and adjust their relational communication…[but] computer-mediated groups can take up to four times as long to exchange the same number of messages as face-to-face groups" (Wilson et al., 2006, p. 19). Since a majority of research comparing CMC to FtF teams is cross-sectional, Wilson et al. (2006) explored the development of trust in both types of undergraduate teams over a 3-week period. Indeed, he found that early measurements of cognitive and affective trust supported a Cues-Filtered-Out account (i.e., CMC teams had lower levels of both types of trust), but that time neutralized the effects of the communication medium such that the CMC teams eventually caught up in trust with the FtF teams. Finally, Chidambaram (1996) also found that the relational distance among virtual team members dissipated to face-to-face levels when virtual teams were given sufficient time to collaborate.

Trust and performance. Trust is an important determinant of effectiveness. McAllister (1995) invited readers to consider trust as a *lubricant* in the social system. Rather than discussing the smooth functioning of a team, this metaphor becomes particularly effective when you consider the friction in a distrusting, "un-lubricated" system. When team members lack trust in one another, they ineffectively employ their resources. The added costs of distrust take various forms such as monitoring, defensive behavior, documenting problems, and re-doing work. It is this misdirected use of time and effort which ultimately negatively impacts both team performance and satisfaction (i.e., effectiveness; Costa, 2003) since team members are not focusing their resources on primary goals and tasks. Additionally, team members may withhold information from one another and thus compromise team learning or may refuse to work with one another on subsequent tasks (Wilson et al., 2006).

While a few studies have found no relationship between trust and performance, an overwhelming majority of studies have demonstrated that team trust is positively related to performance. In a longitudinal study of virtual team trust and performance, Aubert & Kelsey (2003) found that trust and performance were unrelated. Dirks (1999) and Porter and Lilly (1996) also found no relationship between trust in team members and team performance. On the other hand, many studies have found that trust is important for effectiveness (e.g., Costa, 2003; Costa, Roe, & Taillieu, 2001; Dirks, 2000; Dirks & Ferrin, 2002; Jarvenpaa & Leidner, 1998; Klimoski & Karol, 1976; Mayer et al., 1995; McAllister, 1995; Morgan & Hunt, 1994; Smith & Barclay, 1997; Webber, 2008). In a 2001 meta-analysis, Dirks & Ferrin summarized many studies examining the trust-effectiveness relationship. They not only confirmed that trust is positively related to team performance and satisfaction, but also found positive effects of trust on organizational citizenship behavior and communication as well as negative effects on conflict and competitive behavior. Although the above studies focused on the trust → performance relationship, it is also important to note that several studies have demonstrated a positive relationship in the opposite direction (i.e., performance → trust; e.g., Aubert & Kelsey, 2003; Webber, 2008). Additionally, prior task-oriented communication performance is a predictor of team trust as demonstrated in two longitudinal studies by Jarvenpaa and Leidner (1998) and Rico, Alcover, Sanchez-Manzanares, and Gil (2009).

Finally, it is important to note that the Input-Process-Output framework (Hackman & Morris, 1975) is merely a snapshot in time (Marks, Mathieu, & Zaccaro, 2001). Teams typically work through performance episodes, which are "distinguishable periods of time over which performance accrues and is reviewed" (Mathieu & Button, 1992, p. 1759) and separated by goals and goal accomplishment (Marks et al., 2001). Therefore, teams will iterate through the IPO framework multiple times during their lifecycle. While it is unlikely that ad-hoc virtual team members are familiar with one another's performance capabilities or histories when forming initial perceptions, the development of trust will certainly be impacted by performance as teammates cycle through performance episodes.

Trust and team monitoring. In this study of collaborative critical thinking, team trust is considered an essential *input* and team monitoring, a critical team *process*, when team functioning is framed using Hackman & Morris' (1975) IPO model. Team process is defined 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, p. 357). In light of the fact that team processes mediate between team inputs and outputs and therefore play an important role in team performance, Marks et al. (2001) created a useful taxonomy of team processes with three broad categories – transition phase processes, action phase processes, and interpersonal processes. In transition phase processes, teams evaluate and plan activities to guide their goal attainment (e.g., goal specification and refinement, mission analysis, strategy formulation); these activities typically take place *between* performance episodes. During action phase processes team members coordinate, monitor, and backup teammates while tracking systems and progress towards goals; this is the time during which teams engage in activities directly related to goal attainment (i.e., *during* performance episodes). Finally, interpersonal processes take place during both action and transition phases. In these processes, teammates manage conflict, affect, confidence, and motivation – all important predictors of the success of other processes.

Defining team monitoring. Monitoring is an action-phase process that teammates employ during performance episodes (De Jong & Elfring, 2010). Marks & Panzer (2004) as well as

Dickinson and McIntyre (1997) define team monitoring as, “primarily a cognitive operation in which team members observe actions of their teammates and watch for errors or performance discrepancies”. Monitoring, however, has a “two-faced” nature (Bijlsma-Frankema, de Jong, & van de Bunt, 2008). Extant literature differentiates between two types of monitoring, control-based monitoring (CBM; Costa et al., 2001; McAllister, 1995) and need-based monitoring (NBM; McAllister, 1995). Although the behaviors associated with each type of monitoring are similar, the two conceptions are driven by diametrical relationships with trust.

Negative, control-based monitoring. Control-based monitoring is associated with interpersonal distrust (Zand, 1972). In McAllister's (1995) model of trust, perceptions of trustworthiness translate into two basic types of trust behaviors. *Cooperative* behavior is the result of perceptions of trustworthiness while *monitoring* behaviors are indicative of distrust. Control-based monitoring is thus an omen of distrust; those who cannot be relied upon to handle their respective tasks need to be monitored (McAllister, 1995). Suspicious teammates surveil their colleagues to “make sure” that they are performing appropriately. This form of negative monitoring can be experienced as control by those being monitored, which in turn, breeds more distrust in the system (Bijlsma-Frankema et al., 2008; Langfred, 2004).

Multiple lines of research have focused on negative monitoring. While Fransen, Kirschner, and Erkens (2011) found no effect of trust on performance monitoring, the studies of Costa and her colleagues have repeatedly demonstrated an inverse relationship between trust and monitoring (Costa et al., 2001; Costa, 2003; Costa & Anderson, 2011) such that if monitoring is perceived as control, then team performance suffers since monitoring is a signal of distrust. These studies, however, repeatedly operationalize monitoring exclusively as a negative, distrusting, surveillance process and fail to leave room for reporting positive monitoring activity as described below. Langfred (2004) found that high trust in teams may preclude monitoring activity, despite the little-contested notion that monitoring supports team performance. If highly cohesive and trusting teams perceive that monitoring is a sign of distrust, then social pressures to maintain group harmony may dissuade team members from recommending monitoring. However, the apprehension to endorse monitoring is less prevalent in teams with low levels of trust since social sanctions are less costly and the threshold for perceiving a violation of trust is significantly higher. High trust teams thus establish a *norm of non-monitoring* while teams in which colleagues are perceived as untrustworthy freely monitor one another (Bijlsma-Frankema et al., 2008; Langfred, 2004). As a result, performance suffers in those teams in which high autonomy combines with high trust and low monitoring (Langfred, 2004).

Positive, need-based monitoring. Unlike control-based monitoring, need-based monitoring (NBM; McAllister, 1995), also known as mutual performance monitoring (MPM; Salas, Sims, & Burke, 2005), is associated with trust among teammates. McAllister (1995) explains that positive monitoring is characteristic of communal relationships and is driven by affect-based trust, team members' sensitivities to one another's needs, and teammates taken on one another's problems as their own. Salas (2005) explicitly defines mutual performance monitoring as, "the ability to develop common understandings of the team environment and apply appropriate task strategies to accurately monitor teammate performance" (p. 560). Mutual performance monitoring is considered a sign of caring about the progress of others such that teammates can recognize when others are struggling. Teammates can then offer relevant assistance to improve fellow teammates' performance (Marks & Panzer, 2004). This form of monitoring is "enhanced by a deep and affective form of trust" (De Jong & Elfring, 2010) wherein teammates perceive that their colleagues are looking out for them and providing necessary, appreciated assistance, rather than trying to control them. Trust therefore orients teammates towards the needs and goals of others, this is reciprocated, and teammates are willing to help one another with performance demands. Thus, trust and a shared team mental model are prerequisites for high quality mutual performance monitoring (Salas et al., 2005).

Several studies have demonstrated that trust is positively related to monitoring. For example, Bijlsma-Frankema et al. (2008) and De Jong and Elfring (2010) both found that trust has a positive effect on monitoring, and that monitoring mediates the positive relationship between trust and performance in teams of tax consultants and students, respectively. In a longitudinal study, Yee et al. (2010) found that cooperative (i.e., trusting) behaviors decreased as monitoring (i.e., distrusting) behaviors increased in a military peacekeeping simulation as teammates moved from training missions to performance missions. This result is surprising in light of the notion that teammates should increasingly trust one another as they become more mutually proficient in the domain and get to know one another through interaction. However, task- and context-transfer from the training- to the mission-phase created uncertainty, which can be managed by teammates through mutual performance monitoring (i.e., trusting, positive monitoring). While the operationalization of monitoring in this study did not explicitly differentiate between negative CBM and positive MPM, it is likely the case that monitoring was associated with perceptions of support rather than control. Positive monitoring is especially important for team performance under stressful, uncertain conditions since teammates can catch one another's mistakes, lapses, and slips in order to provide their teammates with mission support. Martins et al. (2004), however, points out that monitoring and feedback may be challenging in virtual teams using lean communication channels because high levels of virtuality make it difficult to be aware of a teammate's progress. Finally, performance monitoring must become an accepted norm, even under trusting teams, if it is to be effective at boosting team performance (Salas et al., 2005).

Monitoring and performance. While there is appreciable debate whether team trust is positively or negatively related to monitoring behavior, it is clear that performance monitoring is ultimately a critical determinant of team performance. In multiple studies, monitoring has been shown to positively affect performance (e.g., Bijlsma-Frankema et al., 2008; De Jong & Elfring, 2010; Fransen et al., 2011; Yee et al., 2010). According to Langfred (2004), monitoring in self-managing teams is good and necessary. It can reduce process loss because awareness of teammates' activities can allow for better team coordination and situational awareness (e.g., being aware of others' actions, timing, and resources; Salas et al., 2005). Additionally, monitoring should reduce detrimental group effects such as free riding and social loafing (Langfred, 2004).

Lack of effective monitoring can lead to mission failure, which carries consequences for the entire team. This point is particularly salient when considering interdependent teams operating in dynamic, uncertain environments. In these scenarios, the failure of a single member constitutes the failure of the entire team. Since one of the main tenets of trust is the licensing of personal risk to other parties, it is particularly important that monitoring become a team-level activity because personal risk is inextricably linked with whole-team outcomes. As Langfred (2004) admonishes, high levels of individual autonomy should be accompanied by high levels of monitoring since poor monitoring will lead to decrements in performance.

The positive relationship between mutual performance monitoring and team effectiveness is mediated by backup behaviors. That is, teammates monitor their colleagues to detect when they are in need of assistance, and in turn, to facilitate corrective actions (Marks & Panzer, 2004). While, team monitoring and backup behaviors were previously considered a single construct consisting of observing teammates and being sensitive to performance discrepancies (i.e., monitoring) as well as providing feedback and assistance to those in need (i.e., backup), they have been separated in recent treatments (Marks & Panzer, 2004; Salas et al., 2005). Salas et al. (2005) defines backup behaviors as the "ability to anticipate other team members' needs through accurate knowledge about their responsibilities. This includes the ability to shift workload among members to achieve balance during high periods of workload or pressure." For example, teammates can either provide verbal feedback (i.e., coaching) to enable the struggling team member to self-correct (Salas et al., 2005) or they can physically assist a team member to ensure that all aspects of the team task are completed successfully.

Decision-Making

Individuals and teams need to make important decisions in order to accomplish their goals. Decision-making is the cognitive process of making a decision, of choosing a single option from among a set of alternatives (Hastie, 2001). Decision-making is an immense field with contributions from many disciplines including business, artificial intelligence, medicine, and psychology, among others. Below I discuss several decision-making strategies at multiple levels, which are particularly relevant to collaborative critical thinking. In particular, I focus my discussion on decision-making errors because they are useful in elucidating normal decision-making processes. I broadly follow Duffy's (1993) framework, which proposes that biases and errors in team decision-making stem from one of three sources – cognitive, organizational, and social. Cognitive biases stem from *individual* limitations in information processing, and thus reliance on over-simplified cognitive shortcuts (i.e., heuristics). Organizational biases occur as a result of decisions and policies implemented at higher levels of the organization (e.g., defaults, culture, structure, management, work design, resources). While organizational factors are important, I do not discuss them further because they are of marginal significance for the present study. Finally, bias and error also come from a *team's* social interactions (e.g., social influence/group biases, social projection).

Models of decision-making. Decision-making theories can be broadly categorized into two types, descriptive and normative. Descriptive approaches to decision-making explain how people *actually* make decisions, whereas normative models describe how decisions *should* be made (Edwards & Fasolo, 2001). While below I mostly explain principles of descriptive decision-making, it is also important to describe normative decision-making models and why they are inappropriate for team decision-making in complex, dynamic, and uncertain environments.

Normative decision-making tools are mathematical models designed to quantify the "best" option. Edwards & Fasolo (2001) summarize three normative rules – multi-attribute utility measurement (MAU), Bayes' theorem of probability (Bayes), and maximization of subjectively expected utility (Max SEU). Although an explanation of the specific mathematical principles underlying each of these decision tools is outside the scope of this review, it is important to consider the purpose of each and the requisite conditions that can make this collection of tools effective. These tools rely on a payoff matrix, which is composed of options (these are under the decision-maker's control) and states (conditions in the world not under the decision-maker's control), and outcomes. MAU is a tool to determine utilities for each outcome, or the subjective value/payoff for each option-state combination. Another important step in normative decision-making is to enumerate and determine the probabilities of all possible states. However, given the inherent uncertainty in the world, it is difficult to determine what all the possible states are, let alone their probabilities. The process of gathering evidence to assess probabilities in order to make an "inference under uncertainty" is the domain of Bayes' theorem, which uses evidence such as prior and posterior probabilities and expected losses to make single decisions or a Markov process for dynamic, ongoing decision-making. Finally, an optimization rule, such as Max SEU, is applied to the combination of utilities and state probabilities to make a decision.

A purely normative (i.e., traditional) decision-making strategy, however, is difficult to apply because many of the decision-making steps rely on human input, which is often subject to biases and limitations. For example, a normative approach requires the enumeration of all available options as a first step (Edwards & Fasolo, 2001). However, it is often very difficult for humans to generate an exhaustive list of options, especially in a complex, uncertain, and rapidly changing environments. Additionally, the "traditional" approaches are very computationally intensive and thus hard for humans to process. As Patel, Kaufman, and Arocha (2002) attest, "By the late 1960s, psychologists had amassed a considerable body of research documenting numerous decision-making and reasoning anomalies in individuals. It was apparent that people are not skilled Bayesians and that their probability judgments deviated from the normative standards in systematic ways…such models are not readily applicable if the decision must be made under the kind of constraints (e.g., stress, time pressure, and limited resources) found in many natural settings. It is apparent that we need a better understanding of the process of decision-making in real-world situations." (p. 55, 60). In summary, the classical decision-making approach is brittle and has poor ecological validity. I discuss a selection of these systematic deviations (i.e., heuristics and biases) and alternatives approaches (i.e., naturalistic decision-making, critical thinking) below.

Cognitive biases: Individual judgment under uncertainty. Before discussing how teams make decisions and why it is important for them to engage in critical thinking, it is important to first discuss how *individuals* make decisions in the real world (i.e., a descriptive approach). Although we make many decisions unconsciously throughout the day, there are also times when we engage in volitional decision-making by employing a variety of simple and complex strategies. For example, we can make a list of pros and cons, use a randomization procedure (e.g., flipping a coin) to choose among alternatives, acquiesce to authority, minimax (minimizing losses given a worst case scenario, maximize (finding the *best* option available), or satisfice (continue examining solutions until we find one that is 'good enough') (Simon, 1956).

It is also important to understand the fallibility of individual decision-making. In a seminal paper on decision-making under uncertainty, Tversky & Kahneman (1974) describe three cognitive heuristics – availability, anchoring and adjustment, representativeness – individuals use to assess probabilities and make predictions. Heuristics are mental models that serve as shortcuts to efficiently process information. Unfortunately, these shortcuts are not always correct and can lead to biases and critical errors in judgment.

The availability heuristic suggests that people assume that an event is more frequent because particular occurrences of that event are readily available in their mind. That is, people assess the frequency or probability of an event based on how easily examples of that event come to mind. A contemporary example is home foreclosure. Because we see so many news stories about home foreclosures, we might judge that the likelihood of having our own home being foreclosed on is high. Another availability heuristic bias is rooted in vividness (Shedler & Manis, 1986) such that a single vivid example comes to represent a whole, rather than merely a single of example of the range of possibilities (e.g., skydiving accidents). Yet another related error is the false consensus effect, which is the tendency to overestimate the degree of others' agreement with our own opinions and beliefs. This bias is driven by the fact that our own thoughts, beliefs, and opinions are the ones most available to us.

The anchoring and adjustment heuristic is employed when a person is provided with a value (the anchor) and subsequently estimates a value proximal to the anchor, rather than estimating an original value. A great example of this is the experiment by Northcraft & Neale (1987) using house prices. Participants were asked to assess the value of a house while they were given the asking price (anchor). Both students and realtors were subject to the anchoring effect since the estimated fair prices closely reflected the anchor across conditions (various anchor prices). Notably, these results demonstrate that the anchoring effect is robust despite expert judgment (e.g., professional realtors).

Finally, the representativeness heuristic is the process of making judgments based on how similar something is to a typical example, or a mental prototype. For example, the USS Vincennes shot down an Iranian civilian airliner in 1988, mistakenly believing that it was a fighter plane poised to attack the US Navy ship (Johnston, Cannon-Bowers, & Salas, 1998). The cues, incorrectly perceived by decision-makers, fit into a prototypical example of an aircraft with hostile intent. A corollary to the representativeness heuristic is biased generalization from a sample to the population. For instance, if a new teammate's is exposed first to an unhelpful colleague, he or she may infer that the rest of the team is similarly unhelpful.

Social biases. Groups and teams often need to make decisions. Jones and Roelofsma (2000) differentiate between group and team decision-making. They claim that groups make specific decisions (i.e., making the decision *is* the task), whereas decision-making in teams is an embedded process subserving the performance of a broader, ongoing task (e.g., engaging targets). Thus, although teams are subsets of groups, group decision-making is a subset of team decision-making.

Forsyth (2009) presents a functional model of the process groups typically use in coming to decisions. In the first stage, orientation, groups define a problem, set goals, and plan a strategy. Next, during discussion, groups gather, exchange, and process goal-relevant information, decide whether a decision needs to be made, and identify and evaluate options. The group then makes a decision using one or multiple decision schemes. If no decision is reached, the group can go back to the orientation and discussion phases to reframe the problem and/or gather additional information. If a decision is reached, groups proceed to implement a solution. After implementation, groups gather feedback so that a decision can be evaluated. In this study, we conceive of collaborative critical thinking (discussed below) as a process that directly enhances the orientation and discussion phases of this model.

Jex & Britt (2008) explain that, "Organizations make frequent use of groups for an obvious reason: A group can accomplish more than an individual". This statement underscores a general belief that "two heads are better than one". Forsyth (2009) adds that, "in most cases, groups are better at choosing, judging, estimating and problem solving than are individuals." (p. 315). Groups are therefore often formed with the purpose of performing a task or solving a problem with the intention that *group* processes and output will be qualitatively (e.g., more creative, fewer errors, can handle more complexity) and/or quantitatively (e.g., decision reached sooner, product created faster) better than an individual working alone. Several studies highlight the powerful effects of group synergy. For example, Zimbardo, Butler, and Wolfe (2003) found that students allowed to work in teams got better grades and were more satisfied, confident, and relaxed than students who took the test solo. Lazonder (2005) also found that teams were able to employ more sophisticated Google search strategies and find information more frequently and more quickly than students searching alone.

There are a number of intuitively appealing explanations of why group performance and decision-making should be better than individuals working alone. These include: 1) a belief in the law of large numbers, 2) the belief that the collective knowledge of the group is greater than the knowledge of any individual in the group, 3) the belief that groups are more creative, and 4) the belief that groups offer the opportunity for checks and balances. Empirical research, however, has offered a number of rebuttals and qualifications for these beliefs such that groups can also perform more poorly and make worse decisions than the same number of individuals working alone (Kerr & Tindale, 2004).

While the law of large numbers (the more, the better) is advantageous when aggregating individual judgments and decisions (e.g., reduced standard error on questionnaires), large numbers in groups can exacerbate bias. Since systematic bias aggregates, a decision can become increasingly biased when adding members to a group. In a closely related phenomenon, group polarization, the majority position is intensified by discussion. This occurs because individuals in groups are exposed to more arguments supporting the majority position and therefore become more convinced of that position (Lamm, 1988). In risky shift, an example of polarization, groups tend to make riskier judgments when they come to a decision together instead of when individual judgments are aggregated. When individuals in the group sense the general position of the collective, they will shift their opinions to more closely reflect the collective, and if the position of the group is risky, it seems less risky because multiple people have endorsed it. Alternatively, cautious shift could also occur such that group decisions become more risk averse, cautious, and moderate than aggregated individual decisions (Jones & Roelofsma, 2000).

If you consider the knowledge of the individuals in a group and add it in a serial fashion, the aggregate pool of knowledge will contain more information than any single individual's pool of knowledge. However, when groups come together, much of this information is not shared because group members tend to spend their time discussing shared knowledge, rather than non-overlapping knowledge; large numbers further exacerbate this inclination. For example, Stasser and Titus' (1985) study demonstrates that unshared information is not adequately distributed in groups, which leads to poor applicant selection.

Groups can evoke deeper information processing since discussions prompt additional questions and the generation of alternatives. Furthermore, group members can cross-cue one another's memory stores, and thus enhance recall. However, when gathering groups of people to generate ideas, research shows that brainstorming groups do worse than nominal groups (i.e., members working individually and then aggregating their results). Instead of productively generating new ideas, people working in brainstorming groups tend to suffer from production blocking (the cognitive inability of a group member to both generate new ideas and listen to other group members, mental overload), social loafing (the reduction of effort when working in a group vs. when working individually), and evaluation apprehension (a fear of receiving negative criticism regarding contributions made to the group discussion) (Forsyth, 2009).

There is also belief that group members can elaborate on and critique one another's ideas so that bad ideas will be eliminated and good ideas will be refined. Several biases can stand in the way of such a "checks and balances" system. For instance, the false consensus effect is a tendency to overestimate the amount of similarity between self and others such that a person estimates that others are more supportive of his or her position than they really are (i.e., seeing own behavior as typical) (Ross, 1977). When teams are working in uncertain conditions, this bias can be dangerous because team members may assume that their teammates are interpreting ambiguous information the same way they are (Jones & Roelofsma, 2000). Another phenomenon that can result in poor decision-making is group escalation of commitment (Bazerman, 1994), which describes a group's tendency to continue supporting a decision or course of action despite evidence that it is ineffective (i.e., in opposition to a *rational* decision-making model). Group leaders, who desire to be seen as consistent, need to be particularly heedful of this bias (Jones & Roelofsma, 2000). Furthermore, when groups find themselves in competitive circumstances (e.g., combat), they need to be cautious that escalation does not end up hurting the group more than abandoning a strategy (e.g., bidding wars, unnecessary casualties). Lastly, groups are subject to the groupthink phenomenon wherein a cohesive group values and strives for uniformity (Janis, 1972), which overrides the tenets of good decision-making (e.g., open mindedness, uncensored discussion, individual evaluation of ideas). This can be hazardous for group decision-making because groups may fail to realistically and comprehensively consider all alternative courses of action.

Finally, collaboration creates problems that don't otherwise exist in groups that aggregate their work nominally. For example, collaboration creates meta-work, and members must spend their time doing non-task maintenance. For example, group members must communicate, sort out issues of rank and power/status, resolve conflicting goals, build cohesiveness, and enforce group norms. This time and effort can be alternatively spent by individuals actually doing task-related work (Forsyth, 2009).

Evaluating and choosing among alternatives. Decision-making in the face of a complex array of potential solutions and contingencies can be a daunting task, but ultimately, groups need to make a single decision (Hastie & Kameda, 2005). During the orientation phase, groups can decide which social decision scheme they will use to converge on a single decision. For example, groups can delegate the choice to an individual (e.g., an authority figure), a subgroup (e.g., oligarchy, delegation), or an external party (e.g., outside expert). In averaging, group members rank decision choices nominally. Individual decisions are then combined to converge on an average solution. In plurality schemes, individual decisions are combined and a majority, or perhaps a more substantial plurality requirement, determine the decision. If groups use a unanimous decision strategy, then they continue discussion until a full consensus is reached (e.g., juries). Finally, a group can also leave a decision to chance by using, for example, a random number generator. Each of these strategies has cultural and practical implications (see Forsyth, 2009 for a discussion).

Structured processes and computerized decision support systems can be used to assist decision-making. These processes and techniques are designed to help individuals and groups overcome some of the decision-making constraints discussed in the previous section (e.g., cognitive and social biases, limited Bayesian inference, information overload). Although I only review a limited sample of classic and contemporary decision support processes and computerized systems, literally hundreds have been developed to reinforce various phases of decision-making such as orientation, discussion, decision generation, and decision selection (Forsyth, 2009).

The Delphi method is a structured communication technique used in groups for "the systematic solicitation and collation of judgments on a particular topic through a set of carefully designed sequential questionnaires interspersed with summarized information and feedback of opinions derived from earlier responses" (Delbecq, van de Ven, & Gustafson, 1975, p. 10). This technique is designed to overcome social biases that occur when group members interact face-to-face such as conformity. As such, group members are isolated from one another, and communicate through iterated statistical summaries of survey probes until a stop-criterion is met (e.g., consensus, predetermined number of cycles). This technique also has limitations. For instance, group members can feel isolated, ideas can be communicated ineffectively as a result of poor writing skills, and it can be too time-consuming to solve ad-hoc, dynamic problems (Coovert & McNelis, 1992).

Schurink et al. (2007) developed and evaluated a modern Bayesian decision support system (BDSS) for diagnosing pneumonia. Given the recent transition to electronic health record, patient information can be mined and analyzed by a computerized decision support system to aid in diagnosis. This technique is particularly useful in the absence of explicit diagnostic gold-standards. Although the study did not explicitly compare the classification performance of the BDSS with other methods (e.g., other statistical techniques, physicians), the study found that, after "training" the system, the BDSS was able to accurately predict the absence and presence of pneumonia when compared with a reference diagnosis. Notably, this research demonstrates that normative decision-making approaches can be useful when the number of states is limited (i.e., pneumonia present, pneumonia absent) and there is sufficient data to reliably calculate probabilities (e.g., posterior distributions calculated from symptomatology).

Finally, decision support systems can also be employed for group decision-making in complex, dynamic environments. Schraagen & van de Ven (2008) developed a critical thinking support tool for use in real-time crisis management situations. The software allows users to enumerate their hypotheses and subsequently color code incoming evidence as either supportive or contradictory. This tool helps users offload memory and prevents them from prematurely tunneling in on a hypothesis. Users were thus able keep more alternatives open in environments where information is incomplete or ambiguous (i.e., prevent decision bias) and make better decisions. The authors subsequently extend this tool and develop a prototype that allows groups of decision-makers to visually track which changes in evidence affected which decisions; this helps groups build collective situational awareness.

Naturalistic decision-making. In contrast to normative models of decision-making, the naturalistic decision-making (NDM) approach investigates decision-making in the "real-world" with the goal of understanding how humans make decisions in complex tasks and environments. In their seminal work on NDM, Klein, Orasanu, and Calderwood (1993) found that expert decision-makers relied more on recognition of familiar situations in order to make decisions, whereas novices turned to more deliberate decision-making strategies. Thus, recognitional processes rely on the experience bank of the decision-maker who is able to detect patterns as familiar and realize relevant responses to these patterns. NDM is thus a considerably more holistic and ecologically valid approach in that it considers decisions in light of other pivotal processes (e.g., situation awareness, problem solving, planning, expertise, communication) and conditions (e.g., time pressure, fatigue, stress, unreliable information) that impact decision-making in dynamic environments (Salas & Klein, 2001).

Individual critical thinking. Decision makers must often make choices in complex, dynamic, and uncertain environments. These settings are often characterized by incomplete, contradictory, unreliable, uninformative, and ambiguous information. While even the most seasoned veterans lack situational omniscience in such environments, experienced decision-makers intentionally acknowledge imperfections by evaluating, critiquing, and refining assumptions (Cohen & Freeman, 1997; Cohen, Freeman, & Thompson, 1998; Cohen, Freeman, & Wolf, 1996). If decision-makers consciously surface deficiencies in knowledge, they can more fully consider alternatives and avoid problematic decision-making heuristics such as the tendency seek out evidence in order to maintain an initial interpretation of an uncertain situation (i.e., confirmation bias) even when contradictory evidence accumulates (i.e., tunnel vision) (Cohen et al., 1998; Schraagen & van de Ven, 2008; van Dongen, Schraagen, Eikelboom, & te Brake, 2005). This process of purposeful information evaluation in order to generate more enlightened decisions is called critical thinking.

Decision-making based on simple, probabilistic stimulus-response contingencies fails to consider the intricacy and instability of information in contemporary operating environments. Cohen et al. (1998) argue that Bayesian approaches for complex decision-making are insufficient because decision-makers often cannot exhaustively define all the relevant situational variables (e.g., premises, mechanisms, conclusions) necessary to derive a probability, a priori. Furthermore, a Bayesian approach neglects not only the rapidly evolving nature of events, but also fails to consider the complexity and uniqueness of the circumstances surrounding each decision. The pattern matching approach prompts several important questions about decision-making: What happens when the pattern doesn't precisely match the template? How do decision-makers resolve conflicts between multiple equally probable templates? How do decision-makers generate and evaluate new/alternative templates? When should decision-makers settle on a template for a given pattern and when should they continue looking for a more likely template? (Cohen & Freeman, 1997; Cohen et al., 1998). For example, when decision-makers are faced with novel circumstances, such a probabilistic approach collapses because the premise-conclusion patterns they have previously encountered may be poor prognosticators of outcomes in a new situation. Employees in high reliability occupations such as those found in the military, healthcare, and commercial aviation are often faced with complex decisions. As Flin, Slaven, and Stewart (1996, p. 269) point out, "the emergency you prepare for is never the one that happens," and it is precisely this level of complexity in high reliability occupations, which makes experience or repeated exposure a poor teacher (Baumann, Gohm, & Bonner, 2011).

The Recognition/Metarecognition (RM) framework was developed by Cohen et al. (1996) as an alternative to the probabilistic (i.e., normative) models and as an extension to the pattern-matching approach characteristic naturalistic decision-making. The two-tiered RM framework suggests that accomplished decision-makers are able not only to employ the recognitional skills described by Klein et al. (1993) in naturalistic decision-making, but are also able to use *meta*recognitional skills to make good choices. The meta*re*cognitional process is derived from the notion of metacognition (Flavell, 1976). If metacognition is, "thinking about thinking," then the catchphrase for meta*re*cognition is, "recognizing about recognizing." This mechanism affords a decision-maker the opportunity to critically evaluate weaknesses in his or her own recognitional process by purposely dealing with gaps and flaws in knowledge, resolving conflicts, questioning assumptions, generating alternative explanations, and verifying results (i.e., "critiquing and correcting") (Cohen et al., 1996; van Dongen et al., 2005). The metarecognitional component also allows decision-makers to evaluate whether the decision is even worth evaluating. Thus, the two tiers of the Recognition/Metarecognition framework are complementary such that decision-makers can use their domain experience (recognitional) in novel situations by "monitoring", "mentally marking" and "annotating" weaknesses (metarecognitional). Finally, Cohen et al. (1996) argue that since the RM model fits best when decision are made in novel situations, where typical templates don't fit observed patterns, metarecognition is a *critical thinking* process.

Four main processes characterize metarecognition (Cohen & Freeman, 1997; Cohen et al., 1998, 1996). After making observations about a situation, decision-makers build a narrative story or schema to organize the situation. The first process, the *quick test*, is a monitoring step intended to evaluate whether a decision-maker should even engage in critical thinking. The quick test asks: 1) whether the risk of delay is acceptable (i.e., Is there time to do it?), 2) whether the cost of an error if one acts immediately is high (i.e., Is it worth it?) and 3) whether the situation is non-routine/problematic (i.e., Is this a novel/uncertain situation? If not, is there an acceptable off-the-shelf solution?). If the benefits do outweigh the costs as determined by the quick test, then the decision-maker should proceed with the critiquing and correcting steps of the critical thinking process. First, evidence-conclusion relationships (i.e., arguments) in the story are identified. Second, the arguments are critiqued based on three criteria - incompleteness, conflict, and unreliability. Finally, an attempt is made to resolve problems found within the arguments in the second step. In this action phase, a decision-maker can inhibit action, collect additional data, shift his or her attention, adopt/drop assumptions, create contingency plans, wait for further situation development, or employ any other necessary corrective actions. This critical thinking is iterative such that critiquing and correcting one argument may reveal another. Finally, since the situation on the ground is complex and constantly changing, the critical thinking process must also be dynamic. For example, a quickly moving target may prompt a decision-maker to reapply the quick test and he or she may determine that there is no longer time for critical thinking, or perhaps a new behavior by the target will change the story the decision-maker constructs.

The critical thinking process of "building, verifying, and modifying" can be trained using the STEP technique: 1) Create a **S**tory, 2) **T**est for Conflict, 3) **E**valuate the Story, and 4) Develop Contingency **P**lans. This training strategy was validated in multiple samples. With

STEP training, officers were able to notice more factors in evaluating the intent of a target, identify and explain more conflicting evidence, identify more underlying assumptions, and generate more alternate assessments. Finally, there is also evidence that critical thinking training makes officers more confident in their decisions, and more importantly, improves task performance (i.e., accuracy of assessments; Cohen et al., 1998).

Collaborative critical thinking. Collaborative critical thinking is derived from three research threads: 1) *individual* critical thinking, 2) team process, and 3) team performance in information age warfare (J. Freeman & Hess, 2003). *Individual* critical thinking can take place in collaborative team settings such as cockpits (J. Freeman, Cohen, & Thompson, 1998). Freeman & Hess (2003) argue that an analogous process, *collaborative* critical thinking (CCT), can also take place at the team level. That is, successful teams engage in a process of constructive dissent by judiciously and strategically probing for disagreement within the group. Team disagreement can be interpreted as a symptom of, for example, disparate interpretations of cues, heterogeneity in hypotheses, or conflicting analyses of opportunities to engage in critical thinking. The collaborative critical thinking framework employs a similar process of *quick-testing*, *critiquing*, and *correcting* found in the Recognition/Metarecognition framework, which describes individual critical thinking (Cohen et al., 1996). The necessity and opportunity assessment to engage in CCT is similar to the quick-test in the RM framework. It is again important for team members to: 1) determine whether there is time to engage in CCT, 2) to ensure that engaging in CCT is valuable in light of the cost of an error if the group does not engage in CCT, and 3) to ensure that the situation is sufficiently uncertain. However, one additional criterion is important when drawing an analog to the quick-test at the group level. Specifically, it is important for the group to engage in an assessment of *disagreement*. Disagreement can be measured for each of the three previously mentioned components of the quick-test or for any other decision-making "artifacts" (e.g., cue interpretations, action plans). If sufficient disagreement exists in any of these components, this can signal to the team that the group can potentially benefit from collaborative critical thought. If the opportunity exists and the group is in disagreement per the quick-test, team members can proceed to critique the relevancy and accuracy of assumptions and plans held across the group. Specifically, a team can probe for incompleteness in information or gaps in knowledge, for conflict in interpretations of cues, and for unreliability information or untested assumptions. A team can then take corrective actions such as seeking additional information, developing contingency plans, or distributing previously siloed information across group members. These four processes are summarized in the collaborative critical thinking literature simply as: Monitor, Assess, Critique, Act (Freeman et al., 2003; Hess et al., 2008). Collaborative critical thinking is considered a success if a team can eliminate uncertainty about a situation, or at least illuminate uncertainty so that teams do not fall into decision-making traps such as tunnel vision (Schraagen & van de Ven, 2008) or immediate acceptance of pre-potent cue-response relationships (Hess et al., 2008).

How CCT serves collaboration. Freeman and Hess (2003) present a collaboration model that specifies the: 1) factors which *necessitate* collaboration, 2) factors which influence the *ability* to collaborate, 3) *products* of collaboration, and 4) *effects* of collaboration on mission performance. According to the first parameter, collaboration isn't always necessary. For example, when the nature of the mission is individual, or when one person possesses all of the necessary expertise and resources to accomplish the task or goal, collaboration is perhaps a wasteful process. If, however, expertise or resources are divided then successful collaboration can yield results that cannot be accomplished by a lone individual. The second parameter describes a team's *ability* to collaborate. This is determined in part by the technology available to the team (e.g., communication tools), the team's training and skill in team processes (e.g., negotiation, active listening), team composition (e.g., homo-/heterogeneity of team), and the team's ability to engage in collaborative critical thinking. In turn, a team's ability directly predicts what the team reaps from the collaboration (e.g., solutions, plans, shared knowledge, shared awareness) and how the team performs on mission-relevant criterion measures.

Alternatively, Freeman et al. (2003) frame CCT within Letsky's (2007) collaboration model. In this model, collaboration is a function of five interrelated processes: 1) establishing conventions (process knowledge), 2) developing shared understanding (domain knowledge), 3) developing collaborative knowledge (team knowledge), 4) attaining consensus (negotiating solutions), and 5) validating (testing and revising) conclusions. Within this model, CCT is a mechanism that bridges and refines the relationship between attaining consensus (collaboration process 4) and validating conclusions (collaboration process 5). The collaboration processes collectively predict the effects of collaboration (e.g., synchronization, communications, information management, workload balance) which, in turn, predict mission effects (e.g., Measures of Effectiveness such as kills, losses, and detections; Freeman & Serfaty, 2002). Finally, the model can also account for dispositional or compositional factors which can support or hinder collaborative critical thinking (e.g., systematic, open-minded team members). For example, team members who are high in agreeableness may readily dismiss conflicting information and not engage in critical evaluation of shared information (Ellis et al., 2003; Hess et al., 2008).

Finally, Hess et al. (2008) suggest that CCT can serve all fours stages of the Warner collaboration model - knowledge-base construction, collaborative problem-solving, consensus, outcome evaluation and revision (Warner & Wroblewski, 2004). During knowledge-base construction, team members identify the necessary resources (e.g., personnel, information, tools, team processes and structure) required to successfully collaborate and accomplish the mission. Warner posits that teams then need to jointly solve problems, come to consensus, act, and evaluate their solutions – all processes Hess et al. (2008) theorize can be directly affected by CCT.

These three models are very similar and roughly follow the IPO format that characterizes many models of team interaction (Hackman & Morris, 1975). The IPO framework can be roughly consolidated for the three collaboration models as it relates to CCT specifically. The Inputs then are 1) a necessity to collaborate given an uncertain, complex, dynamic, and high-stakes situation wherein resources such as expertise are distributed among team members, and 2) team composition/dispositional factors. The Process is characterized by the quality of the collaborative critical thought, and the Outputs are 1) the products of collaboration, and 2) the impacts on mission performance.

Managing CCT. A team leader can oversee the entire collaborative critical thinking process to ensure that team resources are prioritized to address the most critical risks and uncertainties first. The Collaboration for Enhanced Team Reasoning (CENTER) tool is a decision-support system designed specifically to help team leaders facilitate collaborative critical thinking by measuring, monitoring, and managing team knowledge and decisions (Freeman, Weil, & Hess, 2006; Hess et al., 2008). CENTER allows leaders to probe individual team members on their beliefs regarding mission elements. For example, a team member may be prompted with a quick-test-related probe such as, "The team has time to critique and refine the plan regarding engaging the target" to which they would respond with a Likert-type rating indicating their agreement or disagreement with the statement. CENTER then aggregates individual responses to provide mean, range, and variance information for each probe so the leader can determine whether team views of the mission are coherent. If, for example, the probe displays an average mean and high variability, CENTER will recommend, based upon this distribution, that the leader further probe team members and engage them in a process of collaborative critical thought through a chat client.

There is good reason to believe that *collaborative* critical thinking, like *individual* critical thinking, can be trained and has a positive impact on performance. While no study to date has examined a direct relationship between CCT training and team-initiated CCT behavior, CCT training has been demonstrated to have a positive effect on novice team performance (Hess et al., 2008). Using another time-pressured CCT tool similar to CENTER, Schraagen & van de Ven (2008) were able to demonstrate that people using the tool were able to accommodate more new pieces of evidence in drawing conclusions, were able to come to better conclusions, and were able to avoid misleading decision heuristics (e.g., confirmation bias) than those not using the tool. However, team members using tools such as CENTER must use critical mission time to code incoming evidence and to respond to prompts, which may result in mission disruption and unnecessary delays in decision-making. Therefore, such an explicit coordination process is likely too time-consuming when teams or team members are under high workload and/or time pressure. While good decision-makers should definitely use critical thinking to overcome decision biases, critical thinking tools are best relegated for *training* team members to use critical thinking (Hess et al., 2008; Schraagen & van de Ven, 2008).

Present Study and Hypotheses

So far I have discussed the landscape that has necessitated the use of teams and, in particular, VTs in modern civilian and military organizations. I have also defined teams and virtual teams and compared their relative benefits, limitations, and relationships with a variety of relevant predictors and outcomes such as trust development, monitoring, and effectiveness. Lastly, I highlighted the importance and process of making high-quality decisions in order to accomplish individual and collective goals. I discussed common decision-making errors committed during individual and group work, and featured collaborative critical thinking as a process of mitigating uncertainty in decision-making and enhancing team collaboration.

While Hess et al. (2008) found that CCT training enhanced performance in virtual teams, no study to date has evaluated the relationship between CCT and trust development. Since trust is a critical determinant of team effectiveness, finding interventions to enhance trust can help teams realize their full potential.

In the present study, I investigate the effects of CCT training on virtual team effectiveness and the development of team trust. Since trust takes time to develop, especially in virtual teams, I use a longitudinal approach wherein team members iterate through multiple performance episodes on a simulated search-and-rescue task. The task is interdependent and the distribution of information creates uncertainty. It should therefore be an appropriate environment for team members to engage in CCT. Costa (2003) argues that multiple individual and team outcomes are important to measure in addition to objective performance. Although studies differ on what is included in this “effectiveness” package, she suggests that it is critical to assess the objective output of the team as well as some attitudinal components and subjective appraisals (e.g., impact of the group on members, attitudinal and continuance commitment, perceived task performance). In this study, I define effectiveness as a combination of objective team performance, team viability, team cooperation, and team perceived collective efficacy.

In the literature review above, I presented overwhelming evidence that trust predicts effectiveness as well as evidence that effectiveness predicts trust. I therefore assume that team trust and team effectiveness will influence one another such that changes in one will drive changes in the other over time (Pavlova, 2012).

Hypothesis 1: Changes in team effectiveness will influence changes in team trust.

Hypothesis 2: Changes in team trust will influence changes in team effectiveness.

There is also good reason to believe that providing CCT training can 1) directly improve team effectiveness, and 2) reinforce trust within teams, which in turn can also boost effectiveness. With respect to the direct route, team members siloed in their own functions may not understand the full operational picture. For example, in complex operations, a teammate may not be fully aware of his or her own knowledge deficiencies. Other teammates can help highlight shortcomings and fill in gaps so that the team can generate a higher quality, jointly negotiated decision. Although monitoring for and highlighting deficiencies enhances collaboration and is clearly good for team outcomes, it is a risky endeavor. Tracking the work progress of others and working around team members can communicate distrust, which in turn can breed performance losses such as teammates hoarding information or wasting time on work unrelated to the focal task (e.g., blame discussions). It follows then that teammates who trust one another will be more willing to engage in CCT and reap the performance benefits thereof.

Hypothesis 3: Teams trained in CCT will be more effective than teams not trained in CCT.

Providing team members with CCT training can also enhance trust by creating a norm of monitoring. CCT is a proactive process; it requires that team members regularly engage in purposeful communication. These intentional exchanges can create a wider highway for the transmission of task-related and social information, both important predictors of trust. Regularly engaging in discussions and probing teammates can make teammates more familiar with one another's performance. In turn, teammates can mitigate distrust since they are able to predict one another's behavior more reliably. Since the majority of information communicated during CCT will likely be task-related, cognitive trust should be particularly impacted. The development of cognitive trust should also contribute to the emergence of affective trust (McAllister, 1995).

Hypothesis 4: Teams trained in CCT will engage in more positive monitoring and less negative monitoring than teams not trained in CCT.

Hypothesis 5: Monitoring will be positively associated with performance in all teams.

In its classical conception, monitoring is driven by a distrust of other team members. That is, the behavior originates based on attitudes towards *people*. Since CCT training is administered *before* participants have had a chance to form impressions of one another, it can communicate that monitoring is a healthy behavior necessitated by the *situation* (i.e., uncertainty, good decision-making), rather than by people attributes. CCT can therefore sanction surveillance to create a norm of monitoring and thus dissociate monitoring from distrust (i.e., negative monitoring). Furthermore, having a teammate "check in" can be a sign of commitment and of care and concern for another teammate's needs and goals, rather than a blunt mechanism for control. Thus, if team members can perceive monitoring as a productive behavior, this can further increase affective trust.

Hypothesis 6: Teams trained in CCT will have higher levels of initial trust than teams not trained in CCT.

Hypothesis 7: Trust and effectiveness will develop more rapidly in teams trained in CCT compared with teams not trained in CCT.

Finally, individual differences can play an important role in trust development and performance. An individual's dispositional propensity to trust others, for example, can predict initial trust levels (Costa, 2003; Mayer et al., 1995). Although Costa (2003) found that propensity to trust only accounted for a small amount of variance in trust, the team members in her study were previously acquainted with one another. In the present study, teammates are completely unfamiliar with one another and have little previous information upon which to make initial trust judgments (i.e., deidentified teammates). Propensity to trust could perhaps explain some portion of how team members establish initial levels of trust. It may also be the case that team members who are overly trusting may fail to engage in the monitoring behaviors associated with CCT. In the same vein, high levels of agreeableness may prevent team members from participating in the process of constructive dissent so important to CCT (Coovert et al., 2005). Lastly, conscientiousness can directly enhance team performance (English, Griffith, & Steelman, 2004) and also attenuate the effects of CCT training on performance. Conscientious individuals are planful, thorough, hard working, and strive purposefully towards goals.

Hypothesis 8: Propensity to trust will be associated with initial team trust.

Hypothesis 9: Conscientiousness will attenuate the relationship between CCT training and effectiveness.

Chapter 2: Method

Participants

Participants were undergraduates enrolled in various Psychology courses at the University of South Florida. They were recruited as three-person teams using the Psychology Department Research Participant Pool (SONA), an online recruiting and scheduling tool. In exchange for participation in the study, participants were compensated with SONA points, which can be used for course credit.

Data were collected from 315 participants (105 teams of 3 players). Two teams (6 participants) were excluded from all analyses because the research team discovered that two of the team members knew one another as friends prior to the study. Prior friendship could translate to higher levels of initial trust and thus lead to unequal experimental conditions. Five more participants were excluded from behavioral analyses (i.e., those involving self-reports of trust, team effectiveness, and team monitoring) due to technical glitches in the survey collection system. These participants were deleted listwise because nearly all of their responses were missing. With the exception of these five participants, the rest of the behavioral dataset was complete because the survey collection software required participants to enter a response for every item before they could move on. Four teams (12 participants) were excluded from any analyses involving DDD objective scenario scores due to technical glitches where the DDD system did not record the scores. After these exclusions, there remained 304 participants (Mean age = 20.3, SD = 3.1; 68% female). Approximately half of the participants were Causasian, 20% Hispanic, 13% Black/African American, 6% Asian/Pacific Islander, and 7% other/multi-racial.

Teams were randomly assigned to either the CCT training condition or the control condition (SURVIVAL). 150 participants were part of a team that received CCT training and 154 received the control training. No statistically significant differences were found in comparing the groups on any demographic variables.

Task

While CCT is an activity best engaged in by experienced domain experts (Hess et al., 2008), a computer simulation was chosen as the platform for evoking CCT, trust, and performance because all participants were equally unfamiliar with this task. This eliminated the possibility of unequal prior practice, which is important in a controlled laboratory study.

Four computers were be used to run the Distributed Dynamic Decision-making (DDD, Version 4.2) Antarctic Search and Rescue simulation (Aptima Inc., Woburn, Massachusetts). This task has been used in a variety of other team studies (e.g., Colquitt et al., 2002; Ellis et al., 2003). This is an interdependent task, which requires team members to collaborate in order to accomplish a variety of objectives in three different scenarios. The team operates out of an Antarctic research base (Station Blue) using Snowcat vehicles to accomplish their goals. Each of the three scenarios has a medical, repair, and recovery objective. The medical objective is to find a lost team, render medical aid, and get them back to Station Blue. The repair objective is to find an antenna and install it. The recover objective varies across scenarios. In Scenario 1 (Appendix A), the team must find an unmanned aerial vehicle. In Scenario 2 (Appendix B), the team must find a gondola, and in Scenario 3 (Appendix C), a downed satellite. The scenarios were developed such that difficulty is held constant across scenarios, but the geographic locations of the various targets (e.g., sensors, lost party, UAV, satellite) differ. Team members completed a training mission followed by three separate 30-minute missions. The order of scenarios was counterbalanced across teams.

There were three roles for team members to occupy. Each team member operated a separate search-and-rescue Snowcat (Red, Green, and Purple) in order to complete the team's tasks. The Snowcats are equipped with 1) communication equipment (text-based chat), 2) navigational equipment that allows the operator to see where he/she is in the terrain and steer the Snowcat, and 3) sensors and probes that can process and read the seismic monitors installed throughout the harsh landscape, which should have recorded the vibrations of the lost rescue party's Snowcats driving past them. Navigating the terrain, processing the seismic monitors, and completing other subtasks utilizes a set of finite resources in the form of fuel, medics, technicians, scouts, and mechanics. These personnel are loaded onto the Snowcat, transported, and deployed throughout the mission. Each resource has an allotment of usable "abilities". For example, if the medic has 10 abilities and a subtask requires 3 medical abilities, the Snowcat is left with 7 usable medic abilities. The task was calibrated such that there are sufficient resources available to complete all of the tasks. However, individual team members will often run out of resources and must rely on and coordinate with others to contribute resources in order to gather information and complete tasks. Each team member initially receives the same amount of resources, and resources are the same across the three scenarios. Additionally, team members must share information about the clues they find individually with other team members so that the team can accomplish its collective mission.

A confederate research assistant served as "headquarters"(Blue) at the basecamp to provide access to the backup supply and fuel resources, but only when the other team members explicitly requested them. Again, while there is a sufficient amount of resources to complete all of the tasks, the supply, including the backup resources controlled by Blue, is finite (e.g., fuel supplies can run out). Team members must therefore be cognizant and strategic about deploying resources. Participants were also instructed to direct any questions they have during the task to Blue, so that a research assistant can render technical assistance. Given the minimal role of Blue, mission scores are calculated only on the performance of the Red, Green, and Purple team members. Finally, all team members were able to communicate with one another through a text-based chat client embedded within the DDD system.

Training

All training materials are derived from the training developed by Aptima, Inc. (Woburn, MA). For a thorough explanation of the technical details regarding the development and content of the CCT and control group training, see the technical report by Hess et al (2006).

Collaborative critical thinking training (CCT). If virtual teams are temporally, geographically, or organizationally distributed, then it is unlikely that such teams will have an opportunity to train how to collaboratively critically think in a face-to-face environment. Thus, CCT training was delivered virtually via a narrated Powerpoint presentation. Participants were given a short quiz (Appendix D) after the training to ensure that they were paying attention and understood the concepts presented in the training. The training explains what CCT is and why it is important. It consists of descriptions, examples, and exercises regarding components of CCT including common individual and group decision-making traps (heuristics, biases, schemas, group process losses), and critical thinking principles (e.g., monitoring, assessing, critiquing and acting on information conflict, unreliability, and incompleteness under uncertainty).

Control group training. Control group participants were also trained virtually using a Powerpoint presentation. Participants in this condition received S.U.R.V.I.V.A.L. training, which presents an acronym-based mnemonic for employing life-saving actions in uncertain environments or situations (e.g., keeping mentally calm, decision making). Following the training, participants applied these eight principles in a written survival exercise. Participants were be presented with a hypothetical disaster scenario during which their tour bus is hijacked while traveling through a jungle in a foreign country. They were tasked with developing a short safety and survival plan based on a limited list of materials available from the tour bus and the natural environment (Appendix E). This training has good face validity in light of the Antarctic Search and Rescue simulation, which features uncertainty in a harsh environment with limited resources. It, however, does not explicitly train behaviors related to CCT.

Measures

All survey measures were administered using a computerized survey tool. Participants used a six-point Likert-type scale (1 = Completely Disagree, 2 = Mostly Disagree, 3 = Slightly Disagree, 4 = Slightly Agree, 5 = Mostly Agree, 6 = Completely Agree) to indicate their endorsement of items on all scales except for the background and personality questionnaires. Items from any scales administered at the same point in time were intermingled to minimize the potential of demand characteristics and to maximize the probability that participants read individual items carefully.

Background. (Appendix F**).** This questionnaire assessed sample demographics (age, race/ethnicity, gender), education (class rank, major), employment (hours worked per week), team experience (frequency of working on teams, team-related training), and military experience.

Personality. (Appendix G**).** The trust facet of agreeableness (10 items) and conscientiousness (10 items) were measured using items from the International Personality Inventory Pool (IPIP) (Goldberg, 1999; Goldberg et al., 2006). These items are modeled on the personality constructs measured by the NEO-PI-R (Costa & McCrae, 1992). Participants used a five-point Likert-type scale to respond (1 = Very Inaccurate to 5 = Very Accurate).

Trust. (Appendix H)**.** McAllister's (1995) trust measure was adapted to be team- rather than individual-referent. Five items assessed cognition-based trust. One item ("Most people, even those who aren't close friends of this individual, trust and respect him/her at work") was deleted from the original scale because it assesses reputation; since participants had no knowledge of one another prior to participating in this study, this item is not applicable. Affect-based trust was assessed using all five items found in the original measure, although the language was slightly modified to reflect teams rather than individuals.

Monitoring. (Appendix I)**.** Need-based monitoring, also known as positive or mutual performance monitoring, was measured using a three-item scale. Two items come from McAllister's (1995) need-based monitoring scale, while a third item was generated for the purposes of this study ("I monitor my teammates because it's part of what a good teammate does"). Control-based monitoring, also known as negative monitoring, was measured with a seven-item scale combining three items from McCallister's (1995) monitoring and defensive behaviors scale and four items from De Jong and Elfring's (2010) monitoring scale, which itself was based on Costa (2003) and Langfred (2004).

Team effectiveness.

Objective team performance**.** The DDD system automatically kept track of team member performance as they accomplished subtasks and major goals. For example, finding the lost rescue team or the unmanned aerial vehicle was worth 300 points, assisting with repair or medical requests earned the participant 50 points, and processing a seismic monitor was worth

10-80 points. Once an objective was processed, points were assigned to the team member who processed the task and the task was made inactive.

Team viability. (Appendix J)**.** This scale was composed of three items assessing a teammate's desire to continue being a part of the team, a proxy for team satisfaction. This measure was composed of one item from the Sinclair (2003) team viability scale and two items from the Lancellotti & Boyd (2008) team satisfaction scale. Although Lancelotti and Boyd (2008) labeled their questionnaire "team satisfaction," the items actually assess team viability (e.g., "I would be willing to work with this team on another project").

Team cooperation. (Appendix K)**.** A five-item scale developed by Conway et al. (2012) measured the extent to which teammate interactions were harmonious. An example item is "I feel like everyone in the team is working towards the group's goals."

Team efficacy. (Appendix L) Perceived collective efficacy was assessed using four items from the Perceived Collective Efficacy assessment used in work groups in Salanova, Llorens, Cifre, Martinez, and Schaufeli (2003). This scale assesses the degree to which team members believe in their team's competence and success. A sample item is: "My group is able to solve difficult tasks if we invest the necessary effort."

Procedure

Face-to-face interaction can preempt trust development outside of the constraints of the experimental task. It was therefore important to carefully control and minimize pre-study participant interactions in order to ensure that all participants had the same opportunities to communicate and develop trust. Participants were escorted as soon as they arrived at the laboratory to separate simulation rooms. Doors to these rooms were closed during the study, except for when researchers needed to provide instructions, answer questions, or set something up on the computer.

Upon arrival, participants were provided an explanation of the study and signed the consent form. Following consent, participants were familiarized with the DDD simulation environment and task. Participants watched a short video that included a narrative about the background of the mission, a briefing about their tasks and goals, and instructions for using the DDD system (e.g., Snowcat navigation, deploying resources, reading sensors, communicating with other teammates). Participants then took part in a training mission to allow them to practice until they were proficient with the DDD system controls (~20 minutes). Participants were provided with two printed documents, which they could use for reference during the missions. These were: 1) a DDD Map and Actions Quick Guide (Appendix M) that was used to remind team members about how to use the DDD interface, and 2) a Tasks and Team Structure Quick Guide (Appendix N) explaining team structure, tasks, strategies, and point values for various actions.

Next, participants were administered either the CCT training or SURVIVAL training and the task corresponding to each training. Following training, a baseline trust measure was taken (Trust 1) and participants were provided a briefing for Mission 1. The mission was launched after all participants had finished reading the briefing. The mission was discontinued after 30 minutes. Following the mission, the Team Effectiveness and Monitoring measures were administered. This marked the end of the first performance episode. The second performance episode began with the measurement of Trust 2, followed by Mission 2, and the post-mission measures. The third performance episode is the same as the second, except the post-mission measures also included the measurement of Trust 4. The Personality and Demographics questionnaires were administered last in order to avoid prompting for propensity to trust (trust facet of agreeableness), conscientiousness, and principles learned from any previous team training participants may have had. Finally, participants were thanked, debriefed about the purposes of the study, and offered an opportunity to ask any final questions. A summary of the study timeline and the measures gathered at each point is provided in Table 1.

Chapter 3: Results

Descriptives

Table 2 reports descriptive statistics, by group, for all measures at the individual level. Table 2 also reports reliabilities (Alpha) for all scales in this study. Reliabilities ranged from 0.63 – 0.95 with only a single scale (Positive Monitoring, Time 2) falling below an acceptable level of 0.7 (Nunnaly, 1978). Scale level correlations among all variables for the CCT group level are reported in Table 3. Scale level correlations among all variables for the control group level are reported in Table 4.

All trust, monitoring, and effectiveness measures, with the exception of DDD scores, were team-referent. That is, all of these items asked about an individual's perceptions of trust, monitoring, or effectiveness *in the team*. Thus, data is analyzed at the individual level. DDD scores reflect an individual team member's performance in the DDD simulation. Interestingly, the DDD scores do not correlate at either the team or individual level (Table 5) with the team-referent ratings of effectiveness (i.e., team viability, team efficacy, team cooperation). This is perhaps because the DDD simulations system's scoring mechanism (i.e., DDD's model of effectiveness) is discordant from the participants' views of what is effective. If effectiveness is to have any impact on trust, it is ultimately that portion of effectiveness that team members can *perceive* that should drive such effects. As such, I focus on the ratings of effectiveness provided by participants in the analyses.

The CCT quiz was administered in order to ensure that participants understood the content of the CCT training. The mean score on the 8-item measure was 7.48 (Min = 4, Max = 8, SD = .82) indicating that most participants understood the CCT training well. The quizzes were reviewed by a research assistant following administration and participants were provided feedback in order to reconcile any gaps in comprehension.

Scale Dimensionality

This section describes a series of confirmatory and exploratory factor analyses to assess the factor structure of the items in all self-report scales. These include trust, monitoring, and the three measures of effectiveness – team perceived collective efficacy, team viability, and team cooperation. All confirmatory factor analyses (CFA) were conducted separately for each time point using Mplus 7 (Muthen & Muthen, 2011), and parameters were estimated using maximum likelihood (ML). Due to the large number of models tested, fit statistics and statistical tests are reported in tables rather than text. RMSEA, TLI, CFI, and SRMR fit statistics are reported. RMSEA values from 0.00 to 0.05 indicate close fit, those between 0.05 and 0.08 indicate fair fit, those between 0.08 and 0.10 indicate mediocre fit, and values above 0.10 indicate unacceptable fit (MacCallum, Widaman, Preacher, & Hong, 2001). TLI and CFI values greater than 0.90 indicate that a model can be accepted (Schumacker & Lomax, 2010), and SRMR values less than .08 indicate good fit (Hu & Bentler, 1999).

Trust. As McAllister (1995) suggested, trust can be divided into cognitive and affective components. In order to examine the dimensionality of trust, a confirmatory factor analysis (CFA) was conducted to determine whether the trust measurements are best fit by a single factor model or the hypothesized two-factor model that separates cognitive and affective trust. For the one-factor model, all 10 trust items were fit to one factor, whereas for the two-factor model, the five items corresponding to cognitive trust were fit to one factor and the five items corresponding to affective trust (per McAllister 1995) were fit to two separate factors. The cognitive and affective trust factors were allowed to correlate. At all four time points, the fit of the two-factor model was superior to the fit of the one-factor model. I therefore analyze cognitive and affective trust separately in all further analyses. Fit information for all models examining trust dimensionality is presented in Table 6.

Monitoring dimensionality. Monitoring was measured using three items that were intended to assess positive, supportive monitoring and seven items intended to assess negative, control-based monitoring. Monitoring dimensionality was examined using a CFA to determine whether a single factor or a two-factor model, with positive and negative components, would best fit the data. Table 7 presents fit information for the one- and two-factor models of monitoring across all three time points.

Although the two-factor models seem to fit better than the one-factor models, the fit of the two-factor models is still unacceptable. I thus also conducted an exploratory factor analysis (EFA) to explore the factor structure of monitoring. The EFA was conducted using SPSS 21 (IBM Corp., 2012) using both maximum likelihood estimation and principal axis factoring with Promax rotation. Both estimation approaches yielded similar solutions, and the principal axis factoring results are presented below. With 10 items, the sample of 304 participants yields a participant:item ratio of 30.4, which far exceeds the most conservative recommendation of 10 participants per item proposed by Nunnally (1978) for EFA. The EFA was conducted on the monitoring items at Time 2. Three factors were retained per the Kaiser criterion (eigenvalues greater than 1). After suppressing all small factor loadings (defined as <0.28 by Sass & Schmitt, 2010) in the factor pattern matrix (Table 8), no cross-loaded items remained in the three-factor solution. As expected, the positive monitoring items loaded on Factor 1; no negative monitoring items loaded on this factor. Negative monitoring items 1, 3, 4, and 5 loaded on Factor 2. Finally, negative monitoring items 2, 6, and 7 loaded on a third factor (Factor 3). No positive monitoring items loaded on either Factor 2 or Factor 3. Because the first two factors are readily interpretable and closely fit the theoretically driven conceptualization of a two-factor monitoring solution, I chose to delete the negative monitoring items that loaded on Factor 3. In order to evaluate this new monitoring scale, the samples at Time 3 and Time 4 were used to check whether the revised factor structure fit better than the original through CFA. The two models with asterisks in Table 7 present the fit information for the revised two-factor models with the items loading on the third factor deleted. The revised models fit the data better than the original two-factor models per a chi-square difference test (Time 3, $X^2(21) = 82.05$, $p<.05$; Time 4, $X^2(21) = 118.44$, $p<.05$) between the original and revised two-factor models. While CFI, TLI, and SRMR indices for the revised models all indicated better fit, RMSEA got worse due to the large change in degrees of freedom between the models. Although these results may be interesting for future researchers investigating the dimensionality of monitoring scales, the original structure of the scale was maintained (i.e., 3 items assessing positive monitoring, 7 items assessing negative monitoring). Despite the empirically driven EFA findings, a content review of the three items that loaded on the third factor did not justify removing them from the negative monitoring scale.

Effectiveness dimensionality. Team collective efficacy (TE), team cooperation (TC), and team viability (TV) were all first evaluated as individual, one-factor models. Fit statistics for all effectiveness CFAs are presented in Table 9. One-factor models for TE and TC fit very well. Fit statistics were unavailable for TV due to model saturation. Another CFA evaluated whether a single effectiveness factor could account for all TE, TC, and TV items; this model fit poorly. Finally, a three-factor model with TE, TC, and TV was evaluated such that all items for each measure loaded on a their respective factor. The TE, TC, and TV factors were allowed to correlate. This model fit well and confirms the three-factor nature of effectiveness. TE, TC, and TV are thus analyzed separately in all ensuing analyses.

Hypothesis Testing

Hypotheses 1 and 2 stated that team trust and team effectiveness would mutually influence one another. In order to test these hypotheses, a series of latent panel models were developed and tested for configural, loading, and path invariance across groups. These structural equation models were fitted using MPlus 7. Cognitive and affective trust were modeled separately for each of the three measures evaluating perceptions of effectiveness (i.e., team viability, team cooperation, team efficacy). The five items measuring cognitive trust at each time point served as indicators for the latent trust variables CogTrust1, CogTrust2, CogTrust3, and CogTrust4. The five items measuring affective trust at each time point served as indicators for the latent trust variables AffTrust1, AffTrust2, AffTrust3, and AffTrust4. Similarly, the items corresponding to team efficacy (TE), team viability (TV), and team cooperation (TC) at each time point were used as indicators of the latent variables TV2/3/4, TE2/3/4, TC2/3/4.

Similar classes of latent variables were connected to one another in an autoregressive fashion (e.g., TV2→TV3→TV4). Additionally, paths were drawn between the most temporally proximal trust and effectiveness latent variables to represent the effects of trust on effectiveness and effectiveness on trust (e.g., TV2→AffTrust2, AffTrust2→TV3). It should be noted that while these models may appear to be cross-lagged, they are not traditional cross-lagged models. In traditional cross-lagged models, two variables of interests are measured at the same time and are both reassessed after a fixed period of time. While trust and effectiveness are measured at the same time in these models, the lag in trust → effectiveness is not the same as the lag in effectiveness → trust. Since effectiveness is measured directly after the end of a performance episode and trust is measured just before the beginning of the next performance episode, the lag in time of effectiveness → trust is minimal. However, the lag in time of trust to the subsequent effectiveness is approximately 30 minutes (i.e., the length of time it takes for the team to perform a mission). In all models, error terms for individual indicators over time were allowed to correlate since the same items were used at different time points. Furthermore, the individual item factor loadings were constrained to be the same over time in order to ensure that the measurement model did not change across performance episodes. Given the large quantity of models, fit statistics are presented in tables and parameter estimates are presented in figures in order to ease readability.

In the first model (Model CV), cognitive trust was modeled with team viability. The fit indices for this model are presented in Table 10. First, each group was modeled individually, and the model fit well for each group. Next, the configural model was developed such that all parameter estimates were freed across groups; this model also fit well. Next, factor loadings were constrained across groups; this model fit well. Finally, paths constraints were added to the factor loading constrained model; this model also fit the data well. Although there were significant differences in the chi-square difference tests between the factor loading invariant model and the model with path constraints, the other fit indices indicated that the model fit well. Kenny (2012) recommends that fit indices, rather than chi-square difference tests, guide decision making in multiple group modeling. Multiple group models can also be compared on invariance in intercepts, error variance, error correlation, disturbance variances, disturbance correlation, and factor intercepts and means. However, since the interest in the current study was in the paths between trust and effectiveness variables, models were only constrained first on factor loadings and then paths. Since both path and factor loadings were invariant across groups, the groups were combined, and an overall model including all participants from both groups, was estimated. The fit indices for the combined model are significantly better than those for the individual groups, which is expected since fit statistics take sample size into account. The combined model is presented in graphic form in Figure 1.

A similar approach was employed for fitting the remaining models, which were Affective Trust with Team Viability (Model AV; Figure 2), Cognitive Trust with Team Efficacy (Model CE; Figure 3), Affective Trust with Team Efficacy (Model AE; Figure 4), Cognitive Trust with Team Cooperation (Model CC; Figure 5), and Affective Trust with Team Cooperation (Model AC; Figure 6). All of the models were combined using the same process as above. That is, multiple group comparisons did no justify freeing factor loadings or path coefficients between groups in any of the analyses. Fit indices for all models are provided in Table 10.

In all models, all factor loadings were significant indicators of their latent variables. In Models CV and AV, all autoregressive paths were significant, all paths from Team Viability to Trust were significant, and all paths from Trust to Team Viability were significant except for the path between Trust3 and Team Viability 4. In Models CE and AE, all autoregressive paths were significant except for the path from Cognitive Trust 1 to Cognitive Trust 2 in Model CE, all paths from Team Efficacy to Trust were significant, and all paths from Trust to Team Efficacy were significant. In Models CC and AC, all autoregressive paths were significant, all paths from Team Cooperation to Trust were significant, and all paths from Trust to Team Cooperation were significant except for the paths from Cognitive/Affective Trust 2 to Team Cooperation in both models and the path from Cognitive Trust 3 to Team Cooperation 4 in Model CC. In general the standardized coefficients associated with the paths from the team effectiveness factors (team viability, team efficacy, team cooperation) to trust factors (cognitive trust, affective trust) tended to be larger than those associated with paths from the trust factors to the team effectiveness factors. While this may reflect true differences in prediction, this issue is confounded by the unequal measurement lags between the two types of paths. Despite these limitations, it is clear that trust predicts effectiveness and effectiveness predicts trust, thus supporting Hypotheses 1 and 2.

Hypothesis 3 proposed that teams trained in CCT would be more effective than teams not trained in CCT and *Hypothesis 7* stated that trust and effectiveness would develop more rapidly in teams trained in CCT compared with teams not trained in CCT. Mixed between-within subjects, repeated measures ANOVAs were used to examine within-person changes on individual variables over time and to test for differences between the training groups. Main effects for the training condition would support Hypothesis 3 and interaction effects between the group and the developmental trajectories of trust or effectiveness variables would support Hypothesis 7.

Cognitive trust was assessed across four time periods (T1, T2, T3, T4). The ANOVA statistics are presented in Table 11 and the graph is presented in Figure 7. There was no significant interaction between cognitive trust and training, $F(3,906) = 0.93$, *ns*, partial eta-squared = 0.00. There was a substantial main effect for time, $F(3,906) = 12.23$, $p<.05$, partial eta-squared = 0.04. The trend was for cognitive trust to monotonically increase over time. Bonferroni-corrected post-hoc tests revealed significant differences between all time points except the difference between Time 1 and Time 2. There was no main effect of training, $F(1, 302) = .05$, *ns*, partial eta-squared = 0.00, which suggests there was no impact of training on cognitive trust development.

Affective trust (Table 11, Figure 8) was also assessed across four time periods (T1, T2, T3, T4). There was no significant interaction between affective trust and training, $F(3,906) = 0.58$, *ns*, partial eta-squared = 0.00. There was a substantial main effect for time, $F(3,906) = 17.66$, $p<.05$, partial eta-squared = 0.06. The trend was for affective trust to monotonically increase over time. Bonferroni-corrected post-hoc tests revealed significant differences between all time points except the difference between Time 1 and Time 2 and between Time 3 and Time 4. There was no main effect of training, $F(1, 302) = .05$, *ns*, partial eta-squared = 0.00, which suggests there was no impact of training on affective trust development.

In order to investigate the development of effectiveness, DDD scores (Table 11, Figure 9) were assessed across three time periods (T2, T3, T4). There was no significant interaction between DDD scores and training, $F(2,604) = 3.33$, *ns*, partial eta-squared = 0.01. There was a substantial main effect for time, $F(2,604) = 41.46$, $p<.05$, partial eta-squared = 0.13. The trend was for DDD scores to monotonically increase over time. Bonferroni-corrected post-hoc tests revealed significant differences between all time points. There was no main effect of training, $F(1, 302) = 2.48$, *ns*, partial eta-squared = 0.01, which suggests there was no impact of training on the development of DDD scores.

Team efficacy (Table 11, Figure 10) was assessed across three time periods (T2, T3, T4). There was no significant interaction between team efficacy and training, $F(2,604) = 0.48$, *ns*, partial eta-squared = 0.00.. There was a substantial main effect for time, $F(2,604) = 12.92$, $p<.05$, partial eta-squared = 0.04. The trend was for team efficacy to monotonically increase over time. Bonferroni-corrected post-hoc tests revealed significant differences across all time points. There was no main effect of training, $F(1, 302) = 0.16$, *ns*, partial eta-squared = 0.00, which suggests there was no impact of training on the development of team efficacy.

Team viability (Table 11, Figure 11) was assessed across three time periods (T2, T3, T4). There was no significant interaction between team viability and training, $F(2,604) = 0.59$, *ns*, partial eta-squared = 0.00.. There was a substantial main effect for time, $F(2,604) = 4.91$, $p<.05$, partial eta-squared = 0.02. The trend was for team viability to monotonically increase over time. Bonferroni-corrected post-hoc tests revealed significant differences between all time points except the difference between Time 3 and Time 4. There was no main effect of training, $F(1, 302) = 0.62$, *ns*, partial eta-squared = 0.00, which suggests there was no impact of training on the development of team viability.

Team cooperation (Table 11, Figure 12) was assessed across three time periods (T2, T3, T4). There was no significant interaction between team cooperation and training, $F(2,604) = 2.02$, *ns*, partial eta-squared = 0.01. There was a substantial main effect for time, $F(2,604) = 10.30$, $p<.05$, partial eta-squared = 0.03. The trend was for team cooperation to monotonically increase over time. Bonferroni-corrected post-hoc tests revealed significant differences between all time points except the difference between Time 3 and Time 4. There was a substantial main effect of training, $F(1, 302) = 4.86$, $p<.05$, partial eta-squared = 0.02, indicating that the CCT trained group consistently reported higher levels of team cooperation than the control group.

Thus, Hypothesis 7 was not supported for any measures of trust or effectiveness as there were no interaction effects between training and the developmental trajectories of any of these variables. Hypothesis 3, which predicted that CCT teams would be more effective than control teams, was not supported for DDD scores, team efficacy, or team viability. Hypothesis 3 was supported for team cooperation such that participants trained in CCT consistently reported that their teams cooperated better across all time points. As such, Hypothesis 3 was partially supported.

Hypothesis 4 stated that teams trained in CCT would engage in more positive monitoring and less negative monitoring than teams not trained in CCT. Negative monitoring (Table 11, Figure 13) was assessed across three time periods (T2, T3, T4). There was no significant interaction between negative monitoring and training, $F(2,604) = 0.45$, *ns*, partial eta-squared = 0.00. There was no main effect for time, $F(2,604) = .80$, *ns*, partial eta-squared = 0.00, suggesting that negative monitoring does not change over time. There was no main effect of training, $F(1, 302) = 0.27$, *ns*, partial eta-squared = 0.00, which suggests there were no differences between the training groups on negative monitoring at any time point. Positive monitoring (Table 11, Figure 14) was also assessed across three time periods (T2, T3, T4). There was no significant interaction between positive monitoring and training, $F(2,604) = 0.12$, *ns*, partial eta-squared = 0.00.. There was a substantial main effect for time, $F(2,604) = 9.16$, $p<.05$, partial eta-squared = 0.03. The trend was for positive monitoring to monotonically increase over time. Bonferroni-corrected post-hoc tests revealed significant differences between all time points except the difference between Time 3 and Time 4. There was no main effect of training, $F(1, 302) = 1.40$, *ns*, partial eta-squared = 0.01, which suggests there was no difference between the groups in positive monitoring at any time point. Thus, Hypothesis 4 was not supported.

Hypothesis 5 stated that monitoring would be positively associated with performance in all teams. Table 12 presents correlations between measures of monitoring and measures of effectiveness separated by team at each time point. In general, all measures of monitoring correlated positively with measures of effectiveness, with the exception of DDD scores, at Time 2 and Time 3. At Time 1, monitoring measures were positively correlated with effectiveness measures, but only for the CCT group. Correlations between positive monitoring and effectiveness tended to be stronger than those between negative monitoring and effectiveness. Thus, Hypothesis 5 was partially supported.

Hypothesis 6 proposed that teams trained in CCT would have higher levels of initial trust than teams not trained in CCT. An independent samples t-test comparing the CCT (M = 23.04, SD = 3.72) and control group (M = 23.34, SD = 4.06) on cognitive trust at Time 1 was not significant, t(302) = -0.01, *ns*. Another independent samples t-test comparing the CCT (M = 21.75, SD = 4.29) and control group (M = 21.45, SD = 4.57) on affective trust at Time 1 was not significant, t(302) = 0.57, *ns*. Thus, for both cognitive and affective trust, Hypothesis 6 was not supported.

Hypothesis 8 stated that propensity to trust would be associated with initial team trust. In order to test this hypothesis, cognitive trust and affective trust at Time 1 were correlated with the trust facet of agreeableness from the IPIP. While propensity to trust was uncorrelated with initial affective trust (r = .10, ns), it was correlated with initial cognitive trust (r = .17, $p < .05$). Since the groups were trained in either the CCT or control conditions before they were measured on their propensity to trust and their initial cognitive and affective trust in their teams, it is also important to examine these correlations separated by group in case the training impacted these relationships. As previously mentioned, there was no difference in initial cognitive and affective between the groups. Additionally, there was no difference between the groups in propensity to trust, t(302) = -1.06, *ns*. In the CCT group, propensity to trust was not correlated with initial affective trust (r = .15, ns), but was correlated with initial cognitive trust (r = .20, $p < .05$). In the control group, propensity to trust was not correlated with initial affective trust (r = .06, *ns*) or with initial cognitive trust (r = .13, *ns*). Thus, Hypothesis 8 was partially supported.

Hypothesis 9 proposed that conscientiousness would attenuate the relationship between CCT training and effectiveness. This hypothesis was not tested because there was no effect of CCT training on objective performance (DDD scores). Although there were group differences in perceptions of team cooperation, there is no theoretical basis for examining why individual conscientiousness might affect perceptions of team cooperation.

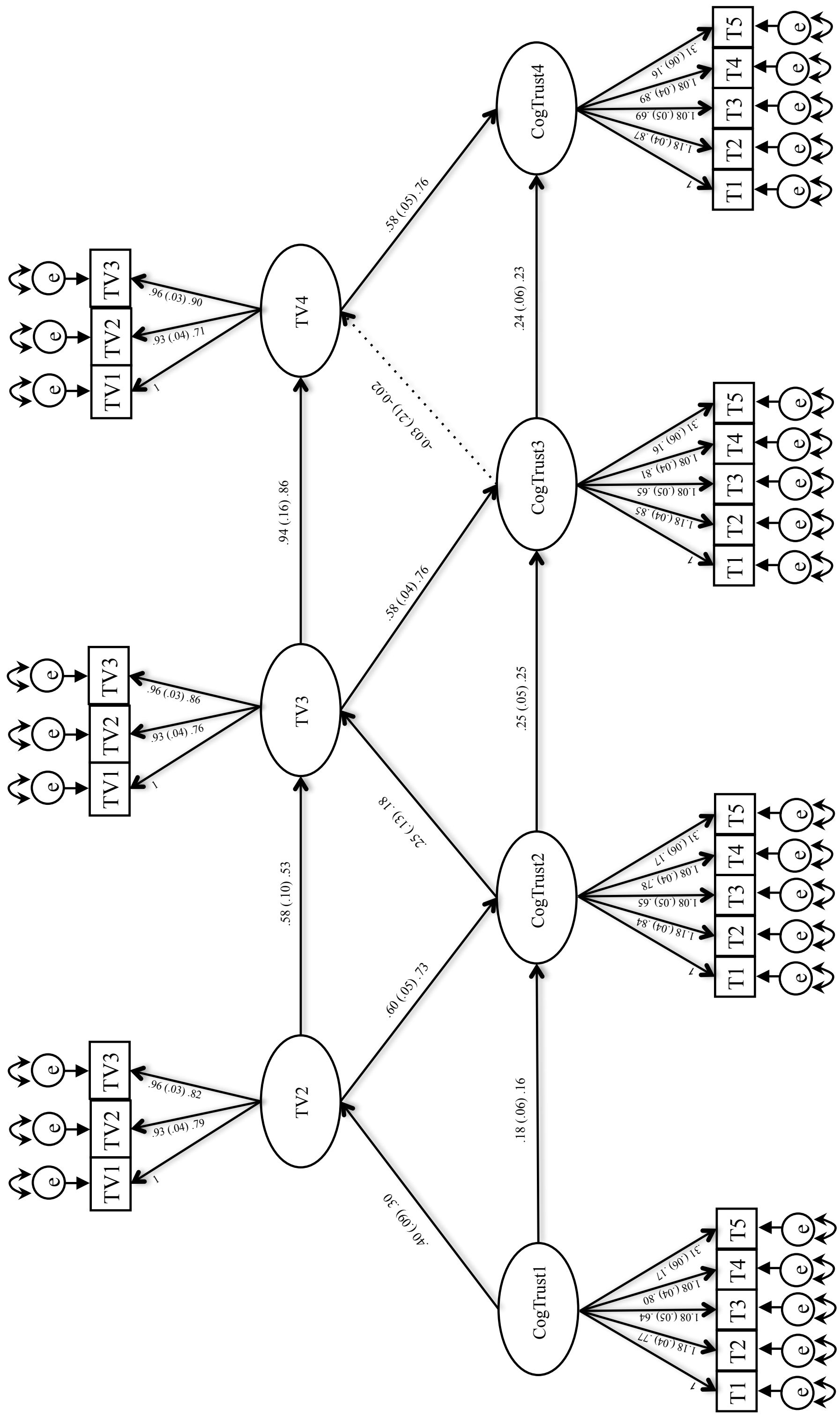

Figure 1. Model CV - Cognitive Trust with Team Viability. All errors for identical items correlated across time periods. All factor loadings for identical items constrained across time periods. Parameters estimates reported as: Raw (Raw SE) Standardized. Model fit: $X^2(343) = 476.79$, $p<.05$; RMSEA [90%CI] = .04[.03 .04]; CFI = .98; TLI = .98; SRMR = .06

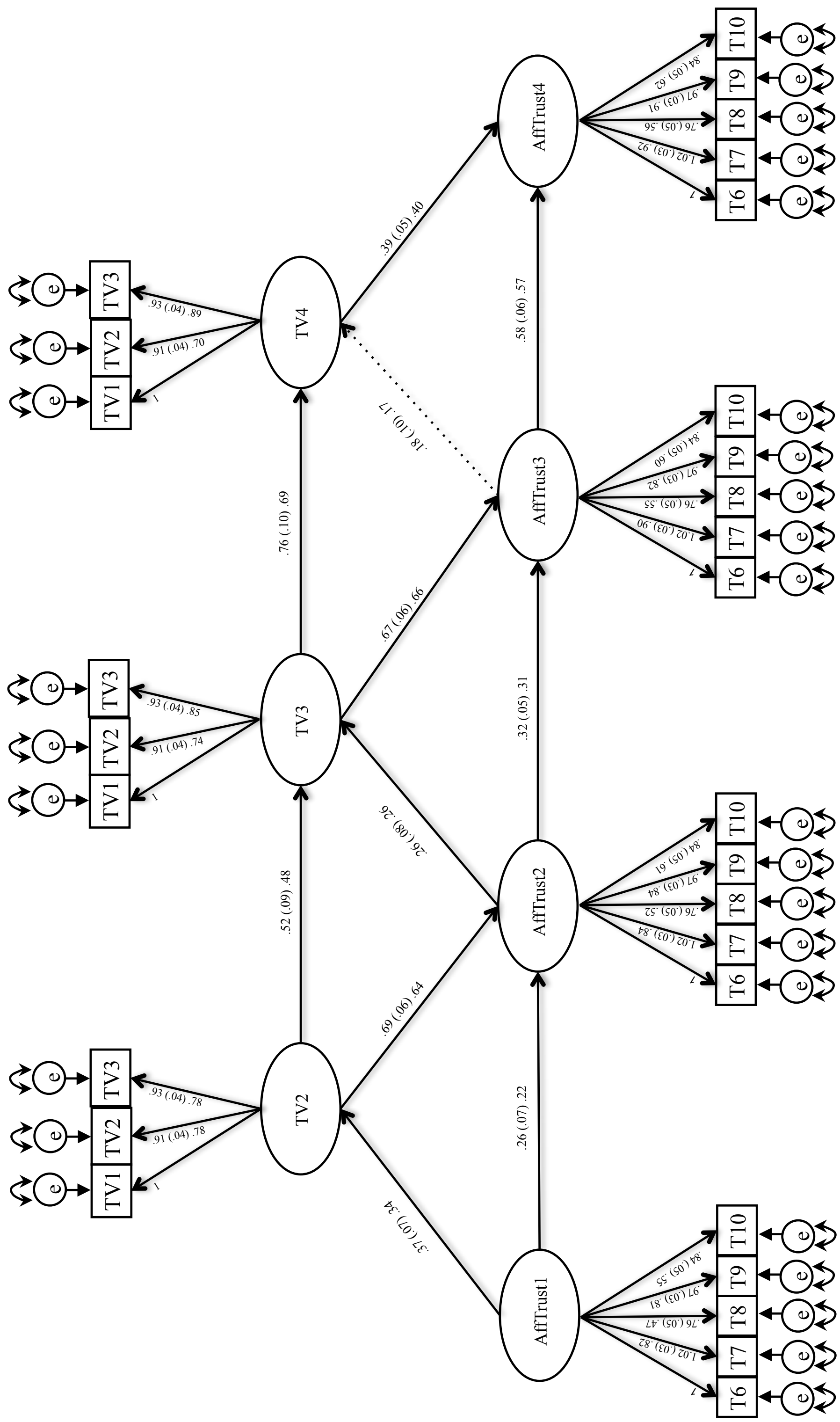

Figure 2. Model AV - Affective Trust with Team Viability. All errors for identical items correlated across time periods. All factor loadings for identical items constrained across time periods. Parameters estimates reported as: Raw (Raw SE) Standardized. Model fit: $X^2(343) = 749.53$, $p<.05$; RMSEA [90%CI] = .06[.06 .07]; CFI = .94; TLI = .93; SRMR = .07

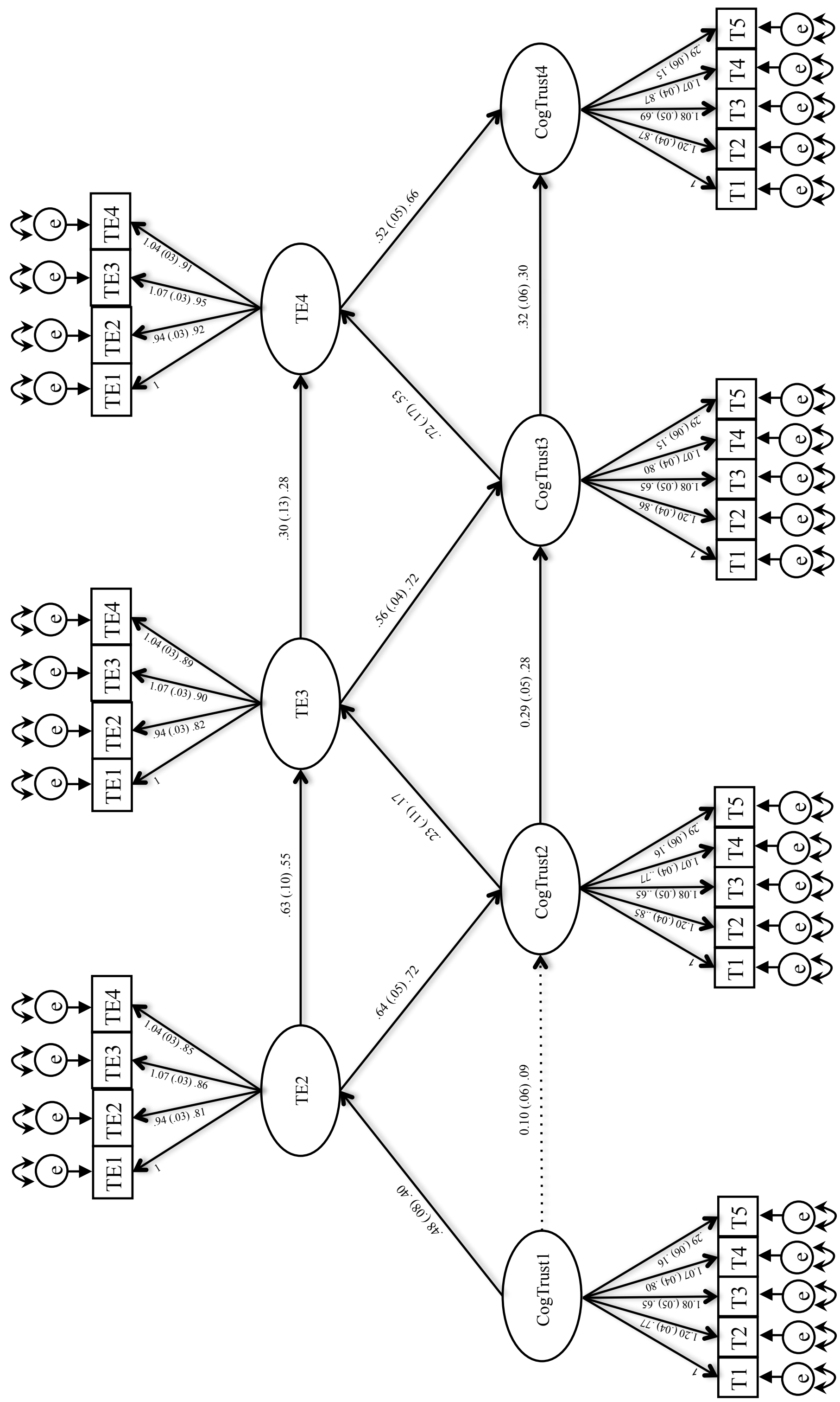

Figure 3. Model CE - Cognitive Trust with Team Efficacy. All errors for identical items correlated across time periods. All factor loadings for identical items constrained across time periods. Parameters estimates reported as: Raw (Raw SE) Standardized. Model fit: $X^2(429) = 702.59$, $p<.05$; RMSEA [90%CI] = .05[.04 .05]; CFI = .97; TLI = .96; SRMR = .06

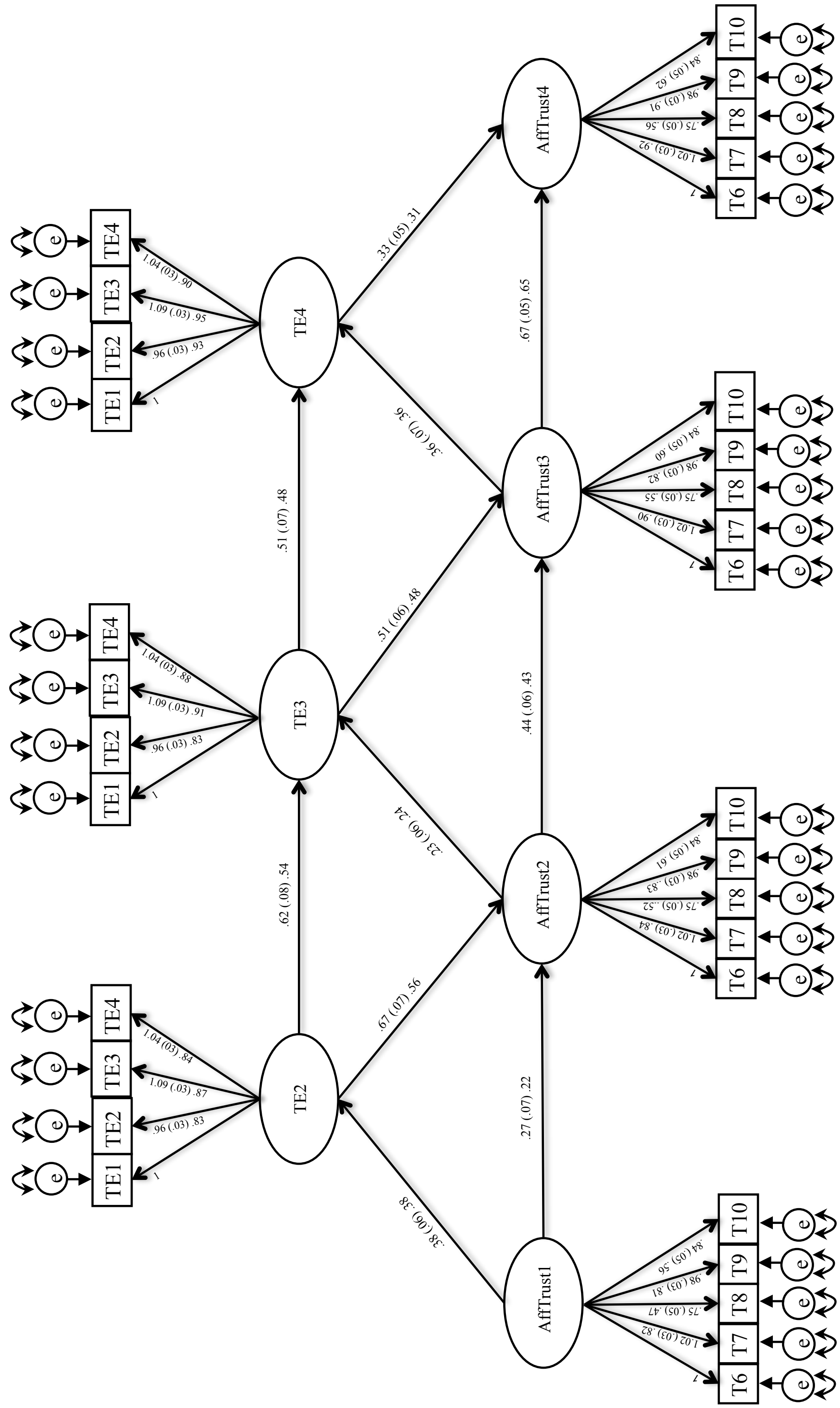

Figure 4. Model AE - Affective Trust with Team Efficacy. All errors for identical items correlated across time periods. All factor loadings for identical items constrained across time periods. Parameters estimates reported as: Raw (Raw SE) Standardized. Model fit: $X^2(429) = 908.44$, $p<.05$; RMSEA [90%CI] = .06[.06 .07]; CFI = .95; TLI = .94; SRMR = .07

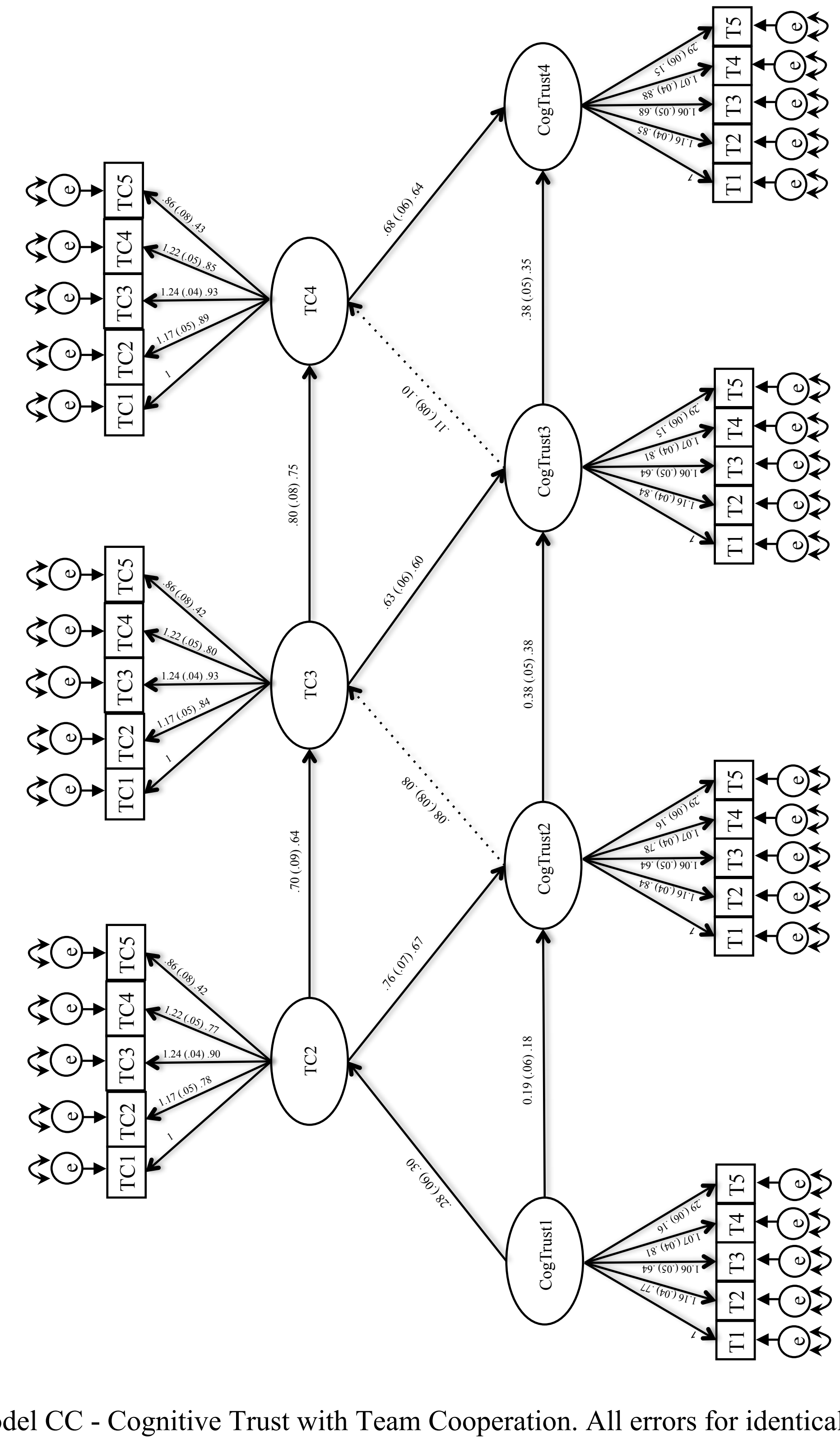

Figure 5. Model CC - Cognitive Trust with Team Cooperation. All errors for identical items correlated across time periods. All factor loadings for identical items constrained across time periods. Parameters estimates reported as: Raw (Raw SE) Standardized. Model fit: $X^2(524) = 979.87$, $p<.05$; RMSEA [90%CI] = .05[.05 .06]; CFI = .94; TLI = .94; SRMR = .07

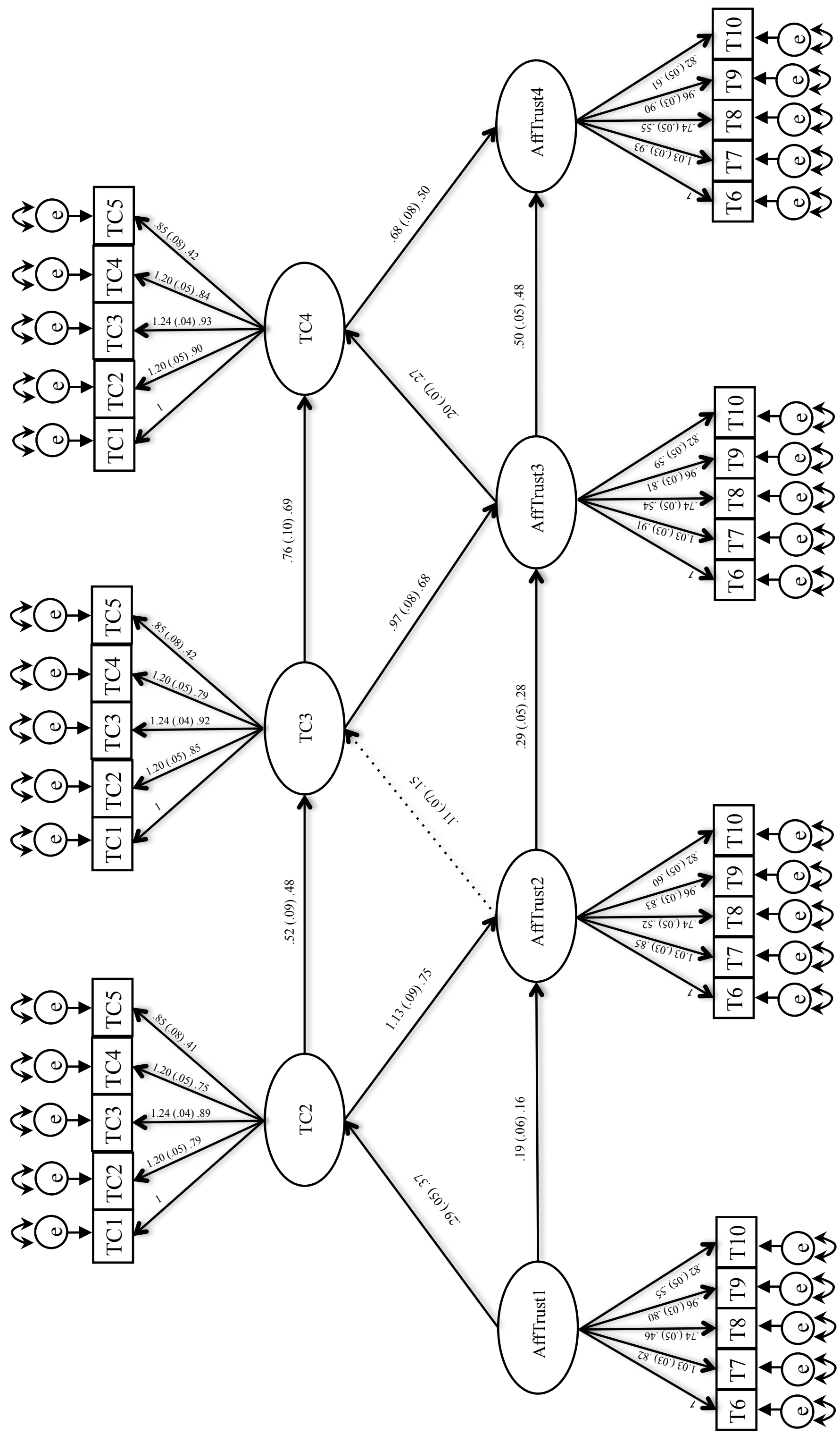

Figure 6. Model AC - Affective Trust with Team Cooperation. All errors for identical items correlated across time periods. All factor loadings for identical items constrained across time periods. Parameters estimates reported as: Raw (Raw SE) Standardized. Model fit: $X^2(524) = 1159.18$, $p<.05$; RMSEA [90%CI] = .06[.06 .07]; CFI = .93; TLI = .92; SRMR = .07

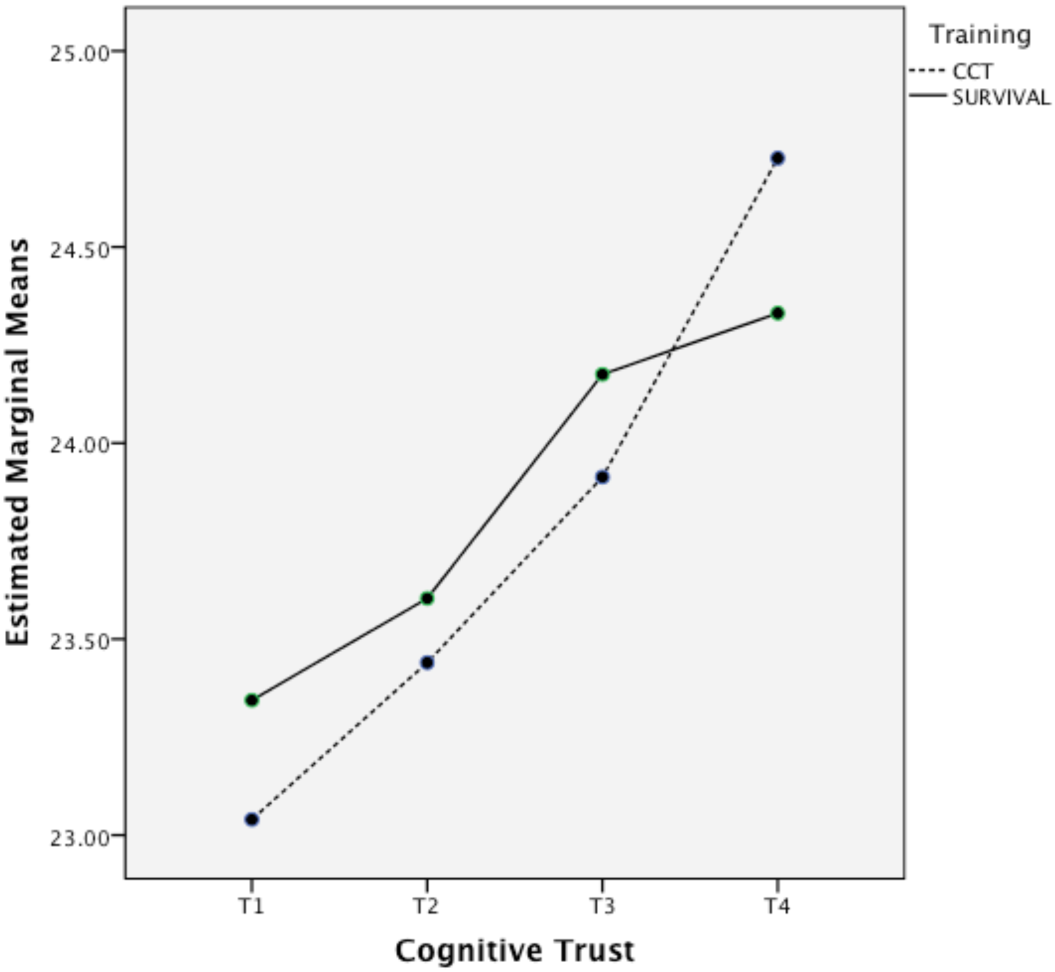

Figure 7. Changes in cognitive trust over time, by training. See Table 11 for ANOVA statistics.

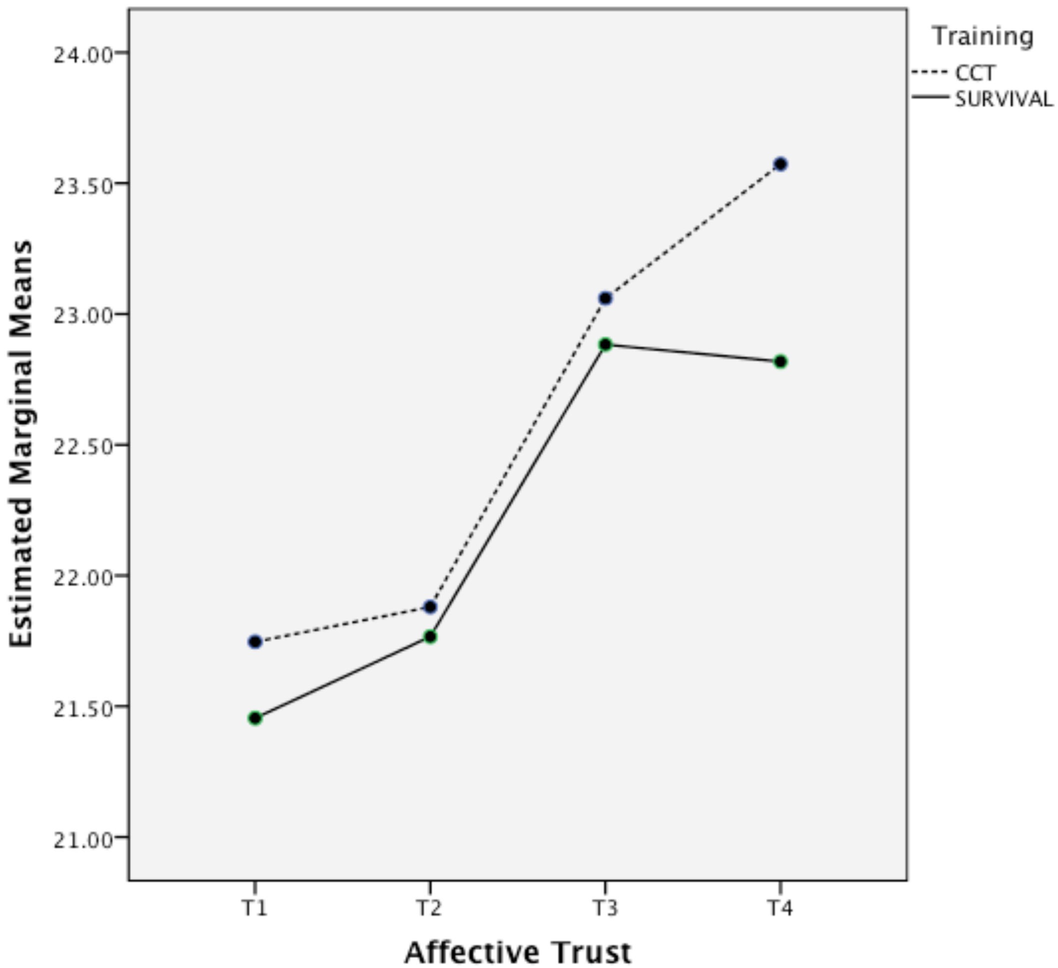

Figure 8. Changes in affective trust over time, by training. See Table 11 for ANOVA statistics.

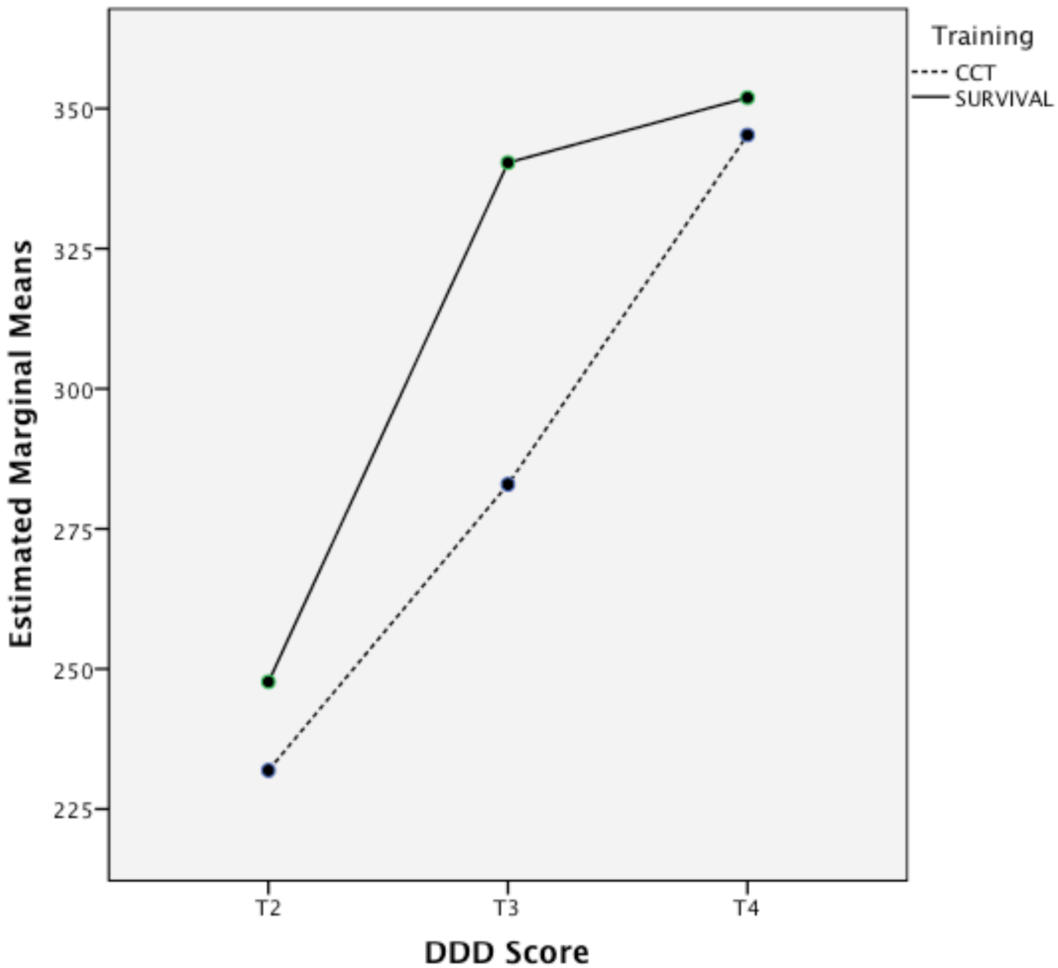

Figure 9. Changes in DDD scores over time, by training. See Table 11 for ANOVA statistics.

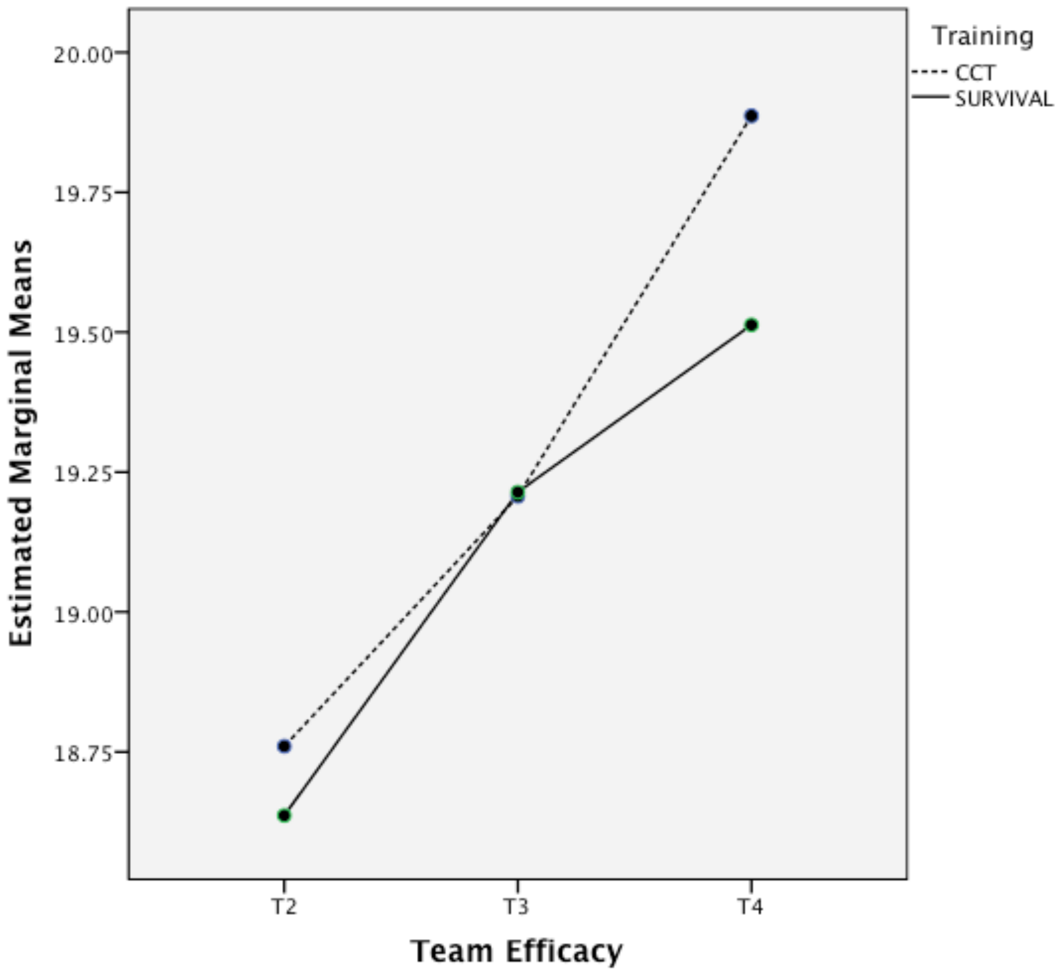

Figure 10. Changes in team efficacy over time, by training. See Table 11 for ANOVA statistics.

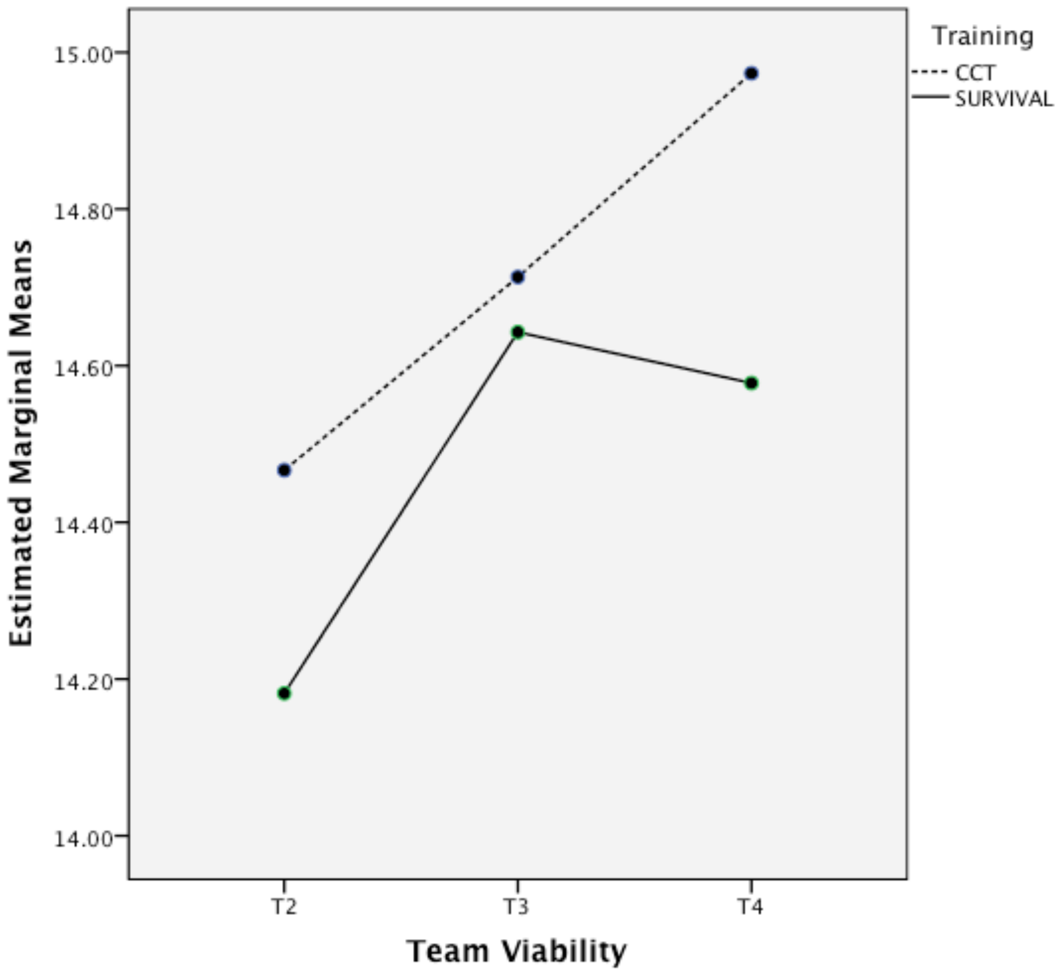

Figure 11. Changes in team viability over time, by training. See Table 11 for ANOVA statistics.

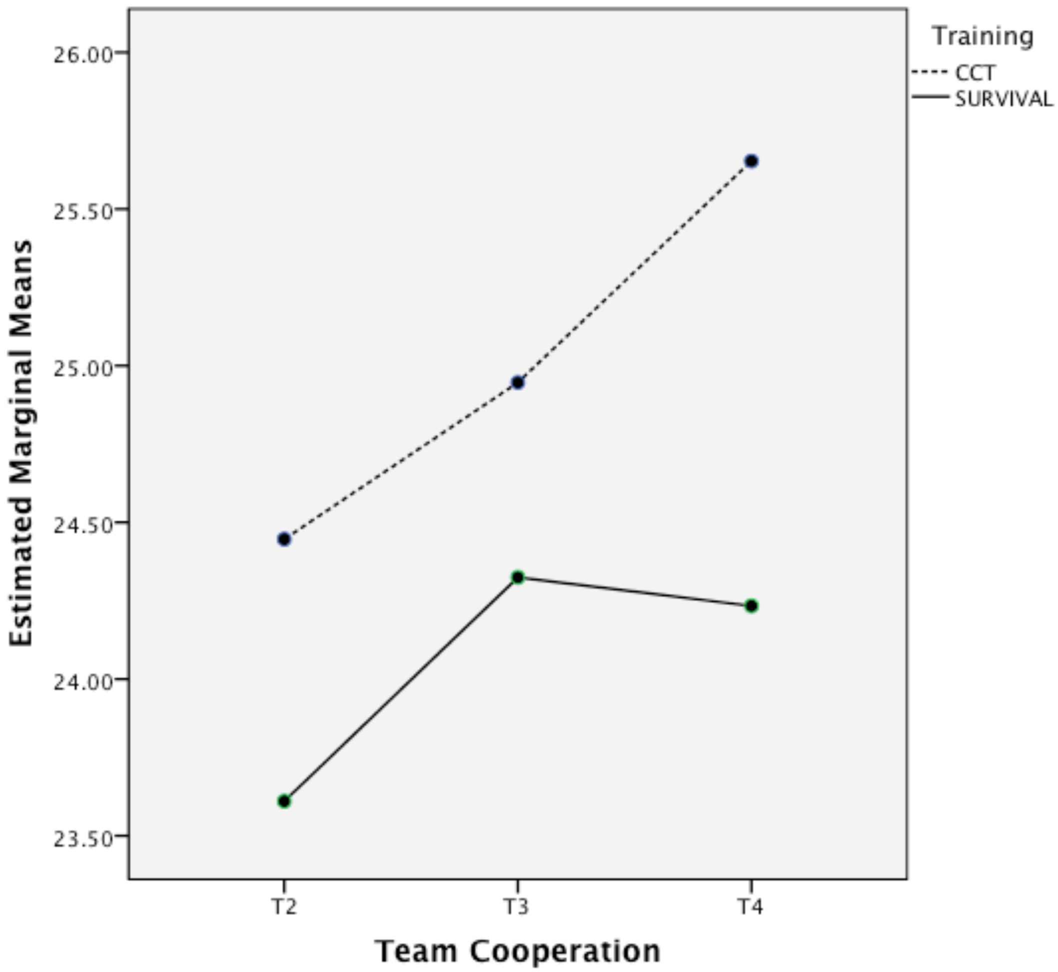

Figure 12. Changes in team cooperation over time, by training. See Table 11 for ANOVA statistics.

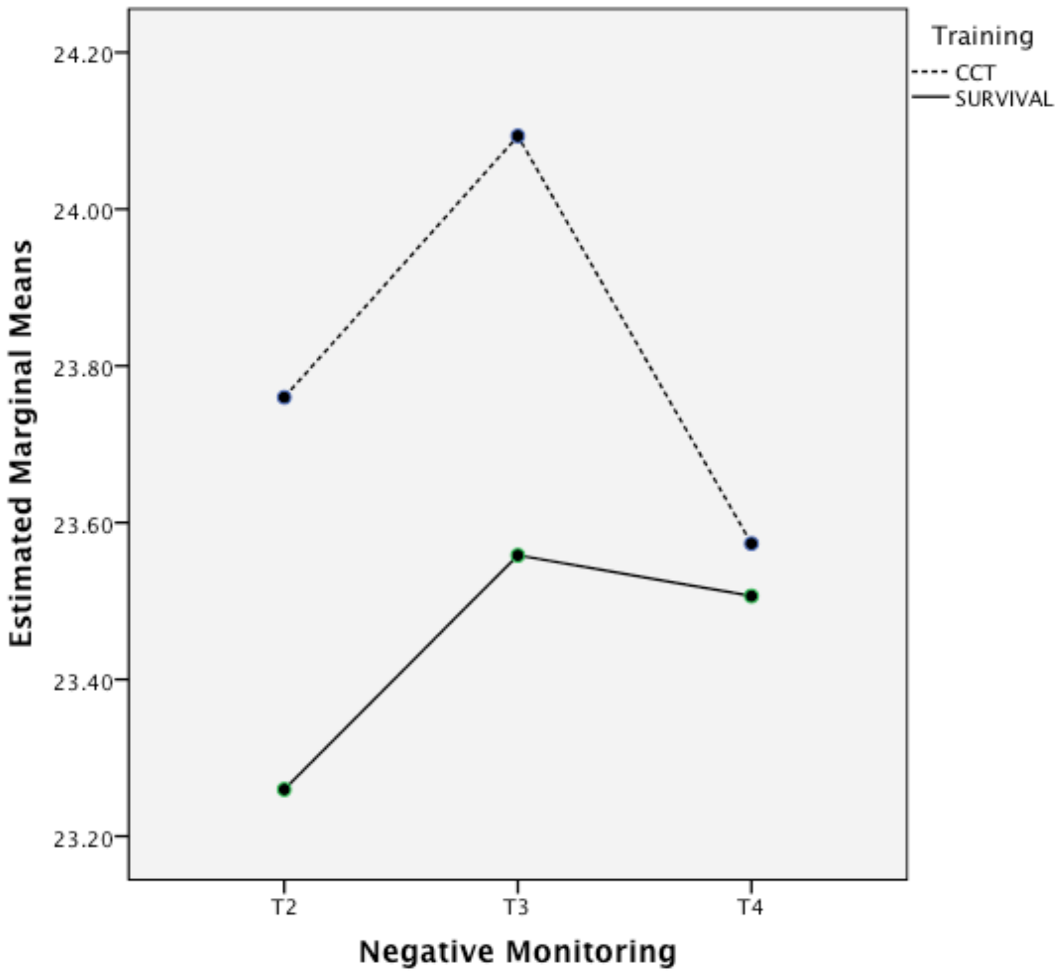

Figure 13. Changes in negative monitoring over time, by training. See Table 11 for ANOVA statistics.

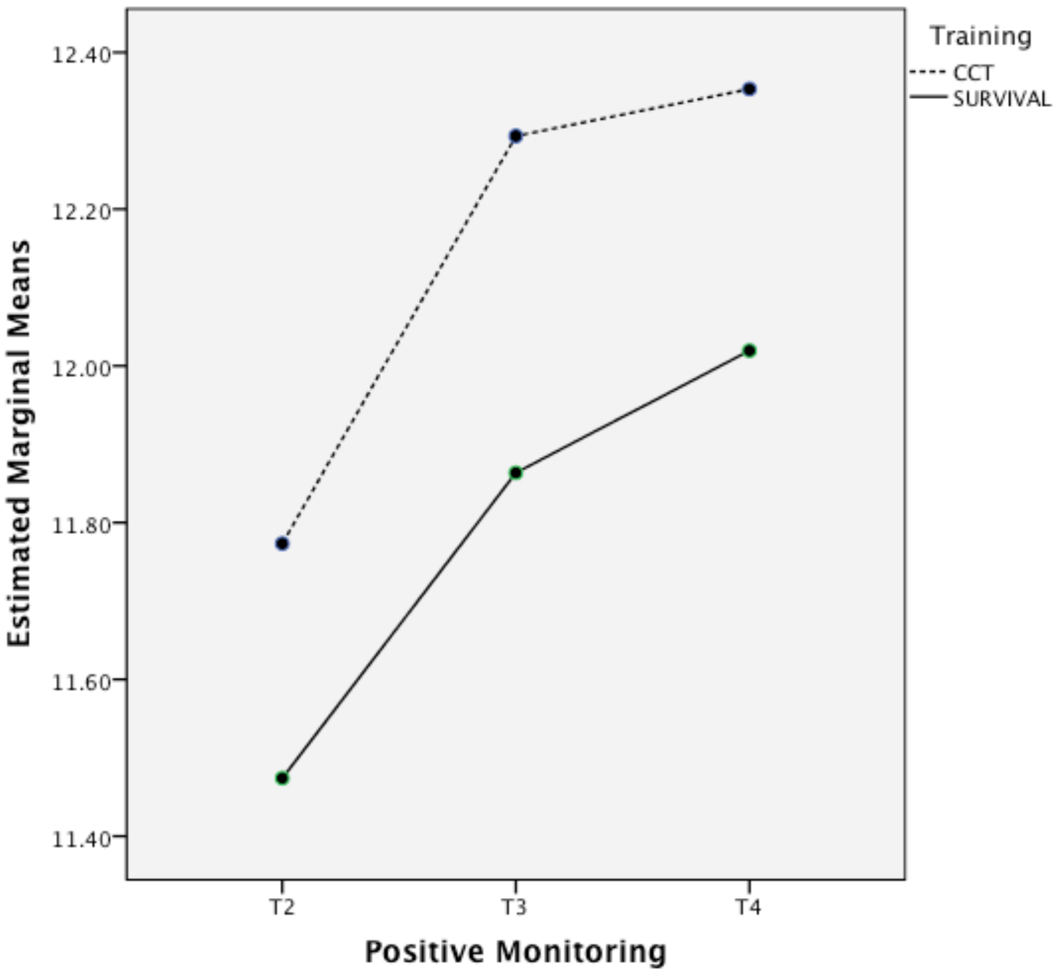

Figure 14. Changes in positive monitoring over time, by training. See Table 11 for ANOVA statistics.

Table 1
Study Timeline

Activities (in order)	**Measure Name**
Consent	
DDD Training	
DDD Practice Mission	
CCT/Control Training	CCT Quiz
Trust Measure	Trust 1 (Cognitive and Affective)
DDD Mission 1	DDD Score
Effectiveness Measure	Team Viability 2, Team Efficacy 2, Team Cooperation 2
Monitoring Measure	Monitoring 2
Trust Measure	Trust 2 (Cognitive and Affective)
DDD Mission 2	DDD Score
Effectiveness Measure	Team Viability 3, Team Efficacy 3, Team Cooperation 3
Monitoring Measure	Monitoring 3
Trust Measure	Trust 3 (Cognitive and Affective)
DDD Mission 3	DDD Score
Effectiveness Measure	Team Viability 4, Team Efficacy 4, Team Cooperation 4
Monitoring Measure	Monitoring 4
Trust Measure	Trust 4 (Cognitive and Affective)
Personality	Trust Agreeableness, Conscientiousness
Demographics	

Table 2
Descriptive statistics

Measure	Items	α	N	Min	Max	Mean	SD	N	Min	Max	Mean	SD
			CCT					Control				
Trust T1	10	0.85	150	1.90	6.00	4.48	0.73	154	1.30	6.00	4.48	0.76
Trust T2	10	0.86	150	2.10	6.00	4.53	0.85	154	2.10	5.90	4.54	0.79
Trust T3	10	0.87	150	1.80	6.00	4.70	0.87	154	1.80	6.00	4.71	0.85
Trust T4	10	0.89	150	1.20	6.00	4.83	0.87	154	1.10	6.00	4.71	0.92
Cog Trust T1	5	0.75	150	1.80	6.00	4.61	0.74	154	1.40	6.00	4.67	0.81
Cog Trust T2	5	0.76	150	2.00	6.00	4.69	0.83	154	2.60	6.00	4.72	0.82
Cog Trust T3	5	0.76	150	2.40	6.00	4.78	0.85	154	2.20	6.00	4.84	0.84
Cog Trust T4	5	0.77	150	1.20	6.00	4.95	0.86	154	1.20	6.00	4.87	0.89
Aff Trust T1	5	0.81	150	2.00	6.00	4.35	0.86	154	1.00	6.00	4.29	0.91
Aff Trust T2	5	0.85	150	1.60	6.00	4.38	1.05	154	1.00	6.00	4.35	1.04
Aff Trust T3	5	0.87	150	1.20	6.00	4.61	1.05	154	1.20	6.00	4.58	1.10
Aff Trust T4	5	0.89	150	1.00	6.00	4.71	1.06	154	1.00	6.00	4.56	1.14
Mon T2	10	0.82	150	1.62	5.24	3.66	0.68	154	1.60	5.62	3.57	0.76
Mon T3	10	0.86	150	1.62	5.19	3.77	0.78	154	1.07	6.00	3.66	0.97
Mon T4	10	0.88	150	1.24	5.64	3.74	0.89	154	1.07	6.00	3.68	1.05
PosMon T2	3	0.63	150	1.29	5.14	3.39	0.81	154	1.00	6.00	3.32	0.90
PosMon T3	3	0.76	150	1.14	5.43	3.44	0.89	154	1.00	6.00	3.37	1.04
PosMon T4	3	0.81	150	1.00	5.43	3.37	1.00	154	1.00	6.00	3.36	1.13
NegMon T2	7	0.81	150	1.67	6.00	3.92	0.81	154	1.33	5.67	3.82	0.87
NegMon T3	7	0.83	150	1.67	5.67	4.10	0.90	154	1.00	6.00	3.95	1.12
NegMon T4	7	0.85	150	1.00	6.00	4.12	0.98	154	1.00	6.00	4.01	1.19
TV T2	3	0.86	150	1.67	6.00	4.82	0.96	154	2.00	6.00	4.73	0.97
TV T3	3	0.87	150	1.00	6.00	4.90	1.02	154	1.00	6.00	4.88	1.09
TV T4	3	0.85	150	1.00	6.00	4.99	1.06	154	1.00	6.00	4.86	1.19
TC T2	5	0.82	150	2.60	6.00	4.89	0.79	154	2.40	6.00	4.72	0.84
TC T3	5	0.83	150	2.20	6.00	4.99	0.82	154	1.20	6.00	4.86	0.91
TC T4	5	0.85	150	1.60	6.00	5.13	0.85	154	1.00	6.00	4.85	0.96
TE T2	4	0.91	150	1.50	6.00	4.69	0.91	154	2.25	6.00	4.66	0.91
TE T3	4	0.92	150	1.00	6.00	4.80	1.06	154	1.50	6.00	4.80	1.00
TE T4	4	0.95	150	1.00	6.00	4.97	1.10	154	1.00	6.00	4.88	1.08
DDD T2	1	-	147	0.0	750.0	230.7	168.4	151.0	0.0	665.0	245.1	153.9
DDD T3	1	-	147	0.0	695.0	282.2	158.1	151.0	0.0	840.0	340.2	180.7
DDD T4	1	-	144	0.0	825.0	345.3	187.4	154.0	0.0	880.0	350.9	185.8
Pers. Trust	10	0.86	150	2.10	5.00	3.66	0.60	154	1.40	5.00	3.54	0.68
Pers. Consc.	10	0.86	150	1.70	5.00	3.71	0.61	154	1.40	5.00	3.79	0.72
DDD Quiz	8	-	150	4.00	8.00	7.48	0.82	-	-	-	-	-

Note. T1 = Time 1, T2 = Time 2, T3 = Time 4; Cog Trust = Cognitive Trust; Aff Trust = Affective Trust; Mon = Monitoring; PosMon = Positive Monitoring; NegMon = Negative Monitoring; TV = Team Viability; TC = Team Cooperation; TE = Team Efficacy; DDD = DDD scenario score; Pers. = Personality

Table 3
CCT Correlation Matrix

	Trust T1	Trust T2	Trust T3	Trust T4	Cog Trust T1	Cog Trust T2	Cog Trust T3	Cog Trust T4	Aff Trust T1	Aff Trust T2	Aff Trust T3	Aff Trust T4	Mon T2
Trust T1	-												
Trust T2	.49**	-											
Trust T3	.31**	.77**	-										
Trust T4	.23**	.68**	.86**	-									
Cog Trust T1	.89**	.42**	.22**	.15	-								
Cog Trust T2	.43**	.88**	.64**	.53**	.48**	-							
Cog Trust T3	.26**	.70**	.89**	.74**	.25**	.72**	-						
Cog Trust T4	.18*	.59**	.75**	.89**	.18*	.58**	.79**	-					
Aff Trust T1	.92**	.47**	.33**	.27**	.65**	.31**	.23**	.14	-				
Aff Trust T2	.46**	.93**	.74**	.68**	.30**	.64**	.57**	.50**	.52**	-			
Aff Trust T3	.30**	.70**	.93**	.81**	.17*	.48**	.67**	.60**	.36**	.76**	-		
Aff Trust T4	.24**	.64**	.80**	.93**	.10	.41**	.59**	.66**	.33**	.72**	.86**	-	
Mon T2	.20*	.27**	.28**	.30**	.10	.17*	.16	.19*	.25**	.31**	.33**	.33**	-
Mon T3	.08	.24**	.41**	.39**	.00	.11	.18*	.22**	.15	.31**	.52**	.47**	.63**
Mon T4	.12	.25**	.40**	.44**	.01	.10	.18*	.26**	.19*	.34**	.51**	.52**	.57**
PosMon T2	.23**	.24**	.21**	.24**	.15	.08	.05	.10	.26**	.32**	.31**	.31**	.42**
PosMon T3	.07	.14	.27**	.29**	-.01	-.04	.05	.13	.13	.26**	.40**	.38**	.33**
PosMon T4	.13	.10	.18*	.27**	.04	-.09	-.05	.08	.19*	.24**	.34**	.39**	.34**
NegMon T2	.25**	.29**	.27**	.29**	.15	.13	.10	.15	.29**	.37**	.37**	.37**	.68**
NegMon T3	.08	.19*	.34**	.36**	-.01	.01	.10	.17*	.15	.31**	.48**	.46**	.47**
NegMon T4	.14	.16	.27**	.35**	.03	-.04	.02	.15	.21*	.29**	.43**	.47**	.45**
TV T2	.38**	.74**	.63**	.61**	.32**	.66**	.56**	.53**	.37**	.68**	.58**	.58**	.21**
TV T3	.22**	.61**	.82**	.78**	.16*	.52**	.74**	.73**	.23**	.58**	.77**	.70**	.20*
TV T4	.10	.53**	.71**	.81**	.08	.46**	.63**	.78**	.09	.49**	.67**	.71**	.23**
TC T2	.41**	.79**	.65**	.59**	.37**	.69**	.59**	.50**	.38**	.74**	.59**	.57**	.32**
TC T3	.22**	.62**	.80**	.76**	.20*	.54**	.74**	.70**	.20*	.58**	.73**	.69**	.26**
TC T4	.16	.53**	.72**	.82**	.11	.43**	.63**	.74**	.17*	.53**	.68**	.76**	.27**
TE T2	.42**	.76**	.70**	.62**	.38**	.67**	.63**	.56**	.39**	.70**	.64**	.58**	.25**
TE T3	.22**	.59**	.82**	.74**	.19*	.53**	.78**	.72**	.22**	.53**	.72**	.64**	.16
TE T4	.09	.55**	.74**	.82**	.06	.48**	.68**	.79**	.11	.50**	.67**	.71**	.19*
DDD T2	-.06	-.14	-.13	-.17*	.00	-.08	-.14	-.23**	-.11	-.17*	-.10	-.10	-.03
DDD T3	.10	-.03	-.06	-.02	.14	.02	.00	-.03	.05	-.06	-.10	-.01	.09
DDD T4	-.04	-.03	-.06	-.01	-.03	.00	-.11	-.09	-.05	-.04	-.01	.06	.19*
Pers. Trust	.20*	.15	.15	.16	.13	.08	.15	.17*	.22**	.19*	.13	.12	.15
Pers. Agree.	.20*	.12	.12	.14	.14	.06	.10	.15	.21**	.15	.12	.11	.14
Pers. Consc.	.19*	.18*	.06	.08	.20*	.16	.04	.06	.15	.17*	.06	.08	.10

* Significant at $p < .05$
** Significant at $p < .01$

Table 3 (cont.)
CCT Correlation Matrix

	Mon T3	Mon T4	PosMon T2	PosMon T3	PosMon T4	NeMon T2	NeMon T3	NeMon T4	TV T2	TV T3	TV T4	TC T2	TC T3
Mon T3	-												
Mon T4	.83**	-											
PosMon T2	.44**	.56**	-										
PosMon T3	.53**	.60**	.73**	-									
PosMon T4	.46**	.59**	.64**	.79**	-								
NegMon T2	.57**	.64**	.95**	.70**	.64**	-							
NegMon T3	.75**	.75**	.72**	.96**	.77**	.74**	-						
NegMon T4	.63**	.78**	.68**	.81**	.97**	.70**	.84**	-					
TV T2	.23**	.21*	.17*	.12	.09	.21**	.17*	.14	-				
TV T3	.37**	.35**	.14	.24**	.16*	.19*	.31**	.24**	.68**	-			
TV T4	.36**	.36**	.15	.26**	.20*	.20*	.33**	.27**	.63**	.82**	-		
TC T2	.29**	.29**	.19*	.09	.09	.26**	.17*	.16*	.71**	.57**	.51**	-	
TC T3	.40**	.37**	.17*	.22**	.10	.23**	.30**	.19*	.61**	.80**	.71**	.69**	-
TC T4	.39**	.41**	.13	.20*	.15	.20*	.29**	.25**	.56**	.74**	.79**	.60**	.83**
TE T2	.31**	.30**	.33**	.23**	.16	.35**	.28**	.22**	.80**	.64**	.57**	.72**	.63**
TE T3	.32**	.31**	.16*	.25**	.13	.18*	.30**	.20*	.56**	.80**	.67**	.51**	.77**
TE T4	.31**	.35**	.17*	.26**	.20*	.20*	.31**	.27**	.53**	.72**	.84**	.48**	.72**
DDD T2	.04	.05	.02	.00	.01	.00	.01	.03	-.03	-.11	-.11	-.04	-.07
DDD T3	.02	.05	-.04	-.04	.04	.00	-.02	.05	.00	-.10	-.07	.12	.00
DDD T4	.10	.16	.02	.08	.10	.09	.10	.13	.03	-.06	-.03	.04	-.03
Pers. Trust	.13	.12	-.01	-.02	-.04	.04	.02	.01	.18*	.19*	.17*	.18*	.17*
Pers. Agree.	.09	.09	.05	-.01	.05	.09	.03	.07	.12	.13	.14	.14	.10
Pers. Consc.	.09	.14	.06	.04	.07	.08	.06	.10	.09	.08	.04	.15	.03

	TC T4	TE T2	TE T3	TE T4	DDD T2	DDD T3	DDD T4	PT	PA	PC
TC T4	-									
TE T2	.52**	-								
TE T3	.68**	.70**	-							
TE T4	.77**	.60**	.74**	-						
DDD T2	-.09	-.05	-.15	-.13	-					
DDD T3	.05	.02	-.06	-.08	.26**	-				
DDD T4	.01	-.03	-.14	-.05	.29**	.27**	-			
Pers. Trust	.24**	.12	.18*	.12	-.12	-.11	.03	-		
Pers. Agree.	.21*	.15	.14	.12	-.11	-.08	-.02	.60**	-	
Pers. Consc.	.05	.18*	.10	.04	-.17*	-.10	-.01	.17*	.23**	-

* Significant at $p < .05$
** Significant at $p < .01$

Table 4
Control Correlation Matrix

	Trust T1	Trust T2	Trust T3	Trust T4	Cog Trust T1	Cog Trust T2	Cog Trust T3	Cog Trust T4	Aff Trust T1	Aff Trust T2	Aff Trust T3	Aff Trust T4	Mon T2
Trust T1	-												
Trust T2	.38**	-											
Trust T3	.42**	.67**	-										
Trust T4	.27**	.60**	.85**	-									
Cog Trust T1	.86**	.32**	.34**	.20*	-								
Cog Trust T2	.29**	.80**	.49**	.39**	.38**	-							
Cog Trust T3	.29**	.60**	.83**	.68**	.34**	.65**	-						
Cog Trust T4	.22**	.57**	.75**	.87**	.25**	.57**	.80**	-					
Aff Trust T1	.89**	.34**	.40**	.27**	.55**	.13	.19*	.14	-				
Aff Trust T2	.34**	.88**	.62**	.59**	.18*	.42**	.40**	.41**	.41**	-			
Aff Trust T3	.42**	.57**	.90**	.78**	.26**	.26**	.51**	.54**	.47**	.65**	-		
Aff Trust T4	.26**	.51**	.77**	.92**	.12	.18*	.46**	.61**	.32**	.62**	.83**	-	
Mon T2	.24**	.29**	.32**	.29**	.13	.03	.10	.10	.28**	.41**	.42**	.39**	-
Mon T3	.18*	.18*	.42**	.42**	.12	.02	.20*	.25**	.20*	.26**	.50**	.48**	.65**
Mon T4	.11	.20*	.42**	.50**	.05	.02	.23**	.31**	.13	.29**	.48**	.56**	.54**
PosMon T2	.18*	.18*	.25**	.26**	.09	-.07	.00	.06	.22**	.32**	.38**	.38**	.46**
PosMon T3	.09	.09	.23**	.27**	-.01	-.13	-.02	.04	.16	.24**	.37**	.40**	.44**
PosMon T4	.03	.07	.16	.24**	-.06	-.12	-.04	.03	.11	.20*	.28**	.36**	.32**
NegMon T2	.22**	.24**	.31**	.31**	.11	-.05	.04	.08	.27**	.40**	.45**	.43**	.70**
NegMon T3	.13	.13	.32**	.35**	.03	-.09	.06	.12	.19*	.27**	.45**	.46**	.55**
NegMon T4	.06	.12	.26**	.35**	-.03	-.09	.04	.12	.13	.25**	.37**	.46**	.43**
TV T2	.21*	.65**	.52**	.47**	.22**	.60**	.52**	.51**	.15	.51**	.40**	.35**	.15
TV T3	.19*	.50**	.82**	.71**	.14	.44**	.76**	.71**	.19*	.41**	.67**	.59**	.19*
TV T4	.16*	.48**	.71**	.80**	.15	.41**	.64**	.78**	.13	.39**	.60**	.67**	.17*
TC T2	.32**	.66**	.55**	.47**	.30**	.52**	.49**	.46**	.26**	.58**	.46**	.39**	.19*
TC T3	.26**	.42**	.77**	.67**	.22**	.33**	.65**	.62**	.23**	.37**	.69**	.59**	.22**
TC T4	.19*	.45**	.72**	.81**	.17*	.35**	.63**	.76**	.16*	.40**	.62**	.71**	.15
TE T2	.28**	.57**	.44**	.37**	.27**	.53**	.43**	.40**	.23**	.44**	.34**	.28**	.09
TE T3	.27**	.52**	.74**	.61**	.18*	.40**	.69**	.60**	.29**	.48**	.61**	.51**	.16*
TE T4	.10	.50**	.71**	.77**	.04	.42**	.64**	.73**	.13	.42**	.60**	.67**	.16*
DDD T2	.01	.06	.03	.12	.04	.05	.06	.14	-.03	.06	-.01	.09	.03
DDD T3	-.04	.16	.17*	.23**	.02	.11	.21**	.24**	-.09	.15	.09	.18*	.16*
DDD T4	-.05	.02	.03	.09	.05	.05	.07	.09	-.14	.00	-.02	.07	.02
Pers. Trust	.21**	.15	.09	.22**	.23**	.04	.06	.17*	.15	.19*	.08	.22**	-.07
Pers. Agree.	.29**	.22**	.18*	.20*	.33**	.24**	.21**	.23**	.19*	.14	.11	.13	-.04
Pers. Consc.	.10	.07	.15	.16*	.13	.03	.11	.12	.05	.08	.15	.17*	.09

* Significant at $p < .05$
** Significant at $p < .01$

Table 4 (cont.)
Control Correlation Matrix

Text	Mon T3	Mon T4	PosMon T2	PosMon T3	PosMon T4	NeMon T2	NeMon T3	NeMon T4	TV T2	TV T3	TV T4	TC T2	TC T3
Mon T3	-												
Mon T4	.78**	-											
PosMon T2	.53**	.49**	-										
PosMon T3	.61**	.58**	.76**	-									
PosMon T4	.50**	.64**	.72**	.85**	-								
NegMon T2	.64**	.57**	.96**	.75**	.68**	-							
NegMon T3	.80**	.71**	.75**	.96**	.81**	.78**	-						
NegMon T4	.64**	.82**	.71**	.83**	.97**	.71**	.85**	-					
TV T2	.14	.16*	.13	.06	.01	.15	.09	.06	-				
TV T3	.33**	.34**	.17*	.17*	.09	.20*	.24**	.19*	.60**	-			
TV T4	.36**	.39**	.23**	.22**	.19*	.24**	.29**	.27**	.46**	.73**	-		
TC T2	.08	.15	.08	-.04	-.06	.13	.00	.00	.77**	.54**	.43**	-	
TC T3	.39**	.37**	.17*	.16*	.11	.21**	.26**	.20*	.51**	.81**	.64**	.57**	-
TC T4	.33**	.40**	.15	.15	.16	.17*	.23**	.25**	.49**	.69**	.84**	.54**	.74**
TE T2	.02	.13	.15	.04	.04	.15	.03	.07	.73**	.49**	.34**	.68**	.38**
TE T3	.28**	.30**	.17*	.12	.11	.19*	.19*	.18*	.57**	.74**	.57**	.56**	.72**
TE T4	.30**	.42**	.23**	.20*	.22**	.24**	.25**	.31**	.48**	.68**	.82**	.46**	.60**
DDD T2	-.02	.02	.01	-.01	-.04	.02	-.02	-.03	-.02	.05	.14	.03	.03
DDD T3	.19*	.13	.16*	.15	.08	.18*	.17*	.11	.22**	.20*	.24**	.22**	.15
DDD T4	.12	.09	.05	.06	-.01	.05	.09	.02	.10	.04	.12	.08	-.03
Pers. Trust	.00	.06	.12	.14	.12	.07	.11	.11	.13	.08	.16*	.13	.11
Pers. Agree.	.04	.03	.01	.10	.02	-.01	.09	.03	.17*	.16	.17*	.21**	.16*
Pers. Consc.	.17*	.27**	.13	.13	.16*	.14	.16*	.21**	.06	.15	.16*	.15	.24**

	TC T4	TE T2	TE T3	TE T4	DDD T2	DDD T3	DDD T4	PT	PA	PC
TC T4	-									
TE T2	.34**	-								
TE T3	.61**	.62**	-							
TE T4	.76**	.50**	.70**	-						
DDD T2	.12	-.01	-.01	.07	-					
DDD T3	.24**	.16	.15	.18*	.30**	-				
DDD T4	.10	.03	-.05	.11	.29**	.28**	-			
Pers. Trust	.19*	.05	.02	.10	.03	.18*	.04	-		
Pers. Agree.	.17*	.06	.08	.10	.02	.08	.11	.67**	-	
Pers. Consc.	.22**	.17*	.25**	.22**	.02	.01	-.02	.12	.19*	-

* Significant at $p < .05$
** Significant at $p < .01$

Table 5

Correlations between DDD scores and subjective team effectiveness measures

		Team Viability	Team Cooperation	Team Efficacy
			Mission 1	
Individual	DDD Score	-0.03	-0.01	-0.03
Team	DDD Score	-0.04	-0.07	-0.02
			Mission 2	
Individual	DDD Score	0.07	0.07	0.05
Team	DDD Score	0.11	0.07	0.17
			Mission 3	
Individual	DDD Score	0.05	0.06	0.03
Team	DDD Score	0.06	-0.02	0.18

Note. No correlations significant

Table 6

Confirmatory factor analyses for trust items

Time	Factors	χ2	df	p	RMSEA [90% CI]	CFI	TLI	SRMR
1	One	199.70	35	0.00	0.12 [0.11 0.14]	0.87	0.83	0.06
1	Two	88.80	34	0.00	0.07 [0.05 0.09]	0.96	0.94	0.04
2	One	317.36	35	0.00	0.16 [0.15 0.18]	0.81	0.75	0.08
2	Two	116.13	34	0.00	0.09 [0.07 0.11]	0.94	0.93	0.05
3	One	340.71	35	0.00	0.17 [0.15 0.19]	0.83	0.78	0.07
3	Two	163.09	34	0.00	0.11 [0.10 0.13]	0.93	0.90	0.05
4	One	279.36	35	0.00	0.15 [0.14 0.17]	0.88	0.85	0.06
4	Two	117.32	34	0.00	0.09 [0.07 0.11]	0.96	0.95	0.05

Note. “One” refers to fit for a single factor solution. “Two” refers to fit for a correlated cognitive and affective trust two-factor solution.

Table 7
Confirmatory factor analyses for monitoring items

Time	Factors	χ2	df	p	RMSEA [90% CI]	CFI	TLI	SRMR	Δχ2	Δχ2 df	Δχ2 p
2	One	217.68	35	0.00	0.13 [0.12 0.15]	0.85	0.81	0.08			
2	Two	164.92	34	0.00	0.11 [0.10 0.13]	0.89	0.86	0.07			
3	One	249.87	35	0.00	0.14 [0.13 0.16]	0.86	0.82	0.08			
3	Two	158.81	34	0.00	0.11 [0.09 0.13]	0.92	0.89	0.07			
3*	Two	76.76	13	0.00	0.13 [0.10 0.16]	0.95	0.92	0.06	82.05	21	0.00
4	One	296.72	35	0.00	0.16 [0.14 0.17]	0.87	0.83	0.07			
4	Two	186.72	34	0.00	0.12 [0.11 0.14]	0.92	0.90	0.07			
4*	Two	68.28	13	0.00	0.12 [0.09 0.15]	0.97	0.95	0.05	118.44	21	0.00

* Two-factor monitoring model validation after items loading on a third factor were deleted based on an EFA

Table 8
Exploratory factor analysis for monitoring items

	Factor		
Item	Neg	Pos	3
MP2_1		0.48	
MP2_2		0.79	
MP2_3		0.51	
MN2_1	0.62		
MN2_2			0.38
MN2_3	0.92		
MN2_4	1.00		
MN2_5	0.80		
MN2_6			0.55
MN2_7			0.65

Note. Factor pattern matrix. Principal axis factoring with Promax rotation. Loadings <0.28 suppressed.

Table 9

Confirmatory factor analyses for team effectiveness items

Time	**χ2**	**df**	**p**	**RMSEA [90% CI]**	**CFI**	**TLI**	**SRMR**
One-Factor Team Cooperation (TC)							
2	7.09	5	0.21	0.04 [0.00 0.09]	1.00	0.99	0.02
3	15.30	5	0.01	0.08 [0.04 0.13]	0.99	0.98	0.02
4	28.03	5	0.00	0.12 [0.08 0.17]	0.98	0.96	0.02
One-Factor Team Efficacy (TE)							
2	3.68	2	0.16	0.05 [0.00 0.14]	1.00	0.99	0.01
3	6.96	2	0.03	0.09 [0.02 0.17]	1.00	0.98	0.01
4	2.61	2	0.27	0.03 [0.00 0.12]	1.00	1.00	0.00
One-Factor Team Viability (TV)*							
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
One-Factor TC, TE, TV							
2	363.87	54	0.00	0.14 [0.12 0.15]	0.88	0.85	0.05
3	374.99	54	0.00	0.14 [0.13 0.15]	0.89	0.87	0.05
4	519.72	54	0.00	0.17 [0.16 0.18]	0.88	0.85	0.05
Three-Factor TC, TE, TV							
2	170.04	51	0.00	0.09 [0.07 0.10]	0.95	0.94	0.04
3	146.82	51	0.00	0.08 [0.06 0.09]	0.97	0.96	0.03
4	201.30	51	0.00	.10 [0.08 0.11]	0.96	0.95	0.04

* Fit statistics not estimated due to model saturation.

Table 10
Fit statistics for trust-effectiveness models

Model	χ2	df	p	RMSEA [90% CI]	pclose	CFI	TLI	SRMR	Δχ2	Δχ2 df	Δχ2 p
Model CV: Cognitive Trust with Team Viability											
CCT Only	505.56	343	0.00	.06 [.05 .07]	0.16	0.95	0.94	0.08			
Control Only	518.82	343	0.00	.06 [.05 .07]	0.11	0.95	0.94	0.07			
Configural model (all free)	1038.36	693	0.00	.06 [.05 .06]	0.05	0.95	0.94	0.08			
Invariance of factor loadings	1048.95	699	0.00	.06 [.05 .06]	0.05	0.95	0.94	0.08	10.59	6.00	0.10
Invariance of paths	1071.12	710	0.00	.06 [.05 .07]	0.04	0.95	0.94	0.08	22.18	11.00	0.02
Combined	476.79	343	0.00	.04 [.03 .04]	1.00	0.98	0.98	0.06			
Model AV: Affective Trust with Team Viability											
CCT Only	604.92	343	0.00	.07 [.06 .08]	0.00	0.93	0.92	0.08			
Control Only	623.10	343	0.00	.07 [.06 .08]	0.00	0.92	0.91	0.08			
Configural Model (all free)	1243.29	693	0.00	.07 [.07 .08]	0.00	0.93	0.91	0.08			
Invariance of Factor Loadings	1255.85	699	0.00	.07 [.07 .08]	0.00	0.93	0.91	0.09	12.56	6.00	0.05
Invariance of Paths	1264.25	710	0.00	.07 [.07 .08]	0.00	0.93	0.92	0.09	8.41	11.00	0.68
Combined	749.53	343	0.00	.06 [.06 .07]	0.00	0.94	0.93	0.07			
Model CE: Cognitive Trust with Team Efficacy											
CCT Only	661.59	429	0.00	.06 [.05 .07]	0.04	0.95	0.94	0.09			
Control Only	664.18	429	0.00	.06 [.05 .07]	0.04	0.94	0.93	0.07			
Configural Model (all free)	1336.83	865	0.00	.06 [.05 .07]	0.01	0.94	0.94	0.08			
Invariance of Factor Loadings	1354.93	872	0.00	.06 [.05 .07]	0.00	0.94	0.93	0.08	18.10	7.00	0.01
Invariance of Paths	1365.11	883	0.00	.06 [.05 .07]	0.01	0.94	0.94	0.09	10.18	11.00	0.51
Combined	702.59	429	0.00	.05 [.04 .05]	0.87	0.97	0.96	0.06			
Model AE: Affective Trust with Team Efficacy											
CCT Only	772.21	429	0.00	.07 [.07 .08]	0.00	0.93	0.92	0.08			
Control Only	791.38	429	0.00	.07 [.07 .08]	0.00	0.92	0.91	0.08			
Configural Model (all free)	1576.29	865	0.00	.07 [.07 .08]	0.00	0.92	0.91	0.08			
Invariance of Factor Loadings	1593.14	872	0.00	.07 [.07 .08]	0.00	0.92	0.91	0.08	16.85	7.00	0.02
Invariance of Paths	1607.96	883	0.00	.07 [.07 .08]	0.00	0.92	0.91	0.09	14.83	11.00	0.19
Combined	908.44	429	0.00	.06 [.06 .07]	0.00	0.95	0.94	0.07			
Model CC: Cognitive Trust with Team Cooperation											
CCT Only	857.01	524	0.00	.07 [.06 .07]	0.00	0.92	0.91	0.08			
Control Only	947.22	524	0.00	.07 [.07 .08]	0.00	0.90	0.89	0.08			
Configural Model (all free)	1816.33	1055	0.00	.07 [.06 .07]	0.00	0.91	0.90	0.08			
Invariance of Factor Loadings	1827.07	1063	0.00	.07 [.06 .07]	0.00	0.91	0.90	0.09	10.74	8.00	0.22
Invariance of Paths	1855.74	1074	0.00	.07 [.06 .07]	0.00	0.91	0.90	0.10	28.67	11.00	0.00
Combined	979.87	524	0.00	.05 [.05 .06]	0.13	0.94	0.94	0.07			
Model TC: Affective Trust with Team Cooperation											
CCT Only	932.93	524	0.00	.07 [.07 .08]	0.00	0.92	0.90	0.08			
Control Only	1003.91	524	0.00	.08 [.07 .08]	0.00	0.90	0.88	0.08			
Configural Model (all free)	1951.01	1055	0.00	.08 [.07 .08]	0.00	0.91	0.89	0.08			
Invariance of Factor Loadings	1965.22	1063	0.00	.08 [.07 .08]	0.00	0.91	0.89	0.09	14.21	8.00	0.08
Invariance of Paths	1975.19	1074	0.00	.07 [.07 .08]	0.00	0.91	0.89	0.09	9.96	11.00	0.53
Combined	1159.18	524	0.00	.06 [.06 .07]	0.00	0.93	0.92	0.07			

Table 11
Repeated measures ANOVA statistics

Source	SS	df	MS	F	p	Partial Eta Squared	Post-Hoc w. Bonferroni
			Cognitive Trust				
CogTrust	314.89	3	104.96	12.23	0.00	0.04	T1=T2
Training	2.13	1	2.13	0.05	0.83	0.00	-
CogTrust x Training	24.05	3	8.02	0.93	0.42	0.00	-
			Affective Trust				
AffTrust	587.14	3	195.71	17.66	0.00	0.06	T1=T2; T3=T4
Training	34.01	1	34.01	0.47	0.50	0.00	-
AffTrust x Training	19.17	3	6.39	0.58	0.63	0.00	-
			Negative Monitoring				
NegMon	18.50	2	9.25	0.80	0.45	0.00	-
Training	30.76	1	30.76	0.27	0.60	0.00	-
NegMon x Training	10.34	2	5.17	0.45	0.64	0.00	-
			Positive Monitoring				
PosMon	54.22	2	27.11	9.16	0.00	0.03	T3=T4
Training	28.61	1	28.61	1.40	0.24	0.01	-
PosMon x Training	0.69	2	0.35	0.12	0.89	0.00	-
			Team Efficacy				
TE	152.50	2	76.25	12.92	0.00	0.04	*
Training	6.07	1	6.07	0.16	0.69	0.00	-
TE x Training	5.70	2	2.85	0.48	0.62	0.00	-
			Team Viability				
TV	34.29	2	17.15	4.91	0.01	0.02	*
Training	14.28	1	14.28	0.62	0.43	0.00	-
TV x Training	4.15	2	2.07	0.59	0.55	0.00	-
			Team Cooperation				
TC	131.78	2	65.89	10.30	0.00	0.03	T3=T4
Training	209.77	1	209.77	4.86	0.03	0.02	CCT>SURVIVAL
TV x Training	25.89	2	12.95	2.02	0.13	0.01	-
			DDD Scores				
DDD	1787001.27	2	893500.64	41.46	0.00	0.13	*
Training	106755.84	2	53377.92	2.48	0.09	0.01	-
DDD x Training	155033	1	155032.69	3.33	0.07	0.01	-

Note. Cognitive Trust and Affective Trust assessed at T1, T2, T3, T4. All other variables assessed at T2, T3, T4.
*All post-hoc comparison significant
- Omnibus test not significant
Unless otherwise indicated (e.g., T1=T2), all other post-hoc comparisons were significant.

Table 12
Correlations between monitoring and effectiveness, by group

	CCT				Control			
Time 1								
	M1Score	TV2	TC2	TE2	M1Score	TV2	TC2	TE2
M2	.00	.21**	.26**	.35**	.02	.15	.13	.15
MP2	-.03	.21**	.32**	.25**	.03	.15	.19*	.09
MN2	.02	.17*	.19*	.33**	.01	.13	.08	.15
Time 2								
	M2Score	TV3	TC3	TE3	M2Score	TV3	TC3	TE3
M3	-.02	.31**	.30**	.30**	.17*	.24**	.26**	.19*
MP3	.02	.37**	.40**	.32**	.19*	.33**	.39**	.28**
MN3	-.04	.24**	.22**	.25**	.15	.17*	.16*	.12
Time 3								
	M3Score	TV4	TC4	TE4	M3Score	TV4	TC4	TE4
M4	.13	.27**	.25**	.27**	.02	.27**	.25**	.31**
MP4	.16	.36**	.41**	.35**	.09	.39**	.40**	.42**
MN4	.10	.20*	.15	.20*	-.01	.19*	.16	.22**

* Significant at $p < .05$
** Significant at $p < .01$

Chapter 4: Discussion

The primary purpose of this study was to evaluate whether a collaborative critical thinking intervention could have an impact on trust development and effectiveness in virtual teams. In light of previous findings (Hess et al., 2008), it was hypothesized that teams trained in CCT would outperform those not trained in CCT due to direct effects on performance (e.g., better decision making). Furthermore, it was argued that CCT training can enhance performance through indirect channels by increasing levels of trust and monitoring, which have well-established positive relationships with team effectiveness (e.g., Dirks & Ferrin, 2001; De Jong & Elfring, 2010). This study did not find differences in positive or negative monitoring, cognitive or affective trust, objective performance, team viability, or team efficacy between team members trained in CCT and those trained in a control condition.

CCT trained teams, however, consistently reported higher levels of team cooperation than teams not trained in CCT. The team cooperation instrument sought to determine the extent to which teammate interactions were harmonious by probing about how well a teammate got along with his or her team, how comfortable they were asking for help from the team, whether the team was cooperative, and whether everyone in the team is working towards the group's goals (Conway et al., 2012). This is an interesting finding because perceptions of team cooperation can predict a team's task outcomes (Pinto, Pinto, & Prescott, 1993). However, it is difficult to determine, within this study, the relationship between team cooperation and task performance since task performance was measured by the DDD simulation scores, which did not correlate with any of the other measures of effectiveness.

As expected, DDD scores did increase across the three performance periods, but it is evident that the DDD scores and the measures of perceived effectiveness measure different facets of performance. It was particularly surprising that there was no relationship between team efficacy and the DDD scores since the team efficacy items assessed perceptions of team competence (e.g., "My team is totally competent to complete the mission"). The lack of a relationship between the two can perhaps be explained by a lack of familiarity with the DDD scoring system. That is, participants did not understand what "good" team performance was within the context of the DDD system. Although participants were trained with respect to the point values of individual tasks in the scenarios, the system only provided feedback on each player's own DDD score. The team's total score as well as the individual scores of other players were not available to a given teammate. Teams were also only able to observe their own performance and did not have an opportunity to build accurate mental models of the ranges of performance possible within the simulation system. Thus, team members may have misjudged how well their teams actually performed.

Collaborative critical thinking is a task best engaged in by domain experts (Hess et al., 2008) because it is anchored in the recognition and metarecognition abilities that come only with extensive experience with a task (Cohen et al., 1996). The participants in this study were all novices with the DDD task. Despite training participants and allowing them the opportunity to develop their newly acquired knowledge in a practice mission, team members consistently increased their DDD scores across the performance episodes. While this may be an effect of a team process (e.g., improved coordination), the consistent score increases may also be a function of continued task learning. Future studies should ensure that practice effects are not present by choosing teams whose members are task experts before the team is trained in CCT. Furthermore, it may be beneficial to evaluate the effects of CCT training in face-to-face teams before applying it in virtual teams. Since CCT requires large volumes of information exchange, the constricted text-based communication channel used in this study may be insufficient for adequate information exchange.

No study to date, including this one, has systematically captured and analyzed actual collaborative critical thinking *behavior* in teams. Presumably, CCT behavior is the mediator between CCT training and any hypothesized effects on performance, trust, and monitoring. Thus, although participants in the CCT group received CCT training, it is unclear whether or not they actually engaged in CCT behavior. Future studies should evaluate CCT behavior to determine whether CCT training leads to increases in CCT behavior. Within-group intervention studies where team collaborative critical thinking and performance is evaluated before and after a CCT intervention will be particularly useful in addressing this issue. Evaluating CCT behavior is a challenging prospect because it requires capturing and analyzing large volumes of team communication and because no system currently exists for systematically evaluating the quantity and quality of CCT behavior.

The CCT framework of monitoring for uncertainty, assessing the opportunity and need to address it, conducting critiques to identify the sources of uncertainty, and devising actions that reduce their impact on the mission (Hess et al., 2008) should guide the development of behavior-based evaluations of CCT. CCT training attempts to instill in trainees the need to *explicitly* consider states that would otherwise be confined to individual team members (e.g., considering plausible, alternative plans). Therefore, if teams are engaging in CCT as it is designed, CCT behaviors should be reflected in team communications. Hess et al. (2008) developed a series of CCT probes, which they as part of an electronic tool to remind team members to engage in CCT.

These probes should be used as a starting point for researchers seeking to codify CCT behaviors. For example, the behavior represented by the prompt, “the team has identified key assumptions that have yet to be tested concerning its goals” could be manifest in DDD chat transcripts as an explicit discussion by team members about whether each sensor provides accurate information. This assumption would be an important one to test since some sensors are designed to provide misleading information.

This study used the CCT training protocol as it was originally developed by Hess et al. (2006). The training defines and characterizes CCT, and participants are taught about the steps involved in CCT and common barriers to critical thinking (e.g., schemas). However, participants are never provided an opportunity to actively practice collaborative critical thinking. Despite the participants clearly understanding the principles of CCT (as demonstrated by high performance on the CCT quiz), the training may not have been sufficient to actually provide participants with the skills to engage in collaborative critical thinking. Since trust was a variable of interest in this study, it was important to control contact between team members prior to their performing together. Therefore, structured CCT practice between team members came at the expense of creating carefully controlled laboratory conditions. Future iterations of the CCT training protocol should create opportunities for CCT practice by perhaps including specific behavioral examples of CCT or CCT role-playing within the context of the particular task the team will be performing (e.g., the DDD scenarios; Arthur, Bennett, Edens, & Bell, 2003).

Relationship between trust and effectiveness

A second purpose of this study was to investigate the relationship between trust and effectiveness. A series of lagged latent factor models were estimated that examined the relationships between cognitive or affective trust and a variety of effectiveness measures (team viability, team efficacy, team cooperation). Multiple group comparisons within each model demonstrated that the CCT and control training groups were invariant with respect to factor loadings and path parameter estimates. Thus, the groups were combined and a single model was estimated for each trust-effectiveness pairing. A strength of this study in investigating the trust→effectiveness and effectiveness→trust effects is the longitudinal nature of this study's design such that there was temporal precedence between trust and effectiveness measurements.

Many studies have demonstrated that trust is an important predictor of effectiveness (e.g., Costa, 2003; Costa, Roe, & Taillieu, 2001; Dirks, 2000; Dirks & Ferrin, 2002; Jarvenpaa & Leidner, 1998; Klimoski & Karol, 1976; Mayer et al., 1995; McAllister, 1995; Morgan & Hunt, 1994; Smith & Barclay, 1997; Webber, 2008), although several studies found that trust does not predict effectiveness (Aubert & Kelsey, 2003; Dirks, 1999; Porter & Lilly, 1996; Pavlova, 2012). This study confirms the majority of previous findings that both cognitive and affective trust predict a variety of effectiveness outcomes (i.e., team viability, team cooperation, team efficacy). This strengthens the notion that finding effective interventions, as this study attempted to do through CCT training, to boost trust in virtual teams is critical for maximizing team performance.

Several studies have also demonstrated that effectiveness predicts trust (Aubert & Kelsey, 2003; Webber, 2008; Pavlova, 2012). The findings of this study echo previous research such that team viability, team cooperation, and team efficacy predict cognitive and affective trust. However, these results should be interpreted with caution because, although the teams performed before the trust measures were taken, there was little delay between the measurement of effectiveness and subsequent trust. Subsequent research could address this concern by temporally separating individual performance episodes to reflect natural breaks in team performance.

Allowing for time in between performance episodes also likely reflects a more accurate state of team interaction since teams perform together, separate, and reconvene.

Monitoring

A third aim of this study was to evaluate the relationships between monitoring and performance and between monitoring and trust. Previous research demonstrated that both types of monitoring are positively related to performance (Bijlsma-Frankema et al., 2008; De Jong & Elfring, 2010; Fransen et al., 2011; Yee et al., 2010). The results of this study support these previous assertions that both positive and negative monitoring are positively related to performance. Thus, it appears that all monitoring is good monitoring with respect to team performance.

The extant literature is divided as to whether monitoring is associated with trust or distrust. Monitoring has a "two-faced" nature (Bijlsma-Frankema, de Jong, & van de Bunt, 2008) such that teammates can monitor one another positively or negatively. Negative, or control-based, monitoring has been associated with interpersonal distrust (Costa et al., 2001; Costa, 2003; Costa & Anderson, 2011) while positive, or need-based, monitoring has been associated with affective bonds indicative of caring and trust among team members. No study to date had included both positive and negative monitoring measures to assess the relationship between the two types of trust (cognitive and affective) and the two types of monitoring (positive and negative). In this study, cognitive trust was not related to either type of monitoring, but affective trust was positively related to both positive and negative monitoring. That is, the greater the emotional bonds of care and concern between teammates (affective trust), the more teammates monitor one another both positively and negatively. This lack of dissociation perhaps implies that the notion of positive and negative monitoring should be abandoned in favor of a unified conception of monitoring (i.e., teammates who care about one another, monitor one another).

The lack of a relationship between cognitive trust and monitoring indicates that perceptions of team member competence, reliability, capability, and dependability were not associated with team monitoring. This finding opposes previous findings that diminished cognitive trust (derived from perceptions of team member performance) is the primary driver of negative monitoring (Costa, 2003).

Trust

Media Richness Theory (Daft & Lengel, 1986; Daft, Lengel, & Trevino, 1987), Social Presence Theory (Short, Williams, & Christie, 1976), and Time, Interaction, and Performance Theory (TIP; Mcgrath, 1991) suggest that virtual teams might have difficulty developing trust due to impoverished communication channels. Although comparing trust development under various media richness conditions was not an explicit aim of the present study, the text-based communication used by team members in the DDD scenarios was quite restrictive with respect to the exchange of social information (Daft, Lengel, and Trevino, 1987). Team members did not meet one another face-to-face at any point, and their interactions were restricted to gameplay in the DDD scenarios and text-based chat within the simulation. Yet despite these limitations, team members reported development in both cognitive and affective trust. Although both cognitive and affective trust developed throughout the teams' time together, initial cognitive trust and cognitive trust at subsequent episodes was consistently higher than affective trust. Although this makes sense in light of previous findings that cognitive trust develops before affective trust (McAllister, 1995), the effect found in this study may not be generalizable to other settings. First, all of the participants were aware that their team members were students at a university, which may constitute grounds for elevated levels of cognitive trust due to the competency requirements associated with a university-level education. Second, levels of affective trust in this study may have been elevated due to the shared social context of participants being aware that they all attend the *same* university. With these limitations in mind, the findings from the present study still demonstrate that it is possible to develop trust under near-boundary conditions of information richness. Enriching the communication medium (e.g., video-based chat) should increase the speed with which team members develop trust (Wilson et al., 2006).

Propensity to trust has been associated with initial levels of trust (Costa, 2003), but participants in previous studies had been acquainted with one another prior to the measurement of initial trust. In this study, teammates were completely unfamiliar with one another, which made a compelling case for examining whether initial trust was associated with individual differences in the propensity to trust. The trust subscale of agreeableness used in this study primarily assessed trust as it related to the motivations of others (e.g., a belief in human goodness, being wary of others, trusting what people say). Thus, the scale was more indicative of the types of factors that might influence affective trust. However, propensity to trust was associated with initial cognitive, but not affective, trust. These results should be interpreted with caution because participants regularly reported that they had trouble filling out the initial trust questionnaire because they had little basis for making initial trust judgments. For example, one item in the initial cognitive trust scale stated, “Given my teammates’ track records, I see no reason to doubt their competence and preparation for our mission.” Thus, the relationship between propensity to trust and reported levels of team trust was assessed at the second time measurement, after team members had an opportunity to perform with their teams. At the second trust measurement, propensity to trust was positively associated with affective trust and not associated with cognitive trust. Future studies should therefore incorporate propensity to trust as a covariate when measuring affective trust.

Limitations and Future Directions

While some limitations have already been discussed in the context of specific findings, there are several additional limitations that should be noted. As the overarching hypothesis of this study, that there would be differences between the CCT- and control-trained teams, was not supported, the recommendations for future directions stem from the limitations of this study and focus on adjusting conditions in future studies so as to maximize the potential effects of CCT training.

Although this study did not find differences between teams trained in CCT and those trained in a control condition, the idea that CCT has promise as an effective intervention for affecting trust, monitoring, and team effectiveness should not be abandoned. The sample of undergraduate student teams in this study may not accurately reflect the population of teams that may benefit from CCT training. Team members were not proficient at the focal task. Thus, inexperience and task learning may have precluded the higher order recognition and metarecognition processes required to engage in collaborative critical thinking. Thus, teams composed of task domain experts may yet benefit from CCT training. As previously noted, the CCT training protocol should also be enhanced with deliberate practice of collaborative critical thinking within the context of the team's task.

The objective performance measure in the present study did not correlated with the attitudinal measures of effectiveness. Although the objective effectiveness measures and the attitudinal measures should measure slightly different components of effectiveness, we nevertheless would expect these measures to covary. Future studies investigating effectiveness in teams can perhaps use a frame-of-reference training approach (Bernardin & Buckley, 1981) to demonstrate what constitutes effective and ineffective performance within the context of the team's task. This may not be a problem for teams outside of a laboratory setting because performance in the real world is accompanied by consequences, so team members can form accurate impressions of performance effectiveness.

The present study used iterated performance episodes and the same monitoring, trust, and effectiveness measures were used across time points. Since participants are repeatedly asked the same questions throughout the study, this can create the possibility for demand characteristics. However, this possibility is mitigated by the fact that there is no reason to suspect systematic effects in a particular direction since the hypotheses about, for example, the direction of the relationship between trust and performance, are unknown to participants. Despite this assertion, it may still be useful to develop alternate forms of these measures since they are administered so closely in time. Another issue with respect to the measures used in this study is the motivation of participants to answer items carefully. There were many items administered at each measurement point, and participants may not have read all items carefully before responding. In several instances, research assistants noted that a particular team member finished his or her survey well ahead of the other team members. Furthermore, several of the reverse-worded items in the scales had lower factor loadings than other items in the scale. This also indicates the possibility of haphazard responding. Shortening the scales and creating alternate forms should help with this problem.

Finally, these data were analyzed as two-level models such that repeated observations were nested within participants. However, participants were also nested at a third level, within teams. Thus, the methods of estimation used in the present study may underestimate the standard errors of estimated coefficients, which could produce Type I errors for between-teams comparisons. However, since no differences were found between the two types of training, the possibility of an overly-liberal test of the null for between-teams effects is a moot issue.

Conclusion

The present study examined the effects of collaborative critical thinking training on virtual team monitoring, trust, and effectiveness. No differences were discovered between teams trained in collaborative critical thinking and those trained in a control condition, with the exception of increased perceptions of collaboration in CCT trained teams. Several findings were replicated from previous studies. Specifically, trust and effectiveness drive one another over time, monitoring has a positive effect on team effectiveness, and propensity to trust is positively related to ratings of team trust. Future research should enhance the CCT training protocol by incorporating CCT practice and conduct studies using samples of team members who are proficient in their task work so as to maximize the potential benefits of CCT training.

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Appendices

Appendix A: DDD Scenario 1 Briefing

Mission 1 – Unmanned Aerial Vehicle

Yesterday, a team departed Station Blue on a mission to install a new antenna and recover a downed unmanned aerial vehicle (also known as a UAV). This new antenna needs to be installed immediately for the critical purpose of tracking meteors that may soon penetrate the earth's atmosphere. The UAV that crashed contains classified data and equipment and must be recovered and transported back to home base.

The team that went out yesterday encountered a severe storm. Before communications were lost, the team's leader reported that the storm had ruptured their Snowcat's fuel tank. In a last ditch effort to make the Snowcat lighter and reach a fuel depot, the team unloaded the antenna somewhere. Station Blue can no longer reach the team. They are lost and their Snowcat is in desperate need of repair.

Your team's job is to mount a search and rescue mission before another severe storm hits the area and puts lives and equipment at further risk. Here are your mission objectives:

- **Medical Objective**: Find the lost team, render medical aid, and get them safely back to Station Blue.
- **Repair Objective**: Find the antenna and install the antenna wherever you find it.
- **Recovery Objective**: Find the unmanned aerial vehicle (UAV)

Appendix B: DDD Scenario 2 Briefing

Mission 2 – Gondola

Yesterday, a team departed Station Blue on a mission to install a new antenna and scout the location of a gondola that came off its cable due to severe weather. This new antenna needs to be installed immediately for the critical purpose of tracking meteors that may soon penetrate the earth's atmosphere. The gondola must be found so that another team can re-attach it; building material deliveries must continue so that construction on a new base station can begin on the other side of a large crevasse.

The team that went out yesterday encountered a severe storm. Before communications were lost, the team's leader reported that the storm had ruptured their Snowcat's fuel tank. In a last ditch effort to make the Snowcat lighter and reach a fuel depot, the team unloaded the antenna somewhere. Station Blue can no longer reach the team. They are lost and their Snowcat is in desperate need of repair.

Your team's job is to mount a search and rescue mission before another severe storm hits the area and puts lives and equipment at further risk. Here are your mission objectives:

- **Medical Objective**: Find the lost team, render medical aid, and get them safely back to Station Blue.
- **Repair Objective**: Find the antenna and install the antenna wherever you find it.
- **Recovery Objective**: Find the gondola.

Appendix C: DDD Scenario 3 Briefing

Mission 3 – Satellite

Yesterday, a team departed Station Blue on a mission to install a new antenna and recover a U.S. Military satellite that fell out of orbit during testing. This new antenna needs to be installed immediately for the critical purpose of tracking meteors that may soon penetrate the earth's atmosphere. The satellite must be found quickly so that 1) engineers can diagnose why it failed, and 2) adversaries don't have an opportunity to steal the classified technologies aboard the satellite.

The team that went out yesterday encountered a severe storm. Before communications were lost, the team's leader reported that the storm had ruptured their Snowcat's fuel tank. In a last ditch effort to make the Snowcat lighter and reach a fuel depot, the team unloaded the antenna somewhere. Station Blue can no longer reach the team. They are lost and their Snowcat is in desperate need of repair.

Your team's job is to mount a search and rescue mission before another severe storm hits the area and puts lives and equipment at further risk. Here are your mission objectives:

- **Medical Objective**: Find the lost team, render medical aid, and get them safely back to Station Blue.
- **Repair Objective**: Find the antenna and install the antenna wherever you find it.
- **Recovery Objective**: Find the satellite.

Appendix D: CCT Training Quiz

Team Name:________________________ **Team Color:**_________________________

Collaborative Critical Thinking (CCT) Review

Please circle the correct answer.

1. The purpose of collaborative critical thinking (CCT) training is to:
   a. Encourage people and teams to make decisions based on confirmation bias
   b. Move people and teams from a state of cognitive constraint to one of openness
   c. Induce people and teams to think using constrained schemas
   d. All of the above

2. CCT is particularly useful for problems when:
   a. Everything is known about a problem
   b. Information for solving a problem is insufficient or contradictory

3. Lack of collaborative critical thinking can lead to:
   a. Tunnel vision
   b. Ignoring, discrediting, and/or underweighing important information
   c. Sticking stubbornly to an initial solution, even when evidence contradicting that solution accumulates
   d. All of the above

4. Groups of good decision makers:
   a. Avoid critiquing gaps, flaws, and assumptions in knowledge
   b. Use a process of constructive disagreement to search for important information differences
   c. Avoid generating and testing alternative explanations to problems
   d. Ignore conflicting information

5. In order to identify and define a problem, groups should:
   a. Define the problem in a way that is understandable to all group members
   b. Ask questions about the situation the group is in
   c. Gather information from one another
   d. All of the above

6. Group members need to actively participate in the exchange of ideas, information, and knowledge.
   a. True
   b. False

7. In order to gather and generate solutions, groups should do all of the following, EXCEPT:
   a. Ignore alternative solutions
   b. Discuss whether any group member has experienced a similar situation
   c. Define what type of information is needed to better understand the problem

8. When evaluating a solution, groups should:
   a. Discuss whether a solution could be wrong
   b. Discuss the potential risks associated with each solution
   c. Discuss whether the solution matches the goal
   d. All of the above

Appendix E: SURVIVAL Training Activity

Team Name:_________________________ **Team Color:**_________________________

SURVIVAL Activity

Consider the following scenario:

You are on vacation in Mexico and Central America. It is about 11:30 AM, and you are riding in the back of a bus crowded with about 35 natives. You have just crossed a mountainous pass from Mexico into Guatemala when local rebels hijack the bus. They enter from the front and back of the bus and order all the passengers to get off the bus. Near the front of the bus one of the rebels hits a passenger with the butt of his rifle and a skirmish starts. Shots ring out and you hear moaning and crying. You fear that you may be next.

With the distraction you sense an opportunity to flee, and you take it. You run into the jungle. Some of the rebels notice your departure and pursue you. You hear bullets flying. After a couple of minutes, you lose your pursuers--they have little patience and they return to the bus. It is time for you to go into survival mode. What do you do next? How do you survive?

In the next 10 minutes, your goal is to devise a strategy that will allow you to survive the next 24 hours in the jungle. Using the SURVIVAL skills you have just learned, list your top five priorities and the first five actions you will take.

Priorities

1.

2.

3.

4.

5.

Actions

1.

2.

3.

4.

5.

Appendix F: Background Questionnaire

1. What is your gender?   Female   Male

2. What is your age? _________________

3. Race (optional)

_____Asian/Pacific Islander
_____Black/African-American
_____Caucasian
_____Hispanic
_____Native American/Alaska Native
_____Other/Multi-Racial
_____Decline to Respond

4. What is your class rank? (please check one)

_____Freshman
_____Sophomore
_____Junior
_____Senior
_____Graduate
_____Non-degree seeking

5. What is your current major? _________________

6. Do you have a job?   Yes   No

If yes, how many hours per week do you work on average? _____hrs/wk

7a. On average, how often do you work as part of a team? (please check one)

_____Never
_____Rarely
_____Sometimes
_____Usually
_____Always

7b. Have you ever had any team-related training? ____Yes ____No

If yes, please describe:

8. Do you have military experience? _____Yes   _____No

If yes, please describe:

Appendix G: Personality Questionnaires

Instructions:

Below, there are phrases describing people's behaviors. Please use the rating scale below to describe how accurately each statement describes ***you***. Describe yourself as you generally are now, not as you wish to be in the future. Describe yourself as you honestly see yourself, in relation to other people you know of the same sex as you are, and roughly your same age. So that you can describe yourself in an honest manner, your responses will be kept in absolute confidence. Please read each statement carefully, and then fill in the bubble that corresponds to the number on the scale.

Trust Subscale (Agreeableness)

I…	How Accurately Can You Describe Yourself?				
	Very Inaccurate	Moderately Inaccurate	Neither Inaccurate or Accurate	Moderately Accurate	Very Accurate
Trust others	1	2	3	4	5
Believe that others have good intentions	1	2	3	4	5
Trust what people say	1	2	3	4	5
Believe that people are basically moral	1	2	3	4	5
Believe in human goodness	1	2	3	4	5
Think that all will be well	1	2	3	4	5
Distrust people**	1	2	3	4	5
Suspect hidden motives in others**	1	2	3	4	5
Am wary of others**	1	2	3	4	5
Believe that people are essentially evil**	1	2	3	4	5

** = reverse scored

Overall Conscientiousness

I...	How Accurately Can You Describe Yourself?				
	Very Inaccurate	**Moderately Inaccurate**	**Neither Inaccurate or Accurate**	**Moderately Accurate**	**Very Accurate**
Am always prepared	1	2	3	4	5
Pay attention to details	1	2	3	4	5
Get chores done right away	1	2	3	4	5
Carry out my plans	1	2	3	4	5
Make plans and stick to them	1	2	3	4	5
Waste my time **	1	2	3	4	5
Find it difficult to get down to work **	1	2	3	4	5
Do just enough work to get by **	1	2	3	4	5
Don't see things through **	1	2	3	4	5
Shirk my duties **	1	2	3	4	5

Appendix H: Trust Questionnaire

Cognition-based trust

	Completely Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Completely Agree
My teammates approach the mission with professionalism and dedication	1	2	3	4	5	6
Given my teammates' track records, I see no reason to doubt their competence and preparation for our mission	1	2	3	4	5	6
I can rely on my teammates not to make my job more difficult by careless work	1	2	3	4	5	6
My teammates consider my team to be trustworthy	1	2	3	4	5	6
If people knew more about my teammates and their background, they would be more concerned and monitor their performance more closely **	1	2	3	4	5	6

** = reverse coded

Affect-based trust

	Completely Disagree	**Mostly Disagree**	**Slightly Disagree**	**Slightly Agree**	**Mostly Agree**	**Completely Agree**
My team has a sharing relationship. We can freely share our ideas, concerns, and strategies	1	2	3	4	5	6
I can talk freely to my teammates about difficulties I am having with the mission and know that they will want to listen	1	2	3	4	5	6
We would all feel a sense of loss if one of us was removed from the team and we could no longer work together	1	2	3	4	5	6
If I shared my problems with my teammates, I know they would respond constructively and caringly	1	2	3	4	5	6
I would have to say that we have all made considerable emotional investments in our working relationship	1	2	3	4	5	6

Appendix I: Monitoring Questionnaires

Need-based (positive) monitoring

	Completely Disagree	**Mostly Disagree**	**Slightly Disagree**	**Slightly Agree**	**Mostly Agree**	**Completely Agree**
Even when others think everything is fine, I know when my teammates are having difficulties	1	2	3	4	5	6
My teammates don't have to tell me in order for me to know how things are going for them in the mission	1	2	3	4	5	6
I monitor my teammates because it's part of what a good teammate does	1	2	3	4	5	6

Control-based (negative) monitoring

	Completely Disagree	**Mostly Disagree**	**Slightly Disagree**	**Slightly Agree**	**Mostly Agree**	**Completely Agree**
In this team we check whether everyone meets their obligations to the team	1	2	3	4	5	6
The quality of the work of my teammates is only maintained by my diligent monitoring	1	2	3	4	5	6
In this team we keep close track of whether everyone performs as expected	1	2	3	4	5	6
In this team we check whether everyone is doing what is expected of him/her	1	2	3	4	5	6
In this team we carefully monitor each other's progress on his/her work	1	2	3	4	5	6
I keep close track of my teammates, taking note of instances where they do not keep up with their responsibilities	1	2	3	4	5	6
I find that I do not need to monitor my teammates closely **	1	2	3	4	5	6

** = reverse coded

Appendix J: Team Viability Questionnaire

	Completely Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Completely Agree
I would be willing to work with this team on another mission	1	2	3	4	5	6
I would avoid being on a mission with this team again **	1	2	3	4	5	6
I feel that this team would work well together on another task	1	2	3	4	5	6

** = reverse coded

Appendix K: Team Cooperation Questionnaire

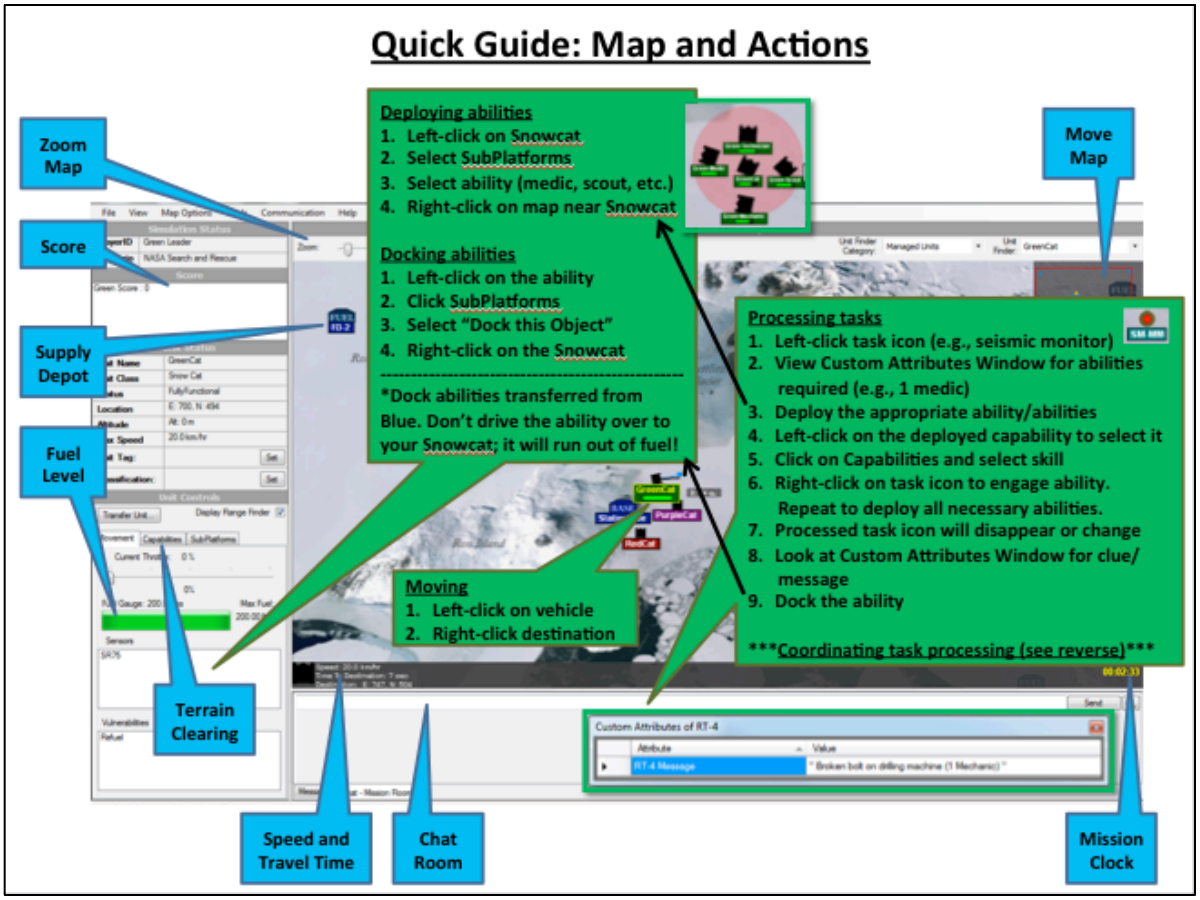
	Completely Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Completely Agree
I get along with my teammates	1	2	3	4	5	6
I am comfortable asking for help from my teammates	1	2	3	4	5	6
My teammates are cooperative	1	2	3	4	5	6
I feel like everyone in the team is working towards the groups' goals	1	2	3	4	5	6
I feel as if everyone in the group is looking out for their own interests **	1	2	3	4	5	6

** = reverse coded

Appendix L: Team Efficacy Questionnaire

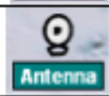
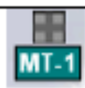
	Completely Disagree	Mostly Disagree	Slightly Disagree	Slightly Agree	Mostly Agree	Completely Agree
I feel confident about the capability of my team to perform the mission very well	1	2	3	4	5	6
My team is able to solve difficult tasks if we invest the necessary effort	1	2	3	4	5	6
I feel confident that my team will be able to effectively manage unexpected complications	1	2	3	4	5	6
My team is totally competent to complete the mission	1	2	3	4	5	6

Appendix M: DDD Quick Guide – Map and Actions



Appendix N: DDD Quick Guide – Tasks and Team Structure

Quick Guide: Tasks

Icon	Task	Points	Notes
Mission Objectives			
	Medical Objective	300	• Objective: Find and aid lost party • Process using scout, mechanic, medic, and/or technician abilities
	Repair Objective	300	• Objective: Find and install antenna • Process using scout, mechanic, medic, and/or technician abilities
Varies with mission (see right)	Recovery Objective	300	• Objective: Find UAV/Gondolla/Satellite    • Process using scout, mechanic, medic, and/or technician abilities
Tasks (these help accomplish Mission Objectives)			
	Clue	-	• Do not need to apply any abilities to read • May or may not be useful
	Seismic Monitor	10-80	• Provides vibration information (e.g., vehicle passing by) • Monitors closest to path of lost party earn the most points. • Process using scout, mechanic, medic, and/or technician abilities • Can take one to three steps to process (analyze, prepare, and/or repair)
	Medical Task	50	• Not mission-critical, but can yield important information • Process using scout, mechanic, medic, and/or technician abilities
	Repair Task	50	• Not mission-critical, but can yield important information (e.g., "It's Cold Out Here" means you're searching in the wrong area) • Process using scout, mechanic, medic, and/or technician abilities
Clues from Medical and Repair Tasks disappear after they are read. Share the info with your team!			
	Emergency Task	75	• Not mission-critical, time-sensitive emergencies • Process using scout, mechanic, medic, and/or technician abilities • **Only 15 minutes to complete!**
	Blocked Terrain	-	• Terrain is blocked • Clear path using terrain clearance capability on Snowcat • Some terrain slows down Snowcat speed; wait or find other route
	Refueling and Resupplying	-	• Request additional fuel and abilities from Blue (use chat). • Don't run out of fuel! If your Snowcat runs out of fuel, you will be removed from the game. • Your Snowcat will only be refueled once. • **Don't try to use your abilities to explore the environment! They cannot detect tasks and they cannot be refueled!** • Abilities are replenished by Blue as a last resort. Coordinate abilities with your teammates first! • Once Blue has transferred an ability, dock it to your Snowcat.

Team Structure

Coordinating Task Processing (from reverse)

<u>When you don't have enough abilities to process a task on your own:</u>

1. Communicate with your team to see who has sufficient abilities to combine with yours to process the task.

2. Both players should deploy the appropriate ability and position it within range of the task icon.

3. Abilities must be applied by both team members at the same time.
   i. Decide how many abilities each team member will apply
   ii. Use the task clock to decide a time to apply the abilities
   iii. When the time comes, both team members must quickly apply the ability within 10 seconds. (e.g., Red right-clicks 3 times while Green right-clicks 4 times)

Appendix O: IRB Approval

USF
UNIVERSITY OF SOUTH FLORIDA

DIVISION OF RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-5618

December 6, 2012

Evgeniya Pavlova
Psychology
4202 East Fowler Ave, PCD4118G
Tampa, FL 33620

RE: **Approved** Amendment Request
IRB#: MS2_Pro00003208
Title: Trust Development in Virtual Teams

Dear Ms. Pavlova:

On 12/5/2012 the Institutional Review Board (IRB) reviewed and approved your Amendment by expedited review procedures.

The submitted request has been approved **from date:** 12/5/2012 **to date:** 3/6/2016 for the following:

Protocol Document(s):
Protocol_2(0.02)

1. Change in study staff: Addition of Mark Grichanik as co-investigator
2. Change in study sites: Addition of Air Force Research Laboratory at Wright-Patterson AFB Ohio as a site; AFRL IRB approval letter provided.
3. Change in compensation: AFRL participants will receive $10
4. Increase total number of participants from 400 to 700
5. Revised protocol, v2 dated 12/4/12.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

John A Schinka, Ph.D.

John Schinka, PhD, Chairperson
USF Institutional Review Board